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# Partial Equilibrium Models for South Asian Countries : Determinants and Evolution of Supply and Demand for main food and feed products

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**Partial Equilibrium Models for South Asian Countries: Determinants  
and Evolution of Supply and Demand for main food and feed  
products**

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## RESUME

Étant les pays les plus peuplés d'Asie du Sud, l'Inde, le Pakistan et le Bangladesh représentent ensemble environ 37% de la population mondiale sous-alimentée. Ainsi, ces pays sont d'un intérêt particulier pour l'analyse de leurs systèmes agricole et alimentaire et pour la réalisation de divers scénarios. Les principaux paramètres d'importance relatifs à l'évolution du système agricole et à l'état de la sécurité alimentaire de ces trois pays sont présentés dans le **premier** et **deuxième** chapitre de cette thèse.

Les déterminants de l'offre sont présentés avec leur évolution dans le troisième chapitre de la thèse. Les élasticités directes et croisées d'offre de surfaces relatives aux produits bruts de chaque culture sont calculées par un modèle translog et analysées dans ce même chapitre. Les résultats indiquent notamment que les surfaces cultivées des principales cultures (blé et riz) sont relativement faiblement élastiques au produit brut par rapport aux cultures mineures.

Les déterminants de la demande pour l'alimentation humaine sont présentés avec leur évolution dans le **quatrième** chapitre de la thèse. Dans le même chapitre, les élasticités revenus, ainsi que les élasticités directes et croisées (compensées et non compensées) relatives aux prix des produits végétaux et des produits animaux principaux pris séparément puis, avec une hypothèse de budgétisation à deux niveaux, ensemble sont calculés pour ces pays en utilisant un modèle LA-AIDS. La relation entre les groupes agrégés de produits végétaux et animaux est également analysée. Il est apparu que les principaux produits alimentaires dans ces pays, comme le blé, le riz, les œufs et le lait sont relativement moins élastiques à leurs propres prix que d'autres aliments (huiles végétales, sucre, etc.). Lorsque les dépenses augmentent dans ces pays, les consommateurs pakistanais et indiens diversifient plus leur consommation qu'au Bangladesh, passant des céréales à plus d'autres produits (lait, œufs).

Les déterminants de la demande pour l'alimentation animale sont présentés avec leur évolution dans le **cinquième** chapitre. Dans le même chapitre, les élasticités-prix directes et croisées pour les différents produits d'alimentation de l'alimentation animale sont calculés en utilisant d'abord une régression pour estimer la demande totale en fonction des productions animales (notamment de volailles, d'œufs et de lait) puis une méthode d'estimation translog à partir de pseudo-données générées par un modèle de formulation nutritionnel pour obtenir les élasticités de demande pour ces trois pays. Il est apparu que dans ces pays, certains tonnages de blé et de riz sont consommés

directement au niveau de l'exploitation par les animaux. Les utilisations totales de sons et de mélasses sont relativement élastiques à leurs prix au Pakistan et en Inde, mais relativement inélastiques au Bangladesh. Le maïs, ingrédient important, est élastique à son prix et substitut des sons dans trois pays.

Dans le **sixième** chapitre, la méthodologie utilisée pour la construction des modèles d'équilibre partiel est présentée ainsi que les modalités de son implémentation dans le logiciel GAMS avec utilisation du solveur non linéaire COUENNE. Les différents scénarios calculés pour 2009 et 2025 montrent l'influence de la variation des principaux paramètres exogènes (population, revenu par habitant, superficie totale cultivée, production animale et rendements des diverses cultures) sur les prix d'équilibre intérieurs, les superficies et les quantités (production, consommation, commerce extérieur) par rapport à la situation réelle de l'année 2009. Il est apparu que toutes choses égales par ailleurs, une augmentation de la population ou des revenus par tête s'accompagnent de hausses de prix et d'une dégradation du commerce extérieur, tandis que des augmentations de surface totale cultivée, de rendements des cultures et des productions animales agissent en sens inverse. Ces dernières évolutions, de même que l'augmentation des revenus par tête tendent à améliorer la situation de la sécurité alimentaire dans ces pays en augmentant les apports journaliers en calories et protéines. Les subventions accordées aux consommateurs pour un seul produit (riz ou blé) ou pour tous les produits peuvent aussi améliorer la situation de la sécurité alimentaire, mais cette politique, coûteuse pour les gouvernements tend à s'accompagner d'une hausse des prix alimentaires et d'une dégradation du commerce extérieur.

Puis trois scénarios illustratifs différents pour 2025, un scénario tendanciel et deux scénarios possibles de «dialogue politique» entre les trois pays sont calculés. Pour le scénario tendanciel, accompagné d'une certaine libéralisation des échanges, dans les trois pays, la situation alimentaire serait améliorée, mais s'accompagnerait d'une certaine inflation sur les prix alimentaires et d'une aggravation du déficit commercial. Tandis que le scénario de limitation de l'augmentation du déficit global de l'Asie du Sud entre 2009 et 2025 (de façon à favoriser les échanges intra-zone) semblerait plus bénéfique pour le Pakistan par rapport aux deux autres pays, le scénario de contrôle et d'harmonisation de l'évolution des prix des produits agricoles dans les trois pays serait plus bénéfique pour l'Inde par rapport aux deux autres pays.

Dans la **conclusion** sont présentées les principales limites à ce travail ainsi qu'aux précédents résultats qui ont un caractère qualitatif et certaines pistes d'amélioration de ces modèles d'équilibre partiel.

**Mots clés:** Alimentations humaine et animale, Bangladesh, Elasticités de demande et d'offre, Inde, Model équilibre partiel, Pakistan, Scenarios, Sécurité alimentaire.

## Abstract

Being the most populous countries of South Asia, India, Pakistan and Bangladesh together represents about forty percent of the world total undernourished population. Thus, these three countries are of particular interest in food and feed analysis. On supply side, the own and cross gross product elasticities for each crop are calculated by translog model. The crop areas of the major crops (wheat and rice) are weakly gross product responsive as compared to the minor crops. On demand side, income elasticities and the own and cross uncompensated price elasticities of main vegetal products and animal products taken separately as well as together are calculated for these countries by using the LA-AIDS model. It appeared that main food products in these countries like wheat, rice, eggs and milk are relatively less price elastic as compared to other food (vegetal oils, sugar). When expenditure rises in these countries, then Pakistani and Indian consumer diversify their consumption from cereals to other products (milk, eggs) more than Bangladeshi. The own and cross price elasticities for different feed products are calculated by using regression model and translog model on pseudo data generated by a feed nutritional formulation for these three countries. It appeared that in these countries, wheat and rice are consumed directly on farm level by animals to some extent. Total brans and molasses are relatively high price elastic in Pakistan and India but relatively inelastic in Bangladesh. Maize is highly price elastic and substitute of brans in three countries. The partial equilibrium model for each of the three countries implemented in the GAMS with nonlinear solver COUENNE has allowed the realization of various scenarios for 2009 and 2025. These scenarios calculated influence of variation in key exogenous parameters (population, per capita income, total cultivated area, animal production and yields of various crops) on domestic prices, area and quantities (, production, consumption, external trade) from the actual situation of 2009. The scenario of limiting the increase in the overall deficit of Southeast Asia between 2009 and 2025 (in order to promote intra-zone exchange) would be more beneficial for Pakistan as compared to the other two countries while the scenario to control and harmonize the evolution of agricultural prices in the three countries would be more beneficial for India compared to the other two countries.

In the conclusion the main limitations and some ways of improving these partial equilibrium models are presented with previous qualitative results.

**Keywords:** Bangladesh, Food security, Human food and animal feed, India, Pakistan, Partial equilibrium model, Scenarios, Supply and demand elasticities.

## **DEDICATION**

This thesis is dedicated to my parents and my wife who have supported me all the way since the beginning of my studies. This thesis is also dedicated to my sisters and brothers who has been a great source of motivation and inspiration.

Finally, this thesis is dedicated to all those who believe in the richness of learning.



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## List of abbreviations used:

Abbreviation		Signification
%	:	Percentage
\$	:	Dollar
BIS	:	Bureau of Indian Standard
CGCA	:	Compound Livestock Feed Manufacturer's Association of India
CPI	:	Consumer price index
ERS	:	Economic research service
FAPRI	:	Food and Agricultural policy research institute
FAO	:	Food and Agriculture Organization
FAOSTAT	:	The statistics division of FAO
GDP	:	Gross domestic product
ha	:	Hectare
LCU	:	Local currency unit
M	:	Million
Mha	:	Million hectares
Mt	:	Million tons
Pak	:	Pakistan
PEM	:	Partial equilibrium model
PSD	:	Production, Supply and Distribution
Rs.	:	Rupees

SOFI	:	The State of Food insecurity in the World
t	:	Metric ton
UNCTAD	:	The United Nations Conference on Trade and Development
USDA	:	United States Department of Agriculture

# Chapter I: Objective and general methodology

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## 1.1. General context

The most important concern of all the time is to attain food security in the world. Global food security is one of the most urging societal issues of our time. Situation is continuously changing in the context of food security i.e. population is increasing with the passage of time. The rising of income and urbanization in developing countries raise many questions about the future food security situation of these countries so policy makers are facing an enormous agenda. Hunger<sup>7</sup> can be demolished by having deep knowledge of risks and forces affecting people's access to food as well as by better policy actions (Braun et al., 2005).

Of course, objective of increasing the food security in a changing environment raise many questions. Some of them concern the public policies which could be implemented and could have probable impacts on 1) agricultural areas and productions 2) food and feed demands 3) external trade balances 4) revenue and cost for producers, consumers and Public Budget. Along with real world mutations, the field of food security has experienced many changes in the last three decades. While the thesis rises different economic questions, which are all tackled from the same perspective. The last paragraph of this section presents the approach that has been used in this thesis as well as the content and organization of the different chapters.

### **Food security conditions are changing:**

It is known that agriculture sector is the main source of food and livelihoods for majority of the world's hungry population in developing countries (Sinha et al., 1988). Approximately 80 percent of hungry people live in rural areas having lack of all facilities<sup>8</sup>.

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<sup>7</sup> *Undernourishment, or hunger*, is defined as food intake that is continuously inadequate to meet dietary energy requirements. *Food insecurity* is defined as a situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life (ACC/SCN 2004).

<sup>8</sup> Hunger Task Force 2003



Agriculture is the main economic sector in developing countries (World Development Report, 2008). 1.3 billion people in this world depend on agriculture and the developing world makes 97% of these people (Hurst, 2006; WB, 2008). So agriculture is the most important sector to improve economic condition and food security.

Demand for agricultural land is mainly linked to food and feed productions (Kampman et al., 2008) even if some land is devoted to “non-food” products such as forests, rubber trees vegetal fibers, biofuels, etc. In some cases an agricultural crop gives after transformation both a food or feed product (like cotton seed) and a non-food product (cotton lint). Cereals are cultivated on about half of arable land then it is oilseeds. In future, there would be more demand for agricultural land as a result of population growth and increased food demand, so situation has also to be improved by increasing agricultural yields and by adopting better technologies.

To meet food demand, it is necessary to increase food supply. That may come from two different ways: 1) to increase cultivated land and/or 2) to raise yields. In old times the food supply increased more by adding cultivated land than by improving crop yield (Evans, 1998) but now it is yield that should be improved due to less availability of cultivated land and environmental constraints. In future, at 2050 horizon there will be need for cultivated land two times more than present to feed future populations (Fischer et al., 1998; Greenland et al., 1998a; Evans, 1998). But much of the spare land is already used for other purposes (Greenland et al., 1998b).

Between 1967 and 1997, the number of undernourished people in developing countries decreased due to more investment in agriculture sector, growth in per capita production of cereals, food availability and decline of world price of major cereals<sup>9</sup>. Even then investment and growth-oriented policy actions are needed to cut hunger<sup>10</sup>. Cereal grain demand in developing countries has been also significantly increased due to increased demand of food and feed grain so many countries having low production started to import cereals to meet their demand. Rising income combined with urbanization rose consumption of animal protein, particularly in form of poultry meat in developing countries which increased more than double between 1967 and 1997 that escalated demand for cereals as feed. While in developing countries, a person normally consume animal protein less than half consumed by person in developed country.

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<sup>9</sup> See Rosegrant et al. 2003, Rosegrant et al. 2001

<sup>10</sup>Braun et al.2005, Rosegrant et al. 2001

Total food production must rise by 70 to 100% by the year 2050, if we have to feed sufficiently a nine billion population at that time (Bruinsma, 2009; Parry et al., 2010; Zhu et al., 2010)

The problem is not only insufficient food production but uneven distribution, so reason of food insecurity is inadequate distribution of food supply among the human population, due to what Conway et al.(1999) have called “notoriously ineffective” world markets. Sugar cane, maize, rice, wheat, soybean, oil palm fruit, barley, sorghum and rapeseed represent more than 50% of total world cultivated areas and food productions.

The world’s population will be more than 8 billion people in 2025 and maximum increase will be in urban population in developing countries (1 billion in 1985 to 4 billion by 2025) so world total food production will have to be more than double in 2025 (McCalla, 1994). In the last estimation of United Nation Organization<sup>11</sup>, the same estimation of world’s population is made for 2025 and an estimation of 9.31 billion people is given for 2050.

According to SOFI (2011), prices of food commodities of world markets, adjusted for inflation, declined substantially from the early 1960s to the early 2000s, when they reached a historic low. They increased slowly from 2003 to 2006 and then surged upwards from 2006 to the middle of 2008 before declining in the second half of that year. The food crisis during 2006-2008, which has greatly affected the food consumption in many developing countries including Pakistan (see Chapter 4) has raised and revived concern about global food security with the need including renewed efforts at agricultural research and its applications in many countries. However, in this work we will focus more specifically on structural changes in the last decades of key parameters such as acreage, yields, etc. The prevailing source of insufficient food consumption in developing countries is lack of access due to low income (World Bank, 1981) although it is not the only cause according to SOFI (1999). Therefore, the effect of income and price on the demand for food in developing countries has been the focus of many studies; see e.g. (Mellor, 1983; Behrman et al., 1987; Alderman, 1988). Average calorie intake has to be increased to improve living standard in developing countries (Bassi et al., 2011).

So taking the importance of different parameters described above (population, land cultivated, yield, price and income per capita, protein and calorie intake), there is always need of an empirical analysis to calculate their impact on food situation.

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<sup>11</sup> World Population Prospects: The 2010 Revision from the UN Population Division.

There are many studies on future food security scenario combining climate effect with food situation (Rosenzweig et al., 1993; Nelson et al., 2010; Perry et al., 2004; Gurler et al., 2005). Most of them agreed on this point that developing countries or low income countries will be characterized by accelerated population with high income that will raise demand for food as well as its cost and environmental risk. There may be situation of food insecurity and environmental risks that can be reduced by improving agriculture productivity of poor farmers, economic growth of poor and trade to fulfil domestic needs.

Agrimonde scenarios were presented by the French National Institute for Agricultural Research (INRA, 2009) at the FAO summit, who concluded that environmental investment, improved biodiversity, developed storage system and industrial development increases the available quantity of calories.

Shell established scenario analysis in the early 1970s to formulate schemes that were vigorous to the uncertainties covering the energy system (Wack, 1985). Scenario is “a description of potential future conditions, developed to inform decision making under uncertainty” (Parson et al., 2007). Its aim is not to predict the future but to present a variety of possible futures under uncertainty<sup>12</sup>.

Being limited in scope, scenario includes only variables having adequate data and models that combine them to help decision-makers for preparing strategies (Lempert et al., 2006). There are two types of models for the global food system: general equilibrium (CGE) models and partial equilibrium (PE) models. In general equilibrium models, whole economy is taken in account to simulate supply, demand and trade of a range of commodities in various sectors, including agriculture, across the global economy. Partial equilibrium models (PEM) take only in account agriculture sector to create a more thorough analysis for agricultural products.

Scenarios are a limited yet valuable tool. Outcomes for food security are often conceptualized by their effects on food availability, accessibility and utilization (Ericksen, 2008). The actual outcomes described in these various scenarios are simplified somewhat by the models used to frame their narratives. Nevertheless, international trade appears to be a crucial determinant of outcomes for the food system. In particular, while climate change is likely to widen the difference in cereal yields between high- and low-income countries, international trade may prevent particularly negative outcomes (Parry et al., 2004).

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<sup>12</sup> Uncertainty about the future means that it is not possible to credibly assign probabilities to the absolute results of the scenarios, but the analysis does allow exploration of a range of plausible futures.

Developing countries in South Asia like Pakistan, India and Bangladesh are characterized by rapid urbanization, rapid economic growth and food insecurity. According to some authors, India, Pakistan and Bangladesh will not get food security even in 2050 (Idso, 2011).

India is second populous country; Pakistan is sixth while Bangladesh is eighth. Sugar cane, rice, wheat, maize, millet, cotton seed, sorghum, soybeans, rapeseed and pulses<sup>13</sup> represent 80% of its total food production in India, Pakistan and Bangladesh. Therefore these three countries and these crops have been selected for our analysis.

As stated previously, the issue of food security for developing countries has many aspects. The first aspect is related to consumer income and their ability to purchase goods. This is directly taken into account in this work, through the analysis of the relationship between changing demands of food and income, this parameter appears explicitly in the demand estimates (chapter 4). Two other aspects could not be addressed in this work due to lack of time and data, including everything about the links between changes in the level of satisfaction of nutritional needs within countries and changes in prices as well as availability in the world market. Similarly, the existence of commercial channels (including logistics) that allows food to reach consumers from (and especially urban) areas from agricultural production, could not be addressed. We therefore focused on the purely quantitative aspects of the supply and demand for food within each of the three countries considered.

## **1.2. General objective and methodology**

The overall objective of this thesis is to understand and explain the mechanisms that are involved in the evolution of agro-food systems of the three main countries of South Asia (Pakistan, India and Bangladesh) and have a direct influence on the present and future food security in these countries. These mechanisms relate specifically to three points: Firstly, the interactions between vegetal and animal products (mechanisms of substitution and complementarity at supply and demand levels). Secondly, these mechanisms involve interactions between different levels of the agricultural sector and more specifically at two levels i) supply and ii) human and animal demand both of which are influenced by the local price and both in the opposite direction have the major influences on local prices. Thirdly, the mechanisms of evolution, involve a number of parameters

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<sup>13</sup> In this whole report the terms « dry beans » and « pulses » are used indifferently

that are considered exogenous in this work (population, crop yields, etc.) and have a direct influence on the levels of supply and demand for different products and therefore also on local prices.

To describe these mechanisms and quantify their respective influence, the construction of three partial equilibrium models (PEM) appears as the most appropriate tool because of its structure (see Chapter 6) and flexibility<sup>14</sup>.

A partial equilibrium model (PEM) is based on a theory of 1870s, referring particularly to the work of French economist Leon Walras and is defined by Parappurathu<sup>15</sup>

“A partial equilibrium is a type of economic equilibrium, where the clearance on the market of some specific goods is obtained independently from prices and quantities demanded and supplied in other markets. In other words, the prices of all substitutes and complements, as well as income levels of consumers are constant. Here the dynamic process is that prices adjust until supply equals demand. It is a powerfully simple technique that allows one to study equilibrium, efficiency and comparative statics. The stringency of the simplifying assumptions inherent in this approach makes the model considerably more tractable, but may produce results which, while seemingly precise, do not effectively real world phenomena economic model”

In spite of the limits indicated by Parappurathu, this methodology is particularly adapted to the economic analysis of the parameters influencing evolution of global national agricultural situations in relation with food security.

We have first to justify the choice of the world sub-region “South Asia” and the necessity to construct three different models having the same structure but with different parameters. Even if people may be interested in global results for this aggregated sub-region, and three main countries of this area have the same colonial history, cereals, other food and feed crops which are predominant in their total domestic production and consumption, but still they present important differences in terms of level of development and food habits, in particular in relation with cultural and religious specificities. In relation with food security problem, there are different reasons to concentrate on India, Pakistan and Bangladesh, even if other countries of this sub-region are important (Sri-Lanka, Iran, etc.) and have commercial relations with them.

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<sup>14</sup> Flexibility means the ability of a model to be used easily, once built and implemented by a computer program, for performing a variety of simulations referred as "scenarios".

<sup>15</sup> <http://www.iasri.res.in/sscnars/socialsci/13-Partial%20Equilibrium%20Model.pdf>

- 1) These three countries are very important in terms of population. India is second populous country, Pakistan is sixth and Bangladesh is eighth populous country. The growth rate of population is also more than world.
- 2) These three countries showed strong economic growth as well as income per capita.
- 3) These three countries represent more than forty percent of world total undernourished people (SOFI, 1999). Calorie and protein per capita intakes are also low as compared to world's mean intake.
- 4) Globally these three countries have presently limited agricultural trade with rest of the world, compared to a country such as China. They have more or less protective economy as compared to outer world.
- 5) Cultivated area per capita is also less as compared to main developed countries. These countries have high population density.
- 6) There is strong growth for production and consumption of animal products, even if their present level is still low. The system of production is mainly traditional but tends to become more industrial especially for poultry and milk. To fulfill the needs of animals, these countries have need of growing quantity of concentrates as feed. So a horizon up to 2025 is made to see that how each country can manage its problems to feed their population and animals.

In complement, it is important to notice that, these reasons are important from national political and economic points of view, but they are also a challenge for the whole world's agricultural markets. The example of China evolution during the last twenty years shows the revolution in world agricultural markets when this country (whose population with 1.37 billion inhabitants in 2010 is inferior to that of the three countries analyzed in this thesis i.e. 1.55 billion) decided, even before its adhesion to World Trade Organization (WTO) in September 2001<sup>16</sup>, to liberalize its imports of food and feed products. As long as China increased its trade surplus in industrial product over developed countries, it increased its deficit in agricultural products. This country was the second net importer for these products with a deficit of 45.3 billion US dollars (after Japan: 50.6) in 2010. This had a major impact on agricultural exports (and internal economic growth) for Brazil, Argentina, United-States and Indonesia which are (in this order) among the five countries (with Netherland) having the most important agricultural surplus.

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<sup>16</sup>Concerning agriculture China agreed to limit its subsidies for agricultural production to 8.5% of the value of farm output (per Article 6.4 of the Agriculture Agreement). China also agreed to apply the same limit to subsidies covered by Article 6.2 of the Agriculture Agreement

We have to justify the fact that in this work, emphasis was devoted to the description of the historical evolutions of specific situations of each country in terms of supply (changes in agricultural land and yields) as well as human and animal demand. The first reason is that these exhaustive descriptions are not found in the scientific literature (this is the case for Bangladesh) and the few studies identified, often with a limited number of products, are old (this is particularly the case for Pakistan). The national information developed by statistics services of these countries (economic survey of Pakistan 2011) have a cyclical approach and lack of ability to access internet on historical data sets so these services do not provide a synthetic vision retrospectively. The second reason is the need before making econometric estimates, to visualize different data sets used (largely from the FAO) and to detect (including visually curves) any "discontinuities" or anomalies. The introduction of some "dummy variables" in the estimated equations is to limit the influence of these "discontinuities" or anomalies of data on the values of calculated coefficients (in particular elasticities), but we should also take some caution in the interpretation of these figures, which must be considered as estimates of orders of magnitude.

The method adopted in this thesis is to use estimate of one supply function and two demand function (human demand and animal demand) for each country for the construction of the PEM. Furthermore, supply function contains cultivated land area, yields and producer prices of main crops while demand function contains consumption per capita for each country and proxy of retail prices<sup>17</sup>. The empirical analysis makes use of detailed national level data for each county. The behavior of consumer and producer of each country is examined. Furthermore, from the use of macro data, an attempt is made to provide economic context to the results and to give insight into their national implication.

### **1.3. General hypotheses and questions to answer**

Like other economic analysis, it is supposed that producers and consumers are “rational” and, consequently, prices resulting from confrontation of supply and demand have a major role in actor’s decisions.

- 1) Producer prices have been shown to have a significant impact on production and allocation of cultivated area to different crops (whether it is price of same crop or other crops). In third

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<sup>17</sup> There is no historical data on retail prices for food products concerning these three countries in FAOSTAT neither in other internal database.

chapter of this thesis, it is calculated how producer prices impact on the decision to choose crop for producer or farmer in India, Pakistan and India. In chapter 6, some analyses are made on how policy makers can eventually make policy to increase the main staple food availabilities in each country.

- 2) Prices and expenditure (income) have a strong impact on consumption for cereals and other foods in these countries. Price of ingredients, levels of animal productions and type of farming have a strong impact on feed demand in quantity and nature of products. In fourth chapter, it is calculated how prices influence consumption behaviour of human. Human demand functions for vegetal foods as well as for animal products are first calculated separately and then calculated simultaneously. Animal demand for concentrates (cereals, oil meals, etc.) is calculated in the fifth chapter of this thesis.
- 3) As it has not been possible in the available time for this thesis to analyse the interactions between the agricultural situation in each country and the world market, so was retained the hypothesis of "small" countries in all three cases. This seems justified where (with the exception of certain products such as vegetable oils) trade with the rest of the world is limited and therefore it can be assumed that in an approximate way, changes of the internal situation in each country (at level of supply, demand, or foreign trade policy) does not affect the world price and availability where these two parameters are mainly influenced by the situation in countries such as the United States, Brazil, Argentina, the EU, Canada, Indonesia, Malaysia, China etc. Raising the hypothesis of "small country" is among the ways to improve the work mentioned in conclusion. These models are described in Chapter 6 and various applications are also presented. From these three hypotheses leading to admit that domestic prices in these countries are not substantially related to price and situations of global markets, it is possible to construct three independent models of partial equilibrium by using the previous calculations of elasticities (see chapter 6)

In this thesis the three PEM constructed models were used for three objectives:

First to determine the relative importance of variations for five main exogenous parameters (population, food expenditure per capita, total cultivated area, yields of the different crops, and animal productions) for each country.

Secondly to compare some simplified hypotheses of public national interventions in form of subventions paid either to agricultural producers or to consumers, also to analyse subvention



being either paid for all food products or to specific products such as rice and wheat which are important foods in the three countries.

Finally we tentatively used the three models for analysing what could be the 2025 agricultural situations when variations of some exogenous parameters between 2009 and 2025 (population, total area cultivated, yields of the different crops, revenue per capita, animal productions) are taken in account in the models with values taken from existing literature.

The main interest of a PEM, when it has been implemented in specific software, is its flexibility and simplicity to use. In its present form these models could have been used for lot of other simulations (effects of modifications of support prices for some crops, effects of liberalization of external trade for some specific products, etc.) but we had to limit our illustrations to a small number of applications.

Because of its structure and of the separation of a) calculations with the chosen software and b) the external data which are 1) the initial situation based on a reference year which can be changed and 2) the elasticities matrixes (which can be actualized or revised without any modification in the equations of the model), a PEM can be considered as a “living” model that can be progressively actualized and completed to take in account some specific aspects (such as external trade policy of the country, tariffs and eventually quotas, relations between internal and world prices, etc.).

From a more general point of view, the construction of such PEM, after a number of improvements, has the interest to put at disposition of public authorities and researchers in the economies of the three concerned countries, a tool for helping the public decision to analyse and compare the consequences (in terms of cost and efficiency) of certain policies within the current functioning of the economic policies of these countries, but also to address new issues such as possible impact for the three countries of the recent agreement (September 2012) SAFTA (South Asia Free Trade agreement). It states “Before the end of 2020, the peak tariff rate for all tariff lines, except for a small number of products in the sensitive lists, will not be more than five per cent. It will be an ultimate goal for achieving complete liberalization process between the two countries”<sup>18</sup>.

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<sup>18</sup> <http://dawn.com/2012/09/22/pakistan-india-sign-three-trade-agreements/>

A partial evaluation of such a highly simplified scenario (scenario 51, Chapter 6) was calculated and presented, for example, at the end of the report, but naturally requires for being realistic to be refined in the context of a further research work. To our knowledge, some econometric models exist (especially for India) that perform agricultural forecasts but there are none specifically oriented towards the analysis of agricultural and trade policies.

## **1.4. General methodology for models of the three agricultural markets**

### **1.4.1. Some specific aspects of the three countries**

South Asian countries like Pakistan, India and Bangladesh represent an important zone of world in term of population, agricultural surface area. This zone is blessed with fertilized agricultural land and huge varieties of agricultural crops. This zone represents population of 1.6 billion (22% of world's total population), 263 million hectares (Mha) of agricultural land (4% of world's total agricultural land). The production of vegetal crops is important in this zone especially cereal production i.e. 365 million tons (Mt). But these countries are characterized by weak production and consumption of animal products like animal meat, milk and eggs etc. They are also characterized by deficiency of vegetal oils and, for some of them, for vegetal protein used in animal feeds. Their position in international market is varied according to their production and consumption.

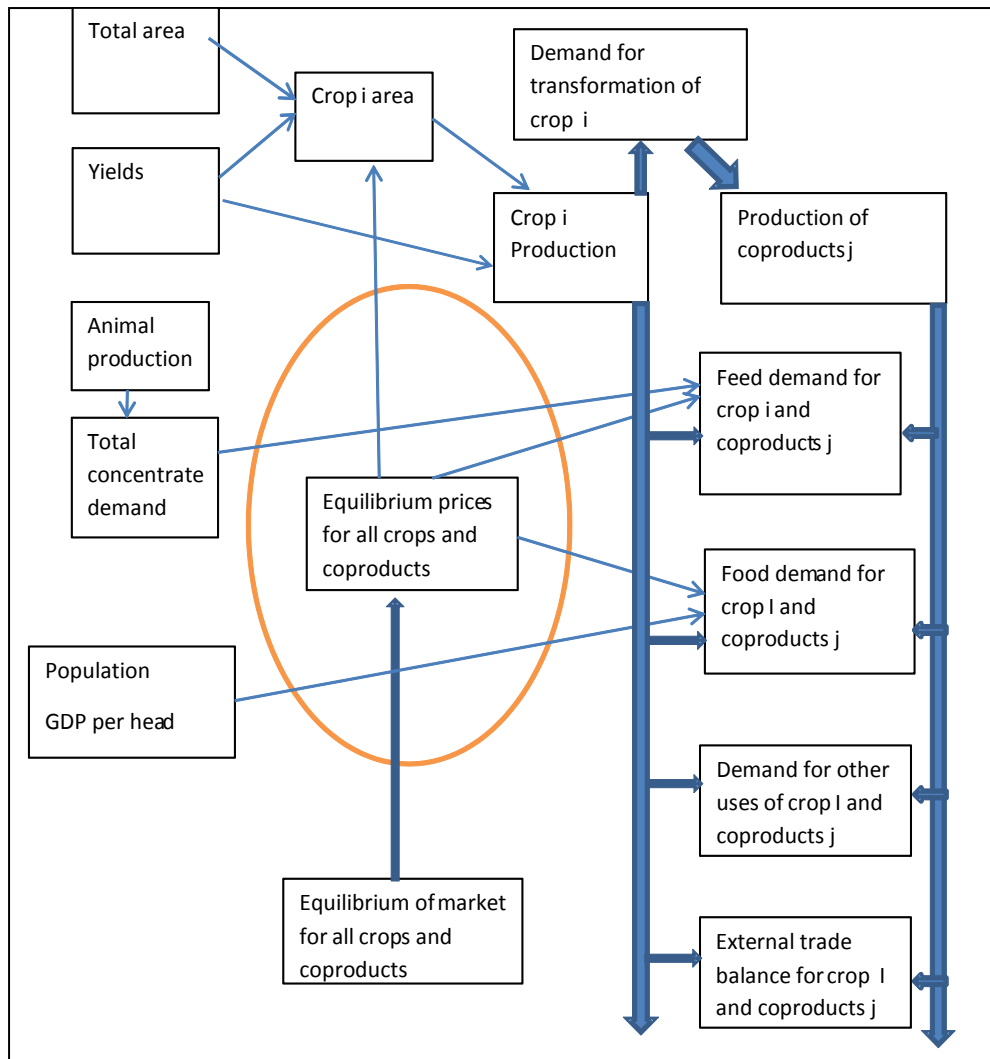
Besides of these characteristics, these three countries have been undergoing important changes during last forty years. Their population has been increased largely as well as their income has been little bit increased. A large amount of population has been migrated from rural areas to urban areas. All these changes resulted in the increase of need of extra food for humans especially of cereals, pulses, and vegetal oils as well as of animal protein like meat, eggs, milk. This zone will have to increase the feed for animals by keeping the traditional system of farming for herbivores and by making poultry farming more modern.

Here a question arises about the future position of these countries in the international market of raw materials especially of cereals and oilseeds plants.

The different quantitative scenarios constructed in chapter 6 have as objective, to indicate what could be the situation of these countries in term of consumption of animal products as well as in term of production of major crops, consumption of vegetal products and position in international market when some different hypothesis are taken in account relative to variations in population, income per capita, exchange rate, different instruments of agricultural policy (support price, custom duty, subsidies).

#### **1.4.2. General structure of partial equilibrium models**

To get objective of this thesis, one has to analyse supply for each country by estimating price elasticity of each crop area in each country as a function of gross product (yield multiplied by price). One has to analyse the demand of each country. But on demand side, one has to calculate human demand of vegetal and animal products as well as animal demand for concentrates. For each product, elasticity of demand as function of prices and income should be calculated for each country. Then partial equilibrium model, the framework of which is described on Figure 1 should be implemented in specific software.



**Figure 1: General framework of the partial equilibrium model for each of the three countries**

This framework represents both relationships (narrow arrows) between the various exogenous parameters considered in the three PEM (population, yields, etc.) and various endogenous variables that are computed by these models (surfaces, production, human demand, etc.). The large arrows shown in the right part of framework show the distribution of production of each crop and by-product for various uses (animal demand and trade, etc.).

For example, the production of crop *i* in a given country is influenced by the total cultivated area in each country of this crop and yield. Cultivated surface of this product is influenced by gross product per hectare of this crop (that is to say the product of the price and yield per hectare of this

crop), and of course the gross product of all other crops. Regarding the co-products (eg sugar), the framework shows that the production is derived directly from the amount of the corresponding crop family (sugar crops) by multiplication by a fixed coefficient that is the average technical efficiency of the sugar crops for each country.

In the form of equation it is supposed that supply of each agricultural product (production plus beginning stock) is equal to sum of human agricultural demand, animal agricultural demand, transformation demand, residual demand (seeds, waste, etc..), final stock and net trade balance of agricultural products.

**Equation 1: Equation of equilibrium for each product**

$$OF_i P_j, X_{ik} + SB_i = DH_i P_j, Y_{ik} + DA_i P_j, Z_{ik} + TR_i U_{ik} + DR_i V_{ik} + SF_i + El_i$$

Where i and j = number of vegetal and animal products

K = number of exogenous variables

$OF_i$  = Quantity supplies of agricultural product of product i

$DH_i$  = Human demand of product i

$DA_i$  = Animal demand of product i

$TR_i$  = Quantity transformed of product i

$DR_i$  = Residual demand (seed, waste, non-food sectors, etc.) of product i

$SB_i$  and  $SF_i$  = Beginning and Final stocks of product i

$El_i$  = Net exterior trade (exports – imports) of product i (it may be positive if product i is more exported or negative if product i is more imported).

$X_{ik}, Y_{ik}, Z_{ik}, U_{ik}, V_{ik}$  = exogenous variables

Then above equation (where stocks are supposed to be constant) can be differentiated and drive to the following equation:

**Equation 2: Condition of equilibrium for each product in case of variation of exogenous variables**

$$\begin{aligned}
 & \partial OF_i / \partial P_j * dP_j + \partial OF_i / \partial X_{ik} * dX_{ik} = \partial DH_i / \partial P_i * dP_i + \partial DH_i / \partial Y_{ik} * \\
 & dY_{ik} + \partial DA_i / \partial P_j * dP_j + \partial DA_i / \partial Z_{ik} * dZ_{ik} + \partial TR_i / \partial U_{ik} * dU_{ik} + \\
 & \partial DR_i / \partial V_{ik} * dV_{ik} + \Delta EL_i
 \end{aligned}$$

By example for each crop i (vegetal products without transformation), the resolution of partial equilibrium system drives us to solve an equations which can be written as:

**Equation 3: Relation between relative prices variations and variations of exogenous variables**

$$EO - \beta * EDH - \gamma * EDA * dP_i / P_i = f(dX_{ik}, dY_{ik}, dZ_{ik}, dU_{ik}, dV_{ik}) + \Delta EL_i$$

Where EO, EDH and EDA are prices elasticities of supply and demand of crop I and  $\beta$  and  $\gamma$  are specific parameters.

If these matrices are known and  $\Delta EL_i$  are fixed to specific values, with the n equations concerning the n products, it is possible to calculate the values of the  $dP_i / P_i$

Then the following variations can also be calculated:

$\Delta OF_i$  = variations of supply of crop i

$\Delta DH_i$  = variations of human demand of crop i

$\Delta DA_i$  = variation of animal demand of crop i

$\Delta TR_i$  = variation of demand for transformation

$\Delta DR_i$  = variation of residual demand of crop i

$\Delta EL_i$  = variations of external trade of crop i

In the case where  $\Delta EL_i$  is not known but  $dP_i / P_i$  is known (by example because it is equal to variations of world price),  $\Delta EL_i$  and all other variables can be calculated

In summary, to construct the partial equilibrium model, it is necessary to calculate elasticities matrices for supply, human food and animal feed demands.

So the different steps of this work are:

- 1) Estimation of supply functions for each country as function of gross product (product of price and yield)
- 2) Estimation of demand functions for each country and calculation of a) Hicksian and Marshallian price elasticities and b) expenditure elasticities for i) vegetal products in human food ii) animal products in human food iii) vegetal crops and by-products in animal feed.
- 3) Mathematical writing of the partial equilibrium model for each country including by-products supply and demand
- 4) Implementation in a specific software of the three sub models
- 5) Definition of some scenarios and calculation of the results

Concerning points 1 to 3, the general following methodologies have been used. More details are given in Chapters 3 to 6.

### **1.4.3. General methodology for supply elasticities**

The ten major cultivated crops are taken for estimating the supply elasticities in these countries: wheat, rice, cotton, sugar cane, corn, pulses, soybean, rapeseed, sorghum and millet. The annual data used is taken from FAOSTAT database available from 1966 to 2007. The share equations, deriving from a translog model, are estimated with GRETL software using a Full Information Maximum Likelihood (FIML) method. The exogenous variable is the revenue per hectare for each crop. The direct and cross price elasticities are calculated by the standard method (Christensen et al., 1968) (Chapter 3.2.)

### **1.4.4. General methodology for food demand elasticities**

The seven products or families of product (wheat, rice, sugar, corn, pulses, millet/sorghum and vegetal oils) are taken into account for calculating the vegetal food demand elasticities while for calculating the animal products demand elasticities, animal products (poultry meat, bovine/buffalo meats, goat/sheep meats, other meats, eggs and milk)<sup>19</sup> are taken. For annual consumption, the used data are taken from FAOSTAT. As no consumer prices are available on a

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<sup>19</sup> Fish products are not taken in this study due to the lack of availability of data specially from their price as indicated later in chapter 4 (4.1.1).

long period so we have used the producer prices multiplied by a constant coefficient specific to each crop as a proxy of retail prices. For vegetal products producer prices are available from 1966 to 2007, but for animal products, they are only available from 1991 to 2007. The functional form is a Linearized Almost Ideal Demand System (LA/AIDS). The share equations have been estimated with GRET, then the Hicksian and Marshallian prices elasticities have been calculated with the methodology described in chapter 4.2. The expenditure elasticities have also been calculated. Total food expenditure elasticities for aggregated vegetal and animal foods demand have also been calculated to take in account the importance of substitutions between these two families of products.

#### **1.4.5. General methodology for feed demand elasticities**

Data concerning feed products are very scarce. FAOSTAT gives only some information on productions, imports and exports of products such as oilseeds meals, cereal bran, and molasses. We have supposed that the “balance” (production plus imports less exports) for these products was totally used in animal feeding. Concerning national prices, we cannot get any historical series but only some estimation for some specific years, so it was not possible to use econometric method to estimate price elasticities. So we have used some econometric method to estimate total feed demand of concentrates<sup>20</sup> in each country in relation with quantity produced of different types of animal products (in particular poultry and milk), then as detailed in Chapter 5, prices and substitution elasticities have been calculated using pseudo-data generated by an animal nutritional formulation model deriving from the FEEDSIM<sup>21</sup> model.

#### **1.4.6. General methodology for partial equilibrium sub models**

The three partial equilibrium models are informatics programs implemented with software GAMS which are built mainly in application of equation 3. They allow calculation of variations of prices (when variations of external trade are known) and variations of external trade (when variations of prices are known) with the methodology defined in chapter 6. When variations of prices are known (or calculated) the variations of all items (areas, yields, productions, food demand, feed demand, external trade, transformation, and other uses) for each product and each

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<sup>20</sup>Concentrates are all vegetal products such as cereals, oil meals, cereal byproducts, etc. that are used in animal feeding and are not green or dried roughages. These products are more concentrated in energy and generally in proteins than forages and roughages which have lower nutritional value due to high contents in cellulose and consequently are not suited to use for monogastrics (poultry, pigs, etc.)

<sup>21</sup> FEEDSIM AVENIR is a French association regrouping industrials and researchers to develop analyses on West of France supplying of raw materials for feed industry. For this objective, the association has developed with INRA a specific simulation model named FEEDSIM. <http://www.feedsimavenir.com/>



country can be calculated. In fact, as indicated in Chapter 6, the different scenarios calculated for 2009 and 2025 use an intermediate methodology (cf. § 6.1.).

## 1.5. Sources of data used in this report

In this thesis for descriptions and estimates, the main source used is the FAOSTAT database available on the FAO website<sup>22</sup>. This database includes almost all the countries of the world, with 11 sub databases (Production, Trade, Food Supply, Food Balance Sheets, Food Security, Prices, Resources, Issues, Forestry, Fisheries, and Metadata). Each sub database contains a set of categories:

- **Production** sub-databases: Crops, Primary Crops, Processed Crops, Live Animals, Livestock Primary, Processed Livestock, Production Indices, and Values of Agricultural Production. The main categories used in this work are from the sub-database Crops: Area harvested, yield, production and Quantity for the sub-base Livestock Primary Production Quantity.
- **Trade** sub-databases: Crops and Livestock Products, Live Animals, Detailed Trade Flows, Detailed Trade Matrices, Trade Indices. The main sub-base used is Crops and Livestock Products with categories: Import Quantity, Import Value (in US dollar), Export Quantity, Export Value (in US dollar) for the calculation of unit values (import or export) then converted in local currencies.
- **Food Supply** sub-databases: Crops primary Equivalent, Livestock and Fish Primary Equivalent. These two sub-databases were specially used for following categories : Total Food Supply Quantity (tons), Food Supply Quantity (Kg/capita/year), Food Supply Quantity (kcal/capita/day), Food Supply Quantity (Protein/capita/day). The second set of data is obtained by dividing the first one by the corresponding annual population indicated in the sub-base Resources. The two last one are obtained by application of standard content of each product in kcal and protein and by dividing by 365 (number of days in a year).
- **Food Balance Sheets** sub-database: Food balance Sheet (synthetic data for each country), Commodity balances (separated in Crops Primary Equivalent and Livestock Primary equivalent). The categories most used in this work are: Production, Imports, Exports, Domestic Supply Quantity, Food, Feed, Seed, Waste, Processed and Other Uses.

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<sup>22</sup> <http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor>

- **Prices** sub-database: Annual Producer Prices, Producers Price Archive. There is also a sub-database named « Consumer Price Indices » but it is mostly incomplete and only gives for some countries general index of consumer but does not give detail for food product.
- **Resources** sub-database: Population (with categories such as Total Population, Population male, Population Female, Agricultural Population, Urban Population, Rural Population) and Resources (with the categories used in this work Land) that includes main categories: Country area, Land Area, Agricultural land, Arable land, Permanent crops area, Permanent Meadows and Pastures, Forest area, Fallow land area, etc. Most of these categories are not available for three concerned countries.

The FAOSTAT database is easily freely available on internet and allows unloading of data sets in spread sheets such as Excel files.

In principle, data are available since 1961, but not always. Otherwise process of updating these data is quite slow and when the econometric calculations were made on the functions of supply and demand, some data (especially prices) were available only until 2007. At the time of the update, some year's figures are added but some historical data are also modified without any explanation being given by the FAO.

Apart from the problems of availability and updating data using the FAOSTAT database (which is a leading international reference and a source of incomparable diversity and magnitude) poses several problems:

- 1) In the case where some data are provided in several sub FAOSTAT database, they can differ significantly (e.g. category Production in sub-base Production (Crops Primary) and Production category in the sub-base Food Balance Sheets).
- 2) The data contained in the database are either from statistical offices of the concerned countries, or simply correspond to estimates by the FAO experts. Given the very large number of digits used and analysed in this thesis, even if we can know for each digit by a symbol in the base (F = FAO estimate) the origin of the data, it is of course not been possible to conduct this analysis in detail that might have helped explain some discontinuities, but has provided no numerical values of replacement.
- 3) In the context of this work, major problems concern sub-base Price, first by the numerous gaps in recent years for these countries and for important products (rice, pulses, for

example), then by the fact that this database is separated into two parts (data "recent" and "archives") without any possibility of recovery and finally by the fact that for animal products there is no data in the archive on the price of meat prior to 1991. This shortens the length of the available series for econometric estimates of demand for livestock products. Finally, the absence of any data on prices at the consumer level is a major handicap in the estimates.

The second database used in this report, mainly for comparison with data from FAOSTAT, is the PSD base of the ERS USDA<sup>23</sup>. This database is frequently used by economists around the world for econometric estimates, but, compared to FAOSTAT, it has three major differences;

- 1) The purpose of this database is primarily to provide a set of statistical data to Administration officials of U.S.A and to researchers a coherent information on the structural changes and cyclical global markets for which the United States is a major exporter. As such the base is frequently updated and even provides "estimates" for the present campaign and some predictions for the next. The base is powered by agricultural officers of United States present in the different countries of the world. For the "developed" countries the statistics provided in PSD are identical to national statistics, by cons for some developing countries (and China), the data may differ significantly from national figures and from those presented in the FAOSTAT database. The base is established periodicity "campaign" (generally September to August) unlike the FAO retains periodicity "calendar year" (January-December). Thus, for example soybean for harvested area and production in the period entitled 1980-1981 (often abbreviated to 1980) are both figures of the northern hemisphere (harvest in September-October 1980) and numbers in the southern hemisphere (harvest in January-March 1981). In contrast, in the period in FAOSTAT entitled "1980" are the numbers of all crops which took place between January and December 1980 whether the northern or southern hemisphere.
- 2) The base PSD is essentially oriented towards main products subject to significant global trade (and interesting the U.S.) and that list of products considered is much smaller than the FAO. For example for important products in the countries of South Asia but having a limited role in the world such as millet, the numbers are missing or reproduced identically for several decades). Similarly and more surprisingly the base PSD provides no data to any country of the world on surfaces and sugar crops productions but only items on the

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<sup>23</sup> <http://www.fas.usda.gov/psdonline/psdquery.aspx>

balance sheets of centrifugal sugar, not on the surfaces of palm, coconut and palm kernel. Data are virtually absent in developing countries with regard to the production of animal products (meat, milk, eggs), except in some cases of broiler meat and turkey.

- 3) Finally, in PSD, the number of balance sheet items is much more limited (in fact for most products and countries) filled positions are only productions, including the trade share with the United States, stocks and domestic uses of each country. Except for oilseeds crushing where figures are given, there are only two categories: Feed and total Food-Waste-Seed and industrial.
- 4) PSD has no data on the prices of agricultural products neither on the level of production nor consumption

The gaps of PSD in relation to the objectives of the present work have thus led us to favour FAOSTAT, despite its shortcomings (especially for the sake of consistency and detail needed on the products and balance sheet) for the analysis of past trends and econometric estimates.

Two other bases have been used for more specific data; specially the data base of the World Bank<sup>24</sup> with respect to any macroeconomic data for the three countries (Gross Domestic Products, exchange rates, etc.) and that of UNCTAD<sup>25</sup> for world prices in dollars at key global trading.

## 1.6. The central role of elasticities in economic analysis

Elasticities play an important role in the modern economy both at the description of certain phenomena in the construction of models.

If we consider a set of  $n$  variable  $y_1, y_2, y_3, \dots$  which are all function of a set of other variables  $x_1, x_2, x_3, \dots$ , that can be noted in summary:  $y_i = f_i(x_i)$ , where  $i = 1 \dots n$ , the elasticity  $E_{ij}$  of the variable  $y_i$  with respect to  $x_j$  ( $j = 1 \dots n$ ) is defined mathematically by the formula:

$$E_{ij} = \partial \ln(y_i) / \partial \ln(x_j)$$

Where  $\partial \dots / \partial \dots$  represents the partial derivative of the function  $f_i$  calculated in the vicinity of a set of values  $x_j$  and where  $\ln(\dots)$  is the natural logarithm.

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<sup>24</sup> <http://databank.worldbank.org/ddp/home.do?Step=1&id=4>

<sup>25</sup> <http://unctadstat.unctad.org/ReportFolders/reportFolders.aspx>

This elasticity can be interpreted as the percentage changes in the variable  $y_i$  when variable  $x_j$  varies by 1% while all other things being equal (that is, without changing the values of  $x_j$  other than included in the derivation). Like all derivation, the calculated numerical value is valid "around the area  $x_j$ " where the calculation was done and for small variations of considered  $x_j$ .

Later in this report, we will use mainly gross product elasticities for surfaces of crops (Chapter 3) and also price elasticities for animal demand (Chapter 5) and human demand (Chapter 4), with income elasticities (or expenditure).

The primary interest of these elasticities (Deaton, A., and J. Muellbauer. 1980b.) is to provide a quantified synthetic measure of "response" of a variable of interest to a variation (low) of another variable. In the case of the elasticities of demand and supply for different products, we distinguish classically direct elasticities and cross-elasticities.

The direct price elasticity of demand for good  $i$  measures the percentage change in consumption of the good when the price of same good increases by 1%. In the case of food where there are usually many alternatives, it is intuitive to think that these elasticities must be negative, that is to say, its demand falls when its price increases. In many empirical works, condition of this negativity of all demand elasticities is even introduced into the estimation procedure. In this work, this condition of negativity of direct price elasticities were not introduced a priori but verified a posteriori and taken as a criterion of validity of the various estimates more naturally with significance levels of the coefficients of the equations used to calculate those thereof.

The cross-price elasticity of demand measures the percentage change in demand for good  $i$  when the price of another good  $j$  increases by 1%. These elasticities can be positive or negative. A positive cross elasticity suggests that when the price of good  $j$  increases, the demand for good  $i$  increases (contrary to what happens for good  $i$  when it is a typical good). We said in this case that the two goods are substitutes. Conversely, if the sign is negative, that is to say that the demand for two goods  $i$  and  $j$  simultaneously decreases when the price of good  $j$  increases, we say that the two goods are complementary.

In cases where the income (or synonymously) the expenditure is introduced into the equation of cost, we also introduced income elasticity that measures the percentage change in consumption of good  $i$  when income (or consumer's total expenditure) increased by 1%. These elasticities can be positive or negative. It generally refers to "normal good" a good whose income elasticity is

positive. In this case, we are also led to price elasticities to distinguish the price elasticities of *Hicksian* (or compensated) and *Marshallian* (or uncompensated) demand. The details of the calculation methods and interpretations are represented in Chapter 4.

In the case of supply function, we define in the same way the direct and cross supply elasticities. Direct supply elasticities are positive, that is to say that for typical products, supply of good *i* increases when the price of one increases, all other things being equal. The cross elasticity of supply of good *i* relative to the price of good *j* measures the percentage change in the supply of good *i* when the price of good *j* increases by one percent. When the sign is positive, the two products have the opposite behaviour (supply of one increase and that of the other decreases) and it is said that the two products are complementary. When the sign is negative, we say that the two products are substitutes.

The objective of chapters 3, 4 and 5 of this report is to present the methods of calculation of these behavioural indicators among various products analysed in terms of supply, human and animal demand then to analyse econometric results obtained, these values are used in Chapter 6 of the report for the construction of partial equilibrium models.

## **1.7. Organization of the report**

This thesis is divided and presented in the following six chapters.

Chapter 1 presented the background and importance of the research problem “South Asian countries position in global markets for raw materials of animal feed: Development of livestock production and development of local feed systems”. Then it finally ended with formulating hypotheses and questions of research while identifying scientific issues.

Chapter 2 presents the general information and importance of three countries (India, Pakistan and Bangladesh) taken in this thesis. This chapter also presents the importance of geography, economy, agriculture and systems of production for each country indicating detailed information for important different variables (population, protein intake, surface area).

Chapter 3 presents the calculation for direct and cross gross product elasticity of supply for the main crops (wheat, rice, corn, cotton, sugar cane, pulses, rapeseed, soybean, millet and sorghum) of each country. This chapter also included the evolution of each variable taken in this calculation as well as review of literature and formulation of methodology for calculating the elasticities.

Then we compared the results for each country with other country then we also compared the calculated elasticities with older literature.

Chapter 4 presents the calculation for direct and cross price elasticities of demand for vegetal products (wheat, rice, corn, cotton, sugar cane, pulses, rapeseed, soybean, millet and sorghum) and animal product (eggs, milk, bovine meat, chicken meat, other meat and goat meat) of each country. This chapter also included the demand elasticities calculation for vegetal and animal products independently but also simultaneously. This chapter also has review of literature and formulation of methodology for calculating demand elasticities. Then the results obtained are compared with ancient literature and within these countries.

Chapter 5 presents the calculation for direct and cross price elasticities of demand for all animal feed ingredients. It also contains the general information and importance of feed sector for each country with their evolution. It also included the formulation of methodology for calculation as well as comparison of results obtained for each country with each other.

Chapter 6 contains the description of the three PEM and presents some illustrative scenarios for 2009 and 2025. This chapter also presents the methodology for writing the informatics programs and analyses the main results and conclusions to be drawn from these calculations.

Chapter 7 presents the main conclusion of this study.

# Chapter 2: Generalities on the three countries studied

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The purpose of this chapter, mainly descriptive, is to make a number of general information on the three studied countries, their place in the regional and global context, their common points and their differences. The presentation of different cropping systems in the studied zone shows the diversity of agricultural and climatic situation and the strong link to the ground (pastures and forages) for traditional products of ruminants. On the other hand, in the scientific literature, it is very difficult to find general information (location, traditional and modern farms, associated or not with other animals and crops) relative to production (relatively recent) of poultry and eggs. The available evidence, usually from professional sources will be presented in Chapter 5.

This chapter also presents the main data used later either as exogenous variables in the econometric estimates, or as elements to interpret some of the results of calculations.

## 2.1. South Asia

### 2.1.1. General presentation

According to the United Nations Geoscheme (*United Nations* geographical region classification), Southern Asia comprises the countries of Afghanistan, Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, and Sri-Lanka. In the following chapters of this report the term of South Asia is generally used to designate only the three countries Pakistan, India and Bangladesh which are of central importance for analysis.





**Figure 2: General map of South Asia**

This zone is home to about one fifth of the world's population (24.6% in 2009), while its land area is only about 640 million hectares (Mha), about 4.9% of world total, that made it both the most populous and densely populated geographical region in the world (about 2.6 people per hectare) that is higher than a world average of 0.5.

**Table 1: Main demographic and geographic indicators for Southern Asian in 2009**

country	Population	Country area	Land area	Number of people per ha of land area	Agricultural area	Agricultural area irrigated	Arable land	Arable land and Permanent crops	Forest area	Other land
World	6771.6	13459.1	13003.5	0.5	4889	NA	1381.2	1533.4	4038.7	4088
Afghanistan	30.6	65.2	65.2	0.5	37.9	1.8	7.8	7.9	1.4	26
Bangladesh	156.1	14.4	13	12	9.1	NA	7.6	8.5	1.4	2.4
Bhutan	0.7	3.8	3.8	0.2	0.5	NA	0.1	0.1	3.2	0.1
India	1173.1	328.7	297.3	3.9	180	63.2	157.9	169.6	68.3	49.1
Iran	73.1	174.5	162.9	0.4	48.5	NA	17.2	19	11.1	103.3
Maldives	0.31	0.03	0.03	10.4	0.01	NA	0	0.01	0	0.02
Nepal	29.4	14.7	14.3	2.1	4.3	NA	2.4	2.5	3.6	6.4
Pakistan	184.4	79.6	77.1	2.4	26.3	19.4	20.4	21.3	1.7	49.1
Sri Lanka	20.7	6.6	6.3	3.3	2.6	NA	1.2	2.2	1.9	1.8
Total South and Southern Asia	1668.5	687.6	640	2.6	309.2	NA	214.6	231.2	92.6	238.1
Share of World	24.64%	5.11%	4.92%		6.32%		15.54%	15.07%	2.29%	5.83%
Three main countries	1513.6	422.7	387.4	3.9	215.4	NA	185.9	199.5	71.5	100.6
Share of South and Southern Asia	90.72%	61.48%	60.54%		69.66%	NA	86.64%	86.29%	77.14%	42.23%

Source: Calculation from World Bank and FAOSTAT; Units: Millions of people, Millions of hectares

Among the countries of Southern Asia, the most important countries are India, Pakistan and Bangladesh which represent collectively about 62% of countries areas (423 Mha) of total area (688 Mha) of this zone and 91% (1,51 billion people out of 1.67 billion) of total population in 2009. These three countries also represent important share of agricultural land of this zone that is 70% (215 Mha) of total agricultural land (309 Mha).

The region of India, Pakistan and Bangladesh, called Greater India, has been governed by the British and Mughals before 1947<sup>26</sup>. Then India got independence then Pakistan and Bangladesh made one unit till 1971. After 1971, Bangladesh got independence. So these countries have the same history and background so there are many similarities of culture and traditions in these three countries. They have nearly the same crops cultivated, and some common habits concerning vegetal food consumption, but there is a lot of diversity of religion which has influences both on animal productions and consumption.

<sup>26</sup> In the following chapters of this report the term of South Asia is generally used to designate only the three countries Pakistan, India and Bangladesh which are of central importance for our analysis.

Before presenting main characteristics for each individual country, it is useful to indicate some general elements which have influences on food and feed system evolutions, either at supply level or at demand level. The first ones refer to description of main farming systems and the second to presentation of main population and economics aspects for Pakistan, India and Bangladesh.

### **2.1.2. Major farming systems in Southern Asia**

Dixon et al. 2001 have identified major farming systems of south Asia that is presented in this section. So we are going to present the brief description of the major farming systems, including the land area and agricultural population as a proportion of the regional total, principal livelihoods and prevalence of poverty.

#### **1) Rice Farming System**

This farming system is characterized by domination of wetland rice cultivation by farmers with or without irrigation. 22 Mha of the total system area of 36 Mha (more than 60%) is under cultivation where 43% of the farming area is irrigated. This system exists in Bangladesh and West Bengal but also in smaller areas of Tamil Nadu and Kerala States of India, and Southern Sri Lanka. This system has considerable number of small ruminants and 50 million bovines which are used for draft Power, milk and manure. In this system, poor farmers having extremely small areas depend on farm off income. This system is characterized by extensive and severe poverty.

#### **2) Rice-Wheat Farming System**

This farming system is dominated by a summer paddy crop and an irrigated winter wheat crop which follows each other. The Rice-Wheat Farming System exists in Northern area and the Indus irrigation area in Sindh and Punjab of Pakistan where it also exists in India and northeast of Bangladesh. More than 60% (62 Mha) of the total land of the system (97 Mha) is under cultivation where 78% (48 Mha) of the cultivated area is irrigated. This system having crop-livestock integration contains about 119 million bovines and 73 million small ruminants. Bovines are used to produce draft power and milk, as well as manure for composting while small ruminants are principally for meat. 40% of the cultivated land in the region is under the Rice and Rice-Wheat Farming Systems that produce the bulk of the marketed food grains that feed the cities and urban areas of South Asia.

#### **3) Highland Mixed Farming System**

This farming system is dominated by the rice-wheat plains of the lowlands and the populated high mountain areas. This farming system exists in the Himalayan range, from Afghanistan to the extreme northeast of India. This system produces mainly cereals, legumes, tubers, vegetables, fodder, fodder trees, orchards and livestock. About 29% (19 Mha) of total system area (65 Mha) is under cultivation. Where about 2.6 Mha (14%) is irrigated while most area depends on rain. This system contains about 45 million bovines and 66 million small ruminants. This system is characterizes by poverty due to remoteness and the lack of social services.

#### **4) Rainfed Mixed Farming System**

The largest area within the sub-continent and small area in Northern Sri Lanka is dominated by rainfed cropping and livestock farming system. 87 Mha (59%) of total system area (147 Mha) is under cultivation. This system contains rice and some wheat, as well as pearl millet and sorghum, a wide variety of pulses and oilseeds, sugarcane, and vegetables and fruit. About 14 Mha (16% of the cultivated area), is irrigated where this system contains about 126 million bovines and 64 million small ruminants, which are partially integrated with cropping. Tube wells and reservoirs are sources of irrigation for small areas. This system is characterized by extensive poverty and droughts.

#### **5) Dry Rainfed Farming System**

This farming system is dominated in an area surrounded by the Rainfed Mixed Farming System in the Western Deccan. This farming system having a higher quantity of irrigation than the moister surrounding areas support a similar range of irrigated and rainfed crops despite the drier climate. About 10 Mha (53%) of the total system area (18 Mha) is cultivated. Where 3.5 Mha (36%) of the cultivated area is irrigated. The level of poverty in this farming system is moderate.

#### **6) Pastoral Farming System**

This farming system is composed of dominated livestock and scattered area of cultivation. This system exists in the semiarid and arid zones, from Rajasthan in India through Pakistan and Afghanistan. The Total system area (55 Mha) contains about 12 million cattle and 30 million small ruminants, as well as a significant number of camels. 4.6 Mha of the total cultivated area (6.8 Mha) is irrigated where it produces rice, wheat and fodder crops and farmers mainly depend on off-farm income. This system provides only three percent of the human population and less

than 10% of the livestock of the region. This system is characterized by moderate to extensive poverty and droughts.

#### **7) Sparse (Arid) Farming System**

This system contains about 57 Mha having about 16 million bovines and 29 million small ruminants. Cultivated area is about 1.7 Mha that is practically under irrigation. There are two kinds of areas. 1) Some irrigated settled area used to provide livelihood 2) The rest is used for grazing where water is available for livestock. There is a gradual transition from the Pastoral System to this system, which has moderate to extensive poverty that is often severe after droughts.

#### **8) Sparse (Mountain) Farming System**

This system exists at height above 3000 meters along the mid-level and upper slopes of the Himalayan Range. This system has an estimated area of 34 Mha with a population of 3 million people, of whom 2.8 million are classified as agricultural. A number of small settlements depend on potatoes and buckwheat, plus cattle and yak herds. 1.9 Mha is under cultivation that is only five percent of total area where only around 10% is irrigated. This system has about 10 million cattle and yaks, and nine million sheep and goats. This system is also characterized by seasonal migration and in some cases by trade, mountaineering and tourism. Poverty here is moderate overall.

#### **9) Tree Crop Farming System**

This farming system comprises scattered area having plantation companies and smallholders producing tea, rubber, coconuts and other tree crops. This system has about three million ha of land, with some 1.2 Mha of annual and permanent cropland. This system exists in the lowlands of Sri Lanka (especially coconuts), Kerala in India (including spices), and the upland areas of India, Nepal, Bangladesh and Sri Lanka (tea estates). Poverty is moderate and largely confined to agricultural workers.

#### **10) Urban Based Farming System**

This system exists in large towns and cities in the region that produce perishable high-value commodities like milk and fresh vegetables now that has expanded. It is generally commercial system with high levels of external inputs having links to the surrounding rural areas for stock

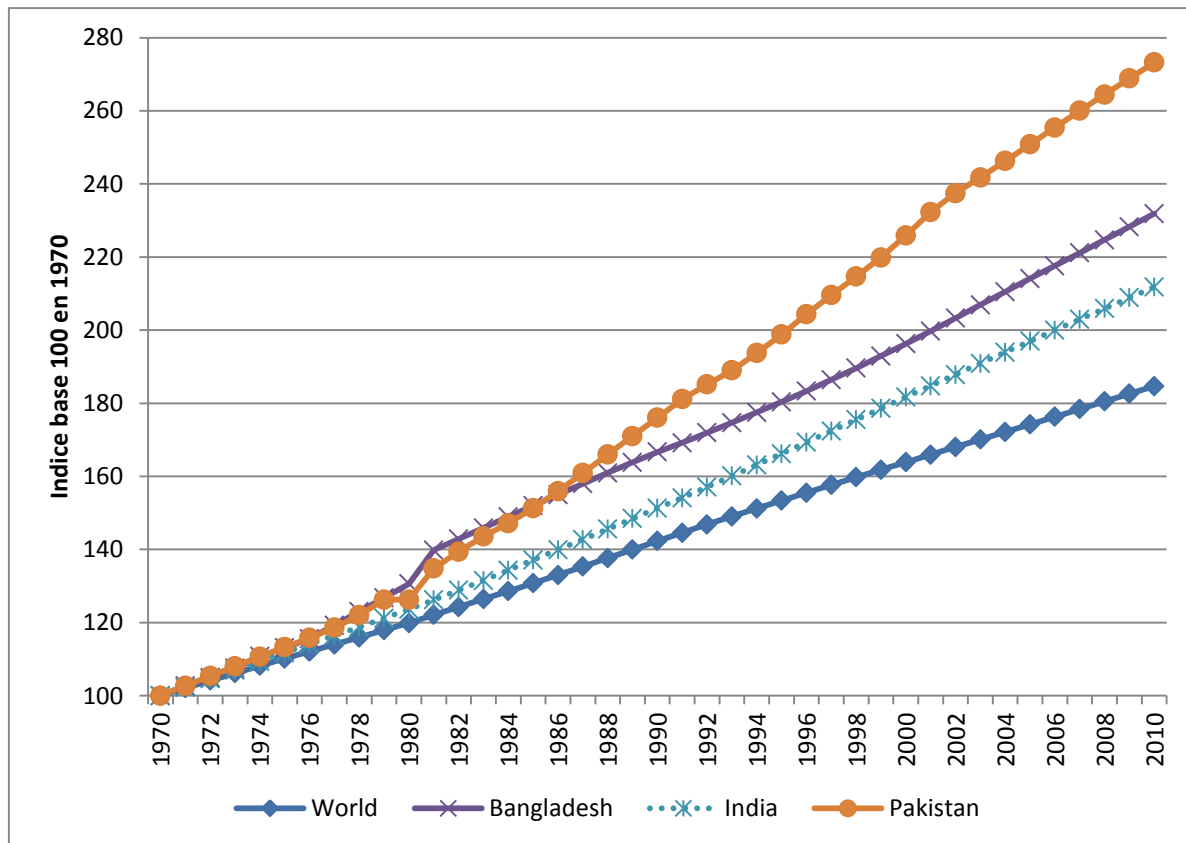
feed and fodder. The system contains an agricultural population of 11 million and about 12 million of bovines (cattle and buffaloes).

### **2.1.3. Evolutions of main demographic and economic parameters for Pakistan, India and Bangladesh**

Population evolution and per capita income are two essential elements to describe the evolution of these three countries.

Concerning **population**, with over 1.5 billion population and significant demographic growth rate, these countries currently represent 22.4% of the world population against less than 19% in the early 70's. During the last decade, the rate of increase, although significant decreased from the previous decades, is still at 1.61% as against "only" 1.20% for the entire world. Of these three countries, India, with over 1.17 billion people is by far the most populous country (77.5% of total South Asia in 2010 against 80.4% in 1970) before Pakistan (184.4 million people or 12.2% in 2010) and then Bangladesh (156 million people or 10.3%).

In terms of growth during the forty last years (1970-2010), the highest rate is recorded in Pakistan (+173%) then in Bangladesh (+132%) and India (+112%). All these figures (Figure 3) are significantly higher than the world global growth (+84%).



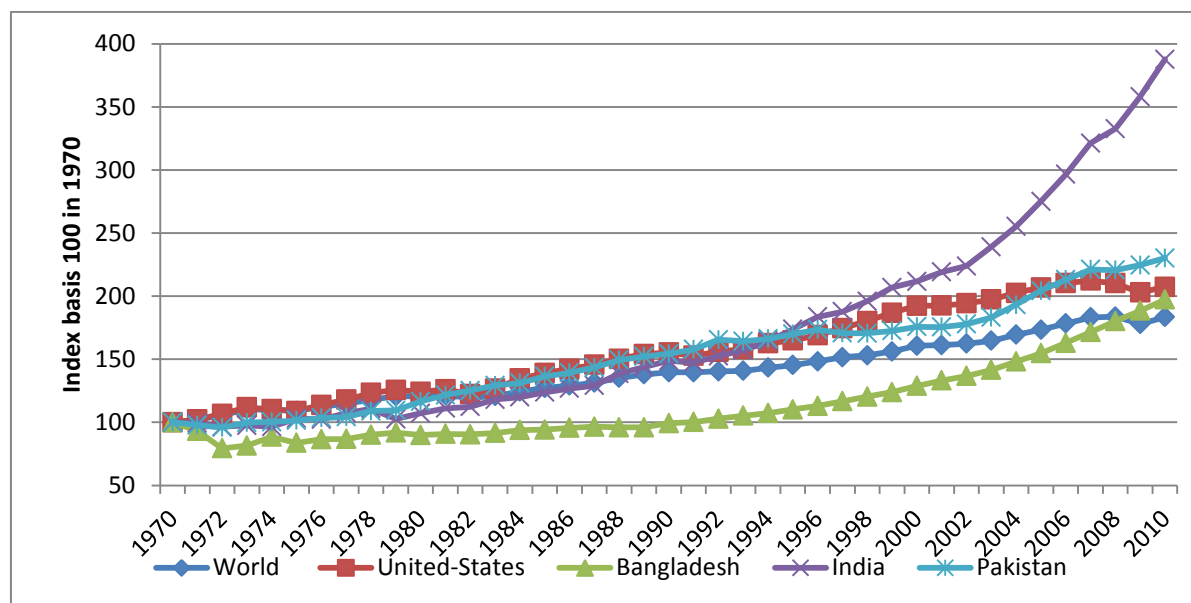
**Figure 3: Evolution of world, Pakistani, Indian and Bangladeshi Populations**

Source: Calculation from World Bank data

Concerning **gross domestic product** (GDP), with 2004 trillion dollars in 2010, these three countries represent only about 3.2% of world total GDP, while their population is over 22%. For example, this share was only 1.3% in 1992, before the economic take off especially of India. It should be noted that during 40 years (1970-2010), while the world GDP was multiplied, in constant dollars, by 3.4 (and in the United States by 3.1), GDP of this zone was multiplied by 7.6 (8.3 for India, 6.7 for Pakistan and 4.4 for Bangladesh respectively). This apparent strong improvement in the performance of these countries, which generally had a strong growth rate of GDP, however, must be tempered by examining the impact of demographic changes and, therefore, we have to look at the evolution of GDP per capita.

In 2010, it is at \$ 830 for India (in constant 2000\$), \$670 for Pakistan and \$557 for Bangladesh against a world average of 6047\$ (and over 37000\$ for the United States). Although the levels for

these countries remain low worldwide but over the last forty years (and especially since the mid-90) experienced strong growth. These changes in constant dollars are naturally much lower than the current evolutions in local currencies in light of both high rates of inflation experienced in these countries and the sharp decline in value of their currencies against dollar.



**Figure 4: Evolution of world, USA, Pakistan, Indian and Bangladesh GDP per capita in constant \$ (2000)**

Source: Calculation from World Bank data

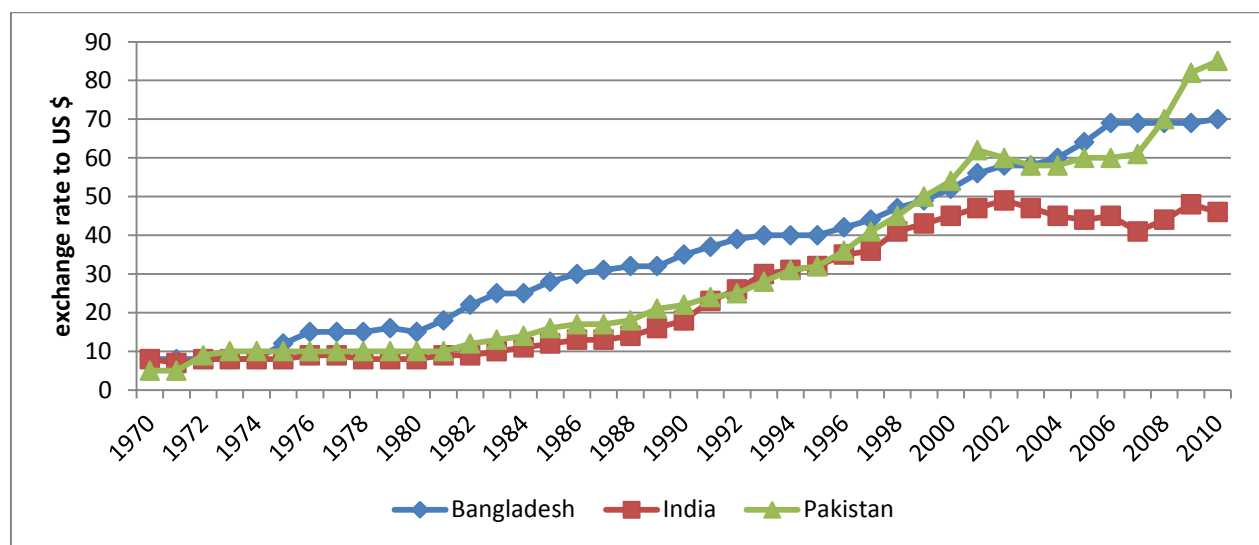
During the last 40 years (Figure 4), while GDP in constant currency has increased between 83% and 107% in world, Bangladesh and United-States (+83%, +98% and +107% respectively), it got higher progression for Pakistan (+130%) and even more for India (+288%). As will be seen later, these different rates of revenue growth had significant effect on food demand in the three South Asian countries.

A large proportion of industrial and food products (with exception of different vegetal oils, notably palm oil imported from international market) consumed in these three countries are of domestic origin. However these countries depend on some important industrial or agricultural export products, so the evolution of their **exchange rates**, particularly against the dollar which is still the main trading currency for major agricultural commodities, is an important factor for their competition in world markets and their gain of money to finance their imports. Some exports that depend on international prices and the parity of each currency can also influence local



consumption (cotton, rice, etc.). The currency of these countries has greatly devalued against the dollar over the last forty years, which naturally favoured their exports and economic growth, but at the same time has penalized their imports, including some food products such as vegetal oils which are highly deficient.

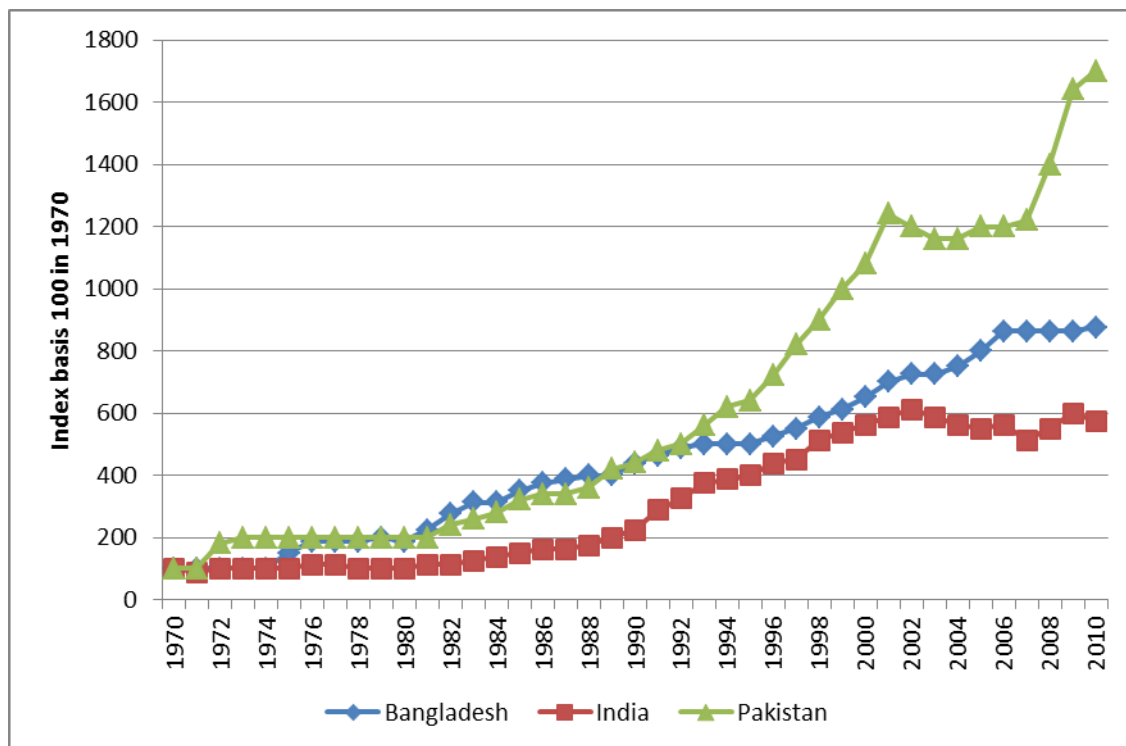
While in India for ten years and in Bangladesh for 5 years, rates were relatively stable (Figure 5), for Pakistan, the deterioration has accelerated since 2006. Compared to the value of local currency unit (LCU) at the beginning of 70's which was about (8 LCU for one US dollar), the exchange rate was multiplied by 5.8 in 2010 for India (46 Indian rupees/\$) and even more for Bangladesh (70 Bangladeshi takas/\$) and Pakistan (85 Pakistan rupees /\$). During previous ten years, while Indian currency was approximately constant, local currency unit lost 35% of its value in Bangladesh and 57% in Pakistan. These evolutions contribute to make some imported food more expensive such as vegetal oils.



**Figure 5: Evolution of Pakistani, Indian and Bangladeshi exchange rates against US dollar**

Source: Calculation from World Bank data

These evolutions of exchange rates can be expressed in form of index (Figure 6)



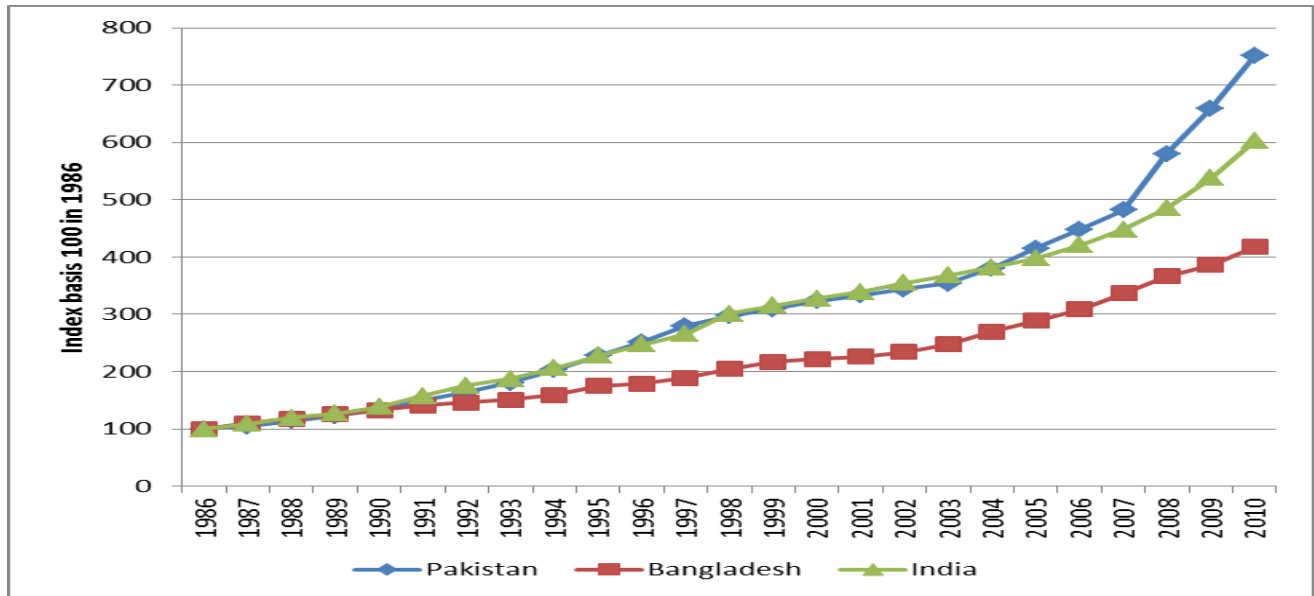
**Figure 6: Evolution of Pakistan, Indian and Bangladesh exchange rates against US dollar in index (basis 100 in 1970)**

Source: Calculation from World Bank data

This figure shows that the devaluation of local currency (Pakistan Rupee) has been the most important for Pakistan, as in 2010, at the official rate, it is necessary to give about 18 times more local money to get one dollar as compared to 1970. The devaluations have been also important for Bangladesh Rupee (multiplication for one US dollar by about 9) and even, at a lower rate, for Indian Rupee (multiplication by 6). It can be observed the huge devaluation of Pakistan Rupee between 2007 and 2010 on the figure, the relative stabilization of Bangladesh Rupee and a tendency of Indian Rupee to re-evaluate between 2002 and 2007.

A major problem for consumers of the three counties is the high rate of inflation that they had to face. The evolution of the Consumer Price Index (CPI) is represented on

Figure 7 shows importance of inflation from 1986 which is the first year for which the value of CPI is given for Bangladesh in World Bank dataset.



**Figure 7: Evolution of CPI index in Pakistan, India and Bangladesh (basis 100 in 1986)**

Source: Calculation from World Bank data.

From 1986 the prices have been multiplied by 7.5 in Pakistan, by 6 in India and “only” by about 4 in Bangladesh. During the last 4 years, the prices continue to rise at high rate everywhere, but the highest rate is observed in Pakistan with nearly a doubling of prices.

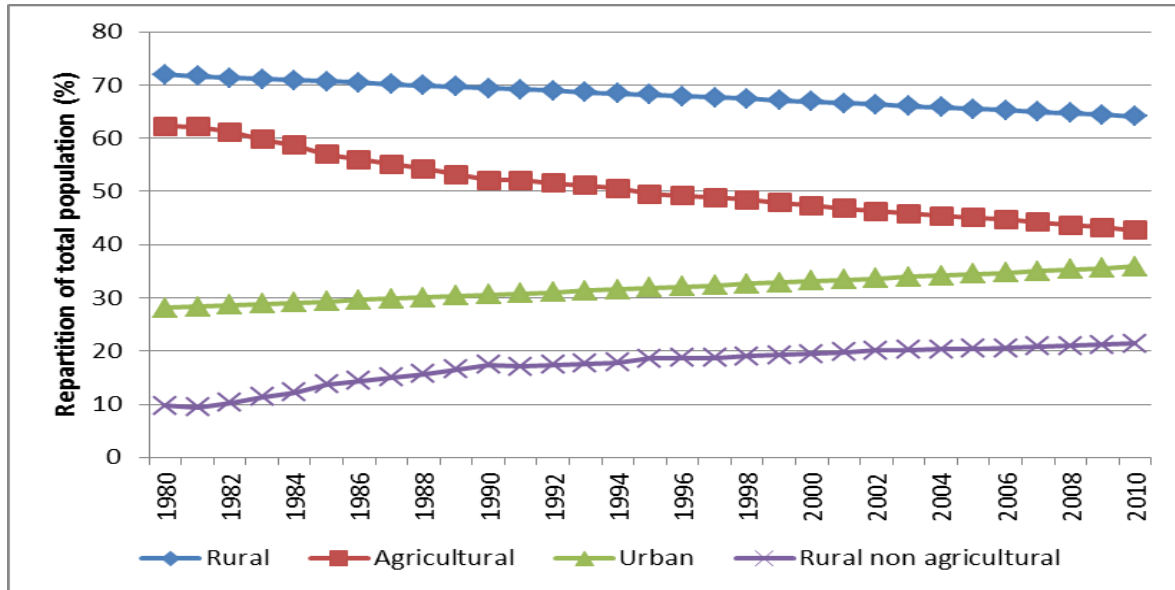
## 2.2. Pakistan

### 2.2.1. Generalities on population evolution

Pakistan is situated in south Asia where it is surrounded by India, Iran, China, Afghanistan and Arabian Sea. Its population is around 170.5 million, had grown at an average rate of 2.5% per annum from 1980 to 2009. Today, it is the sixth populous country in the world and till 2050, population of Pakistan will be 82% more than today respectively (Idso, 2011). The number of males is dominant. Whereas rural population increased gradually at the rate of 2.14% but on the other hand, urban population increased at rate of 3.5% due to urbanization. Thus overall non farming population increased at rate of 3.98%.

If we consider year 1980 as base year then total population in 2009 is 1.5 times more than population in 1980. Likewise, urban population is 2.4 times more than in 1980, farming population is 1.5 times of 1980 and non-farming rural population in 2009 is four times more than

in 1980. Thus we can feel a huge increase in non-farming rural population due to finding work in cities or urbanization, mechanization, and education level.



**Figure 8: Evolution of repartition of total population in Pakistan**

Source: Calculation from FAOSTAT<sup>27</sup>

In Pakistan, population became more urbanized with a share of around about 36% in 2010 against 28% in 1980, but rural population remains very important with more than 111 million people in 2010 (64% of total population). An important phenomenon is a decrease of agricultural population along time from 62% to 43%, with the emergence of an important rural non-agricultural population which increased from less than 10% in 1980 to more than 21% in 2010. Globally during the last thirty years while the total population increased by 93 million people, urban population increased by 40 million (43% of the total increase), rural non-agricultural population by 29 million (31%) and agricultural population by “only” 24 million (26%). This tendency to urbanization can be shown by describing the importance of the 8 mains cities of the country which represent more than 26 million people<sup>28</sup>.

<sup>27</sup> Population data refers to the World Population Prospects: The 2010 Revision from the UN Population Division,

<sup>28</sup> These towns with population in millions of habitants in 2005 are: Karachi :11.51M, Lahore:6.19M, Faisalabad:2.40M, Rawalpindi:1.75M, Multan:1.37M, Hyderabad:1.35M, Gujranwala:1.34M, Peshawar :1.19M.

This evolution had an important influence on the nature of food consumed, as less and less people are producing their own food on their farm, so more and more people have to buy it, either locally (rural non-agricultural population) either through other channels of distribution.

### 2.2.2. Generalities on economic aspects

In spite of structural shift towards industrialization, agriculture sector is still the largest sector of the economy with deep impact on socio-economic set up. It is the source of the livelihood of almost 44.7% of the total employed labour force in the country. With the present contribution to GDP at 21.8% (economic survey of Pakistan, 2008-2009), agriculture sector is the mainstay of the rural economy around which socio-economic privileges and deprivation revolve. Thus given for its stretched distinct forward and backward linkages particularly with the industrial sector, a large impact on balance of payments and highest share in employment, agriculture sector has assumed an added significance in backdrop of global food crunch and food security. The agricultural area increased from 25110 to 26980 between 1977 and 2007 (table 3) while the area under permanent crops also increased from 273 to 833 i.e. 3 times. It means that permanent crops make a large chapter of agricultural products cultivated in this country. GDP and GDP per capita increased at growth rate of 14.28 and 11.44 respectively from 1980-2009.

In Pakistan, protein and calorie intake per capita has been increased but it is still very low as compared to developed countries. The protein and calorie intake has been increased at growth rate of 0.47% and 0.32% respectively. There are still a large number of populations which are suffering of malnutrition.

**Table 2: Quantity of calories, protein and fat supply in the three countries:**

year	Pakistan			India			Bangladesh		
	Food supply (kcal/capita/day)	Protein supply quantity (g/capita/day)	Fat supply quantity (g/capita/day)	Food supply (kcal/capita/d ay)	Protein supply quantity (g/capita/d ay)	Fat supply quantity (g/capita/d ay)	Food supply (kcal/capita/d ay)	Protein supply quantity (g/capita/d ay)	Fat supply quantity (g/capita/d ay)
1980-85	2204	54	48	2104	52	35	2079	46	17
1986-90	2246	56	54	2224	55	38	2145	46	20
1991-95	2323	59	61	2248	55	41	2098	45	20
1996-00	2385	61	64	2294	55	45	2214	48	26
2001-05	2322	59	67	2254	55	45	2397	53	27
2006-09	2389	61	73	2325	57	49	2434	55	28
growth rate	0.32%	0.47%	1.69%	0.4%	0.37%	1.39%	0.63%	0.76%	2.08%

Source: calculation from FAOSTAT

In Pakistan, feed crops which are being used in livestock and poultry feeding as grains to meet the energy requirement are wheat, corn, sorghum and millet. These cereal crops are basically grown in the country to meet human dietary needs with a primary focus on wheat and rice, which are mainly used for human consumption. However their milling by-products, bran, rice polish and rice tips are used in livestock and poultry feeding.

Concerning income, it is important to express it in constant currency. The term Constant dollars refer to a metric for valuing the price of something over time, without that metric changing due to inflation or deflation. Constant dollars are used to compare the "real value" of an income or price to put the "nominal value" in perspective. The term specifically refers to dollars whose present value is linked to a given year. Here we have taken reference year 2005. The annual growth rate can be seen for each year represented by red line showing zigzag movement (figure 4). In 1975 and 2005, there were high annual growth rate and in 1979, there was the lowest annual growth rate (-7%). The blue line showing the income per capita is more smooth and begins from 300\$ in 1975 to 800\$ in 2007. It means that over all income rate increased during last 30 years.

A consumer price index (CPI) is a measure to estimate the average price of consumer goods and services purchased by households. Above graph (figure 7) shows the trend of inflation during last 35 years by taking CPI base in 2005. And the result shows the increase in price of basket of goods and services from 10 in 1975 to 160 in 2009. The growth rate was highest in 2007 and 1976 but lowest in 2003 and 1986.

Concerning exchange rates evolution, before 1981, like many countries, Pakistan rupee was linked to the US dollar. For a long time it was constant (fixed by government). In January 1982, the rupee was de-linked from the US dollar and the government followed a managed planned floating exchange rate policy. This policy allowed the exchange rate to fluctuate against the US dollar. However, this resulted in a gradual devaluation of rupee in terms of US dollar. In Pakistan state bank of Pakistan set daily exchange rate, which it used to purchase and sell US dollars in business with other authorized banks. Exchange rate increased till 70 rupees/US dollar in 2007 and line showing %age of devaluation fluctuate more.

Total area of Pakistan is 79610 thousands hectares of which 2522 thousands hectares consist of inland water and 77088 thousands hectares consist of land. The area of forest was 2239.3 thousand hectares in 1997 but in 2007, it decreased to 1816.4 due to deforestation for cultivation

or construction of colonies. On the other side, agricultural area was 25110 thousands of hectares in 1977 but in 2007, it became 27300 thousands of hectares after increase. Agricultural land consist of arable land, land under permanent crops, meadows and pastures. Arable land also increased from 19837 thousands of hectares in 1977 to 21500 thousands of hectares in 2007. The area under permanent crops also increased from 273 thousands of hectares in 1977 to 800 thousands of hectares in 2007.

**Table 3: Evolution of area repartition for each country.**

		1977			1987			1997			2007		
		Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh
Area of country	a	79 610	328 726	14 400	79 610	328 726	14 400	79 610	328 726	14 400	79 610	328 726	14 400
Inland water	b	2 522	31 407	1 383	2 522	31 407	1 383	2 522	31 407	1 383	2 522	31 407	1 383
Land area	c=a-b	77 088	297 319	13 017	77 088	297 319	13 017	77 088	297 319	13 017	77 088	297 319	13 017
other land	d							47 869			47 972		
area of forest	d							2 239			1 816		
Agriculture area	f=c-d-e+f+g+h	25 110	180 789	9 991	25 920	181 650	10 115	26 980	180 856	9 365	26 880	179 709	9 268
Arable land	f	19 837	163 260	9 131	20 499	163 270	9 235	21 351	161 518	8 390	21 047	158 104	7 838
Permanent crops	g	273	5 000	260	421	6 500	280	629	8 500	375	833	11 180	830
Meadows and pastures	h	5 000	12 529	600	5 000	11 880	600	5 000	10 838	600	5 000	10 425	600

**Unit: hectare; Source: calculation from FAOSTAT**

Concerning vegetal production, one has to notice that there are two principle crop seasons in these three countries, namely the “Kharif”, the sowing season which begins in April-June and ends during October-December; and the “Rabi”, which begins in October-December and ends in April-May. Rice, sugarcane, cotton, corn, mong, mash, bajra and jowar are “Kharif” crops while wheat, gram, masoor, tobacco, rapeseed, barley and mustard are “Rabi” crops. Major crops, such as, wheat, rice, cotton and sugarcane accounts for 33.4% of the value added in overall agriculture. Thus, the four major crops (wheat, rice, cotton and sugarcane), on average, contribute 29.8% to value added in overall agriculture and 6.5% to GDP.

## **2.3. India**

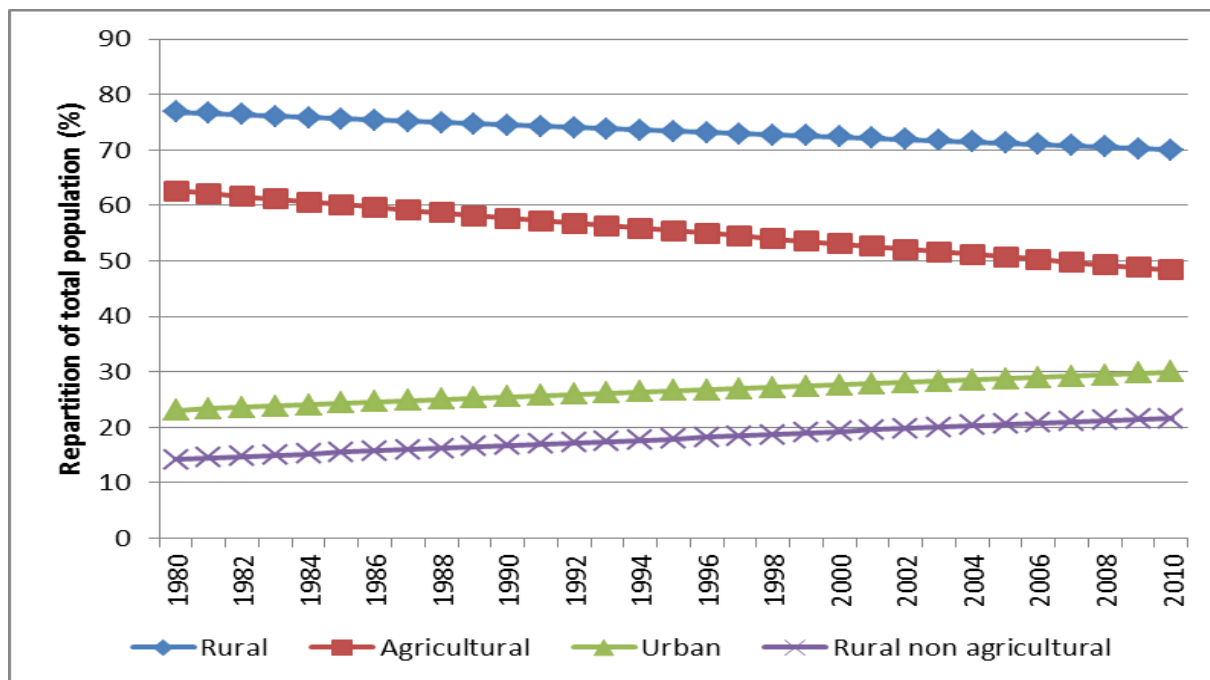
### **2.3.1. Generalities on population evolution**

India is the most important country of South Asia in term of surface and population. It is the seventh largest country by geographical area, the second most populous country with over 1.2 billion people. Bounded by the Indian ocean on the south, Arabian sea on the south-west, and the Bay of Bengal on the south-east, it shares land borders with Pakistan to the west; China, Nepal and Bhutan to the north-east; and Burma and Bangladesh to the east. The Indian economy is the world's eleventh-largest by nominal GDP and third-largest by purchasing power parity (PPP). Following market-based economic reforms in 1991, India became one of the fastest-growing major economies; it is considered a newly industrialized country. However, it continues to face the challenges of poverty.

Agriculture plays an important, though declining role in the economy. Despite India's economic development, over 70% of the population still lives in rural areas. Agriculture is the key sector for employment with around 60% of the labour force. Agriculture including allied activities, accounted for 14.5 per cent of gross domestic product (GDP) at 2004-05 prices (economic survey of India, 2012).

India is second populous country of world and its population will be 33% more than today till 2050 (Idso, 2011). Total population of India increased from 1980 to 2009 at the rate of 1.8% per year. In population of India, the number of males is dominant whereas rural population increased gradually at the rate of 1.48%. But on the other hand, urban population increased at rate of 2.7% due to urbanization. Thus overall non farming population increased at rate of 2.97%. If we consider year 1980 as base year then total population in 2009 is 1.8 times more than population in 1980. Likewise, urban population is 2.3 times more than in 1980, farming population is 1.4 times of 1980 and nor farming rural population in 2009 is 2.4 times more than in 1980.





**Figure 9: Evolution of repartition of total population in India**

Source: Calculation from FAOSTAT

As an indication of the country's urbanization, India had 36 cities in 2005 having more than 1 million inhabitants with a total population of 91 million people<sup>29</sup>

### 2.3.2. Generalities on economic aspects

The Indian economy has seen high growth rates more than 8% since 2003. From 1980 to 2009, GDP and GDP per capita grew at a rate of 13.83% and 11.84% respectively. However it's GDP per capita is still very low (estimated at 56695 Indian rupees per capita), so it remains classified by the World Bank as a low income country. The World Development Report 2008 states that over one third of the population of India was living below the poverty line in 2004-2005, managing on less than \$1 per day.

On the other hand, agriculture land increased slightly from 1977 to 1997 then it decreased but land under cultivation of permanent crops increased more than two times between last three

<sup>29</sup> Mumbai (Bombay): 12.78M, Delhi:11.06M, Bangalore: 5.16M, Calcutta: 4.65M, Chennai (Madras): 4.37M, Ahmadabad: 3.80M, Hyderabad: 3.62M, Pune (Poona): 3.06M, Surat: 2.93M, Kanpur: 2.84M, Jaipur 2.68M, Lucknow: 2.49M, Nagpur: 2.24M, Indore:1.85M, Patna:1.61M, Bhopal:1.61M, Ludhiana:1.56M, Thana:1.50M, Agra:1.44M, Vadodara:1.43M, Nashik:1.30M, Pimpri-Chinchwad:1.30M, Kalyan: 1.27M, Meerut:1.23M, Jamshedpur:1.21M, Faridabad: 1.21M, Varanasi (Benares): 1.17M, Ghaziabad: 1.16, Amritsar:1.10M, Rajkot:1.10M, Allahabad: 1.08M, Visakhapatnam: 1.07M, Jabalpur:1.05M, Haora:1.03M, Aurangabad:1.03M, Sholapur:1.01M.

decades. Due to having large population under poverty, the protein and calorie intake per capita in India is lower than Pakistan. The protein and calorie intake per capita in 1980 was 1990Kcal and 48 g which increased with growth rate of 0.40% and 0.37% to 2331 kcal and 57g respectively in 2009.

Cereals are the staple food in India, providing over half the calories consumed, while pulses are the main protein supplement in the diet. Rising incomes and the influence of globalization have contributed to changes in the diet pattern with a slight decrease in cereals consumption and an increase in pulses, edible oils, fruits and vegetables, milk and meat, which is growing from a low base. In the case of edible oils, the fall in prices after the liberalization of imports further stimulated consumption.

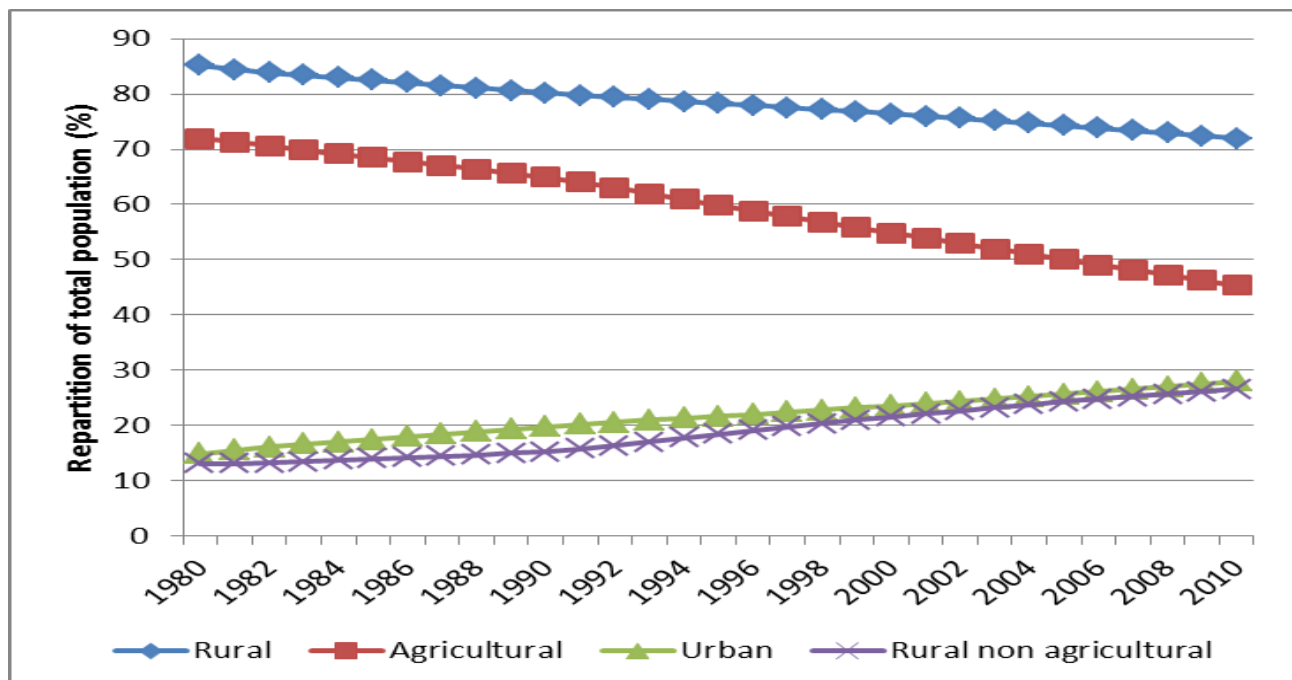
As shown on figure 7 , India showed high inflation rates with an increase in price of basket of goods and services from 7 in 1975 to 135 in 2009 (CPI index basis 100 in 1986). Concerning exchange rates, state bank of India set daily exchange rate, which it used to purchase and sell US dollars in business with other authorized banks. The indian rupee has been devaluted from 8 rupees per dollar to 48 rupees per dollar during 1970-2009 (figure 5). But it is relatively stable as compared to pakistan and bangladesh. Whereas GDP of india has been increased from 136.6 million dollar to 1018.2 million dollar during 1970-2009 that is approximately 8 times more (figure 4).

## **2.4. Bangladesh**

### **2.4.1. Generalities on population evolution**

Bangladesh is also located in South Asia and it is bordered by India, Burma and the Bay of Bengal to the south.

Total population of Bangladesh increased from 1980 to 2009 at the rate of 2.09% per year. In population of Bangladesh, the number of males is dominant whereas rural population increased gradually at the rate of 1.53%. But on the other hand urban population increased at rate of 4.17% due to urbanization. Thus overall non farming population increased at rate of 4.41%.



**Figure 10: Evolution of repartition of total population in Bangladesh**

Source: Calculation from FAOSTAT

As in the two other countries, Bangladesh remains a rural country with more than 72% of its population living in this area. Like Pakistan and India, the agricultural population decreased in percentage more than rural population and an important number of populations of urban and rural non-agricultural people have emerged. Between 1980 and 2010, compared to an increase of 68 million people for total population, urban population has increased by 30 million, rural non-farming by 29 million and agricultural by only 9 million.

The moderate phenomenon of urbanization is illustrated by the fact that only two towns (Dhaka and Chittagong, with a total of 16 million people in 2005) had more than 1 million inhabitants.

#### **2.4.2. Generalities on economic aspects**

The economy has grown at the rate of 6-7% per annum over the past few years. More than half of the GDP is generated by the service sector; while nearly half of Bangladeshis are employed in the agriculture sector. According to the final estimate of Bangladesh Bureau of Statistics (BBS), the country had GDP growth of 5.74% in 2008-09.

Agriculture is an important sector of the economy of Bangladesh and one of the main drivers of economic growth. The contribution of this sector to GDP stood at 20.49% in 2008-09. According to the revised estimate of BBS, the overall contribution of the broad agriculture sector at constant price is 20.24% of GDP in 2009-10. Overall GDP and GDP per capita increased at growth rate of 10.69% and 8.46% respectively from 1980 to 2009. Though the direct contribution of the agriculture sector has decreased slightly, its indirect contribution to the overall growth of GDP is significant. Besides, about 43.6% of the total labor forces of the country are engaged in agriculture sector. The land is devoted mainly to rice and jute cultivation as well as fruits and other produce, although wheat production has increased in recent years; the country is largely self-sufficient in rice production

While population increased quickly, on the other hand, agriculture land slightly decreased from 1977 to 2009 but land under cultivation of permanent crops increased more than three times between last three decades. Due to having large population under poverty, the protein and calorie intake per capita in Bangladesh is lower than Pakistan and India. The protein and calorie intake per capita in 1980 was 2070 Kcal and 46 g respectively which increased to 2481 kcal and 58g in 2009 at growth rate of 0.63% and 0.76% (table 2).

The CPI (1986 as base year) indicates that price of basket of goods and services increases from 9 in 1975 to 134 in 2009 corresponding to a multiplication of prices by 15 (figure 7).

Concerning exchange rates, state bank of Bangladesh set daily exchange rate, which it used to purchase and sell US dollars in business with other authorized banks. The bangali takka has been devaluted from 7 takkas per dollar to 69 takkas per dollar during 1970-2009 (figure 5).

## **2.5. General conclusions**

The three countries have a number of common characteristics. Firstly, the sharp increase in total local populations (but with different average annual rates) that is much faster than the global average and also a strong increase in urban populations (and those located in larger cities). Rural non farming population is also having strong growth in all three countries, while agricultural population is decreasing in percentage. While in 1980, in Pakistan, there were about 50 billion agricultural people to feed about 80 billion urban and rural people (ie. a ratio of 1.6 farmer for

one inhabitant), in 2010, each farmer has to feed 2.3 people. In India this ratio has increased from 1.6 to 2.1 and, in Bangladesh, from 1.4 to 2.2.

In addition, GDP per capita has increased more strongly in the three countries between 1970 and 2010, with acceleration in India since the early 2000s, but levels (between 550 and 850 U.S. dollars per capita) remains low as compared to the global average. Such strongest economic growth has been accompanied by both high inflation (measured by CPI) particularly in Pakistan and a sharp deterioration in their exchange rates against the dollar, which has contributed to exports but limited and / or adds the cost of imports.

One other very important indicator is the decreasing arable area available for feeding total population of each of these countries and also for each farmer. In Pakistan, the total arable land had only increased between 1980 and 2010 by 0.55 Mha (+2.8%, rate much lower than population) so the availability of arable land per total population has decreased from 0.25 ha to 0.12 (from 0.40 to 0.28 per farmer). In India, the total arable land has decreased by 5.4 Mha (-3.3%) so the availability of land per inhabitant decreased from 0.23 to 0.13 (from 0.37 to 0.27 per farmer). In Bangladesh total arable land decreased by 1.4 Mha (-15.1%) so availabilities of hectares per person decreased from 0.11 to 0.05 for total and from 0.16 to 0.12 for farmers.

This general description of agricultural situation for the three countries shows that the share of food and feed crops has increased inside total arable lands due to the importance of yield progress but the problem is raised by the contradiction between a limited agricultural area, a rapidly growing population, more urbanization, higher income and wishing to have better and more diversified food diets.

# Chapter 3: Estimation of supply functions for main crops

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The objective of this chapter is to present first the evolution of production, surfaces, yields and producer prices of various crops in each country. This allows firstly to justify the choice of products that have been retained in present econometric analysis and PEM of Chapter 6 and to visualize any anomalies that may exist in FAO statistical data used for estimation of elasticities. As mentioned earlier, these elasticities are a set of key parameters that are conventionally introduced into the PEM to represent the mechanisms of land allocation between different crops and therefore to make simulations. The hypothesis was that the introduction of national average prices of different crops significantly influences variations of surfaces. This hypothesis will be validated by the significance of the coefficients of the various equations and expected signs (positive) of calculated direct elasticities.

## 3.1. General presentation of main crops evolution in Pakistan, India and Bangladesh

These three countries are very important agricultural producers especially for cereals (like rice), some oilseeds and sugarcane. Regarding the 9 major grain crops (wheat, rice, corn, millet and sorghum, rapeseed, cottonseed and soybean, pulses), production of the three countries increased from 140 Mt in "1968"<sup>30</sup> to approximately 366 Mt in "2006" which is an increase of 226 Mt (161%) that is attributable to 76% in India, 13% in Pakistan and 11% in Bangladesh (see table 4). The share of India was 78.2% at beginning of period then decreased slightly to 76.5% in "2006", while Pakistani share progressed from 9.1 to 11.5% and that of Bangladesh fell to about 12% of about 1 point.

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<sup>30</sup> To minimize the effect of annual variations of surfaces and performance for the two countries, we have compared the average of the years 1966 to 1970 (centered on 1968 and marked "1968") to the average 2004-2008 (centered on 2006 and noted "2006") that is gap of 38 years

**Table 4: Evolution of productions of main crops in Pakistan, India and Bangladesh**

	Average 66-70				Average 2004-2008				Variation				Evolution			
	Pakistan	India	Bangladesh	Total	Pakistan	India	Bangladesh	Total	Pakistan	India	Bangladesh	Total	Pakistan	India	Bangladesh	Total
Wheat	5 716	15 414	69	21 200	21 328	72 905	909	95 142	15 612	57 491	840	73 943	273%	373%	1211%	349%
Rice, paddy	2 848	57 140	16 572	76 560	8 558	138 973	41 346	188 876	5 709	81 833	24 774	112 316	200%	143%	149%	147%
Rapeseed	227	1 401	116	1 744	330	7 058	200	7 588	103	5 657	84	5 844	45%	404%	73%	335%
Pulses, Total + (Total)	834	10 616	311	11 761	1 005	13 905	276	15 186	171	3 289	-35	3 425	20%	31%	-11%	29%
Cottonseed	1 037	2 118	5	3 160	4 161	7 301	24	11 485	3 123	5 183	19	8 325	301%	245%	408%	263%
Maize	678	6 005	3	6 686	3 239	16 533	674	20 445	2 561	10 528	671	13 759	378%	175%	22353%	206%
Soybeans	1	12	0	13	0	8 976	54	9 030	-1	8 964	54	9 017	-70%	72287%		68621%
Millet	355	9 033	58	9 445	251	11 148	18	11 417	-104	2 115	-40	1 972	-29%	23%	-69%	21%
Sorghum	288	9 380	1	9 669	171	7 326	0	7 498	-118	-2 054	0	-2 172	-41%	-22%	-29%	-22%
Total	11 985	111 119	17 135	140 239	39 042	284 124	43 501	366 667	27 057	173 005	26 366	226 428	226%	156%	154%	161%
Cotton lint	519	1 043	2	1 564	2 108	3 594	12	5 714	1 589	2 552	9	4 150	306%	245%	407%	265%
Sugar cane	22 258	114 403	7 703	144 365	52 878	291 166	5 834	349 879	30 620	176 763	-1 869	205 514	138%	155%	-24%	142%

Source: FAOSTAT; Unit: Thousand tons

The increase of 226 Mt of total grain production is primarily attributable to the increase of rice paddy (increase of 112 Mt of which 82 Mt is in India, 6 MT in Pakistan and 25 MT in Bangladesh) and wheat (increase of 74 Mt of which 57 Mt is in India, 16 MT in Pakistan and 6 MT in Bangladesh). Cottonseed and corn also increased by about 12 Mt each.

For cotton lint, there is also a sharp increase (+1.6 Mt or 306%) in Pakistan and also (2.5 Mt or 245%) in India. For sugarcane overall progress is more modest (142%) with the highest share in India (+155%) then in Pakistan (+138%), but a significant reduction in Bangladesh (-24%).

Very large increases in production are indicated above a priori due to both increases in those areas and yields. The purpose of the remainder of this section is to analyse more specifically the causes of land area allocation in each country, taking into account both the price received by farmers and yields.

**Table 5: Evolution of areas of main crops in Pakistan, India and Bangladesh**

	Average 66-70				Average 2004-2008				Variation				Evolution			
	Pakistan	India	Bangladesh	Total	Pakistan	India	Bangladesh	Total	Pakistan	India	Bangladesh	Total	Pakistan	India	Bangladesh	Total
Wheat	5 774	14 598	88	20 460	8 430	27 099	493	36 022	2 656	12 501	406	15 562	46%	86%	463%	76%
Rice, paddy	1 502	36 785	9 787	48 074	2 640	43 765	10 641	57 046	1 138	6 980	855	8 973	76%	19%	9%	19%
Rapeseed	473	3 041	209	3 723	349	6 528	236	7 113	-124	3 487	27	3 391	-26%	115%	13%	91%
Pulses, Total + (Total)	1 685	22 187	419	24 291	1 597	23 111	331	25 039	-88	924	-88	748	-5%	4%	-21%	3%
Seed cotton	1 718	7 804	13	9 534	3 049	9 085	15	12 149	1 331	1 282	2	2 614	77%	16%	13%	27%
Maize	613	5 618	3	6 234	1 029	7 840	118	8 987	416	2 223	115	2 753	68%	40%	3497%	44%
Soybeans	2	28	0	30	0	8 401	36	8 437	-1	8 372	36	8 407	-88%	29689%		28212%
Millet	774	19 662	70	20 505	458	11 902	29	12 389	-316	-7 760	-40	-8 116	-41%	-39%	-58%	-40%
Sorghum	533	18 237	1	18 771	280	8 665	0	8 945	-253	-9 572	-1	-9 826	-48%	-52%	-65%	-52%
Sugar cane	582	2 493	163	3 238	1 044	4 401	151	5 595	461	1 908	-12	2 357	79%	77%	-8%	73%
Total	13 655	130 453	10 752	154 859	18 875	150 797	12 051	181 723	5 221	20 344	1 299	26 864	38%	16%	12%	17%

**Source: Calculation from FAOSTAT; Unit: Thousand hectares**

Regarding the surface area under cultivation for 10 main crops taken here in these three countries, FAOSTAT indicates that total surface area under these ten crops (see table 5) increased from 154 thousand hectares in 1968 to 181 thousand hectares in 2006 with an increase of 17%. This increase is mainly attributed to augmentation of soybeans surface area that has been increased from 0.03 to 8 thousand ha (almost complete in India) during 38 years then rapeseed increased from 4 to 7 thousand ha (+3 or 91% increase). Total surface area of these countries under wheat increased by 76% from 20 to 36 thousand ha of which Bangladesh, India and Pakistan showed evolution of 463%, 86% and 46% respectively. Cultivated surface area for sugar cane, rice, cotton seed and corn also increased by 73%, 19%, 27% and 44% respectively. While on the contrary, only sorghum and millet area decreased by 40 and 52% respectively.



**Table 6: Evolution of yields of main crops in Pakistan, India and Bangladesh**

	Average 66-70				Average 2004-2008				Variation				Evolution			
	Pakistan	India	Bangladesh	Total	Pakistan	India	Bangladesh	Total	Pakistan	India	Bangladesh	Total	Pakistan	India	Bangladesh	Total
Wheat	0.99	1.06	0.79	1.04	2.53	2.69	1.84	2.64	1.5	1.6	1.1	1.6	156%	155%	133%	155%
Rice, paddy	1.9	1.55	1.69	1.59	3.24	3.18	3.89	3.31	1.3	1.6	2.2	1.7	71%	104%	129%	108%
Rapeseed	0.48	0.46	0.56	0.47	0.95	1.08	0.85	1.07	0.5	0.6	0.3	0.6	97%	135%	53%	128%
Pulses, Total (Total)	0.49	0.48	0.74	0.48	0.63	0.6	0.84	0.61	0.1	0.1	0.1	0.1	27%	26%	12%	25%
Maize	1.11	1.07	0.91	1.07	3.15	2.11	5.71	2.27	2	1	4.8	1.2	185%	97%	524%	112%
Soybeans	0.46	0.44		0.44	1.12	1.07	1.48	1.07	0.7	0.6		0.6	143%	143%		143%
Millet	0.46	0.46	0.83	0.46	0.55	0.94	0.62	0.92	0.1	0.5	-0.2	0.5	19%	104%	-25%	100%
Sorghum	0.54	0.51	0.67	0.52	0.61	0.85	1.36	0.84	0.1	0.3	0.7	0.3	13%	64%	105%	63%
Sugar cane	38.23	45.89	47.26	44.58	50.66	66.16	38.75	62.53	12.4	20.3	-8.5	17.9	33%	44%	-18%	40%
Cotton lint	0.3	0.13	0.18	0.16	0.69	0.4	0.81	0.47	0.4	0.3	0.6	0.3	129%	196%	347%	187%
Cottonseed	0.6	0.27	0.36	0.33	1.36	0.8	1.62	0.95	0.8	0.5	1.3	0.6	126%	196%	348%	185%

**Source: Calculation from FAOSTAT; Unit: ton per ha**

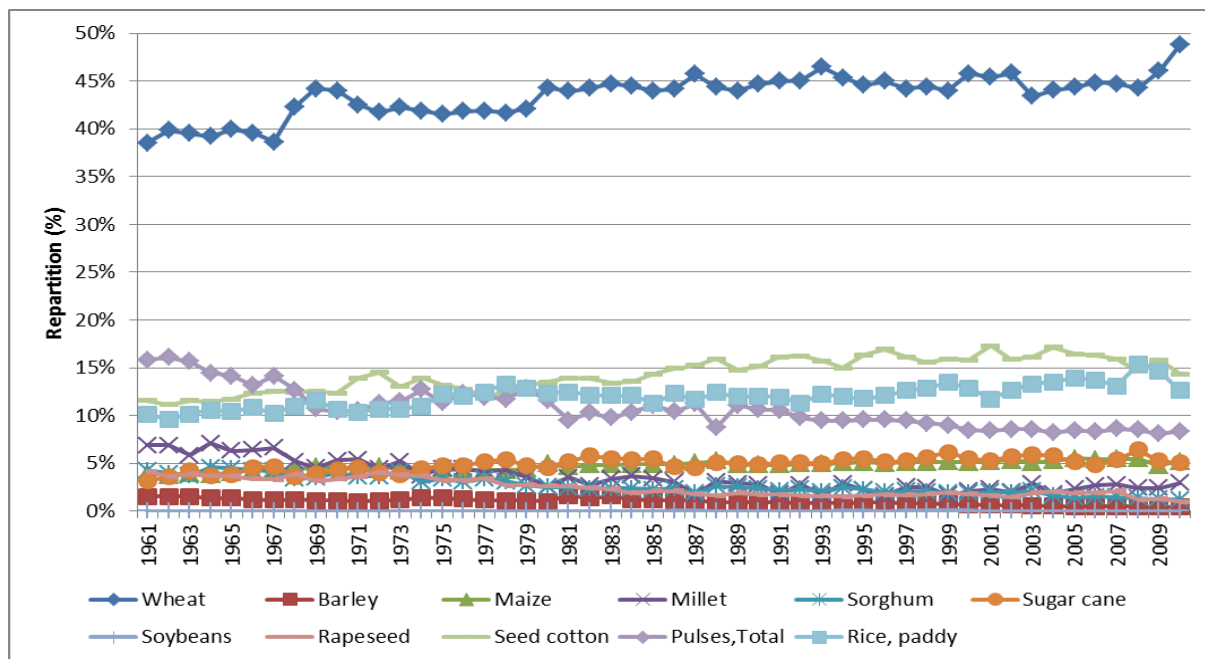
If the evolution of yield for all crops taken into analysis (

Table 6) for these three countries is analysed then it can be seen that yield of cotton seed and cotton lint increased by 185% and 187% respectively during last 38 years for all three countries. This increase is attributed to Bangladesh (348%) then India (196%) and Pakistan (126%). Wheat yield stood second that increased by 155% for all three countries during time period taken while soybean yield stood third with 143% of increase. For rice paddy, rapeseed, corn, soybeans, millet and sorghum, yield showed an increase of 108%, 128%, 112%, 143%, 100% and 63% respectively. Where sugarcane and pulses yield remained modest with 40% and 25% of increase.

### **3.1.1. Pakistan**

For Pakistan, the total area of the ten main crops increased from 11.3 Mha in 1966 to 18.0 in 2008; that is equivalent to a mean annual growth of 0.15 Mha or 1.02%, which is less than the mean growth rate of population (2.5 %). Over the past 38 years while the surface area has increased by 46% (+5.5 Mha), some crops have experienced significantly rapid net progression (pulses +141%, cotton +78%, sugar cane +79%, rice +76%, corn +68% et wheat +46%) while soybeans after a period of growth until 2000 then showed its surface collapse to 50,000 hectares (against a maximum of about 8 million ha). Other crops such as rapeseed, millet and sorghum have all experienced significant declines of 19% for the first product and 40 to 48% for the other two. Overall the increase is attributable mainly to total area of wheat (+ 2.7 million ha), cotton (+1.3 Mha) and rice (+ 1.1 Mha).

In fact, the important point for the following translog estimation concerning each country is the evolution of repartition between main crops and the objective of the model development is to calculate the relative influence of relative yields and relative prices on total agricultural area allocation.



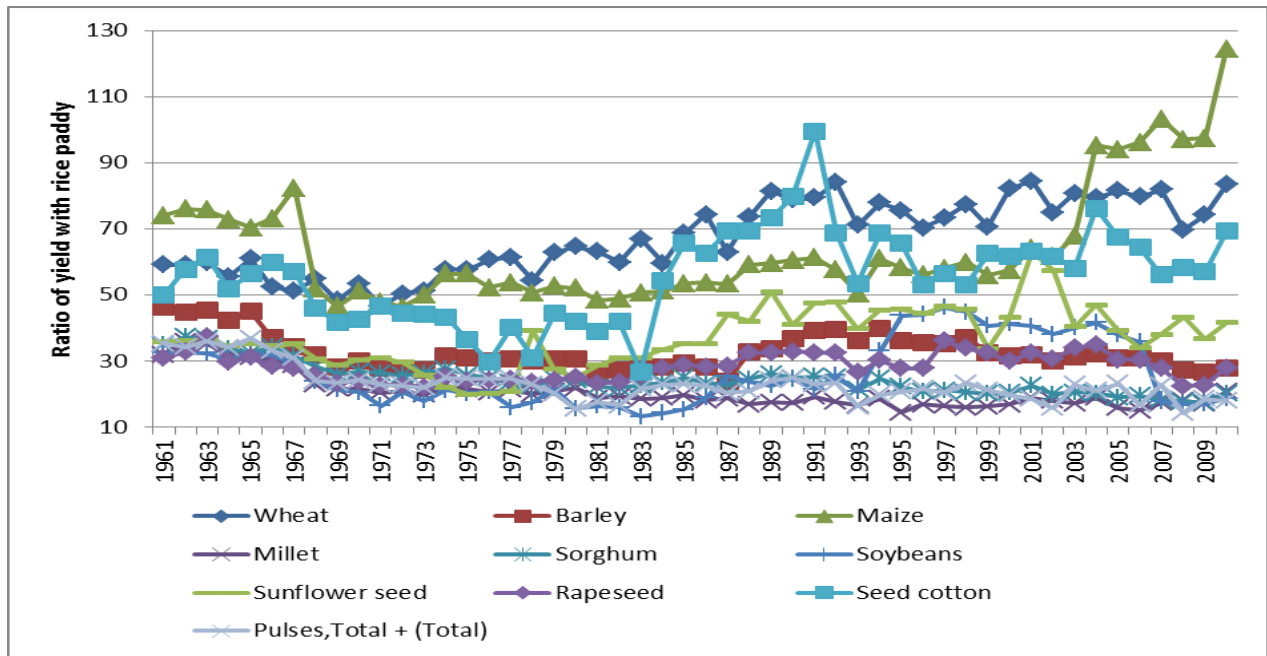
**Figure 11: Evolution of repartition of main crops in India**

**Source:** Calculation from FAOSTAT; **Unit:** Percentage of surface area for each crops relative to total surface of indicated crops.

For Pakistan, wheat is traditionally the main crop in term of cultivated area with a share of the total area of different crops taken in account in this report which increases from 39% at beginning of the period to 49% in 2010 (the mean value is 43%). The second crop is cotton with a share of 14% in 2010 against 12% in 1961. This share has significantly varied from year to year with a lower share of 11% in 1962 and more than 17% in 2001. Rice has a mean share of 12% and fluctuated between a high share of 15% in 2009 and 10% in 1971. The fourth category is the whole family of pulses with a mean share of 1%. The all other crops represent about 19% in average during 1961-2010, with some predominance for corn and sugar crops.

It is essentially the increase of average yields during this period that increased the productions. For five products (corn, wheat, cotton, rapeseed, soybean), their yield became more than doubled. While for others, the performance gains were more modest (71% for rice and 39% for pulses) or low (millet + 18% and sorghum + 11%). For sugarcane, the yield trend which had increased significantly up to 2007 (+72% compared to 1966) collapsed in 2008 with a yield loss of more than 50% over the previous year with growth of 56% throughout the period.

The yields for all crops have increased strongly during the last 50 years, but the important factor is the relative increase of each of them. In the following figure 12, evolution of ratio of yields compared to rice paddy has been represented. It means that for each year and each product, the value represented is the effective yield of the crop divided by the yield of rice during the year and multiplied by 100.



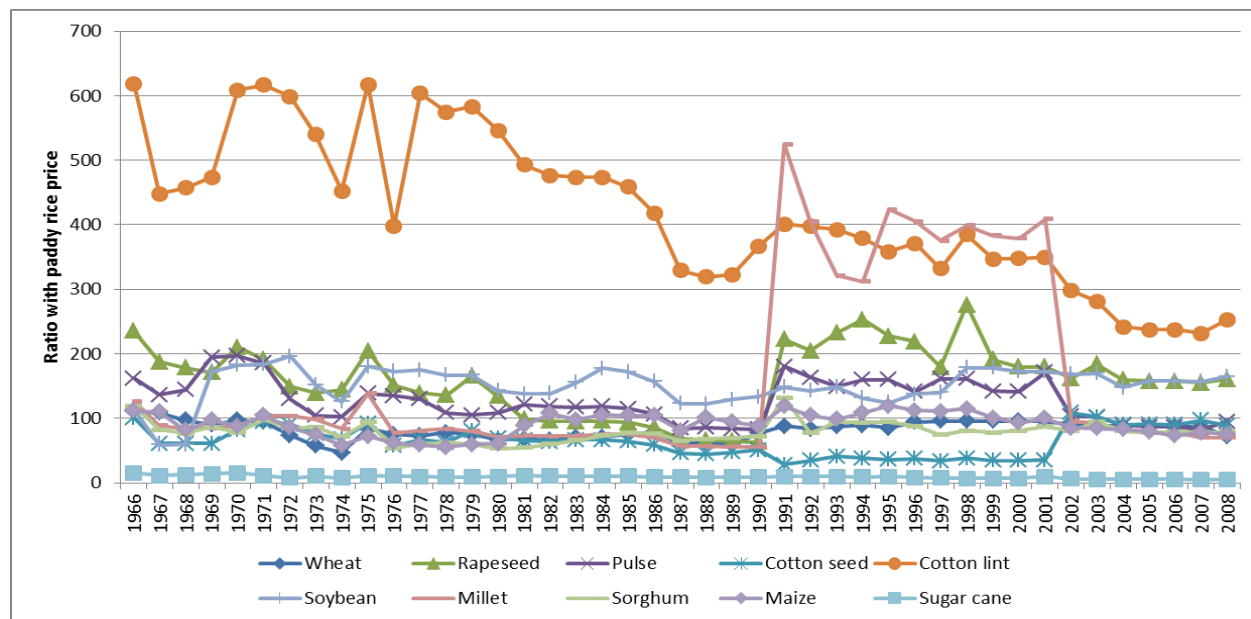
**Figure 12: Evolution of crops yields relative to rice paddy yields in Pakistan, Unit: Percentage**

Source: Calculation from FAOSTAT; Unit: percentage

Rice paddy is the crop with the most important average yield in Pakistan during the whole period. The second most productive crop is wheat with a ratio of 67% followed by corn (64%). All other crops have low relative yield like other cereals (millet, sorghum), all oilseeds (rapeseed, soybean) and total pulses (ratio of only 23%). It is important to notice that between “1968” and “2006” the ratio increased by 59% for corn, by 51% for wheat, and by 31% for cotton.

Yield for each product varies from year to year according to specific climatic condition, but figure 12 shows that the relative yields were also very fluctuating. For corn, wheat and seeds cotton, to some extent, there was a trend toward better productivity than rice paddy. On contrary, millet, sorghum, and total pulses revealed a net decreasing trend of competitiveness.

In current local currency account, the prices received by farmers for all crops have been increased, largely due to inflation, so the most important factor to explain evolution of areas is the relative price which has been calculated with comparison to rice paddy (figure 13).



**Figure 13: Evolution of relative prices to rice paddy in Pakistan**

Source: Calculation from FAOSTAT; Unit: Percentage

In average on the whole period, rapeseed, soybean and millet had the higher prices among crops with ratio to rice paddy near to 160%. The case of millet is specific with an apparent huge increase between 1991 and 2002 which could be due to a bias in FAO data<sup>31</sup>. For cotton, there are quotations for two by-products: lint with a mean price ratio of 424 that have much decreased along time (Figure 13) and cottonseed with a mean ratio of only 64%. For sugarcane price the ratio is only about 9%. This low level is due to the composition of this product very different to that of grains and is partly compensated by high yields (on average 17 times more than that of paddy rice).

**Table 7: Means, standard errors and coefficient of variation for share areas, yields and prices concerning Pakistan**

<sup>31</sup> For producer prices, the FAO data base is composed of two parts the “archive” data base with data up to 1990 and the “new” data base with data from 1991 without any chingang. It is probable that for some products there are some discontinuities on references and that has been taken in account in the econometric estimations by introducing in the model some dummy variables.

	Total mean	Standard Error	Coefficient of variation	Total mean	Standard Error	Coefficient of variation	Total mean	Standard Error	Coefficient of variation
	Share areas			relative yields			Relative prices		
Wheat	43.47%	2.19%	5.00%	67.24	11.19	16.6%	81.87	13.99	17.09%
Barley	1.01%	0.33%	33.1%	32.71	5.44	16.6%			
Maize	4.76%	0.46%	9.6%	64.12	17.59	27.4%	90.42	18.04	19.95%
Millet	3.6%	1.58%	43.9%	20.58	5.23	25.4%	161.81	141.44	87.41%
Sorghum	2.67%	0.93%	34.9%	24.5	4.83	19.7%	79.11	15.63	19.75%
Sugar cane	4.92%	0.71%	14.4%	1734.3	313.51	18.1%	9.09	2.5	27.47%
Soybeans	0.02%	0.01%	74.8%	26.56	9.89	37.2%	150.96	28.79	19.07%
Rapeseed	2.46%	0.9%	36.6%	28.29	4.08	14.4%	159.53	53.63	33.62%
Seed cotton	14.34%	1.73%	12.1%	55.62	13.85	24.9%			
Pulses.Total	10.74%	2.13%	19.8%	22.99	5.37	23.4%	127.61	32.99	25.85%
Rice. paddy	12.02%	1.21%	10.00%	100	0	0.00%	100	0	0.00%
Cotton seed							64.18	22.94	35.75%
Cotton lint							421.1	117.76	27.96%

Source: Calculation from FAOSTAT; Unit: Percentage

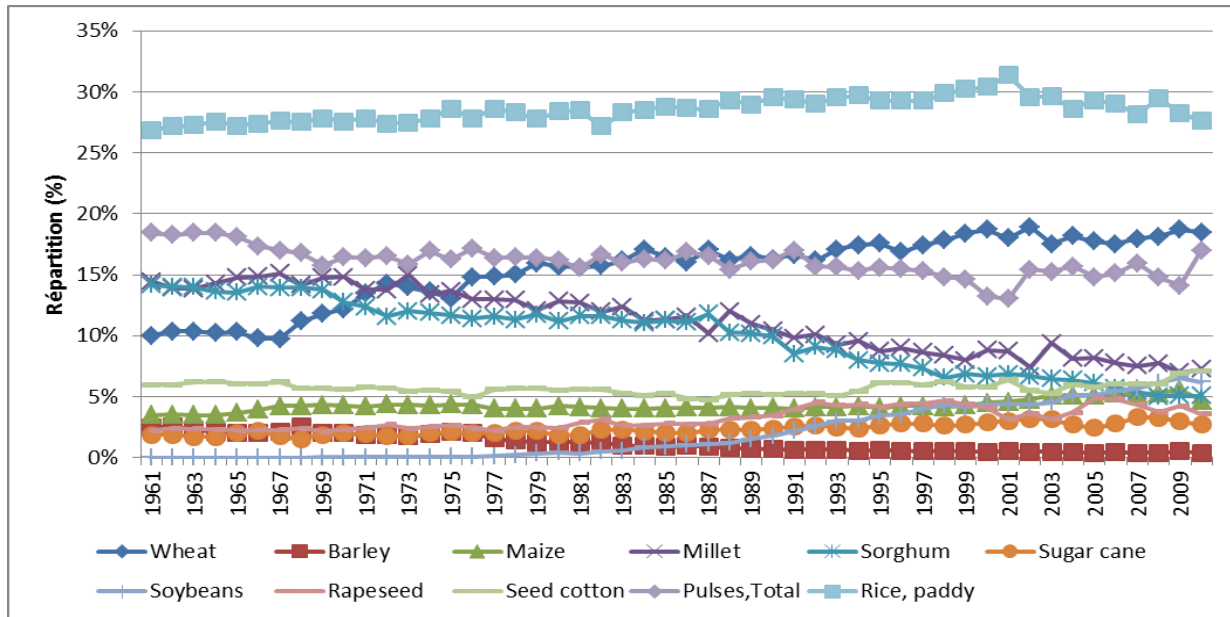
It is shown in table 7 that except for relative area of wheat, all these relative parameter have generally relatively high standard errors and coefficients of variation<sup>32</sup>. This tends to indicate that farmers effectively adjust each year their land allocation in relation with economic (prices) and technical (yield) parameters.

### 3.1.2. India

For India the total area for these 10 crops increased from 115.8 Mha in "1966" to 136.1 in "2006" (+20.3 Mha) which corresponds to an average increase of 0.47 Mha per year by 0.37%. This figure is well below than the average growth rate of the population (1.87%). So, like Pakistan, yields increased which caused most of the increase in production.

In India, surface areas that have been more increased in percentage are those of rapeseed (+115%), wheat (+85%) and sugarcane (77%). While soybean that was virtually nothing in the middle 60s increased to 8.4 Mha in "2006". Rice, pulses and cotton have been increased from about 16 to 18%. Finally surfaces of millet and sorghum have increased sharply (from 40 to 52%). Overall the increase in total area of over 20 Mha is mainly due to wheat (+12.5 million ha), soybeans (+8.4 Mha) and rice (+6.6 Mha).

<sup>32</sup> The coefficient of variation is equal to standard error divided by the mean of the variable.

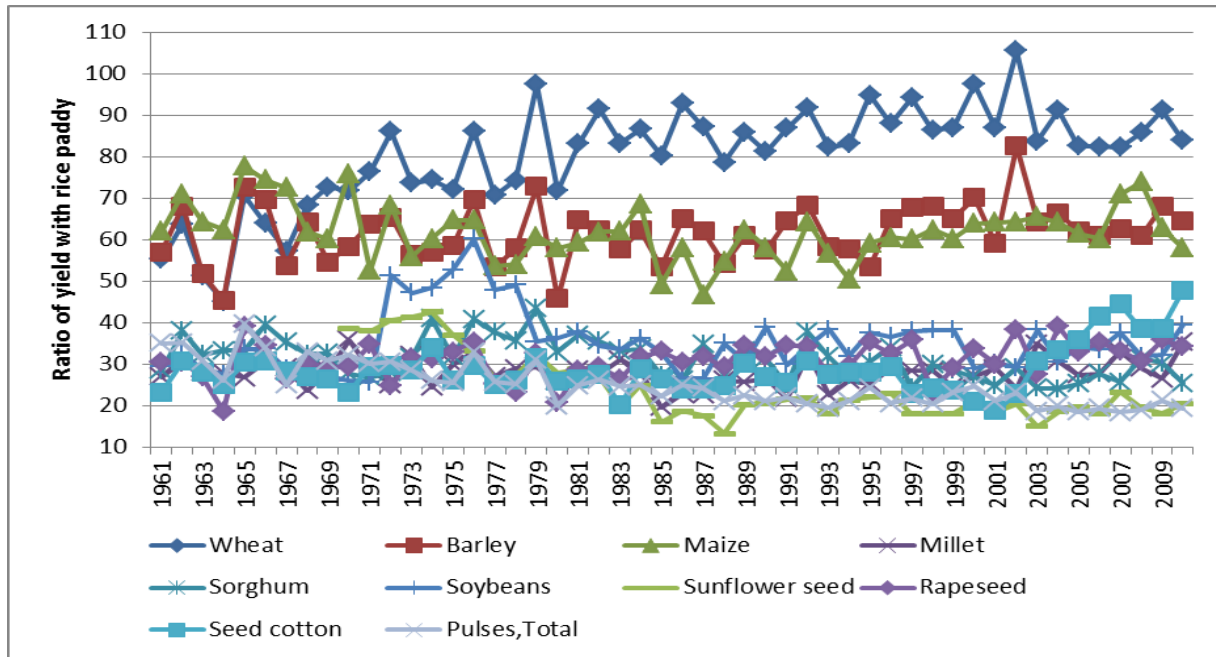


**Figure 14: Evolution of repartition of main crops in India**

Source: Calculation from FAOSTAT; Unit: Percentage

Contrary to Pakistan, rice is the most important crop in term of area with a mean share of about 29% followed by pulses (16%) and wheat (15%) in India. Millet and sorghum together represent 21% while shares of soybean and rapeseed have been considerably increased between “1968” and “2006” (multiplication by 260 and +69%). Wheat, corn and sugar cane have also increased much while, as is apparent on Figure 14, millet and sorghum had a strong regression as in Pakistan.

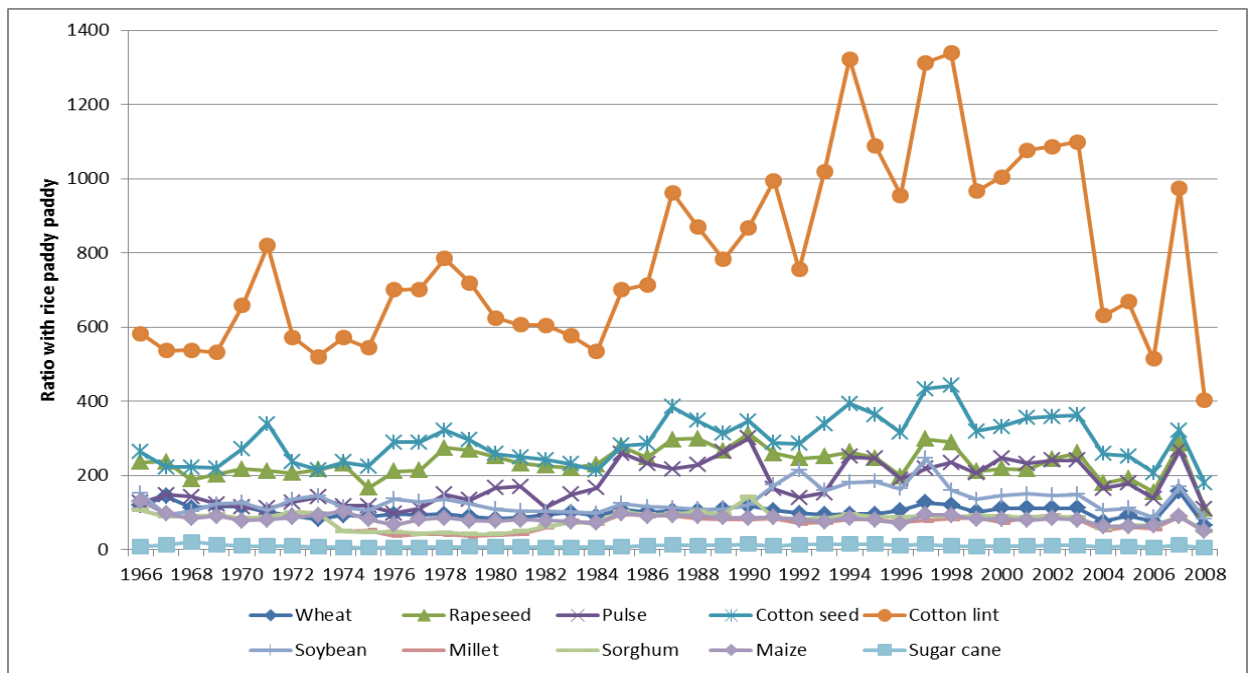
In terms of yield, the highest increases were recorded for cotton (195 and 283%) then for wheat (159%), for soybeans (+142%) and rapeseed (+135%). The increases for other products were lower, particularly for pulses, sugarcane and sorghum. No crop has average yield equal or superior to rice paddy during the period 1961-2010. This factor is important to explain the continuous interest of farmers for this crop (figure 15).



**Figure 15: Evolution of relative yields to rice paddy in Pakistan**

Source: Calculation from FAOSTAT; Unit: Percentage

For corn and barley, yields are generally near to 62% of that of paddy rice, with moderate annual fluctuations. For all other crops, relative yields are always low and fluctuate within a range of 20 to 40%





### **Figure 16: Evolution of relative prices to rice paddy in India**

**Source: Calculation from FAOSTAT; Unit: Percentage**

In India, the more specific evolution of prices is that of cotton lint which was relatively stable in a first period, then increased quickly between 1984 and 1994 by 12 times that of paddy rice, then decreased lower than 1961 with huge fluctuation (figure 16). Cotton lint is a major component of seed cotton with cottonseed which in 1998 was quoted 4 times that of rice. In 2008, all crops prices were low compared to rice price which was particularly affected by world crisis on cereals and specific political measures were taken by Indian government on exports.

**Table 8: Means, standard errors and coefficient of variation for share areas, yields and prices concerning India**

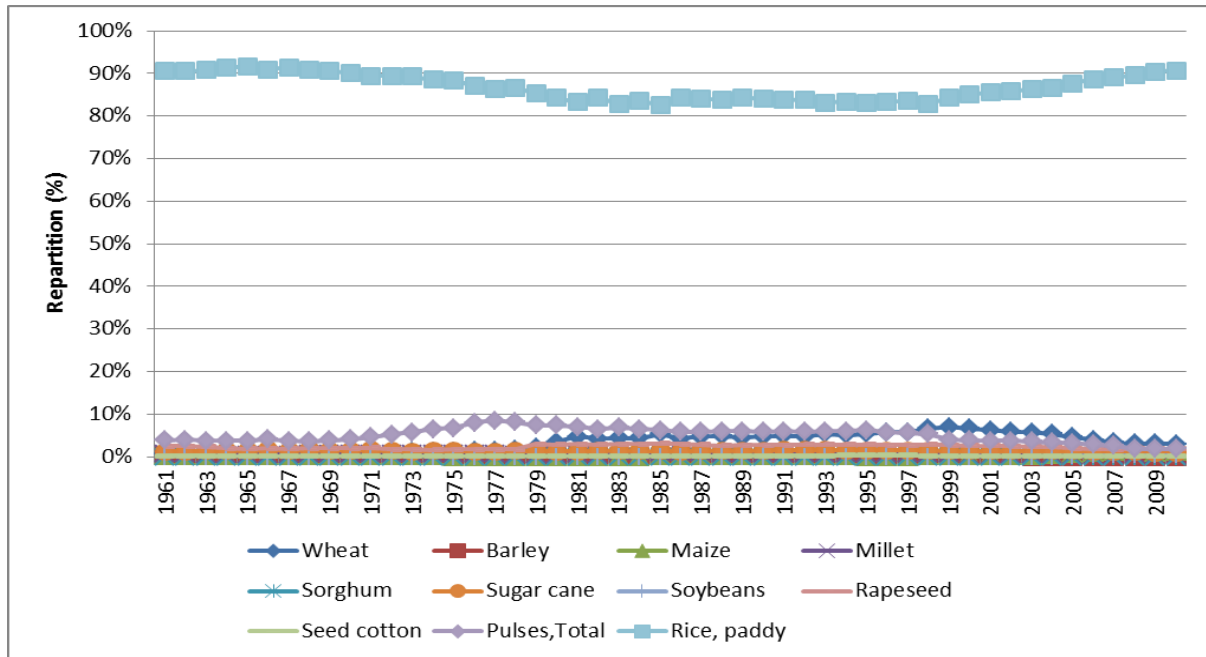
	Total mean	Standard Error	Coefficient of variation	Total mean	Standard Error	Coefficient of variation	Total mean	Standard Error	Coefficient of variation
	Share areas			relative yields			Relative prices		
Wheat	15.38%	2.81%	18.3%	80.39	12.21	15.2%	102.48	17.14	16.73%
Barley	1.18%	0.71%	60.2%	61.7	6.95	11.3%			
Maize	4.29%	0.47%	10.9%	61.82	6.71	10.8%	83.41	12.74	15.27%
Millet	11.25%	2.6%	23.1%	27.85	3.47	12.4%	74.18	19.55	26.35%
Sorghum	10.01%	2.93%	29.3%	31.28	4.87	15.6%	80.37	21.96	27.32%
Sugar cane	2.33%	0.46%	19.7%	2621.45	381.76	14.6%	10.23	3.42	33.44%
Soybeans	2.00%	2.18%	108.8%	35.37	7.57	21.4%	132.86	33.78	25.43%
Rapeseed	3.2%	0.87%	27.2%	30.92	4.42	14.3%	234.32	41.75	17.82%
Seed cotton	5.71%	0.49%	8.5%	28.62	5.81	20.3%			
Pulses.Total	16.1%	1.18%	7.3%	24.96	5.22	20.9%	178.21	55.7	31.25%
Rice. paddy	28.55%	0.99%	3.5%	100	0	0.00%	100	0	0.00%
Cotton lint							787.06	242.97	30.87%
Cotton seed							293.28	63.05	21.5%

Source: Calculation from FAOSTAT; Unit: Percentage

All the relative parameters show important dispersion along time like in Pakistan. This dispersion indicates that like Pakistani farmers, Indian producers can modify each year their allocation of land as a function of evolution of economic and technical parameters.

### 3.1.3. Bangladesh

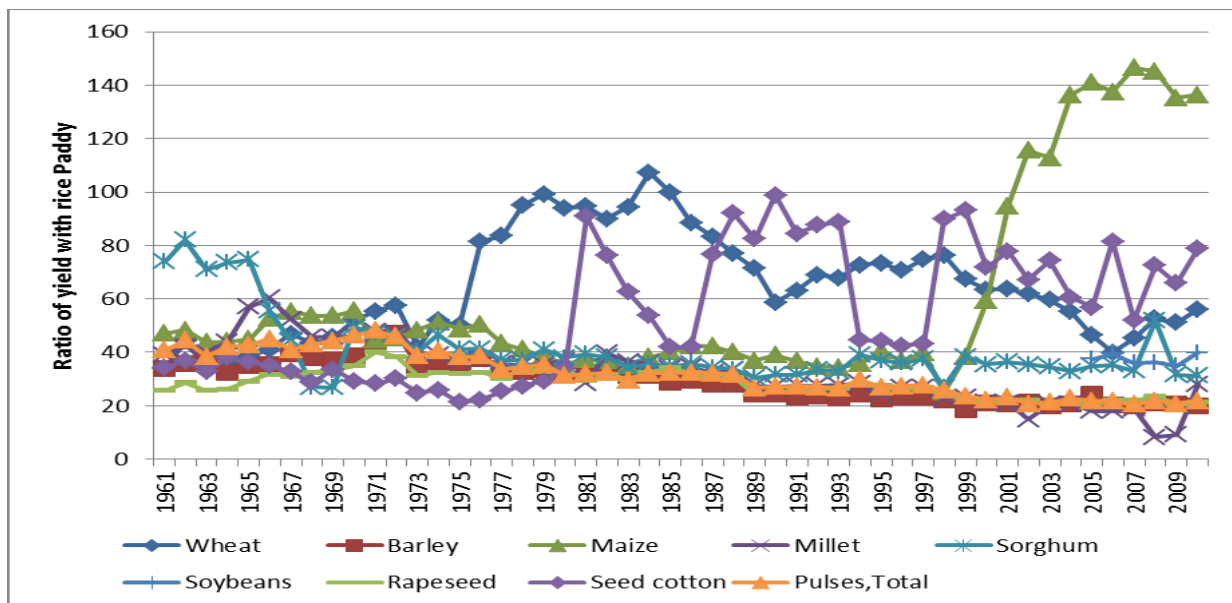
In Bangladesh, rice is by far the dominant crop with a share of total crops between 91% in 1961 and 90% in 2010 with a moderate decrease during the years 1980 to 2000.



**Figure 17: Evolution of repartition of main crops in Bangladesh**

Source: Calculation from FAOSTAT; Unit: Percentage

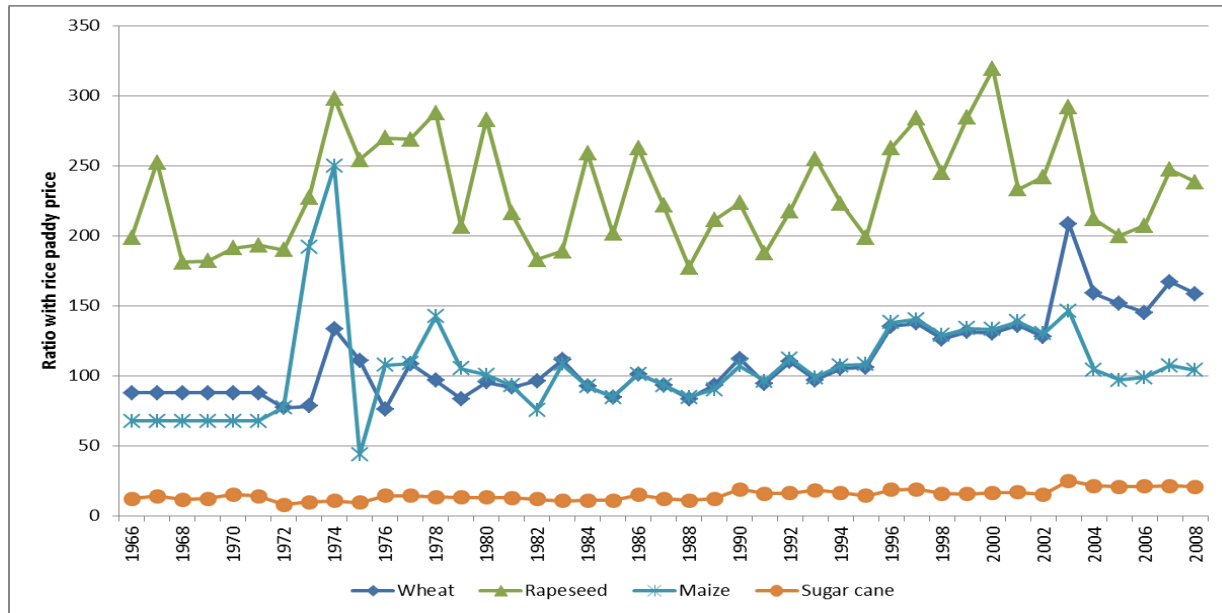
The regression of rice during this period was mainly due to a moderate increased share of pulses and of wheat to some extent (figure 17).



**Figure 18: Evolution of relative yields to rice paddy in Bangladesh**

Source: Calculation from FAOSTAT; Unit: Percentage

Concerning yields, the most important factor is the rapid increase of corn productivity and relatively good average yield of wheat during the 10 last years. These ratios fluctuate however between years due to climatic conditions being eventually different in rice belt and wheat belt.



**Figure 19: Evolution of relative prices to rice paddy in Bangladesh**

Source: Calculation from FAOSTAT; Unit: Percentage

Concerning prices, rapeseed had always the higher price (between 2 and 3 times that of rice) without any apparent trend while corn and wheat had generally closed relative prices. But during the last 5 years, price of wheat tends to be increased. On figure 19, it is possible to see the impact of the world crisis on maize prices due to huge URSS buys from United States.

**Table 9: Means, standard errors and coefficient of variation for share areas, yields and prices concerning Bangladesh**

	Total mean	Standard Error	Coefficient of variation	Total mean	Standard Error	Coefficient of variation	Total mean	Standard Error	Coefficient of variation
	Share areas			relative yields			Relative prices		
Wheat	3.41%	2.08%	61.00%	64.38	19.85	30.8%	110.92	28.97	26.12%
Barley	0.15%	0.1%	66.5%	29.1	7.36	25.3%			
Maize	0.18%	0.38%	214.4%	60.32	36.57	60.6%	106.59	35.67	33.46%
Millet	0.57%	0.24%	42.3%	32.55	11.48	35.3%			
Sorghum	0.01%	0.00%	44.4%	40.94	12.96	31.7%			
Sugar cane	1.35%	0.14%	10.7%	1882.76	620.52	33.00%	14.76	3.82	25.86%
Soybeans	0.04%	0.1%	276.4%	37.3	1.97	5.3%			
Rapeseed	2.36%	0.48%	20.3%	28.18	4.9	17.4%	231.96	37.92	16.35%
Seed cotton	0.13%	0.06%	45.6%	53.99	24.15	44.7%	206.34	162.94	78.96%
Pulses.Total	5.05%	1.68%	33.3%	32.03	8.32	26.00%			
Rice. paddy	86.76%	3.04%	3.5%	100	0	0.00%	100	0	0.00%

**Source: Own calculation; Unit: Percentage**

All the relative parameters show important dispersion along time like other two countries (table 9). Such as for India and Pakistan, the area repartition shows an important variation, which is sign of allocation changes by framers and can be put in relation with variation in ratios of prices and yields.

### **3.1.4. General conclusions on the three countries**

As conclusion, it can be pointed out that, while the wheat is by far the first crop (about 48% in "1968" and "2006") in Pakistan while in India and Bangladesh, it is the rice that is dominant. But all wheat-rice constitutes over 60% in Pakistan, 50% in India and 70% in Bangladesh where these two crops are generally associated in rotations.

In terms of performance, the levels for Pakistan and India were relatively low in "1968" as compared to the world's average, the two countries with similar levels of wheat, canola, corn, soybean, millet and sorghum. Pakistan had better yield of cotton seed, cotton lint and sugar cane. In "2008", yields of the two countries have tended to be closer, Pakistan has however an advantage in terms of cotton (lint and seed), corn and pulses.

Some complementary remarks have to be made on prices concerning the three countries

For prices in common, it appears that very large increases are primarily due to the role of inflation. When Pakistani prices are converted into constant local currency (Pak Rupee) and are divided by the Pakistan Consumer Price Index (CPI) with basis 100 in 2005, it appears that, in constant value, the prices received by farmers during the last three years compared to the values in the beginning of the seventies are in a range of 90-110 % for seven crops (wheat, rice, rapeseed, soybean, millet, sorghum, corn). They increased much more for cottonseed (index 150), and decreased significantly for pulses, cotton lint and sugar cane. For India, even if some prices remain within the range of 90-110% (pulses, cottonseed, cotton lint,) we observe a more important progression of constant rice price (+20), and decrease of about 30% for wheat, millet, sorghum, corn ,soybean and rapeseed). Like Pakistan, sugar cane prices show a big decrease (about 50%)

The national prices paid to farmers for different crops can also be converted in current dollars using the same data base (source: USDA ERS International Macroeconomic Data Set) series average annual nominal exchange rates (1970-2008). It appeared on the different graph (not presented here) that for a same product, the two national prices expressed in dollars have some similar tendencies but generally different levels and often some big deviations during some years, before prices tend to converge after that period. It is difficult to know if these seeming erratic evolutions are representatives of real phenomenon or are due to discontinuities in used series. For Pakistan, it has been possible to “correct” some FAO data with national data, but the same work could not be done for India. With these considerations in mind, it appear that correlation coefficients (1969-2008) between Pakistan and Indian prices are “relatively high” for some products (rice: +0.583, wheat: +0.575, soybean: +0.421, sorghum: +0.541), moderate for some others (cottonseed: +0.315, corn: +0.165, sugar cane: 0.191). For all other products (in particular cotton lint) correlations are very low.

These Pakistan and India national prices expressed in dollars can be compared with some “international” reference prices. The source used is the UNCTAD (United Nation Conference on Trade and Development) series "free market Commodity Prices, annual 1960-2009". It appeared that for wheat correlations of farmers prices with Argentina FOB prices are respectively 0.467 and 0.796 for Pakistan and India, and with US FOB Gulf prices: 0.504 and 0.837. For rice, with Thailand product FOB Bangkok correlations are 0.444 and 0.715, for cotton lint with Memphis quotations: 0.442 and 0.478, for soybean with CAF Rotterdam: 0.596 and 0.610, and for corn

with US product FOB Gulf: 0.362 and 0.504. This can be concluded that domestic prices seemed to be influenced by international market for these crops (in a more important manner in India), but they are also largely influenced by local consideration and may be, local agricultural policies.

## **3.2. Methodology used for estimations**

According to Nerlove et al. 1960, research on supply response has main goal to deepen the knowledge of price mechanism of supply response. Farmer always makes some actions more desirable than other on the basis of his objectives, infrastructure, technology and market structure. Thus, farm price has effect on the choice of production alternatives with available resources and their impact on resource accumulation (Rao 1989). There are many factors including prices and non-price factors that effect on decision of land allocating. Non price factors are weather, irrigation, technology and availability of inputs (Mamingi 1996).

Many studies<sup>33</sup> emphasized the importance of price to augment the supply although many studies have tried to calculate supply elasticities for single crops and other tried to calculate aggregate supply elasticities for agriculture sector. But most of all studies concluded that the supply of almost all crops are less or much responsive to price incentive.

Most time-series studies are for particular crops and use acreage as a proxy for output because acreage is thought to be more subject to the farmer's control than output because output is affected by other factors which have an impact on yields like climate, soil, water availability and technology etc.

Individual crops respond more or less strongly and quickly to price factors, but growth in one crop usually takes resources away from other crops. The price elasticity of agriculture is overall very low in short run because the main factors of production (land, capital, and labour) are fixed.

In the context of whole-farm enterprise mix, a decision to produce one crop affects other crops in three ways.

First, competitive if different crops demand the same resources at the same time, the decision to produce more of one crop may reduce the production of other crops.

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<sup>33</sup>See Behrman, 1998; Thamarajakshi, 1977; Nebery, 1981; Tsakok, 1990 and Sadoulet 1995; Mckay et al. 1997; Thiel, 2003; Mendeza et al; 2003.

Secondly, complementary if changes in the production of a particular crop may influence the production of other crops in the same direction assuming all the crops require the same resources but at different times of year.

Thirdly, two crops may be independent, if each is grown in a different geographical area or different season and has different resource requirements

Responses of farmer to price incentive is the main question to respond for better understanding the economic circumstances on food supply and farmer welfare. One has to understand the farmer land allocation behaviour to different crops for answering this question. Many studies emphasized determinants that determine the farmer land allocation behaviour (Feder, 1980; Just *et al.* 1983; Bellon *et al.*, 1993; Brush *et al.*, 1992; Smale *et al.*, 1994). These determinants are output prices, learning from past records.

One can consider this question with reference to the problem of farmers' choice of land allocation. Farmers' land allocation decisions have long been a subject of economics. Many studies<sup>34</sup> use market prices to value farmers' output as a determinant of land allocation decision, along with socio-economic and agro-ecological variables.

Many studies<sup>35</sup> on acreage response of India, Pakistan and Bangladesh emphasized the importance of positive impact of price incentive for land allocation decision. Among these studies, some are for individual crops and other explained the aggregate supply. But almost all studies concluded that price incentive of one crop has a positive impact on land allocation for that crop when all other factors are constant. So that policy makers can control the production by better price policies for improving the farmer welfare as well as economic conditions of all people.

The response of farm production (acreage) to expected commodity prices is a key relationship in agricultural policy development. What policy determinants concerning prices affect the farmer decisions to produce a particular commodity and the way the decision to produce one commodity affects the production levels of other commodities.

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<sup>34</sup>Feder, 1980; Just *et al.*, 1983; Bellon *et al.*, 1993; Brush *et al.*, 1992; Smale *et al.*, 1994

<sup>35</sup>See Krishna, 1963; Krishna 1967 ; Falcon, 1964; Madhavan 1972 ;Cummings, 1975; Narayana *et al.* 1981; Alam 1992 ; Shahabuddine *et al.* 1995 ; Tweeten, 1986; Rahman 1996 ; Yunus 1993 ; Khan and Iqbal, 1991; Ashiq, 1992; Hussain and Sampath, 1996; Mushtaq, 2000; Mythili 2008; Dorosh *et al.* 2001 ; Niamuttulah 2009; Nosheen *et al.* 2011; zulfiqar *et al.* 2011 ;



In this chapter, a statistical approach is applied to determine the influence of variation of gross product per hectare of different main crops on allocation of cultivated surface area in India, Pakistan and Bangladesh. In the first section of this chapter, direct and cross GPH elasticities to acreage of different crops are calculated while the second part covers comparison between farmer reactions to revenue per hectare<sup>36</sup> of one country with other.

Concerning crop cultivation, there is a specific aspect different from occidental cropping. Generally farmers had a double cropping, one crop is cultivated during the “Rabi” (October to March) period and one other is cultivated during the « kharif » (March to September). It would have been interesting to take in account this aspect in models developing but available data base does not provide any form of historical series of the repartition of each crop in “Rabi” and “kharif”, but for some specific years (Agricultural situation of Pakistan year 2009-2010), there is a separation for main crops it appears that the sum of “Kharif” crops is not equal to “Rabi” crops and that this repartition can be changed from year to year. More some crops have varieties that can be cultivated as “Kharif” and others as “Rabi”. The hypothesis is that when the farmer takes decision for allocation of crops, he takes the total “developed” area into the account that he can cultivate in the two seasons of year. This “total available area” to divide between crops is in fact different to the physical area of his farm but the same calculation as usual can be made on this basis.

In the field of microeconomics (Guyomard et al.1996), the choice of allocating system of production when one knows the prices received by farmers ( $p_i$ ), the yields ( $y_i$ ) and the direct cost of production per hectare ( $C_i$ ) (i.e. when one knows the value of gross product  $V_i = Y_i * P_i$  and the gross margin  $M_i = Y_i * P_i - C_i$ ) is conventionally written as a program of profit maximization:

$$(1) \quad \text{Max} = S_i * M_i$$

Where  $S_i$  is surface area cultivated under crop  $i$ .

Under general constraints, the first one concerning total available area for cultivation:

$$(2) \quad S_i = S_{\text{total}}$$

Generally in linear programming systems different other constraints expressing availabilities in some production factors (labour, machines, etc...) are introduced

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<sup>36</sup>Even if « revenue » is more ambiguous than « gross product per hectare » the two terms are used in this report in synonymous way.

As illustrated by linear programming problem, the key characteristic of the dual relationship, is that all of the information about the solution to the primal can be obtained from the corresponding dual, and all of the information with respect to the solution of dual can be obtained from the corresponding primal. Either the maximization or the minimization problem may be solved as the primal, and all information regarding the solution to the dual is obtained without resolving the problem. Production (vs. demand) function has corresponding dual cost (revenue) function. The term dual used in this context means that all of the information needed to obtain the corresponding cost (revenue) function is contained in the production (demand) function and conversely the cost (revenue) function contains all the information needed to derive the production (demand) function.

In the classical theory of producer the profit function is written as

$$= S_i * M_i = S_i * (V_i - M_i) = S_i * (V_i - M_i) = S_i * V_i - S_i * C_i$$

As we have no information on the specific costs for each crop, it was assumed that this cost is equal for each:

So  $C_i = C \forall i$ , the preceding equation can be written as

$$= S_i * V_i - C * S_i = S_i * V_i - C * S_{total}$$

As  $C * S_{total}$  is a constant, the maximization of  $S_i * V_i$  is equivalent to the maximization of

$$(3) R = S_i * V_i \quad \text{which is the total gross product.}$$

The solution of problem defined by equations 2 and 3 allows to calculate the optimal area for each crop  $i$

$$S_i^* = f_i(V_i, S_{total})$$

And the maximum revenue is:

$$(4) R^* = f_i(V_i, S_{total}) * V_i = g(V_i, S_{total})$$

A partial equilibrium model allows evaluation of the impact of changes in specific variables regarding specific agricultural commodities, assuming no change for the remaining variables of commodities. As a result, this provides the centre of attention to sector analysed. Here one is

more focused on relation of revenue per hectare of specific agricultural products with allocation of surface area to different agricultural commodities.

In fact, the farmer has no information on the effective gross product when he takes his decision of land allocation, so he has to make an anticipation based on information about preceding years concerning prices and yields. The anticipated gross product per hectare of each product ( $V^a$ )<sup>37</sup> is defined by:

$$(7) \quad V_i^a = p_i^a * Y_i^a$$

In the particular case of cotton, one has to consider that the total revenue is composed together by the sale of the cotton lint with parameters  $Y_{lint}^a$  and  $P_{lint}^a$  and of the cottonseed with parameters  $Y_{cseed}^a$  and  $P_{cseed}^a$ .

So for this crop  $V_{cot}^a$  is written:

$$(8) \quad V_{cot}^a = Y_{lint}^a * p_{lint}^a + Y_{cseed}^a * P_{cseed}^a$$

With introduction of anticipated gross product the total revenue of the farmer can be written:

$$(9) \quad R^a = g S_i, V_i^a = (S_j * V_j^a)$$

And the maximum revenue is:

$$R^{*a} = g S^*_i, V_i^a = h(V_{ia}, S_{total})$$

The translog production function was introduced in 1971 by Christensen, Jorgenson and Lau, and was logical choice given the difficulties posed by other functional forms. It is simply a second order Taylor's series expansion of  $\ln(R^{*a})$  in  $\ln(V_i)$  and  $\ln(S_{total})$  whereas the Cobb-Douglas is a first order expansion. The revenue function as a Taylor's series can be written as:

$$\ln R^a = \beta_0 + \beta_i \ln V_i^a + \frac{1}{2} \beta_{ij} \ln V_i^a * \ln V_j^a + a_0 * \ln S_{total} + b_i \ln V_i^a * \ln(S_{total}) + \frac{1}{2} c_0 * \ln S_{total} * \ln S_{total}$$

<sup>37</sup>In fact the farmer allocation is also dependent of the input prices (fertilizer, seeds, irrigation water, capital and labor cost), but we have no statistical information on the evolution of these cost by crop neither for Pakistan nor for India. So we consider only output gross products in estimations, even if in a complementary tentative study we introduce price of urea in Pakistan translog model.

Such as in many empirical studies, the hypothesis of homothetic revenue was introduced in the estimations, it expresses that if total area is increased by k%, the optimal revenue is also increased by k%. This condition can be expressed by

$$\partial \ln R^{*a}(V_i, S_{total}) / \partial \ln S_{total} = 1$$

$$\partial \ln R^{*a}(V_i, S_{total}) / \partial \ln S_{total} = a_0 + \sum b_i \ln V_i^a + c_0 * \ln S_{total}$$

It implies that  $a_0 = 1, b_i = 0 \forall i$  and  $c_0 = 0$

For anticipated prices and yield, it is considered that the farmer uses a moving average of the preceding year's data.

For yield the equation is:

$$(14) \quad Y_i^a(t) = \frac{1}{N1} * \sum_{d=1}^{N1} Y_i(t-d) \quad \text{For } d=1 \text{ to } N1$$

For price:

$$p_i^a(t) = \frac{1}{N2+1} * \sum_{d=0}^{N2} p_i(t-d) \quad \text{For } d=0 \text{ to } N2$$

The difference between the two equation is due to the fact that for price, due to the fact that it concerns calendar year average, farmers have an information about the price concerning the year of plantation and collect, but for yields, they don't and so have to refer only on preceding years. One empirical advantage of using "smoothed" data for prices and yields is to limit the impact on equations estimated parameters of the uncertainty on the "true" values. The values of  $N1$  and  $N2$  (the same for all products) have been chosen for each country in a manner to get the best estimations on the basis of the  $R2$  adjusted and the sign of direct gross product elasticities<sup>38</sup>. The counterpart is that the estimated coefficients of equations (and the elasticities) are smaller (in absolute value) than those which would have been calculated with "true" annual values.

The transposition of Shepard lemma gives

$$(15) \quad S_i^* = \partial R^a / \partial V_i^a$$

It can be written as

$$(16) \quad S_i^* = (R^a * (\partial R^a / \partial R^a)) / (V_i^a * \partial V_i^a / \partial V_i^a) = R^a / V_i^a * (\partial R^a / \partial R^a) / (\partial V_i^a / \partial V_i^a)$$

<sup>38</sup> For Pakistan  $N1=5$  and  $N2=4$ , for India  $N1=2$  and  $N2=3$ , for Bangladesh  $N1=2$  and  $N2=1$

That is equivalent to:

$$(17) \quad S_i * V_i^a R^a = \partial R^a R^a \quad \partial V_i^a V_i^a = \partial \ln(R^a) \quad \partial \ln(V_i^a)$$

Where

$S_i * V_i^a R^a = r_i$  is the anticipated part of the crop  $i$  in the total anticipated revenue

In the particular case where one utilizes a translog function for total revenue without cross terms in  $\ln(S_{\text{total}})$  as justified previously due to hypothesis of homothetic revenue .

We have:

$$(19) \quad r_i = \partial \ln(R) \quad \partial \ln(V_i) = \beta_i + \beta_{ij} \ln(V_j)$$

The function 19 has a number of other virtues, in addition to its close linkage to Cobb-Douglas, it is linear, which makes parameter estimation simple. Some mathematical relations are to be satisfied by the coefficients  $\beta_{ij}$  to express the equality of the two second order partial derivatives of  $\ln(R)$  in function of  $\ln(V_i)$  and  $\ln(V_j)$  which implies symmetrical conditions:

$$(11) \quad \beta_{ij} = \beta_{ji} \quad \forall i, j$$

The homogeneity of equation 19 in  $\ln(V_j)$  implies:

$$(13) \quad \beta_{ij} = 0$$

More as  $r_i = 1$  then  $\beta_i = 1$

Due to homogeneity of zero degree of equation 19, gross product (or prices) can be either expressed in current local currency or in deflated values.

For anticipated prices and yield, it is considered that the farmer uses a moving average of the preceding year's data.

For yield the equation for anticipation is:

$$(14) \quad Y_i^a t = 1 N1 * Y_i(t - d) \quad \text{For} \quad d=1 \text{ to } N1$$

For price:

$$p_i^a \quad t = 1 \quad N2 + 1 * \quad p_i(t - d) \quad \text{For} \quad d=0 \text{ to } N2$$

The difference between the two equation is due to the fact that for price, due to the fact that it concerns calendar year average, farmers have an information about the price concerning the year of plantation and collect, but for yields, they don't and so have to refer only on preceding years. One empirical advantage of using "smoothed" data for prices and yields is to limit the impact on equations estimated parameters of the uncertainty on the "true" values. The values of  $N1$  and  $N2$  (the same for all products) have been chosen for each country in a manner to get the best estimations on the basis of the  $R2$ adjusted and the sign of direct gross product elasticities<sup>39</sup>. The counterpart is that the estimated coefficients of equations (and the elasticities) are smaller (in absolute value) than those which would have been calculated with "true" annual values.

For estimation purpose when one has choice of a functional form for the revenue function, one can use  $i$  equations of the revenue shares (as written in Equation 2) to determine the coefficients of the revenue function then the value of the different gross product surface elasticities for each crop. In fact as by definition  $\sum r_i = 1$ , one has to estimate only  $i-1$  equations, the coefficients of the last one (in occurrence that concerning wheat) being calculated from those of the other equations. The system has been estimated with the free software GRETl and the method FIML (Full Information Maximum Likelihood) which is equivalent to the SUR method (Seemingly Unrelated Regression) iterative and gives results which are independent of the equation not included in the system. In the case of translog it can be demonstrated that the expressions of surface gross product elasticities can be calculated from the parameters of the system of equations ( $\beta_{ij}$ ) and the part of each crop in the total revenue ( $r_i$ ) and are obtained by formulas:

**Equation 1: Equations for calculation of direct and cross gross product elasticities**

$$(20) \quad E_{ii} = \partial \ln(S_i) / \partial \ln(V_i) = (\beta_{ii} + r_i r_i - r_i) / r_i$$

$$(21) \quad E_{ij} = \partial \ln(S_i) / \partial \ln(V_j) = (\beta_{ij} + r_j r_i) / r_i$$

<sup>39</sup> For Pakistan  $N1= 5$  and  $N2=4$  , for India  $N1= 2$  and  $N2=3$  , for Bangladesh  $N1 =2$  and  $N2= 1$

Where  $E_{ii}$  is own elasticity of crop  $i$  surface to its gross product and  $E_{ij}$  is cross elasticity of crop  $i$  surface to gross revenue per hectare of crop  $j$ . To be consistent with economic theory all the own elasticities must be positive, i.e. if all other revenues are constant, the area of a crop increases when its gross product increases.

It is supposed here that 1) implemented policy is constant and does not change 2) prices of inputs and outputs change in parallel 3) yield of crops changes in parallel with technic adapted and mechanization 4) production of other crops (not taken here) does not have interaction with crops taken here.

### **3.3. Analysis of equations parameters and elasticities for Pakistan, India and Bangladesh**

The table 10, 11 and 12 show the estimated parameters for the 8, 9 and 5<sup>40</sup> equations of the translog system for Pakistan, India and Bangladesh respectively. The all coefficients of all crops of all equations are significant which tends to prove that our proposed hypothesis is correct. It also tends to prove that the gross product of crop influences on decision of land allocation of this crop. The  $R^2$  values are nearly always high, more than 0.85. For a same crop they are higher in India than in Pakistan. The  $R^2$  adjusted values are also generally high (more than 0.80) but slightly lower for Pakistan than for India. Although for some crops these values are lower, that indicates less good estimations when the different relations between parameters of the different equations are taken in account. It is mainly the case concerning  $R^2$  adjusted for some products in Pakistan: soybean: 0.433, millet 0.575. While for Bangladesh, the  $R^2$  values are nearly always high, more than 0.75 except of corn where the  $R^2$  adjusted values is lower but also significant high (more than 0.69). Although for corn these values are lower, that indicates less good estimations when the different relations between parameters of the different equations are taken into account. It is mainly the case concerning  $R^2$  and  $R^2$  adjusted for corn (0.50 and 0.37 respectively). The  $R^2$  values of maize for Bangladesh as well as millet and soybean for Pakistan are weak due to fact that these crops represent a very small part of national production of each county. In addition there are large fluctuation in data for price and yield for these three products.

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<sup>40</sup> For Pakistan, it is impossible to include the equation for pulses and for Bangladesh; it is not possible to calculate the equations for pulses, millet and sorghum. Soybeans, millet and sorghum are non-significant crops in Bangladesh.

**Table 10: Coefficients of the different equations (Rapeseed, Rice and Cotton)**

	Rapeseed			Rice			Cotton		
	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh
<b>Constant</b>	0.039*** (0.005)	0.018** (0.007)	0.026*** (0.003)	0.157*** (0.02)	0.471*** (0.01)	0.95*** (0.006)	0.132*** (0.03)	-0.042** (0.02)	0.002*** (0.001)
<b>Rapeseed</b>	0.017*** (0.001)	0.035*** (0.006)	0.017*** (0.002)	-0.001 (0.002)	-0.005 (0.005)	-0.02*** (0.003)	-0.006*** (0.002)	-0.005 (0.004)	-0.0003 (0.0004)
<b>Rice</b>	-0.001 (0.002)	-0.005 (0.005)	-0.017*** (0.003)	0.115*** (0.01)	0.24*** (0.01)	0.08*** (0.007)	-0.055*** (0.01)	-0.113*** (0.007)	-0.003*** (0.001)
<b>Pulses</b>		-0.002 (0.002)	0	0	-0.004** (0.002)		0	-0.002 (0.002)	
<b>Cotton</b>	-0.005*** (0.002)	-0.005 (0.004)	-0.0003 (0.0003)	-0.055*** (0.01)	-0.113*** (0.007)	-0.003*** (0.001)	0.258*** (0.02)	0.238*** (0.01)	0.002*** (0.0001)
<b>Corn</b>	0.001 (0.001)	-0.003* (0.002)	-0.003*** (0.001)	-0.005*** (0.001)	-0.007*** (0.002)	0.009*** (0.002)	-0.013*** (0.001)	-0.007*** (0.001)	0.0001 (0.0002)
<b>Soybeans</b>	0.001*** (0.000)	-0.004** (0.002)	0	0.0001* (0.0000)	-0.009*** (0.003)		0.0000 (0.0000)	-0.009*** (0.002)	
<b>Sugarcanne</b>	-0.005*** (0.002)	0.004 (0.002)	-0.003** (0.001)	-0.015* (0.007)	-0.029*** (0.004)	-0.04*** (0.003)	-0.07*** (0.01)	-0.033*** (0.004)	0.0001 (0.0004)
<b>Sorghum</b>	0.002*** (0.001)	0.001 (0.003)		-0.005 (0.001)	-0.006* (0.003)		-0.002 (0.001)	-0.014*** (0.002)	
<b>Millet</b>	-0.001 (0.001)	-0.004* (0.002)		-0.007*** (0.002)	-0.013*** (0.002)		-0.0001 (0.003)	0.002 (0.002)	
<b>Wheat</b>	-0.005*** (0.002)	-0.016*** (0.004)	0.006*** (0.002)	0.03*** (0.01)	-0.053*** (0.008)	-0.04*** (0.005)	-0.112*** (0.009)	-0.05*** (0.007)	0.001** (0.0004)
<b>dum_66_79</b>		0.001 (0.002)			0.007 (0.006)			0.002 (0.009)	
<b>dum_71_74</b>			-0.002 (0.001)			0.001 (0.005)			0.0003 (0.0004)
<b>dum_91_92</b>	-0.002 (0.001)			-0.011 (0.006)			0.04*** (0.01)		
<b>dum_91_01</b>		0.007*** (0.002)			-0.006 (0.006)			0.02** (0.008)	
<b>dum_93_01</b>	-0.009*** (0.001)			0.003 (0.006)			0.031*** (0.01)		
<b>dum_99_01</b>		-0.004 (0.002)			-0.004 (0.005)			0.02* (0.008)	
<b>dum_02_08</b>	-0.009*** (0.002)	0.002 (0.003)		0.006 (0.007)	-0.026*** (0.008)		0.019 (0.012)	0.03*** (0.012)	
<b>Trend</b>		0.0003** (0.0001)	0.00004 (0.00006)		0.0003 (0.0004)	-0.001*** (0.0001)		-0.002*** (0.0005)	0.0001 (0.0001)
<b>R<sup>2</sup></b>	0.887	0.887	0.75	0.788	0.957	0.82	0.797	0.926	0.87
<b>R<sup>2</sup> ajust</b>	0.842	0.825	0.69	0.703	0.934	0.77	0.715	0.884	0.84

Source: Own calculation; \*, \*\* and \*\*\* represent probability levels of 10%, 5% and 1% respectively



**Table 11: Coefficients of the different equations (Sugarcane, corn and Soybean)**

	Sugar cane			Corn			Soybeans		
	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh
<b>Constant</b>	0.002 (0.02)	0.03*** (0.01)	0.03***	0.059*** (0.003)	0.056*** (0.002)	-0.002 (0.003)	0.0001 (0.0001)	0.008 (0.005)	
<b>Rapeseed</b>	-0.005*** (0.002)	0.004 (0.002)	-0.003***	0.001 (0.001)	-0.003* (0.002)	-0.003*** (0.001)	0.0002 (0.0000)	-0.004** (0.002)	
<b>Rice</b>	-0.015* (0.007)	-0.029*** (0.004)	-0.029***	-0.005*** (0.001)	-0.007*** (0.002)	0.009*** (0.002)	-0.0001* (0.0000)	-0.009*** (0.002)	
<b>Pulses</b>	0	-0.003*** (0.001)		0	-0.0002 (0.0008)			-0.004*** (0.0007)	
<b>Cotton</b>	-0.07*** (0.014)	-0.033*** (0.004)	-0.033***	-0.013*** (0.001)	-0.007*** (0.001)	0.0001 (0.0002)	-0.0005 (0.0000)	-0.009*** (0.002)	
<b>Corn</b>	-0.004*** (0.001)	-0.002*** (0.001)	-0.002***	0.024*** (0.001)	0.03*** (0.001)	0.003*** (0.001)	0.00005** (0.0003)	-0.0002 (0.0006)	
<b>Soybeans</b>	0.00003 (0.0005)	0.008*** (0.001)		0.000** (0.0000)	-0.0002 (0.0006)		0.0001*** (0.0002)	0.012*** (0.0012)	
<b>Sugarcanne</b>	0.153*** (0.014)	0.071*** (0.004)	0.008***	-0.004*** (0.001)	-0.002*** (0.0008)	-0.002** (0.001)	0.0003 (0.0005)	0.008*** (0.001)	
<b>Sorghum</b>	-0.002** (0.001)	-0.002 (0.001)		0.0001 (0.0004)	-0.0018 (0.001)		-0.0001* (0.0005)	0.003** (0.0012)	
<b>Millet</b>	-0.006** (0.002)	-0.002* (0.001)		-0.002*** (0.0005)	0.002** (0.001)		-0.0001 (0.0002)	0.004 (0.003)	
<b>Wheat</b>	-0.05*** (0.009)	-0.012*** (0.004)	0.004	-0.001 (0.001)	-0.009*** (0.001)	-0.007*** (0.002)	0.0002 (0.00007)	0.004 (0.003)	
<b>dum_66_79</b>		0.002 (0.004)			-0.0005 (0.0007)			-0.003* (0.002)	
<b>dum_71_74</b>			0.002			-0.002 (0.002)			
<b>dum_91_92</b>	-0.003 (0.01)			-0.002** (0.001)			-0.0003 (0.0003)		
<b>dum_91_01</b>		0.002 (0.004)			0.0007 (0.0007)			0.005*** (0.002)	
<b>dum_93_01</b>	0.02** (0.008)			-0.001 (0.001)			-0.0001 (0.0004)		
<b>dum_99_01</b>		-0.001 (0.004)			0.0006 (0.0007)			0.003* (0.002)	
<b>dum_02_08</b>	0.039*** (0.01)	0.007 (0.006)		-0.002 (0.001)	0.005*** (0.001)		-0.0002*** (0.0005)	0.01*** (0.003)	
<b>Trend</b>		0.001** (0.0003)	0.001**		-0.0001* (0.0005)	0.0001*** (0.0006)		0.0005*** (0.0001)	
<b>R<sup>2</sup></b>	0.838	0.927	0.927	0.976	0.972	0.50	0.595	0.966	
<b>R<sup>2</sup> ajust</b>	0.773	0.887	0.887	0.967	0.956	0.40	0.433	0.947	

Source: Own calculation; \*, \*\* and \*\*\* represent probability levels of 10%, 5% and 1% respectively

The significance of different parameters at the probability levels of 10%, 5% and 1% are indicated on tables by one star (\*), two stars (\*\*) and three stars (\*\*\*) respectively. For the

coefficients of own gross product value in the equation of each crop (in fact of each  $r_i$  that is the part of global revenue of  $i$  crop), the sign is always positive (in accordance with theory) and the value is generally significant at 5% probability. Many coefficients corresponding to cross effects are also significant. The Durbin-Watson coefficients (DW) often indicate some autocorrelation between the residuals of each equation. This fact has not been corrected, as according to our opinion, the data are too much uncertain to justify this correction (for example by introducing the lagged value of  $r_i$ ). This variable is calculated by a formula taking in account the lagged values of prices and yields.

**Table 12: Coefficients of the different equations (Millet, Pulses, Sorghum and Wheat)**

	Millet			Drybeans			Sorghum			Wheat		
	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh
Constant	0.035*** (0.006)	0.091*** (0.004)			0.047*** (0.003)		0.03*** (0.003)	0.12*** (0.005)		0.548	0.193	0.03*** (0.005)
Rapeseed	-0.001 (0.001)	-0.005* (0.002)			-0.002 (0.002)		0.001*** (0.001)	0.001 (0.003)		-0.005	-0.016	0.006*** (0.002)
Rice	-0.007*** (0.002)	-0.013*** (0.002)			-0.004** (0.002)		-0.005*** (0.001)	-0.006* (0.003)		-0.028	-0.053	-0.04*** (0.005)
Pulses	0	-0.001 (0.001)			0.02*** (0.001)			0.001 (0.001)		0	-0.005	
Cotton	-0.0001 (0.003)	-0.002 (0.001)			-0.002 (0.002)		-0.002 (0.001)	-0.01*** (0.002)		-0.112	-0.053	0.001** (0.0004)
Corn	-0.002*** (0.000)	0.002** (0.001)			-0.0002 (0.0009)		0.0001 (0.0004)	-0.002 (0.001)		-0.001	-0.009	-0.007*** (0.002)
Soybeans	-0.0001 (0.0002)	-0.0004 (0.001)			-0.004*** (0.0007)		-0.0001* (0.00005)	0.003** (0.001)		0	0.004	
Sugarcane	-0.006** (0.002)	-0.002* (0.001)			-0.003*** (0.001)		-0.002** (0.001)	-0.002 (0.002)		-0.05	-0.012	-0.004** (0.002)
Sorghum	0.001*** (0.0003)	-0.008*** (0.001)			0.0007 (0.001)		0.007*** (0.001)	0.04*** (0.002)		-0.001	-0.018	
Millet	0.009*** (0.001)	0.035*** (0.001)			-0.0005 (0.001)		0.001*** (0.0004)	-0.007*** (0.002)		0.005	-0.007	
Wheat	-0.005** (0.002)	-0.007** (0.003)			-0.005** (0.002)		-0.0005 (0.001)	-0.02*** (0.003)		0.191	0.169	0.04*** (0.005)
dum_66_79		-0.004*** (0.001)			0.0005 (0.0012)			-0.005*** (0.002)			0	
dum_71_74												0.003 (0.005)
dum_91_92	-0.004*** (0.002)						-0.002*** (0.001)			-0.016		
dum_91_01		-0.0004 (0.001)			-0.003*** (0.001)			-0.003 (0.002)			-0.019	
dum_93_01	-0.01*** (0.001)						-0.005*** (0.001)			-0.028		
dum_99_01		0.001 (0.001)			-0.007*** (0.001)			0.005*** (0.002)			-0.01	
dum_02_08	-0.01*** (0.002)	0.002 (0.002)			-0.006*** (0.002)		-0.005*** (0.001)	0.01*** (0.002)		-0.038	-0.038	
Trend		-0.001*** (0.000)			0.0009 (0.0008)			-0.001*** (0.0001)			0.002	0.001*** (0.0001)
R <sup>2</sup>	0.697	0.984			0.936		0.94	0.98				0.85
R <sup>2</sup> ajust	0.575	0.975			0.9		0.92	0.97				0.81

Source: Own calculation; \*, \*\* and \*\*\* represent probability levels of 10%, 5% and 1% respectively

The elasticities indicated in table 13 express the variation of surface of each crop due to 1% change of the gross product per hectare of this crop or other.

**Table 13: Gross product direct and cross areas elasticities for Pakistan India and Bangladesh**

		Corn	Cotton	Pulses	Millet	Rapeseed	Rice	Sorghum	Soybean	Sugar Cane	Wheat
Corn	Pakistan	0.008	-0.069		-0.055	0.038	-0.094	0.011	0.004	-0.015	0.172
	India	0.057	0.026	0.012	0.104	-0.09	0.101	-0.039	0.002	0.001	-0.174
	Bangladesh	0.762	0.062			-1.6	5.55			-1.07	-3.6
Cotton	Pakistan	-0.004	0.021	0	0.008	-0.003	-0.002	0.001	0	-0.005	-0.018
	India	0.003	0.147	0.013	0.02	0.009	-0.069	-0.022	-0.02	-0.044	-0.036
	Bangladesh	0.072	0.136			-0.177	-0.652			0.045	0.58
Pulses	Pakistan										
	India	0.018	0.187	0.088	0.001	-0.086	0.113	0.068	-0.217	-0.084	-0.088
	Bangladesh										
Millet	Pakistan	-0.161	0.44		0.123	-0.108	-0.707	0.136	-0.002	-0.562	0.84
	India	0.1	0.194		0.249	-0.117	-0.091	-0.236	-0.003	-0.01	-0.085
	Bangladesh										
Rapeseed	Pakistan	0.091	-0.116		-0.088	0.612	0.023	0.15	0.002	-0.377	-0.298
	India	-0.087	0.083	-0.057	-0.118	0.273	0.165	0.072	-0.136	0.201	-0.396
	Bangladesh	-0.187	-0.018		0	0.04	-0.11	0	0	-0.146	0.42
Rice	Pakistan	-0.019	-0.006		-0.05	0.002	0.089	-0.037	-0.001	0.027	-0.003
	India	0.008	-0.054	0.006	-0.007	0.013	0.037	0.013	-0.016	-0.008	0.007
	Bangladesh	0.012	-0.001			-0.002	0.001			-0.002	-0.008
Sorghum	Pakistan	0.052	0.099		0.227	0.305	-0.876	0.399	-0.02	-0.324	0.137
	India	-0.035	-0.19	0.042	-0.219	0.066	0.145	0.503	0.104	0.016	-0.432
	Bangladesh										
Soybean	Pakistan	0.005	-0.496	-0.367	-0.009	-0.346	-0.486	0.286	0.096	0.781	0.536
	India	1.497	-0.528		-0.234	0.354	-1.825	-1.655	0.944	0.737	0.71
	Bangladesh										
Sugar Cane	Pakistan	-0.002	-0.015		-0.032	-0.026	0.021	-0.011		0.169	-0.104
	India	0.000	-0.16	-0.021	-0.004	0.075	-0.037	0.006	0.115	0.018	0.006
	Bangladesh	-0.055	0.002			-0.064	-0.058			0.24	-0.066
Wheat	Pakistan	0.019	-0.035		0.031	-0.013	-0.002	0.003	0.000	-0.068	0.066
	India	-0.03	-0.062	-0.01	-0.015	-0.07	0.016	-0.083	0.037	0.003	0.214
	Bangladesh	-0.224	0.03			0.22	-0.212			-0.078	0.266

Source: Own calculation

Confirming to what was expected, the signs of direct elasticities are always positive for India, Pakistan and Bangladesh for nine products (Wheat, corn, cotton, sugar cane, rice, sorghum, millet, rapeseed, soybean) and for pulses in India. But for Pakistan, it was necessary to exclude pulses from the translog system<sup>41</sup>, so we tried to make a specific estimation with parameters independent of the equations of the other products based on the formula:

$$(22) \quad \text{Log}(S_{db}) = a_0 + a_1 * \log(S_{db}(-1)) + a_2 * \log(P_{db}(-1)) + a_3 * \log(P_r(-1))$$

<sup>41</sup> When this product is included in translog system, the different coefficients did not appear significant and some direct elasticities for other product also came negative.

The coefficients are:

$$(23) \quad \begin{matrix} 1\_Sdb = 2,07637 & +0,567427*1\_Sdb_{-1} & +0,120239*1\_Pdb_{-1} & +0,028171*1\_Pr_{-1} \\ (3.810) & (4.964) & (1.918) & (0.4821) \end{matrix}$$

$R^2 = 0.9355$ ,  $R^2_{adjusted} = 0.9304$ ,

This results show that for pulses, the surface at time  $t$  is very linked to the value at time  $t-1$  and,  $a_2$ , which can be considered as the own and cross elasticities for pulses is near 0.12 but is significant only at 10% probability. The price of rice ( $Pr$ ) which is supposed to be the product the most linked to pulses (these two products are essentially designated to farmer family food) is not significant.

The elasticities indicated in table 13 have not been calculated for specific years but as mean values for the period 1966-2008. The values of  $r_i$  and  $r_j$  appearing in equations (20) and (21) have been replaced by their mean on the period.

Concerning, the own gross product elasticities of crops areas in India, it is observed that the value is high for sorghum (0.503) and rapeseed (0.273), near 0.2 for millet, wheat and cotton, and lower than 0.1 for rice, pulses, corn, soybean and sugar cane. For Pakistan, one has two high values for soybean (0.944), rapeseed (0.612) and sorghum (0.399), near 0.1 for rice, wheat, sugar cane and millet, and low for cotton and corn (0.008). For Bangladesh, the value is high for corn (0.762), wheat (0.266) and sugarcane (0,241) while these values are weak for cotton (0.136), rapeseed (0.039) and rice (0.0012)

Globally, in the two countries (Pakistan and Bangladesh) sorghum and rapeseed areas appear to respond significantly to commercial revenue. This can be explained by the fact that these two crops are not used on farms, but send to manufacturers for transformation (crushing) or industrial animal feeding. For soybean, which is in the same case, the elasticity is also relatively high for India. In Pakistan, the elasticity is much more important as area is very small compared to India. For all other crops, the own elasticities are generally low (compared to that in developed countries) and lower in Pakistan than in India. This indicates that the farmers are only weakly influenced by prices as either 1) an important part of their crop (rice, wheat, pulses, etc.) is necessary for family needs independently of prices and revenue per hectare or 2) the crop is sold

to manufacturers (cotton by example) but, in the areas where this crop is cultivated there is no real alternatives to it.

Wheat and rice occupy a central position in the agricultural farming system in Pakistan and India. Their elasticities are low for rice in Pakistan and India (respectively 0.089 and 0.037) and for wheat in Pakistan (0.066), but more important in India (0.214). This can be explained by the fact that in Pakistan, wheat is the first cereal consumed in food, and, by this fact it is necessary for farmer to maintain a significant area of this crop if gross product is less competitive compared to some other crops, but in India where food is more based on rice the wheat are is more influenced by prices. Rice being staple food occupies a central position in the agricultural farming system in Bangladesh. So it is first major crop having more than 80% of surface area among six crops taken in this paper. Own gross product elasticity for rice is the lowest value (0.001). It means that 1% increase in gross product per hectare of rice can increase its area by 0.001. The elasticity coefficients, though small, however do underline the role of gross product per hectare in influencing the area planted to rice crop. One of the important reasons for having low value of elasticity coefficients may be the very large area already devoted to rice cultivation and its dominance of the cropping patterns hence not leaving much scope for further extension of rice area. In Bangladesh, Wheat is second largest crop in term of surface area among six crops taken in account here. The elasticity coefficient of wheat is 0.266 that is higher than rice. It means that there is scope of its area extension. The elasticity coefficient of corn is the highest (0.762) representing highest influence of gross product per hectare on its area in time period taken for estimation. One of the main reasons is the high price of corn or development of good market structure for it. Elasticity coefficient of cotton (0.136) and sugarcane (0.241) also represent that surface area cultivated for these two crops has been increasing due to increase gross product per hectare.

In general, supply for all products is relatively inelastic (less than 1) that means when gross product per hectare increases by 1% then farmer reacts but less than 1%. But further, the direct gross product elasticities of staple food (like wheat in Pakistan, rice in India and Bangladesh) are relatively more inelastic as compared to small crops (maize in Bangladesh, rapeseed in Pakistan and India). That can be explained by fact that most farmers in these countries having small area tried to be secured by cultivating staple crop like wheat or rice then he can either consume it or sell it.

It is also interesting to analyse the situation of substitution and complementary of crops among them, on the basis of the signs of the cross elasticities. When the sign is positive, this indicates that an increase in the gross revenue of a crop simultaneously increases the area of the other crops, they are said “complementary crops”). When the effect is inverse (cross elasticity is negative) the two crops are said to be substitutes. In fact the values of gross products elasticities are very much influenced by the importance of each crop area (a small crop having tendency to have a higher revenue elasticity compared to a “major” crop) and the matrix of these own and cross elasticities is not symmetric. So it is interesting to introduce the Allen-Uzawa partial elasticities of substitution (Christev A. 2007) which, in the case of a translog function are defined by  $\sigma_{ij} = E_{ij}/r_j$  where  $E_{ij}$  is the gross product elasticity and  $r_j$  is the share of crop  $j$  in the total revenue. The Allen-Uzawa elasticities have the same sign than the gross product elasticities and form a symmetric matrix. Even if there has been a lot of discussion after the seminal work of Uzawa (1962), they are a statistical information widely reported in empirical studies of production and can be considered as indication on the “ease to change” (or substitution) between two factors in a multiproduct technology. The matrix is not presented here but table 14 summarizes our results for three countries. In this table all figures smaller than 0.5 in absolute value have been deleted as they can be considered to be too small to draw valid conclusions on the two crops relationship.

**Table 14: Matrix of substitutions and complementarities**

		Corn	Cotton	Pulses	Millet	Rapeseed	Rice	Sorghum	Soybean	Sugar Cane	Wheat
Corn	Pakistan			NA	S	C	S	C	C		C
	India			C	C	S	C	S			S
	Bangladesh		C			S	C		S		S
Cotton	Pakistan			NA	C	S			S		
	India			C	C	C		S	S	S	
	Bangladesh	C				S	S			C	C
Pulses	Pakistan	NA	NA		NA	NA	NA	NA	NA	NA	NA
	India	C	C			S	C	C	S	S	S
	Bangladesh										
Millet	Pakistan	S	C	NA		S	S	C	S	S	C
	India	C	C			S	S	S	S		S
	Bangladesh										
Rapeseed	Pakistan	C	S	NA	S			C	C	S	S
	India	S	C	S	S		C	C	S	C	S
	Bangladesh	S	S				S			S	C
Rice	Pakistan	S		NA	S			S	S		
	India	C			S	C		C	S		
	Bangladesh	C									I
Sorghum	Pakistan	C		NA	C	C	S		S	S	C
	India	S	S	C	S	C	C		C		S
	Bangladesh										
Soybean	Pakistan	C	S	NA	S	C	S	S		C	C
	India		S	S	S	S	S	C		C	C
	Bangladesh										
Sugar Cane	Pakistan			NA	S	S		S	C		S
	India		S	S		C			C		
	Bangladesh	S				S	S				S
Wheat	Pakistan	C		NA	C	S		S	C	S	
	India	S		S	S	S		C	C		
	Bangladesh	S	C			C	S			S	

Source: Own calculation, NA=Not available

For wheat which is a major crop in the two countries, it appears that this crop is a significant substitute for rapeseed and a complementary crop to soybean in the two cases. But relationships are different for corn, millet and sorghum: wheat is a substitute for corn and millet in India and a complement in Pakistan. On contrary, wheat is a complement for sorghum in India and a substitute for this crop in Pakistan. At last, wheat is a substitute for pulses in India and a substitute for sugarcane in Pakistan. In Bangladesh, for wheat that is also a very important, this crop is a substitute for rice, corn and sugar cane but relationships are opposite for rapeseed and cotton.

For rice which is also a very important crop in India and Pakistan, this crop is in the two cases a substitute for millet and for soybean, but relations are inverse for corn and sorghum. In the two countries, there appears no significant relation between wheat and rice. In Bangladesh, for rice that is a major crop, it appears that this crop is a significant complement for corn and there appeared no significant relation between other crops and rice. The main reason behind this may be its importance as a staple food covering large area and land suitability.

Globally, there are only ten relationships between crops which are the same in the two countries: cotton-millet (C), cotton-soybean (S), millet-rapeseed (S), millet-rice (S), millet-soybean (S), rapeseed-sorghum (C), rapeseed-wheat (S), rice-millet (S), rice-soybean (S), sugarcane-soybean (C), wheat-soybean (C). where in Bangladesh, Globally, there are different relationships between crops which are taken into account: cotton-wheat (C), cotton-rice (S), cotton-rapeseed (S), cotton-corn (C), cotton-sugarcane (C), rapeseed-rice (S), rapeseed-wheat (C), rapeseed-cotton (S), rapeseed-corn (S), rapeseed-sugarcane (C), maize-wheat (S), maize-rice (C), maize-rapeseed (S), corn-cotton (C), corn-sugarcane (S), sugarcane-wheat (S), sugarcane-rice (S), sugarcane-rapeseed (S), sugarcane-corn (S). Where “C” represents compliments and “S” represents substitute.

In fact three types of crops are taken in analysis: food crops, cash crops and feed crops. In Pakistan, India and Bangladesh, wheat and rice are used as staple food so they are less competitive to each other and are generally considered as complementary crops, but in our results there is no significant relationship. Cash crops (cotton, sugarcane) are more responsive to own gross product; they are substitutes in India, but have no significant relationship in Pakistan. Feed crops like millet, sorghum, corn are generally considered as substitutes of each other at demand level, but this relationship does not appear at supply level. In India feed industry is more developed than in Pakistan, so traditional feed like millet, sorghum, corn, in India are generally sold to feed manufactures while they are directly used by farmers as feed in Pakistan.

It is difficult to explain, the different results of gross products elasticities, Allen-Uzawa partial substitution elasticities for the different crops and of the three countries. However it seems possible to draw some conclusions from our results, even if, as it was said previously, the figures presented are highly dependent on the quality of data used in the estimations (mainly concerning prices received by farmers indicated by FAO, but also in some cases concerning areas evolutions which have been corrected with national data when possible).



In addition to above results, following point can be added for three countries.

- 1) Farmer in India seems to react to the market price more than Pakistani and Bangladeshi farmer. Indian producers are engaged to commercialization more than Pakistani farmers because in Pakistan, farmers have small holding and do subsistence farming. But in India now cooperative farming is evolving.
- 2) There are powerful monopolies or oligopolistic structures in major crops markets which distort the incentives for the producers resulting in wasteful and inefficient use of national resources in Pakistan and Bangladesh but in India it has been mostly controlled by adopting efficient agriculture policy.
- 3) In India, sector of food and feed industry is more developed as compared to Pakistan and Bangladesh. So there is greater demand of all types of crops with good incentive but in Pakistan within feed and food sector, traditional crops that can be used directly without processing are sowed to meet the needs of human beings and animals like wheat, rice, millets, sorghum, and corn.
- 4) In India, there is more marketed surplus as compared to Pakistan and Bangladesh. Because India has a larger cultivated land, big population and larger economy as compared to Pakistan and Bangladesh.
- 5) In Pakistan and Bangladesh, yield is also low for crops as compared to India due to limited access to improve production technologies, credits and other inputs. There is also lack of marketing systems, efficient research, extension, and farmer linkages in Pakistan.

### **3.4. Comparison of Pakistan, India and Bangladesh elasticities with literature data**

Now, one can compare our results of elasticities with the values calculated by other authors for the three countries.

Many studies have emphasized to calculate the acreage response to price for wheat and rice for these countries due to their importance in term of cultivated area under these crops and their consumption.

There are many studies<sup>42</sup> on acreage price elasticities for Pakistan which concluded generally that Pakistani farmers react rationally to income incentive. Authors like Tweeten (1986), Pinckney (1989), Khan et al. (1991), Ashiq (1992), Hussain et al.(1996) used classical regression analysis of Nerlove model for data from 1956 to 1993. While Mushtaq et al.2002 used cointegration approach for data from 1960 to 1996. These studies cover only major crops like wheat, rice, cotton and sugarcane. Their overall general conclusion is that farmers in Pakistan respond rationally to economic incentives. Our elasticity estimates are similar to previous results which are summarized in Table 15. Elasticities estimated by Tweeten (1986), Pinckney (1989), Khan et al. (1991), Ashiq (1992), Hussain et al.(1996) and Mushtaq et al.2002 for wheat fall between 0.11 and 0.93, but our estimate is 0.06. Likewise elasticities for sugarcane estimated by Tweeten (1986), Khan et al. (1991) and Mushtaq et al.2002 fall between 0.47 and 5. Elasticities estimated by Tweeten (1986), Khan et al. (1991) and Mushtaq et al.2002 for cotton fall between 0.12 and 1.62, but our estimate is 0.02. The elasticities estimated by all these authors for rice fall between 0.17 to 0.62 and our estimate is 0.09. The difference between results is due to different methodologies adopted and also sample period that is more than all (42 years) in our study.

**Table 15 Comparison of supply elasticities according to different authors for Pakistan**

	Pakistan								
	Present study	Tweeten (1986)	Pinckney (1989)	Khan et al. (1991)	Ashiq (1992)	Hussain et al.(1996)	Mushtaq et al.(2002)	Khan (2003)	FAPRI
Wheat	0.066	0.27	0.20	0.11	0.46–0.49*	0.21	0.93	0.31	0.23
Rice	0.089	0.43		0.53	0.46–0.62*		0.38–0.46*		0.29
Cotton	0.021	0.54		0.12			0.30		
Millet	0.123							1.71	
Sugar cane	0.169	0.70		0.47			5.01		0.07
Sorghum	0.399							0.11	0.2
Corn	0.008							0.11	0.28

\* means elasticities for different region

There are also many studies<sup>43</sup> for estimating acreage response to price for major cereals crops in India. Mythili 2006 used Nerlove model for data from government reports from 1970-2000 while Gulati et al. 1999 used cross sectional district data from 1970 to 1990 then Kumar et al. 1997 used national sample survey for different income group from 1983 to 2004. These authors took only major crops like rice, wheat, cotton and sugarcane (Table 16). Their estimates calculated for rice range from 0.02 to 1.9 and out estimate (0.037) falls between these values. The estimates of acreage response for wheat by these authors (Gulati et al. 1999; Kumar et al. 1997 and Mythili

<sup>42</sup>Krishna (1963), Cummings (1975), Tweeten (1986), Pinckney (1989), Khan et al. (1991), Ashiq (1992), and Hussain et al. (1996), Farooq et al. (2001)Mushtaq et al.2002.

<sup>43</sup> Gulati et al. 1999; Kumar et al. 1997; Surekha et al.2005 ; Mythili 2006

2006) are between 0.06 and 0.98. Our estimate is also between this range. The elasticity estimated by Mythili 2006 for cotton, sugarcane and rapeseed are 0.15-0.85, 0.20-0.21 and 0.19-0.28 respectively. Our estimates for cotton (0.15) and rapeseed (0.27) are between his values but for sugarcane, our estimate (0.02) is below than his value.

**Table 16 Comparison of supply elasticities according to different authors for India**

	India				
	Present study	FAPRI	Mythili (2006)	kumar et al. (1997)	Gulati et al. 1999
Corn	0.057	0.21			
Cotton	0.147		0.119-0.121*		
Pulses	0.088				
Millet	0.249				
Rapeseed	0.273	0.34	0.258-0.252*		
Rice	0.037	0.11	0.075-0.078*	0.02	0.06-0.17*
Sorghum	0.503	0.3			
Soybean	0.096	0.36			
Sugar cane	0.018	0.21	0.267-0.268*		
Wheat	0.214	0.29	0.066-0.071*	0.06-0.98*	0.006

\* means elasticities for different region

Our gross product elasticity for rice in Bangladesh is 0.001 that is less than value calculated by Rehman et al.1993; Shahabuddin et al.1995; Dorosh et al.2002. But like these studies, rice is relatively inelastic in our analysis that means production of rice is less affected by production price due to having already a lot of area under its cultivation. We also compared our elasticity for wheat with Rehman et al.1993; Shahabuddin et al.1995; Dorosh et al.2002. Our value is below than values calculated by Rehman et al.1993; Shahabuddin et al.1995 but higher than Dorosh et al.2002 (table 17). Rehman et al.1993 used Nerlove model for data from 1972 to 1983 taken from Bangladesh bureau of statistics while Shahabuddin et al.1995 used Mcguirk and Mundlak model of dynamic approach for data from 1984 to 1991. Then Dorosh et al.2002 used Nerlovian model for data from 1973 to 2000. Like other two countries, these authors also covered only major crops like wheat and rice.

**Table 17 Comparison of supply elasticities according to different authors**

	Bangladesh			
	Present study	Rehman et al.(1993)	Shahabuddin et al.(1995)	Dorosh et al.(2002)
Corn	0.762			
Cotton	0.136			
Rapeseed	0.04			
Rice	0.0012	0.06	0.062	0.05-0.16*
Sugar cane	0.24			
Wheat	0.266	0.61	0.147	0.12

\* means elasticities for different region

The difference between our values and other may be due to different methodology adopted, time period taken for analysis and above all gross product per hectare is used i.e. price multiply by yield while all other authors used prices of output.

In general, there are important difference between our results and the data of FAPRI. It is important to analyse the reasons of these differences which can be of two natures. First, it can be due to data used and period taken in account for the econometric estimations. Second, it can be due to differences in the methodology used.

For Pakistan, the elasticities cited by FAPRI correspond to the result published by Khan 2003.

In the table 15, elasticity calculated by khan 2003 in Pakistan shows price own elasticity of different crops. If one compares our results with khan's elasticity, one can see the same signs but difference of magnitude. There is a reason behind it that khan used directly price of output but one use gross product per hectare i.e. price multiply by yield. Collective effect of price and yield on allocation of surface area for each crop is calculated. In addition, moving average of price and yield variable is used to avoid sudden fluctuation.

As elasticities are important parameters widely used in empirical works with agricultural models, it is important to compare our results with the values calculated by other authors. In fact, in general literature, there is only information on the own elasticities. Data available in the elasticity database of FAPRI have been used and the results are summarized in table 15. In general, there are important difference between our results and cited by FAPRI, but there is no information on the sources and methodologies concerning FAPRI data. Concerning wheat, it can be observed,

our elasticity is near that of FAPRI for India (0.214 versus 0.290), but for Pakistan it is much smaller (0.066 versus 0.230) and is also smaller than that calculated by Khan (0.31). The data of FAPRI and Khan for a “subsistence” crop in Pakistan seems high as they are near those of developed countries where farmers are very responsible to market prices such as Australia and even European Union, even if, in this zone, the impact of direct, now decoupled aids can be important. Concerning rice, our figures are lower than those of FAPRI for India and Pakistan, but also for this last country figure of FAPRI (0.29 versus 0.089 for us) seems high as more important than for Australia. Concerning corn, the same conclusion can be drawn but it can be observed that FAPRI figures are higher for India and Pakistan than for Australia.

### 3.5. Conclusions

The analysis included a total of 10 crops (rice, wheat, cotton, rapeseed, soybean, sugarcane, maize, pulses, sorghum and millet), but some products are not significantly present in some countries or functions of supply that could not be estimated satisfactorily, so we finally retained 9 crops for Pakistan, 10 crops for India and 7 crops for Bangladesh in the systems of equation. The most of the coefficients of the three Translog systems of equations estimated for the three countries are significant and the signs of the direct elasticities for the selected products are all positive. This tends to justify the initial hypothesis of significant influence of domestic prices to production. Satisfactory results (statistically) also justify specific approach that was chosen to know that land allocation is directly influenced not only by the price of each product, but by the anticipated gross product. Two articles<sup>44</sup> are published from this chapter.

In the absence of precise information on the method of determination of it that we tested the hypothesis that it was equal to the product of the average of the last known prices  $N1$  by last known yields  $N2$ . Parameters  $N1$  (5 for Pakistan, 2 for India and Bangladesh) and  $N2$  (4 for Pakistan, 3 for India and 1 for Bangladesh) were determined on the basis of comparisons of the econometric results obtained (significance of the coefficients of the equations and signs of direct elasticities). It is observed that the values of  $N1$  and  $N2$  are lower for Bangladesh as compared to Pakistan and India, which can be interpreted by saying that the farmers of this country are more responsive to market last signs while those other countries have a more rigid behavior and alter

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<sup>44</sup> See Yaseen et al. 2011 and Yaseen et al. 2011

their rotations when the crude product developments have significantly evolved over a longer period. On the empirical point of view, this approach also helps to limit the impact of some data points (prices or yields) of possibly having values "abnormal" in the database of the FAO.

# Chapter 4: Estimation of food demand for vegetal and animal products

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Demand for food is a field that has encouraged much activity in economic research and has a long history within the economics profession. At least, ever since Malthus (1798) there has been a recurring focus on availability of food. The particular concern of Malthus was that the growth in population would eventually produce demands for food exceeding supply. Approximately 309 million of around 850 million undernourished people in the world live in India, Pakistan and Bangladesh according to the State of Food Insecurity in the World (SOFI 2011). So these countries are much concerned by this problem.

Insufficient food consumption in developing countries, is due to low local production and inability to buy in international currencies on world markets, but is also due to the lack of access due to low income (World Bank 1981) although it is not the only cause according to SOFI (1999). Therefore, the effect of income and price on the demand for food in developing countries has been the focus of many studies; see e.g. (Mellor 1983; Behrman and Deolalikar 1987; Alderman 1988). So in this following part of study, the effect of price and income (expenditure) on the consumption of different food products (vegetal and animal) are calculated and their different relations (substitutes or compliments) are presented. General presentation of main evolution for food consumption is presented for each country then followed by methodology used to calculate food demand and their results.

The objective of this chapter is to first present the main features of the current situation and historical development of consumption of vegetal and animal products from a descriptive point of view. This description is justified by the fact that such works do not currently exist in the literature. Then we present the methodological framework that was chosen to estimate the various functions of food demand and to introduce the formulas that were used for the calculation of various price and income elasticities that are used in the three PEM presented in Chapter 6. The results of these calculations are presented for all products for each country, and then compared with other results available in the literature.

The obtained results also help to justify the hypothesis made in the introduction of significant influence of local prices and incomes.

## **4.1. General presentation of main evolutions for food consumption in Pakistan, India and Bangladesh**

### **4.1.1. Generalities on the three countries**

Vegetal products are very important and traditional components of human diets in the three countries with a particular emphasis on rice and, in some cases, wheat. According to FAO, total consumption of cereals was nearly 135 kg/capita/year in Pakistan, 148 in India and 195 in Bangladesh in “2006” where this can be compared to world mean of 147.8kg in same year. During the period “1968” – “2006” this consumption remained nearly constant in India but decreased by 15% in Pakistan and increased by 26% in Bangladesh. These evolutions can be explained by some specific cultural or social habits, but more by the level and evolution of income per capita and the uses of complementary/substitute vegetal or animal products.

In Pakistan all cereals except wheat, which is traditionally the main staple food used in the country are continuously decreasing (mainly rice and secondary cereals: Millet, sorghum, and others cereals) which can be linked to the increase of animal products consumption due to the development of urbanization which drives workers to use more bread and wheat products, and to be at more distance from auto consumption of traditional cereals on farm.

In India, there is a more diversified food consumption based mainly on rice and wheat. But the tendency is to increase much wheat demand (+68%) and to decrease traditional cereals consumption. Like Pakistan, this can be explained by a tendency of increasing urbanization and income.

In Bangladesh, the diet remains nearly completely based on rice, and in spite of a growing demand for wheat (+67%), wheat has still a moderate place.

Use of pulses in food is traditional for the three countries and corresponds to a large variety of individual products which can be different in term of mode of utilization, availabilities and prices. So it can be considered as a homogenous category but has been aggregated because of a lack of detailed data mainly for prices. Globally the consumption per capita has decreased in



Bangladesh by 6%, in India by 29% and in Pakistan by 42% for pulses, but levels remains close or superior to world mean (6.3kg/capita/year in 2006). This evolution is largely due to slow increases in local productions characterized by low yields while the development of imports having only a moderate role to satisfy this demand therefore driven to higher prices for pulses compared to cereals.

Sugar is part of traditional diet where quantity consumed in “2006” are greater than world average (23.9kg/capita/year in 2006) for Pakistan (29kg), slightly lower for India (20kg) but much more lower for Bangladesh (9Kg). Due to the high price of this product and the necessity to buy it from sugar mills or distributors at retail prices, contrary to other products which can be produced and used directly on farms, the limitation of income per capita is an important factor. The tendency of consumption is decreasing in Pakistan (-12%) and also in Bangladesh (-39%), but in India the evolution is positive and the level of consumption per capita tends to be closer to that of Pakistan.

Concerning vegetal oils, the three countries were characterized by very low levels of consumptions compared to world average at the end of years 60. During the last 40 years, one can observe a huge increase (with a multiplication factor of 2.0 for India and 3.8 for Pakistan, Bangladesh being in intermediate position with a multiplication by 2.7). In recent years the consumption in Pakistan (around 12 kg) was near to world average level in 2006 (11.0 in 2006). It was lower in India (8kg) and the lowest in Bangladesh (6kg). Among all vegetal food products, oils were by far the most dynamic product in the three countries. These evolutions were associated with important changes in the place of the different main oils, in relation with development of imports of some main products such as palm oil. It must be noticed that in this analysis, the evolution of contribution of animal fats (traditional ghee, butter, etc.) is not taken that is used for coverage of lipid demand in diets<sup>45</sup>.

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<sup>45</sup> The traditional ghee and butter are not taken in this study due to the lack of sufficient data of price and consumption in all statistics.

**Table 18: Evolution of vegetal products consumption per capita and per year in Pakistan, India and Bangladesh**

	average 66-70			average 2004-2008			variation			evolution		
	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh
Rice (Milled Equivalent)	23.8	66.9	156.86	15.12	70.24	171.5	-8.68	3.34	14.64	-36.5%	5%	9.3%
Wheat	106.62	34.48	11.08	108.92	58	18.46	2.3	23.52	7.38	2.2%	68.2%	66.6%
Maize	9.58	9.38	0.04	9.44	5.06	5.34	-0.14	-4.32	5.3	-1.5%	-46.1%	13250%
Millet	5.54	15.42	0.88	0.66	8.6	0.12	-4.88	-6.82	-0.76	-88.1%	-44.2%	-86.4%
Sorghum	4.34	17.4	0	0.92	5.58	0	-3.42	-11.82	0	-78.8%	-67.9%	
Other cer	0.6	4.04	0.2	0.22	0.74	0.02	-0.38	-3.3	-0.18	-63.3%	-81.7%	-90%
Cereals (Total)	150.48	147.62	169.06	135.28	148.22	195.44	-15.2	0.6	26.38	-10.1%	0.4%	15.6%
Pulses + (Total)	11.08	16.14	4.54	6.38	11.5	4.28	-4.7	-4.64	-0.26	-42.4%	-28.7%	-5.7%
Sugar & Sweeteners + (Total)	32.9	18.06	14.94	28.86	20.2	9.18	-4.04	2.14	-5.76	-12.3%	11.8%	-38.6%
Rape and Mustard Oil	0.64	0.78	1.02	1.2	1.86	0.7	0.56	1.08	-0.32	87.5%	138.5%	-31.4%
Soyabean Oil	0.64	0.12	0.44	0.24	1.38	1.94	-0.4	1.26	1.5	-62.5%	1050%	340.9%
Sunflowerseed Oil	0.08	0.02	0	0.96	0.44	0	0.88	0.42	0	1100%	2100%	
Cottonseed Oil	1.3	0.14	0	2.14	0.56	0	0.84	0.42	0	64.6%	300%	
Palm Oil	0	0	0	6.54	1.56	2.64	6.54	1.56	2.64			
Oilcrops Oil, Other	0.36	2.98	0.66	0.48	2.28	0.36	0.12	-0.7	-0.3	33.3%	-37.5%	-100%
Vegetable Oils + (Total)	3.02	4.04	2.12	11.56	8.08	5.64	8.54	4.04	3.52	282.8%	100%	166%

**Source: Calculation from FAOSTAT; Unit: kg/capita/year**

In three countries, the growing place of animal products can be observed in diets, but the levels consumed in “2006” for total meat remained very low compared to world mean (40.5 kg/capita/year). While it was higher (13kg/capita) for Pakistan but lower for India and Bangladesh (around 4kg). For eggs, with a mean world level of 8.5 kg in 2006, the situation is the same and, as for meat, India and Bangladesh levels are lower than that of Pakistan. For milk, the situation is very different as compared to a world mean level of 84.5kg per capita, Pakistan appeared as a “large” consumer with more than 163kg, India as a “medium” consumer with 67kg and Bangladesh remained a “small” consumer with only 18kg. If the total consumption of this South-Asian area is considered then due to its important population, it represents the major consuming zone in the world.

The demand for animal products in these three countries is largely influenced by economic aspects such as income per capita and relative prices, but also influenced by cultural and religious aspects. In Pakistan and Bangladesh, pig meat is not consumed and some other meat such as mutton and goat are associated with religious events. In India, bovine meat is nearly not

consumed but pig meat is allowed for a part of the population. In the three countries, poultry meat is allowed with respect to some religious rules for slaughtering and eggs are also allowed. Considering both these aspects on meat consumption and generally their high prices, particularly during some religious events, milk appears to be the most valuable and less expansive source of animal proteins for many people.

So generally, it is in Pakistan where strongest growth for consumption of all products was recorded. There was a strong increase in consumption of poultry meat, eggs and milk in all these three countries but Bangladesh is always characterized by lower growth rate for these products.

Although this product family (Fish and Seafood) is not taken into account in this analysis (due to the diversity of products and the lack of data on prices) but it is worthy to note the importance of the position of "Fish and seafood" specially in Bangladesh which represents 16 kg/capita/year of its consumption while global average is nearly 17.6kg/capita/year however, the levels are much lower in India and especially in Pakistan.

**Table 19: Evolution of animal products consumption per capita and per year in Pakistan, India and Bangladesh**

	average 66-70			average 2004-2008			variation			evolution		
	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh
Bovine Meat	4.98	2.3	2.2	7.42	1.7	1.3	2.44	-0.6	-0.9	49%	-26.09%	-40.91%
Mutton & Goat Meat	2.4	0.74	0.5	2.76	0.68	1.16	0.36	-0.06	0.66	15%	-8.11%	132%
Pigmeat	0	0.3	0	0	0.34	0	0	0.04	0		13.33%	
Poultry Meat	0.2	0.2	0.82	3.04	1.36	1.26	2.84	1.16	0.44	1420%	580%	53.66%
Meat, Other	0.2	0.1	0.1	0.1	0.1	0.1	-0.1	0	0	-50%	0%	0%
Meat + (Total)	7.8	3.64	3.58	13.34	4.16	3.84	5.54	0.52	0.26	71.03%	14.29%	7.26%
Eggs + (Total)	0.2	0.42	0.64	2.36	2	1.44	2.16	1.58	0.8	1080%	376.19%	125%
Milk - Excluding Butter	106.78	33.22	11.36	163.1	67.22	17.54	56.32	34	6.18	52.74%	102.35%	54.4%
of which Milk, Whole	57.22	23.62	10.68	93.74	40.08	15.84	36.52	16.46	5.16	63.82%	69.69%	48.31%
Fish, Seafood + (Total)	1.6	2.6	10.04	1.9	5.18	15.84	0.3	2.58	5.8	18.75%	99.23%	57.77%

**Source: Calculation from FAOSTAT; Unit: kg/capita/year**

At the same time, large developments have been taken place regarding the total consumption of vegetal and animal products therefore their structure has been changed in these three countries (Table 20).

**Table 20: Evolution of shares of different products in vegetal and animal consumptions in Pakistan, India and Bangladesh**

	average 66-70			average 2004-2008			variation			evolution		
	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh
Rice	12%	36.8%	82.4%	8.3%	37.5%	79.9%	-3.7%	0.7%	-2.4%	-30.7%	2%	-2.9%
Wheat	54%	19%	5.8%	59.9%	31%	8.6%	5.8%	12%	2.8%	10.8%	63.3%	48.4%
Mil/Sorg	5.1%	18.1%	0.5%	0.9%	7.6%	0.1%	-4.2%	-10.5%	-0.4%	-82.8%	-58.1%	-87.9%
Maize	4.9%	5.1%	0%	5.2%	2.7%	2.5%	0.3%	-2.4%	2.5%	5.8%	-47.5%	11507.3%
Totpulses	5.7%	8.9%	2.4%	3.5%	6.1%	2%	-2.2%	-2.7%	-0.4%	-38.4%	-30.8%	-16.6%
Totsugar	16.8%	9.9%	7.9%	15.9%	10.8%	4.3%	-0.9%	0.9%	-3.6%	-5.3%	8.6%	-45.6%
Totvegoils	1.5%	2.2%	1.1%	6.4%	4.3%	2.6%	4.8%	2.1%	1.5%	313.1%	94.1%	136.3%
Total	100%	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%
Bovine meat	4.3%	6.2%	14.1%	4.1%	2.3%	5.7%	-0.2%	-3.9%	-8.4%	-4.7%	-62.4%	-59.7%
Ovine meat	2.1%	2%	3.2%	1.6%	0.9%	5.1%	-0.5%	-1.1%	1.9%	-25.7%	-53.4%	58.3%
chicken meat	0.2%	0.5%	5.3%	1.7%	1.8%	5.5%	1.5%	1.3%	0.3%	871.7%	244%	5.1%
Othermeats	0.2%	1.1%	0.4%	0.1%	0.6%	0.5%	-0.1%	-0.5%	0.1%	-65.6%	-46.2%	35.7%
Total eggs	0.2%	1.1%	4.1%	1.3%	2.7%	6.3%	1.1%	1.6%	2.2%	656.3%	141.5%	53.7%
Total milk	93%	89.1%	72.9%	91.2%	91.6%	76.9%	-1.8%	2.5%	4%	-1.9%	2.8%	5.4%
Total	100%	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%

Source: Calculation from FAOSTAT; Unit: Percentage<sup>46</sup> in quantity of consumption of vegetal products and animal products separately.

Although the percentage declined slightly between "1968" and "2006", rice remains by far, with nearly 80% of its share, the main vegetal product used in Bangladesh, while its share remained fairly stable at 37% in India. Contrary to other two countries, it is wheat in Pakistan that is in first position with a progressing share from 54 to 60%, while that of rice regressed from 12% to 8%. Traditionally, Millet / sorghum was mostly consumed in India (18% in "1968"), but this product was characterized by sharp decline in all three countries.

Pulses were also largely consumed in India, but like millet / sorghum, this product family was also characterized by decline in the country like Pakistan and Bangladesh. The sugar was consumed at a higher percentage in Pakistan (17%) then India (10%) and Bangladesh (8%), but these evolutions are mostly characterized by the sharp decline of its place in the vegetal products consumed in Bangladesh while it was relative stable in India but slightly decreased in Pakistan.

<sup>46</sup> The numbers (in percentage) on upper side of table is obtained by dividing quantity consumed of each product by total consumption of vegetal products indicated here and adopted same method for animal products on lower part of table

Contrary to sugar and millet/sorghum, consumption of vegetal oils rose sharply in the three countries with the highest multiplication factor of 4 in Pakistan and multiplication factor of 2 in India and Bangladesh.

Regarding the animal products, milk<sup>47</sup> was and is by far, the first animal product consumed in the three countries, with shares ranging in tonnage from 73 to 91%. The proportion of eggs like some meat has experienced a significant increase during the period however the phenomenon was significant in the three countries, amending the structure of consumption of the meat for all three countries. (Table 21)

**Table 21: Evolution of the structure of consumption of meat**

	average 66-70			average 2004-2008			variation			evolution		
	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh
Bovine Meat	63.8%	63.2%	61.5%	55.6%	40.9%	33.9%	-8.2%	-22.3%	-27.6%	-12.88%	-35.33%	-44.91%
Mutton & Goat Meat	30.8%	20.3%	14%	20.7%	16.3%	30.2%	-10.1%	-4%	16.2%	-32.76%	-19.59%	116.29%
Pigmeat		8.2%			8.2%			-0.1%			-0.83%	
Poultry Meat	2.6%	5.5%	22.9%	22.8%	32.7%	32.8%	20.2%	27.2%	9.9%	788.76%	495%	43.25%
Meat, Other	2.6%	2.7%	2.8%	0.7%	2.4%	2.6%	-1.8%	-0.3%	-0.2%	-70.76%	-12.5%	-6.77%
Meat + (Total)	100%	100%	100%	100%	100%	100%	0%	0%	0%	0%	0%	0%

**Source: Calculation from FAOSTAT; Unit: percentage**

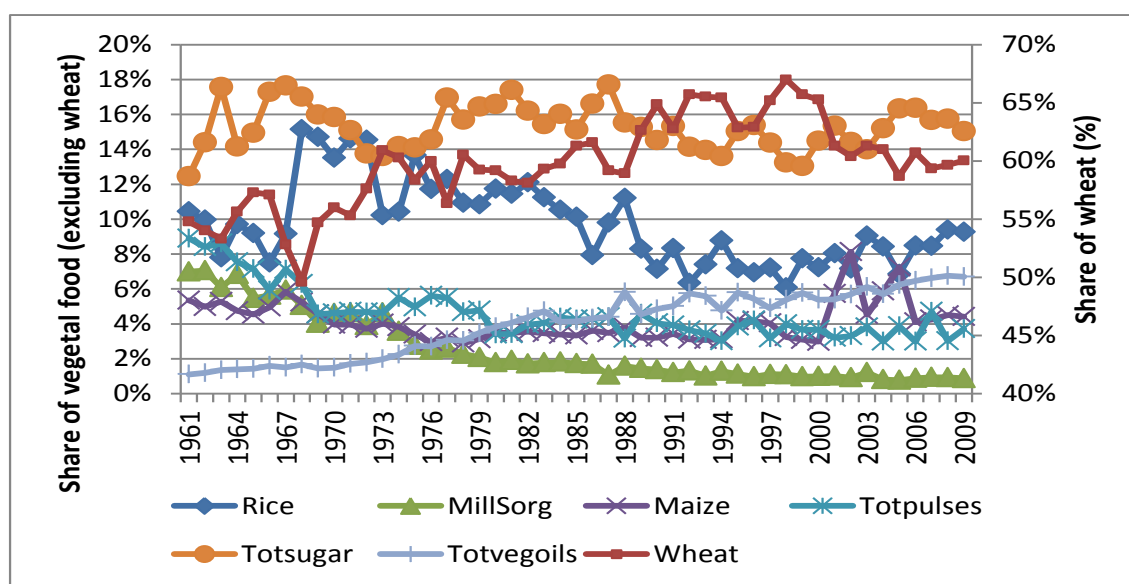
Whereas in year "1968" beef (cattle and buffalo) was leading consumed animal product in the three countries with more than 61% but then decreased. On the contrary, concerning the meat of sheep and goats, these two products regressed sharply in Pakistan and India with a cumulative percentage passing from 95% to 76% and 84% to 57% respectively (see table 21).

In fact, it is poultry meat (mainly chicken meat) that rose sharply by 33% of the total animal products in India and Bangladesh but 23% in Pakistan. The case of Bangladesh is particularly different because in "1968" the poultry sector already had a very significant proportion of the consumption of meat while it was still marginal in India and especially in Pakistan. Overall in the three countries, there is a strong increase of the role of poultry sector as meat and eggs in food consumption.

<sup>47</sup> It goes without saying that if this product was calculated on a dry matter basis, instead of tonnage "raw" the figure would be much lower.

### 4.1.2. Pakistan

Between 1961 and 2010, the share of various vegetal foods had some significant trends as for rice but in all cases significant changes appeared from one year to another, which can be explained by a priori annual changes of prices. This variability of consumption in terms of distribution can be characterized by coefficients of variation (equal to the ratios of the standard deviations to the mean). A high level of these variations shows significant trend upward or downward or strong variations from one year to another in the absence of medium term trend (figure 20). Among these products, it is family “millet / sorghum” which has the highest coefficient (it is also one that has the lowest average) with 76%, followed by vegetal oils (46%). On the contrary wheat with a coefficient of variation of only 6% was appeared the most stable followed by sugar (8%).



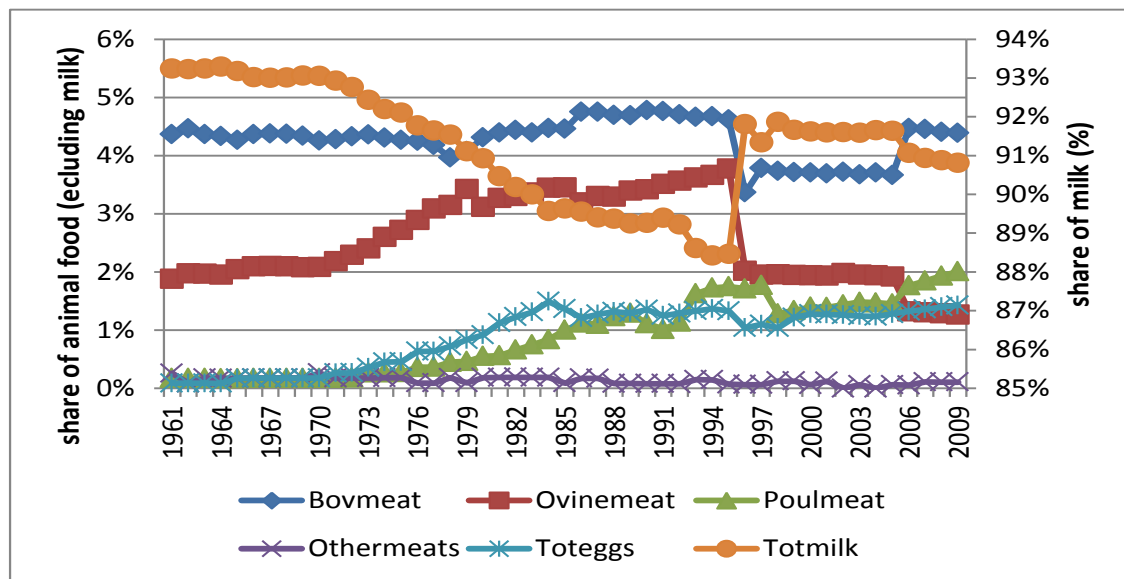
**Figure 20: Evolution of shares of different vegetal products in vegetal consumption for Pakistan**

Source: Calculation from FAOSTAT

For animal products, fluctuations are also generally highly important (30% for meat of sheep, 55% for eggs and 69% for poultry meat; two latter products that have very significant upward trends). On the contrary, Milk is the most stable product with a coefficient of variation less than 2% (figure 21). One should mention two specific developments (first: cut in half of the share of sheep meat between 1995 and 1996 then second: significant drop for the beef share between 1996

and 2005). These developments appeared especially in relation to the strong increase in milk consumption from 1996 (increase of 20% in only one year).

One may wonder if these figures which are much involved in the calculation of elasticities correspond to a real phenomenon or a statistical revision of the database of the FAO.

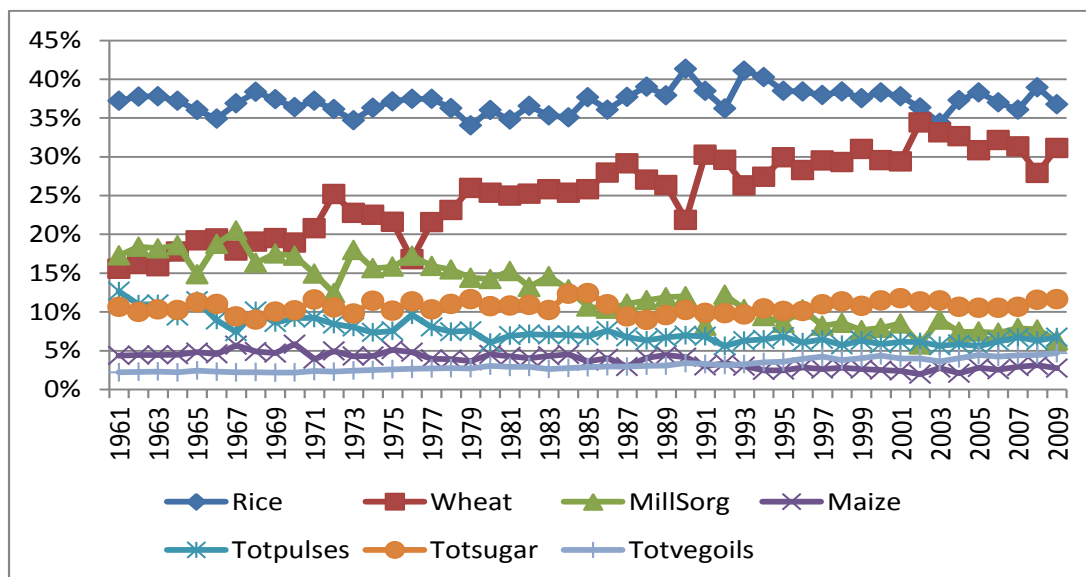


**Figure 21: Evolution of shares of different products in animal consumption for Pakistan**

Source: Calculation from FAOSTAT; Unit: Percentage

### 4.1.3. India

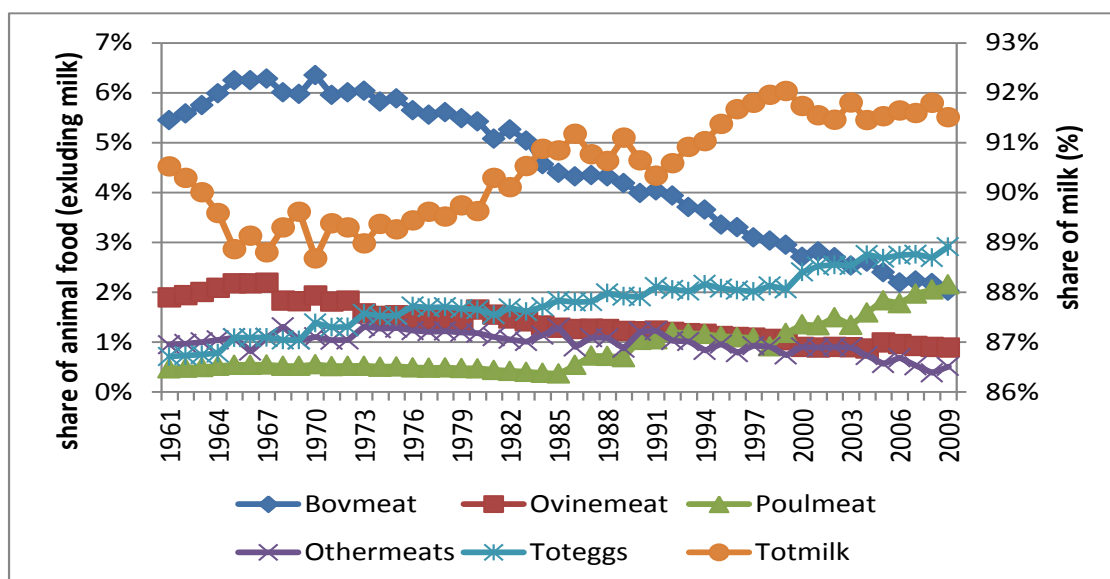
In India, rice is still the main vegetal food with a percentage share that has fluctuated from 34% in 1979 to 41% in 1990 (figure 22). On the other hand, wheat for his share appeared with annual fluctuations and significantly increasing trend (coefficient of variation 20%). In 2002, the share of these two products was very similar (34% against 36%). Rice and sugar are the most stable products throughout the period, with coefficients of variation of only 4% and 8% respectively.



**Figure 22: Evolution of shares of different products in vegetal consumption for India**

Source: Calculation from FAOSTAT

Concerning animal products, excluding milk whose share has increased quite regularly between 1975 and 1999, before stabilization thereafter, any product does not represent now more than 3%. The most significant phenomenon is the steady decline in the share of beef and progression of eggs and poultry meat.



**Figure 23: Evolution of shares of different products in animal consumption for India**

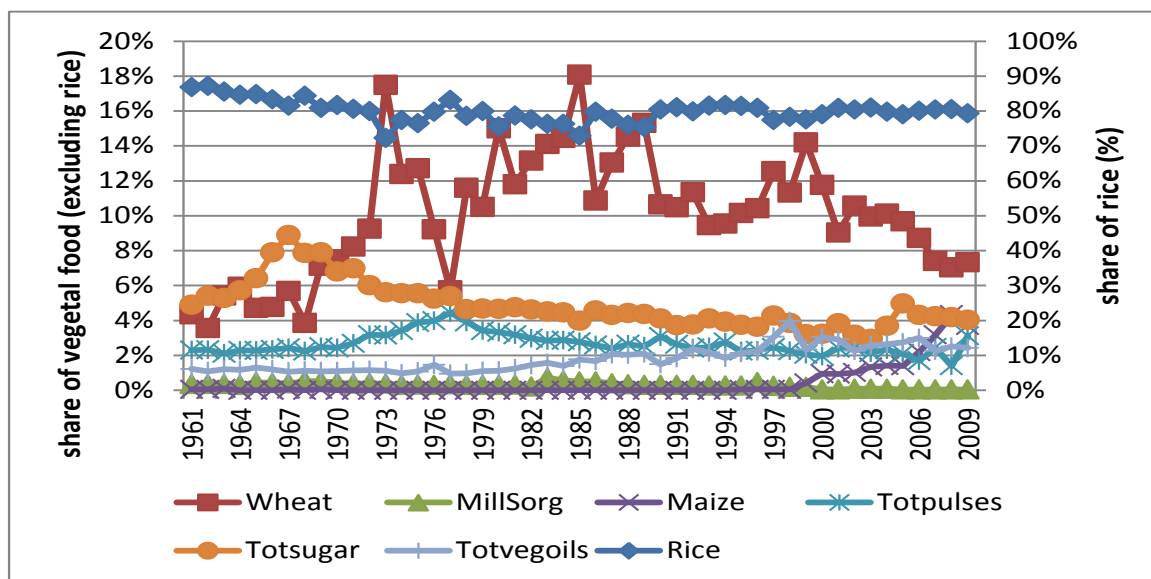
Source: Calculation from FAOSTAT



Concerning the coefficients of variation, milk is by far the most "stable" with a coefficient of variation of only 1%. For all other products, trends and / or annual fluctuations are significant and the coefficients ranged from 22% for "other meat" to 57% for poultry.

#### 4.1.4. Bangladesh

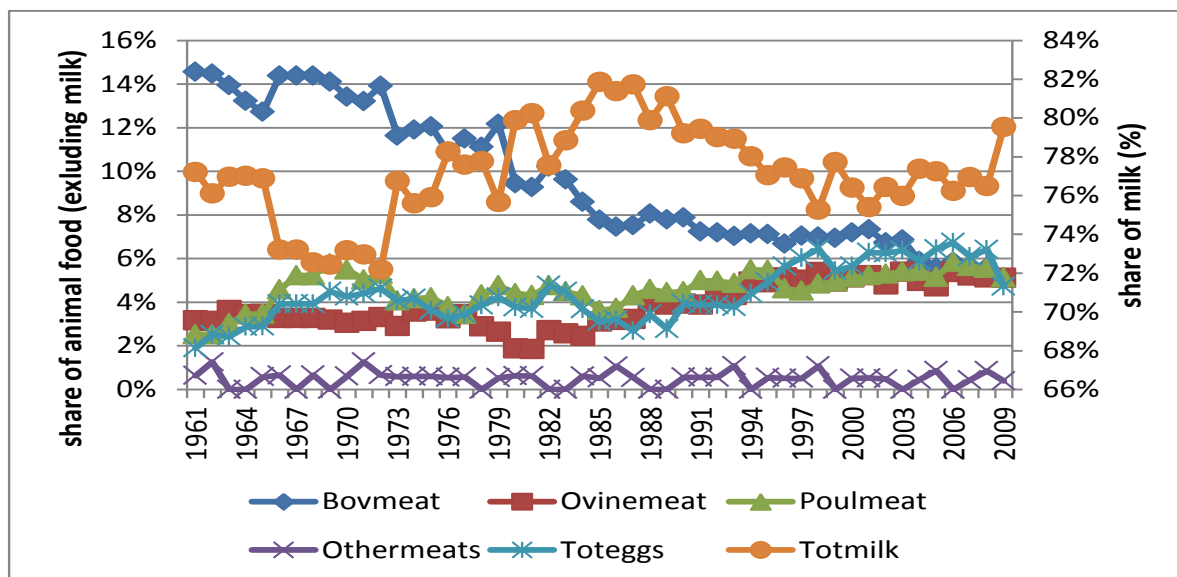
As mentioned above, the structure of consumption for vegetal products in Bangladesh is unique because of the considerable weight of rice (between 75 and 67% depending on the year) that is characterized by relatively "stable" consumption with a coefficient of variation of only 4%. Wheat that had important shares of total consumption between 1973 and 1999 then these shares were decreased on the last few years.



**Figure 24: Evolution of shares of different vegetal products in vegetal consumption for Bangladesh**

Source: Calculation from FAOSTAT

Concerning the animal products, like Pakistan and India, milk is still the overwhelmingly dominant product but with a significant decrease between 1965 and 1972; decrease to which one can question the reality of the phenomenon or effect of a statistical bias. Despite this, this product has a coefficient of variation much lower than those of all other products (ranging from 17 to 72%).



**Figure 25: Evolution of shares of different products in animal consumption for Bangladesh**  
Source: Calculation from FAOSTAT

## 4.2. Methodology used for food demand estimations

### 4.2.1. The LA/AIDS approach

The Almost Ideal Demand System (AIDS) was proposed by Deaton et al. (1980a; 1980b), which has considerable advantages over all other models. We used the linear approximation version of the AIDS model called LA/AIDS employed by Alderman (1988). The AIDS Model has become the model of choice for many applied demand analysts. The model is grounded in a well-structured analytical framework, accommodates certain types of aggregation, is apparently easy to estimate, and permits testing of the standard restrictions of the classical demand theory.

The AIDS model is based on a particular form of the cost function (or expense) belonging to the class "Price Independent Generalized Logarithm" (see Holt et al., 2009).

This function is written as:

$$\ln C(p, U) = 1 - U \ln a(p) + U \ln b(p) \quad (1)$$

Where  $p$  is the vector of prices of the  $n$  products and  $U$  denotes the utility index. This index is comprised between 0 and 1, 0 corresponding to subsistence and 1 to bliss.

The function  $a(p)$  and  $b(p)$  are positive linearly homogeneous functions defined by:

$$\ln a p = \alpha_0 + \sum_k \alpha_k \ln p_k + \frac{1}{2} \sum_k \sum_j \gamma_{kj}^* \ln p_k \ln p_j \quad (2)$$

And

$$\ln b p = \ln a p + \beta_0 \sum_k p_k^{\beta_k} \quad (3)$$

The share expenditure is defined by:

**Equation 4: Definition of expenditure share for each product**

$$s_i = \frac{p_i x_i}{M} \quad (4)$$

Where  $p_i$  is the price of  $i$ th good,  $x_i$  is the amount consumed of  $i$ th good and  $M$  is total expenditure of the  $n$  goods.

Using the Sheppard lemma, Deaton et al. (1980a; 1980b) demonstrated that the share equation for utility maximizing agents is:

$$s_i = \partial \log c p \quad \partial \log p_i \quad 5$$

That can be written as

**Equation 5: Estimated equation for share of each product**

$$s_i = \alpha_i + \sum_{j=1}^n \gamma_{ij} \ln p_j + \beta_i \ln \frac{M}{P} \quad \text{where } i, j = 1, 2, \dots, n \quad (6)$$

Where  $P$ , in the standard method, is a price index defined by

$$\ln P = \alpha_0 + \sum_{k=1}^n \alpha_k \ln p_k + \frac{1}{2} \sum_{k=1}^n \sum_{j=1}^n \gamma_{kj} \ln p_k \ln p_j \quad (7)$$

With

$$\gamma_{ij} = \frac{1}{2} \gamma_{ij}^* + \gamma_{ji}^* \quad (8)$$

Linear homogeneity of cost function, symmetry of the second-order derivatives, and adding up across the share equations implies the following set of restrictions:

**Equation 6: Relations between coefficients corresponding to homogeneity and symmetry conditions**

$$\alpha_i = 1, \quad \gamma_{ij} = \gamma_{ji} = 0, \quad \beta_i = 0, \quad \gamma_{ij} = \gamma_{ji} \quad (9)$$

In the original form, we can see that the equations relative to shares (6) is not linear in coefficients when P is replaced by its expression in (7). This fact induces some complications for estimation of parameters with standard software (such as GRETLM that we use for this work) and so for elasticities calculation. So we used, as it is classical for empirical research, the linear version (LA/AIDS) of the AIDS approach.

In this version the price index is approximated by the linear function:

**Equation 7: Functional form of the linearized price**

$$\ln P = \sum_i s_i \ln p_i \quad (10)$$

And the elasticities are calculated by the following expressions:

- 1) for the Marshallian (or uncompensated) elasticity of product i consumption relatively to price of product j:

**Equation 8: Formula for calculation of Marshallian elasticities**

$$\text{Marshallian elasticity} = E^M = -\delta_{ij} + \frac{\gamma_{ij}}{s_i} - \beta_i \frac{s_j}{s_i} \quad (11)$$

Where  $\delta_{ij}$  is the Kronecker delta term (that is 1 when  $i = j$  or 0 when  $i \neq j$ )

- 2) for the expenditure (income) elasticity of product i consumption

### Equation 9: Formula for calculation of Income elasticities

$$\text{Income elasticity} = E^R = 1 + \frac{\beta_i}{s_i} \quad (12)$$

3) For the Hicksian (or compensated) price elasticities

### Equation 10: Formula for calculation of Hicksian elasticities

$$\text{Hicksian elasticity} \quad E^H = E^M + (E^R s_i) \quad (13)$$

The data used in the estimates are essentially those currently available in the FAOSTAT database. Regarding the food taken into account, we selected seven product families, including three individual products (rice, wheat and corn), two products together (millet/sorghum) and three families of products (pulses, sugar and sweeteners, vegetal oils). Annual statistics for human consumption are available for all categories of products and for each country from 1966 to 2007. Concerning prices the database provides only price "producer" for rice, wheat, millet/sorghum, sugar cane, and pulses. We chose the latter price as an indicator of the average price of all the family "pulses". For sugar, as there is no listing on the market price, we selected the price of sugarcane divided by 0.14 (this number corresponding to the average yield of 14% of sugar cane in sugar). For the category millet/sorghum<sup>48</sup>, price was taken as the average price of each product weighted by the respective share of consumption of these products in total consumption of both products.

It is important to notice that due to the linearity in prices of the share equations defined in equation (6), the fact to use producer prices instead of consumer prices has no influence on prices and expenditures elasticities as far as those two set of prices evolve in parallel. This is an

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<sup>48</sup> For sugar, producer price was not available in FAOSTAT so we selected the price of sugarcane divided by 0.08 (the average yield of 8% sugar in sugar cane according to Pakistan sugar mills association). For vegetal oils, FAOSTAT provides no price. Given the growing importance of palm oil, price for this product was calculated, based on FAOSTAT data of foreign trade, the unit values of imports (imports in value divided by imports in quantity). Where possible, we performed the same calculations for imports of soybean and rapeseed oils. These values are only available for some years, so we calculated regression equations of the price for each of these oils based on that of palm oil and supplemented missing price data with the equations. We calculated the weighted average unit values of these three products and then converted in local currency. For the category millet/sorghum, price was taken as the average price of each product weighted by the respective share of consumption of these products in total consumption of both products.

important not demonstrated hypothesis<sup>49</sup>, but it is necessary to perform estimations in time series. The application of AIDS model with seven product families involves estimating for each country a system of six equations (in each case wheat has been removed from the system) representing the shares of expenditure. FIML (Full Information Maximum Likelihood) method (in this case equivalent to the method SUR/I (Seemingly Unrelated Regression Iterative)) ensures that the coefficients of the equations are independent of the equation which is not taken into account. The coefficients of this excluded equation are estimated by taking into account the fact that the sum of the share of expenditure for all the products is equal to one.

In practice taking into account possible economic events unrelated to changes in prices and incomes, and even the presence of some unreliable data (or outliers), it is conventional to introduce some "dummy variables" that are intended to counteract these problems. That's what we did for each country. However, despite the presence of these variables, the mainstreaming of seven product families for India and Bangladesh led to non-significant results (in statistical terms), or inconsistent in terms of coefficients. For India and Bangladesh six families (rice, wheat, corn, millet/sorghum, sugar and vegetal oils) have been taken in account but pulses were not introduced. We conclude that for these two countries we do not have pertinent data for these kinds of estimations. Either the prices used for pulses family is not significant for consumers, or the demand for pulses is largely dependent on pulses imports at prices which are different from local. For India (and Bangladesh) we can observe that in 2007 only 25% (5%) of total correspond to pulses, 15% (41%) to peas and 60% (52%) to a category "other pulses", the nature and prices of which are not known. The income per capita has no significant influence on pulses demand. So we concluded that for pulses in India and Bangladesh income and prices elasticities were equal to zero.

#### **4.2.2. Interpretation and uses of the lagged variables**

In general, changes in price or income do not influence food market immediately and completely in the year in which it took place. In fact the impact on consumption of each product is felt over several periods and depends on the situation during the previous period. To model this, we introduced the lagged value of the share of expenditure in the second member of the various expenditure share equations.

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<sup>49</sup> However where data is available, we can observe a high correlation coefficient between retail and producer prices, and graphically simultaneous evolution, mainly for crops but also to some extent for sugar and vegetal oils.

A simplified equation is:

$$s_i t = g_0 + a_i s_i t - 1 + c_i * \ln p_i t + d_i * \ln M t / P t \quad 14$$

The parameter  $a_i$  measures the importance of the "memory" effect.

In term of variation between year t and year t-1, one can write:

$$\Delta s_i t = a_i * \Delta s_i t - 1 + c_i * \Delta \ln p_i t + d_i * \Delta \ln \frac{M t}{P t} \quad 15$$

Let's suppose that 1) during consecutive n years (from t-n to t), corrected expenditure price index  $M(t)/P(t)$  does not change (hence  $\Delta \ln (M(t)/P(t)) = 0$ ) and 2) the price changes with same percentage x each year (hence  $\Delta \log (p_i(t)) = x$ ). One can show:

$$\Delta s_i t = a_i^n \Delta s_i t - 1 + c_i * (1 + a_i + a_i^2 + \dots) * x \quad 16$$

That can be written as:

$$\Delta s_i t = a_i^n \Delta s_i t - 1 + c_i * (1 - a_i^n) / (1 - a_i) * x \quad (17)$$

If  $a_i$  is inferior to 1 (and very small), then the term  $a_i^n$  become negligible and variation of expenditure share (at constant income) is equal to  $c_i * x$  multiplied by a specific coefficient  $k = (1 - a_i^n) / (1 - a_i)$  that permits to pass from short term elasticity  $E^{ST}$  to long term elasticity  $E^{LT}$ .

Generally (for the Hicksian, Marshallian and income elasticity) one can write:

$$E_{ij}^{LT} = k E_{ij}^{ST} \quad (18)$$

In the "normal case" ( $|a_i| < 1$ ) long-run elasticities have the same sign as the short-term elasticities and are greater in absolute value when  $a_i$  is positive.

From our elasticities calculations, it is important to draw some policy implications concerning the possibility to ameliorate the nutritional intake of population more specifically in terms of calories and proteins.

### 4.2.3. The nutrient elasticities

From the values of calculated elasticities for the different vegetal products it is possible to calculate the different elasticities for protein and caloric demand.

The vegetal protein (respectively caloric) intake/capita/day can be written:

$$Q = q_i * x_i + Q_0 \quad 19$$

Where  $q_i$  is the content of product  $i$  in considered nutrient (in gram of protein or calories per gram of product),  $x_i$  is the amount of product  $i$  consumed per capita and per day and  $Q_0$  is the amount of protein (respectively kilocalories) given by other vegetal foods. From this equation we have:

$$\frac{\partial Q}{\partial \ln p_i} = Q * \frac{\partial \ln Q}{\partial \ln p_i} = q_i * x_i * \frac{\partial \ln x_i}{\partial \ln p_i} \quad 20$$

More generally, with 2 nutrients (N) corresponding to protein or calorie:

$$E_i^N = \frac{\partial \ln Q}{\partial \ln p_i} = q_i * x_i * Q * \frac{\partial \ln x_i}{\partial \ln p_i} \quad 21$$

With  $r_i = q_i * x_i / Q$  is the share of total proteins (respectively calories) given by product  $i$ . We have

**Equation 11: Formula for calculation of nutrient Hicksian and Marshallian elasticities**

$$E_j^N = r_i * E_{ij} \quad 22$$

$E_{ij}$  is the Hicksian or Marshallian elasticity of  $i$ th product relative to price of  $j$ th product. The same calculations can be made for income elasticities:

**Equation 12: Formula for calculation of nutrient Income elasticities**

$$ER_i^N = r_i * E_i^R \quad 23$$

$E_i^R$  is the income elasticity of product  $i$ .



It is supposed like other econometric studies for estimating the function of demand that during the period in which econometric estimation is done 1) implemented Public food policies are (nearly) constant and have not changed significantly 2) food preferences and tastes of “average” consumer are nearly constant 3) evolution of forms of food distribution (local market, traditional shops, supermarkets, etc..) had no significant influence on evolution of consumers buying 4) consumption of other products (not taken here) does not have interaction with products taken in account here 5) distribution between rich and poor people has not been significantly changed during time period taken and so the “average” consumer kept the same characteristics. These assumptions were not probably observed in reality, but are necessary to make econometric estimations. These assumption simplified reality but in the extension of this work, it would be possible to introduce other variable as function of data availability.

The calculations of food matrixes elasticities are an important challenge for economical simulations as in present scientific literature there is no standard data available or they are old or not clearly documented for Pakistan, India and Bangladesh. These matrixes are necessary, in association with supply and feed demand elasticities, to calculate, for each country, what could be new market equilibrium in response to some exogenous modifications such as national policy interventions, international prices evolution and exchange rates modifications, human and animal population increases. A major problem in econometric research concerning less-developed countries is often the lack of reliable data. In particular, time series analysis requires consistent data at a reasonable time span, which often is not available.

## **4.3. Analysis of main results for vegetal foods**

### **4.3.1. General results**

The different results of estimations for the three counties are indicated on tables 22 to 30.

Table 22 shows the coefficients of the six (or five) equations of the AIDS model for Pakistan, India and Bangladesh respectively. We also introduced lagged variable to correct the autocorrelations between years. The significance of the different parameters at the probability levels of 10%, 5% and 1% are indicated on this table by one star (\*), two stars (\*\*) and three stars (\*\*\*) respectively.

**Table 22: Coefficient of the different vegetal demand equations**

	Rice			Maize			Millet/Sorghum			Sugar			Vegetal oils			Dry bean		
	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh
constant	0.46*** (-0.18)	0.97*** (-0.33)	1.08** (-0.42)	0.08 (-0.07)	-0.02 (-0.07)	0.01 (-0.03)	0.29*** (0.06)	-0.15 (-0.21)	0.02 (-0.01)	-0.44* (0.25)	0.54*** (-0.18)	0.06 (-0.15)	-1.2*** (-0.30)	0.18 (-0.14)	-0.11 (-0.2)	0.58*** (-0.18)		
Rice	0.09*** (-0.02)	0.26*** (-0.02)	0.11*** (-0.02)	-0.007 (-0.005)	-0.005 (-0.003)	-0.001 (-0.002)	-0.001 (0.004)	-0.008 (-0.01)	-0.001* (-0.001)	0.007 (-0.01)	-0.05*** (-0.009)	-0.02*** (-0.008)	-0.01 (-0.01)	-0.05*** (-0.007)	-0.02** (-0.01)	-0.007 (-0.01)		
Maize	-0.008 (-0.006)	-0.06** (-0.03)	-0.001 (-0.002)	0.01*** (-0.005)	0.01** (-0.005)	0.0002 (-0.001)	-0.003 (-0.002)	-0.02* (-0.01)	0.0004 (-0.0003)	-0.0003 (-0.01)	-0.01 (-0.01)	-0.0003 (-0.002)	-0.004 (-0.002)	-0.001 (-0.01)	-0.00006 (-0.001)	-0.008 (-0.006)		
Millet/Sorghum	-0.001 (-0.004)	-0.02 (-0.01)	-0.002* (-0.001)	-0.003 (-0.002)	-0.001 (-0.002)	0.0005 (-0.0003)	0.01*** (-0.002)	0.05*** (-0.008)	-0.0007 (-0.001)	0.01** (-0.003)	0.003 (-0.007)	(-0.001* (-0.001)	0.001 (-0.003)	-0.01* (-0.005)	0.0001 (-0.0004)	-0.01** (-0.004)		
Sugar	0.007 (-0.01)	-0.06*** (-0.01)	-0.02*** (-0.008)	-0.0003 (-0.006)	-0.008** (-0.003)	-0.0003 (-0.002)	0.01** (-0.004)	-0.008 (-0.008)	-0.001* (-0.001)	0.04*** (-0.02)	0.10*** (-0.007)	0.04*** (-0.007)	-0.06*** (-0.01)	-0.01** (-0.005)	-0.0007 (-0.005)	0.001 (-0.01)		
Vegetal oils	-0.01 (-0.01)	-0.04*** (-0.01)	-0.02** (-0.009)	-0.004 (-0.003)	-0.0004 (-0.002)	-0.00006 (-0.001)	0.001 (0.003)	-0.0001 (-0.007)	0.0002 (-0.0005)	-0.06*** (-0.01)	-0.02*** (-0.007)	-0.0007 (-0.004)	0.10*** (-0.01)	0.08*** (-0.005)	0.02*** (-0.006)	0.002 (-0.007)		
Wheat	-0.07 (-0.01)	-0.08*** (-0.03)	-0.06*** (-0.07)	0.01 (-0.007)	-0.005 (-0.005)	0.0005 (-0.002)	-0.01** (-0.004)	-0.04*** (-0.02)	0.003* (-0.002)	-0.01 (-0.01)	-0.03* (-0.01)	-0.02** (-0.007)	-0.02** (-0.01)	0.014 (-0.01)	0.001 (-0.007)	-0.03*** (-0.01)		
Dry bean	-0.007 (-0.01)			-0.01 (-0.006)			-0.009** (-0.004)			0.001 (-0.01)			0.001 (-0.007)			0.05*** (-0.01)		
Lag (1)	0.37*** (-0.07)	-0.1 (-0.06)	0.04 (-0.10)	0.39*** (-0.12)	-0.06 (-0.15)	1.24*** (-0.07)	0.15* (0.08)	0.05 (-0.07)	0.56*** (-0.14)	0.24*** (-0.08)	-0.15*** (-0.05)	0.50*** (-0.08)	0.02 (-0.007)	0.09** (-0.038)	0.19* (-0.11)	0.2** (-0.07)		
Log (expenditure)	-0.08 (-0.03)	-0.08 (-0.06)	-0.04 (-0.07)	-0.01 (-0.01)	0.01 (-0.01)	-0.002 (-0.007)	-0.06*** (0.01)	0.05 (-0.03)	-0.003 (-0.002)	0.13** (-0.05)	-0.07** (-0.03)	-0.01 (-0.03)	0.25*** (-0.06)	-0.04 (-0.02)	0.02 (-0.03)	-0.11*** (-0.03)		
R <sup>2</sup>	0.87	0.93	0.7	0.73	0.89	0.93	0.85	0.88	0.6	0.66	0.92	0.7	0.85	0.933015	0.74	0.86		
R <sup>2</sup> adjust	0.83	0.9	0.6	0.65	0.85	0.91	0.8	0.83	0.5	0.56	0.89	0.58	0.8	0.909092	0.66	0.81		
DW	1.117	1.275	1.72	1.97	1.434	1.49	0.706	1.406	2.2	1.045	1.036	1.7	0.812	0.767	2.04	1.608		

Source: Own calculation, (\*), (\*\*), and (\*\*\*) represent level of significance at 10%, 5% and 1%.

The  $R^2$  values for all products of Pakistan are more than 0.70 except for sugar (0.66) while for all products of India,  $R^2$  values are higher than 0.80. The  $R^2$  values for all products of Bangladesh are higher than 0.70 except of millet/sorghum (0.60). The  $R^2$  adjusted values for all products of Pakistan are more than 0.70 except of corn (0.65) and sugar (0.56) while for all products of India,  $R^2$  adjusted values are higher than 0.80. The  $R^2$  adjusted values for all products of Bangladesh are higher than 0.70 except for rice (0.6), millet/sorghum (0.5) and sugar (0.58). Considering the  $R^2$  adjusted values and significance of main coefficients, our results are satisfactory. Concerning Durbin-Watson, values are generally near to 2 and always superior to 1.1 except for millet/sorghum for Pakistan as well as vegetal oil for Pakistan and India.

The major number of coefficients of all crops of all equations is significant that tends to prove that our hypothesis proposed is correct. It proves that prices and expenditure (income) influence on consumption of food products (either vegetal or animal products). For the coefficients of the own price value in the equation of each vegetal product (in fact of each  $s_i$  which is the part of total expenditure due to this product) the sign is always negative (in accordance with theory) and the value is very generally significant at 5% probability. Many coefficients corresponding to cross effects are also significant.

Table 23 represents Hicksian (compensated) short term elasticities for seven products (rice, corn, millet/sorghum, sugar, vegetal oil, wheat and pulses) of India, Pakistan and Bangladesh respectively. For India concerning direct price elasticities, we observe that in absolute term, the value is the largest for sugar (-0.16), millet/sorghum (-0.15), vegetal oil (-0.11), corn (-0.10), wheat (-0.08) and rice (-0.01), while for Pakistan, the largest value is for sugar (-0.57) then for corn (-0.46), millet/sorghum (-0.39), pulses (-0.35), vegetal oil (-0.32) wheat (-0.30) and rice (-0.04). For Bangladesh, the largest value is for millet/sorghum (-1.35) then corn (-0.94), vegetal oil (-0.40), sugar (-0.15), wheat (-0.11) and rice (-0.06).

**Table 23: Matrix of Hicksian short term direct and cross elasticities for vegetal products**

		Rice	Pulses	Corn	Millet/Sorghum	Sugar	Vegetal oil	Wheat
Rice	Pakistan	-0.04	0.03	-0.05	0.01	0.22	0.14	-0.31
	India	-0.01		0	0.03	0.02	-0.01	-0.03
	Bangladesh	-0.06		0	0	0.02	0.01	0.02
Pulses	Pakistan	0.03	-0.35	-0.05	-0.07	0.16	0.25	0.05
	India							
	Bangladesh							
Maize	Pakistan	-0.21	-0.22	-0.46	-0.09	0.14	0.05	0.79
	India	0.05		-0.1	0.05	-0.19	-0.08	0.27
	Bangladesh	0.46		-0.94	0.15	0.07	0.02	0.24
Millet/Sorghum	Pakistan	0.07	-0.4	-0.12	-0.39	0.65	0.3	-0.12
	India	0.19		0.02	-0.16	0.1	-0.02	-0.13
	Bangladesh	-0.01		0.25	-1.35	-0.55	0.11	1.55
Sugar	Pakistan	0.15	0.1	0.02	0.08	-0.57	-0.2	0.41
	India	0.05		-0.03	0.05	-0.16	0.01	0.09
	Bangladesh	0.34		0	-0.02	-0.15	0.03	-0.21
Vegetal oil	Pakistan	0.06	0.11	0.01	0.02	-0.13	-0.32	0.25
	India	-0.04		-0.02	-0.01	0.01	-0.11	0.16
	Bangladesh	0.26		0	0	0.04	-0.4	0.1
Wheat	Pakistan	-0.08	0.01	0.05	-0.01	0.17	0.15	-0.3
	India	-0.07		0.03	-0.04	0.06	0.09	-0.08
	Bangladesh	0.16		0.01	0.04	-0.14	0.05	-0.11

Source: Own calculation

From Hicksian elasticities matrix it is possible to calculate the Allen substitution matrix which is a symmetric matrix and indicates the intensity of relations between two products (table 24). When the sign is positive, products are substitutes and vice versa. When two products are complement then price decrease of one product increases other product consumption. A **substitute good**, in contrast to a complementary good, is a good with a positive cross elasticity of demand. This means a product's demand is increased when the price of another product is increased.

**Table 24: Matrix of Allen substitution elasticities**

		Rice	Pulses	Maize	Millet/Sorghum	Sugar	Vegetal oil	Wheat
Rice	Pakistan	-0.43	0.27	-2.11	0.7	1.45	0.62	-0.82
	India	-0.02		0.12	0.44	0.11	-0.08	-0.15
	Bangladesh	-0.07		0.56	-0.01	0.42	0.31	0.19
Pulses	Pakistan	0.27	-3.56	-2.22	-4.06	1.04	1.08	0.12
	India							
	Bangladesh							
Maize	Pakistan	-2.11	-2.22	-18.76	-4.78	0.91	0.22	2.08
	India	0.12		-4.38	0.73	-1.29	-0.66	1.33
	Bangladesh	0.56		-291.35	78.61	1.2	0.56	2.8
Millet/Sorghum	Pakistan	0.7	-4.06	-4.78	-20.96	4.22	1.3	-0.31
	India	0.44		0.73	-2.4	0.7	-0.19	-0.64
	Bangladesh	-0.01		78.61	-701.09	-9.76	2.53	18.5
Sugar	Pakistan	1.45	1.04	0.91	4.22	-3.68	-0.86	1.1
	India	0.11		-1.29	0.7	-1.09	0.08	0.43
	Bangladesh	0.42		1.2	-9.76	-2.6	0.69	-2.51
Vegetal oil	Pakistan	0.62	1.08	0.22	1.3	-0.86	-1.41	0.68
	India	-0.08		-0.66	-0.19	0.08	-0.9	0.77
	Bangladesh	0.31		0.56	2.53	0.69	-9.42	1.22
Wheat	Pakistan	-0.82	0.12	2.08	-0.31	1.1	0.68	-0.79
	India	-0.15		1.33	-0.64	0.43	0.77	-0.37
	Bangladesh	0.19		2.8	18.5	-2.51	1.22	-1.35

Source: Own calculation

Table 25 represents different relationships between vegetal products studied here. Wheat is complement of rice for Pakistan and India but substitute for Bangladesh. Corn and vegetal oils are substitutes of wheat for three countries. It appears that, for rice, there is no significant relation for India and Bangladesh, but for Pakistan, rice is a substitute for millet/sorghum and complement for corn, sugar, vegetal oil and pulses. For all countries there is no relation between rice and wheat. Corn is always a complement of millet/sorghum and wheat and a supplement of sugar. Vegetal oils are always supplements of wheat.

**Table 25: Relationships between different vegetal products**

		Rice	Pulses	Maize	Millet/Sorghum	Sugar	Vegetal oil	Wheat
Rice	Pakistan		S	C	S	S	S	C
	India			S	S	S	C	C
	Bangladesh			S	C	S	S	S
Pulses	Pakistan	S		C	C	S	S	S
	India							
	Bangladesh							
Maize	Pakistan	C	C		C	S	S	S
	India	S			S	C	C	S
	Bangladesh	S			S	S	S	S
Millet/Sorghum	Pakistan	S	C	C		S	S	C
	India	S		S		S	C	C
	Bangladesh	C		S		C	S	S
Sugar	Pakistan	C	S	S	S		C	S
	India	S		C	S		S	S
	Bangladesh	S		S	C		S	C
Vegetal oil	Pakistan	S	S	S	S	C		S
	India	C		C	C	S		S
	Bangladesh	S		S	S	S		S
Wheat	Pakistan	C	S	S	C	S	S	
	India	C		S	C	S	S	
	Bangladesh	S		S	S	C	S	

Source: Own calculation

The coefficients of lagged expenditure share appearing in table 22 are generally significant and important, which indicated high “memory effects”, that is the food consumption in year  $t$  is influenced by consumption during the preceding years. In all cases this coefficient is lower than 1 except for corn in Bangladesh. This fact indicates that the system is “unstable” and demand can oscillate during years. This problem has not been corrected due to the fact that in Bangladesh corn is a very small non-traditional product, but in this case long term elasticities cannot be calculated. When the coefficient of lagged variable in share equation is positive, the long term elasticities are greater than short term elasticities (this is generally the case and multiplicative coefficient can be important. For India, coefficients are generally near 1. In some cases coefficients are low, which indicate a “no memory situation”, consumption in year  $t$  is weakly influenced by prices and consumption in preceding years.

Long term Hicksian demand elasticities of India, Pakistan and Bangladesh are represented by table 26.



**Table 26: Long term Hicksian elasticities**

		Rice	Pulses	Maize	Millet/Sorghum	Sugar	Vegetal oil	Wheat
Rice	Pakistan	-0.07	0.04	-0.08	0.02	0.35	0.23	-0.49
	India	-0.01		0	0.03	0.02	-0.01	-0.03
	Bangladesh	-0.06		0	0	0.02	0.01	0.02
Pulses	Pakistan	0.03	-0.43	-0.07	-0.09	0.2	0.3	0.06
	India							
	Bangladesh							
Maize	Pakistan	-0.35	-0.36	-0.74	-0.14	0.23	0.08	1.28
	India	0.05		-0.09	0.05	-0.18	-0.07	0.25
	Bangladesh	-1.89		3.87	-0.63	-0.28	-0.1	-0.97
Millet/Sorghum	Pakistan	0.08	-0.47	-0.14	-0.46	0.77	0.35	-0.14
	India	0.2		0.02	-0.17	0.11	-0.02	-0.14
	Bangladesh	-0.02		0.59	-3.14	-1.28	0.25	3.6
Sugar	Pakistan	0.19	0.13	0.03	0.1	-0.74	-0.26	0.54
	India	0.04		-0.03	0.04	-0.15	0.01	0.08
	Bangladesh	0.69		0.01	-0.04	-0.29	0.06	-0.42
Vegetal oil	Pakistan	0.06	0.11	0.01	0.02	-0.14	-0.33	0.26
	India	-0.04		-0.02	-0.01	0.01	-0.12	0.18
	Bangladesh	0.31		0	0.01	0.05	-0.5	0.13
Wheat	Pakistan	-0.04	0	0.02	0	0.07	0.07	-0.13
	India	-0.08		0.04	-0.05	0.07	0.11	-0.09
	Bangladesh	0.04		0	0.01	-0.04	0.01	-0.03

Source: Own calculation

For India, the value in absolute term is the largest for millet/sorghum (-0.17) then for sugar (-0.15), vegetal oil (-0.12), corn (-0.09), wheat (-0.09) and rice (-0.01), while for Pakistan, the largest value is for sugar (-0.74) then for corn (-0.73), millet/sorghum (-0.46), pulses (-0.43), vegetal oil (-0.33) wheat (-0.13) and rice (-0.07). For Bangladesh, the largest value is for corn (3.86) then for millet/sorghum (-3.14), sugar (-0.74), vegetal oil (-0.33), wheat (-0.13) and rice (-0.06).

The expenditure elasticities are indicated on table 27. They are generally positive (normal goods) and the higher values are for sugar in Pakistan (2.11), for wheat in India (2.15) and Bangladesh (1.48). These clearly indicate that when income (expenses for vegetal food products) increase Indian and Bangladeshi people buy firstly more wheat (which is an appreciated cereal allowing a diversification from rice) then more vegetal oils, sugar and rice, but less subsistence food such as corn and millet/sorghum. Millet/sorghum and pulses are “inferior good” in Pakistan (elasticities -2.09 and -0.15). This can be explained by the fact that in these countries, more population live in rural areas and when expenditure increase then rural people preferred to buy animal products as protein source. While all the vegetal products are normal goods in India.

Elasticities are important parameters widely used in empirical works with agricultural models. It would be interesting to compare our results with the values calculated by other authors. In fact, in general literature, all results available are calculated globally for vegetal and animal products (sometimes for non-food products) so the comparisons of values for price (the share for each product is very different) and income (in our estimation it refers to only vegetal food expense and to whole expense in other studies) elasticities are not pertinent.

The table 27 also expresses the Marshallian elasticities for seven (or six) products (rice, corn, millet/sorghum, sugar, vegetal oil, wheat and pulses) of India, Pakistan and Bangladesh respectively. Confirming to what was expected; the signs of direct price elasticities are always negative. The mean shares are also indicated on table 28. Concerning the Marshallian own price demand elasticities in India, we observe that the absolute value is the highest for wheat (0.52) followed by rice (0.32), vegetal oil (0.25), sugar (0.24), millet/sorghum (0.19) and corn (0.11). This indicates that, when the expense for vegetal food products is constant, people react highly and quickly to price changes for these two basis food (wheat and rice). Indian consumer is less reactive to price of millet/sorghum and corn which are more consumed on farms. For Pakistan, the highest absolute value is for sugar (0.85), vegetal oil (0.80), wheat (0.55), corn (0.47), then millet/sorghum (0.35), pulses (0.33) and rice (0.10). These figures show that Pakistan consumers react highly to price changes mainly for wheat, vegetal oils and rice, but also for other products. For Bangladesh, the highest absolute value is for millet/sorghum (1.35), corn (0.94), rice (0.82), vegetal oil (0.47), pulses (0.33), wheat (0.24) and sugar (0.19). So our results are different for each country but rice, corn and wheat are relatively price inelastic products in all countries (level inferior to 1).

All vegetal products taken here are normal goods except of vegetal oils for three countries, wheat for India and Bangladesh, sugar and millet in Pakistan because they are expenditure elastic ( $>1$ ). It means when income rises, Pakistani consumer buy more vegetal oils and sugar. But all products are relatively price inelastic ( $<1$ ) except for millet/sorghum. For staple food like wheat in Pakistan and India, consumer react more to price as compared to other vegetal products like rice and maize in Bangladesh.

**Table 27: Expenditure and Marshallian short term elasticities**

		Expenditure share	Expenditure elasticity	Rice	Pulses	Maize	Millet/Sorghum	Sugar	Vegetal oil	Wheat
Rice	Pakistan	0.15	0.163	-0.06	0.01	-0.06	0.01	0.2	0.1	-0.37
	India	0.5	0.72	-0.32		-0.01	-0.02	-0.09	-0.1	-0.18
	Bangladesh	0.83	0.94	-0.82		0	0	-0.03	-0.03	-0.06
Pulses	Pakistan	0.1	-0.15	0.04	-0.33	-0.05	-0.07	0.18	0.28	0.1
	India									
	Bangladesh									
Corn	Pakistan	0.04	0.63	-0.28	-0.28	-0.47	-0.1	0.04	-0.09	0.55
	India	0.03	0.28	-0.07		-0.11	0.03	-0.24	-0.11	0.21
	Bangladesh	0.003	0.40	0.14		-0.94	0.15	0.05	0.01	0.2
Millet/Sorghum	Pakistan	0.02	-2.08	0.28	-0.19	-0.07	-0.35	0.97	0.77	0.67
	India	0.08	0.42	0.01		0.01	-0.19	0.04	-0.07	-0.22
	Bangladesh	0.002	-0.91	0.73		0.26	-1.35	-0.5	0.15	1.63
Sugar	Pakistan	0.1	2.11	-0.04	-0.08	-0.02	0.04	-0.85	-0.61	-0.28
	India	0.07	0.51	-0.17		-0.04	0.01	-0.24	-0.05	-0.02
	Bangladesh	0.03	0.82	-0.33		0	-0.02	-0.19	-0.01	-0.28
Vegetal oil	Pakistan	0.13	1.83	-0.15	-0.1	-0.05	-0.02	-0.46	-0.8	-0.54
	India	0.1	1.11	-0.52		-0.04	-0.09	-0.15	-0.24	-0.07
	Bangladesh	0.04	1.48	-0.94		0	0	-0.04	-0.47	-0.02
Wheat	Pakistan	0.5	0.68	-0.15	-0.06	0.03	-0.02	0.06	0	-0.55
	India	0.24	2.14	-1		-0.02	-0.19	-0.26	-0.16	-0.52
	Bangladesh	0.09	1.48	-1.05		0	0.03	-0.23	-0.01	-0.24

Source: Own calculation

The seven vegetal products taken in account in our analysis represent important share of total protein and caloric intakes in the three countries (table 28). Table 28 represents that Wheat and rice are the major sources of protein and calories in these countries among all products analyzed here.

**Table 28: Protein and calorie intakes in 2007 for Pakistan, India and Bangladesh**

	PROTEINS								
	PAKISTAN			INDIA			BANGLADESH		
	g/capita/day	repartition	repartition	g/capita/day	repartition	repartition	g/capita/day	repartition	repartition
Total proteins	59.2	100%		57.4	100%		50.5	100%	
Animal products	23.5	40%		10.2	18%		7.8	15%	
Vegetal products	35.7	60%	100%	47.2	82%	100%	47.2	94%	100%
Seven main vegetal products	31.9	54%	90%	40.6	71%	86%	38.2	76%	81%
Wheat	22		62%	15		32%	3.7		7.8%
Rice (Milled Equivalent)	2.8		8%	13.2		28%	29.9		63%
Maize	1.8		5%	1.2		2.5%	1.7		3.6%
Millet/Sorghum	0.4		1%	3.8		8.1%	0		0%
Sugar (Total)	0.1		.3%	0.1		.2%	0.1		.2%
Pulses (Total)	4.7		13%	7.3		15%	2.8		6%
Vegetal Oils (Total)	0.1		.3%	0		0%	0		0%
	CALORIES								
	PAKISTAN			INDIA			BANGLADESH		
	kcal/capita/d	repartition	repartition	kcal/capita/d	repartition	repartition	kcal/capita/d	repartition	repartition
Total calories	2293	100%		2352	1		2281	1	
Animal products	468	20%		197	0.084		83	0.964	
Vegetal products	1825	80%	100%	2155	0.916	100%	2198	0.036	100%
Seven main vegetal products	1658	72%	91%	1910	0.812	89%	2055	0.901	93%
Wheat	843		46%	514		24%	126		6%
Rice (Milled Equivalent)	148		8%	703		33%	1591		7%
Maize	65		4%	47		2%	62		3%
Millet/Sorghum	15		.8%	131		6%	1		0%
Sugar (Total)	262		14%	193		9%	79		4%
Pulses (Total)	77		4.2%	122		6%	45		2%
Vegetal Oils (Total)	248		14%	200		9%	151		7%

Source: Calculation from FAOSTAT

### 4.3.2. A specific application of the estimation for years 2006-2008 in Pakistan

According to UNCTAD database, in current US dollars, world prices for main grains and oilseed products surge again in 2010 and 2011 and got their highest historical levels notably for wheat, maize and soybeans products. A number of articles analyzed the reasons of these evolutions

(Trostle, 2008; Gomez, 2008; Carrasco *et al.*, 2012; Laap, 1990). Generally, main reasons presented for the price inflation are the strong global growths in average income combined with rising population which has increased the demand for food, particularly in developing countries over the last decades. Other factors that have added to global food commodity price increase include, at a structural level, the declining value of local currency compared to US dollar, the rising energy prices, the diminution of research in agricultural field, the development of biofuels and some more short term reasons: drop of some crops productions due to climatic problems, interventions of some governments to control imports or exports, speculation on world markets. Some studies emphasize more precisely on local conditions and interrelationships between world and South-Asian markets evolution (Carrasco *et al.*, 2012; World Bank South Asian region, 2010).

The demand elasticities allow us to determine the effects of the different variables (demography, income, prices) on evolution of consumption of these products (Table 29).

The main vegetal food products prices increased rapidly during the years 2006 to 2008 which was manifested by the fact that the consumer price index (CPI) by the World Bank dataset increased during these years by 31.3%, 25.5% and 18% in Pakistan, Bangladesh and India respectively. On this period the current gross domestic product increased, in local currency unit (LCU) by 47.8% in Pakistan (12.8% in constant LCU), 37.5 in Bangladesh (15.8%in constant LCU) and 46.8% (22.5%in constant LCU) in India. Using the calculated elasticities matrices presented previously we can explain the most important evolutions of total consumption of main vegetal foods in these countries during this period (2002-2005 and 2006-2008) and to decompose them for each country in four effects; 1) the population effect, 2) the expenditure effect (more precisely the vegetal expense based on expenditure elasticities) 3) the total price effect (based on the Marshallian elasticities). As the sum by line for each product of the Marshallian elasticities is equal to the income elasticity (but with the inverse sign), the sum of these effects (income and prices) is the same if each of them is calculated with current LCU values or is deflated by the CPI.

**Table 29: Decomposition of recent demand evolution into price, income and population effects (between 2002-2005 and 2006-2008)**

		real evolution	total effect	residuel	population effect	Expenditure effect	substitution effect	Price increase effect	total priceeffect
		1		3=1-2	4	5	6	7	8=6+7
PAKISTAN	Rice	14.07%	8.2%	5.87%	5.51%	-0.73%	2.89%	0.53%	3.42%
	Pulses	5.47%	7.11%	-1.64%	5.51%	0.68%	1.42%	-0.49%	0.93%
	Sugar	6.54%	6.12%	0.42%	5.51%	-8.2%	2.87%	5.95%	8.81%
	Vegoils	15.59%	-0.44%	16.03%	5.51%	-9.46%	-3.35%	6.86%	3.51%
	Wheat	4.34%	5.48%	-1.14%	5.51%	-3.06%	0.82%	2.22%	3.04%
INDIA	Rice	6.49%	5.89%	0.59%	4.54%	9.36%	-0.16%	-7.85%	-8.01%
	Sugar	4.58%	9.67%	-5.09%	4.54%	6.62%	4.06%	-5.55%	-1.49%
	Vegoils	13.43%	9.79%	3.65%	4.54%	14.39%	2.92%	-12.07%	-9.14%
	Wheat	-1.24%	3.84%	-5.08%	4.54%	27.8%	-5.19%	-23.31%	-28.5%
BANGLADESH	Rice	2.04%	1.41%	0.63%	3.86%	6.01%	-0.23%	-8.23%	-8.46%
	Sugar	11.3%	4.3%	7.00%	3.86%	5.25%	2.38%	-7.19%	-4.81%
	Vegoils	-1.12%	-1.25%	0.13%	3.86%	9.41%	-1.63%	-12.89%	-14.51%
	Wheat	-20.92%	1.12%	-22.04%	3.86%	9.45%	0.75%	-12.95%	-12.19%

Source: Own calculation

The total price effect can be decomposed in a “substitution effect” which is obtained by multiplying the Hicksian matrix by the vector of price variations and a “price surge” effect that is equal to the difference between the total price effect and the “substitution effect”. For evaluation of the “income” effect we calculated that only a percentage of the current LCU GDP per capita increase was devoted to vegetal food expenses (56% for Pakistan, 66% for India and 82% for Bangladesh). For this calculation only relative variations of prices are necessary, but not absolute values. As model was estimated using corrected producer prices, we gave preference to this approach, after verification that the hierarchy of evolution was mainly the same for these prices in each country. We had to correct the evolution of wheat prices in Pakistan and Bangladesh where producer prices underestimated increase in retail price.

For Pakistan, we can consider that our model gives relatively good results for pulses, sugar and wheat with an unexplained factor of less than 1.7%. For rice, the price has increased two times more than price of wheat, pulse or sugar, we underestimated the observed increase in

consumption per capita. It is the same situation for vegetal oils, whose price had also much increased. We can observe generally negative effects of “income” due to the fact that during this period the expense for vegetal foods increased less than the CPI. Without this correction of “inflation illusion” we should have an income effect of 18.4% (instead of -3.1%) and a total price effect of -18.3% (instead of 3.0%) for wheat. For India and Bangladesh we have nearly good results for the main product which is rice. For these two countries, the vegetal food expenses have increased more than CPI so the income effects are always positive. For these three countries, population evolution (as well as income for India and Bangladesh) appears to be the most important and regular cause of augmentation of demand for vegetal products. From the calculated matrix of elasticities, it is possible to calculate the elasticities for two main nutrients (proteins and calories) by using equations 22 and 23 (table 30).

The result shows that these Marshallian price elasticities for each nutrient are very low. This is due to the fact that nearly all products have nearly similar composition of proteins and calories (except for sugar and oils which contains nearly no protein but are more rich in calories). So when the price of one product increase by 1%, the consumption of all products modifies but the total intake of protein and calories are not much modifies (except for sugar and oils mainly for Pakistan). For wheat we have more important effects on both nutrients due to the fact that when its price alone increases, it has an important negative effect on the apparent power of purchase and the whole consumption of vegetal food product, mainly in Pakistan and India. The expenditure elasticities are more important as an increase in income increases consumption of all products as well as the total protein and caloric intakes. A hypothetic subvention of 1% on prices for each product has a limited impact on protein and caloric intakes (colons 7 and 8 of table 30) except for wheat in Pakistan and India as well as rice in India and mainly in Bangladesh. It is then possible to calculate the subvention which is theatrically necessary to increase protein and caloric intake by respectively 1g/capita/day and 100 Kcal/capita/day





### 4.3.3. Discussion

The seven vegetal products taken in account in our analysis represent important share of total protein and caloric intakes in the three countries (table 28).

According to other studies (Mittal 2006; Kumar et al.2011; Chaterjee *et al.*2007), cereals in India are expenditure inelastic products but in our study all products are expenditure inelastic except for wheat and edible oils. Edible oils are expenditure elastic like peanut oil in other study (Pan et al. 2008). This implies that as expenditure or income level increases, the proportion of expenditure or income on wheat and edible oils is much higher than other products in our analysis. While all the products in our analysis are price inelastic showing that the demand of staple food may not be affected adversely with increase in food price inflation (Kumar et al.2011).

For Pakistan, all the products taken into analysis are price inelastic like other studies (Haq et al.2011; Bouis 1992). According to Haq et al 2011, wheat is staple food in Pakistan therefore price increase does not change much its consumption. Expenditure elasticities indicated that all products are normal goods except for pulses and millet/sorghum. Rice and wheat are expenditure inelastic that means when expenditure or income increases, consumer prefers to buy other expensive item.

Whereas in Bangladesh all the products in our analysis are expenditure inelastic except of wheat while edible oil is inferior good. But according to other studies (Huq et al.2010; Ali 2002), all cereals are expenditure inelastic except of wheat. The compensated own price elasticity indicated that all food items except for millet/sorghum are price inelastic. In Bangladesh, rice represents major part of food as staple product so here price inflation does not affect its consumption like India.

The consumption of major food has revealed a structural shift in dietary pattern due to changes in tastes, easier access, income increase, changes in relative price and urbanization pattern (Radhakrishna et al., 1992; Kumar, 1998; Murthy, 2000; *Kumar* et al., 2011; Mukherjee et al., 2011) but still cereals occupy a central position in the dietary pattern of Pakistan, India and Bangladesh (Chaterjee et al., 2007; Zaman, 2011; Mukherjee et al., 2011). Therefore animal products are also very important for providing protein and calories in these three countries (table 31).

**Table 31: Protein and caloric intakes from animal products in 2007 for Pakistan, India and Bangladesh**

	PROTEINS								
	PAKISTAN			INDIA			BANGLADESH		
	g/capita/day	repartition	repartition	g/capita/day	repartition	repartition	g/capita/day	repartition	repartition
Total proteins	59.2	100%		57.4	100%		50.5	100%	
Animal products	23.5	39.7%	100%	10.2	17.8%	100%	7.8	15.4%	100%
Vegetal products	35.7	60.3%		47.2	82.2%		47.2	93.5%	
Six main animal products	15.6	26.35%	66.38%	5.9	10.3%	57.8%	3.6	7.13%	46.15%
Eggs	0.7		2.9%	0.6		5.9%	0.4		5.12%
Milk	9.9		42.12%	3.8		37.25%	1.5		19.2%
Bovine	2.8		11.9%	0.6		5.9%	0.6		7.7%
Chicken	1.1		4.6%	0.5		4.9%	0.5		6.4%
Other meat	0.1		0.42%	0.1		0.98%	0.1		1.3%
Goat meat	100%		4.2%	0.3		2.9%	0.5		6.4%
	CALORIES								
	PAKISTAN			INDIA			BANGLADESH		
	kcal/capita/day	repartition	repartition	kcal/capita/day	repartition	repartition	kcal/capita/day	repartition	repartition
Total calories	229300%	100%		235200%	100%		228100%	100%	
Animal products	46800%	20.4%	100%	19700%	8.4%	100%	8300%	3.6%	100%
Vegetal products	182500%	79.6%		215500%	91.6%		219800%	96.4%	
Six main animal products	29400%	12.82%	62.82%	9900%	4.21%	50.25%	5300%	2.3%	63.8%
Eggs	1000%		2.13%	800%		4.06%	600%		7.2%
Milk	22100%		47.22%	7700%		39.08%	3000%		36.1%
Bovine	3800%		8.12%	600%		3.04%	600%		7.22%
Chicken	1200%		2.56%	500%		2.5%	600%		7.22%
Other meat	0%		0%	0%		0%	0%		0%
Goat meat	1300%		2.78%	300%		1.5%	500%		6.02%

**Source: Calculation from FAOSTAT**

Animal proteins are more nutritionally valued than vegetal protein (Cheeke, 1993). Milk, bovine and chicken meats are main protein and caloric resources in these countries. The consumption of livestock products have been increased in south Asia due to economic development, changes in dietary pattern, population growth rates and expanding urbanization (Chantalakhana, 1996; Rutherford, 1999; Mubyarto et al., 1973). Therefore it is also important to calculate direct and cross price demand of main animal products showed in table 31. In following chapter, the results of demand elasticities by the same method used for vegetal products are presented in detail.

## 4.4. Analysis of main results for demand of animal products

The different results of estimations for demand of animal products for the three countries are indicated on tables 32 to 37.

The coefficients of the five (or four) equations of the AIDS system for Pakistan, India and Bangladesh respectively are represented in table 32. The R<sup>2</sup> value for eggs of Pakistan is the weakest among the three countries. While R<sup>2</sup> values for all other products of three countries are more than 0.60. The R<sup>2</sup> adjusted values represent the same trend as R<sup>2</sup> values. Although for some animal products, these values are lower than 0.7 so we can consider that globally our results are satisfactory. Concerning Durbin-Watson, values are generally near to 2 and always superior to 1.1 except for other meats for Pakistan and India. So we can consider that the forms of equations with a lagged variable correct well the autocorrelations between years. The significance of the different parameters at the probability levels of 10%, 5% and 1% are indicated on this table by one star (\*), two stars (\*\*), and three stars (\*\*\*) respectively. For the coefficients of the own price value in the equation of many crop (in fact of each  $s_i$  which is the part of total expenditure due to this product) the sign is always negative (in accordance with theory) and the value is very generally significant at 5% probability. Many coefficients corresponding to cross effects are also significant.

**Table 32: Coefficients of equations of animal product demand**

	Eggs			Milk			Bovine			Chicken			Other meat		
	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh	Pakistan	India	Bangladesh
constant	0.12*** (0.04)	-0.12*** (0.04)	-0.42*** (-0.08)	-0.9*** (0.35)	1.31*** (0.12)	1.24*** (0.1)	0.41 (0.25)			0.02 (0.005)	-0.80*** (0.12)	0.20*** (0.06)	0.004*** (0.001)	0.20*** (0.02)	
Eggs	0.02*** (0.003)	0.04*** (0.004)	0.20*** (0.04)	-0.01* (0.01)	-0.03*** (0.004)	-0.09*** (0.02)	-0.01* (0.001)			0.007*** (0.002)	-0.005 (0.003)	-0.02 (0.02)	-0.0002*** (0.0002)	-0.001*** (0.001)	
Milk	-0.012* (0.01)	-0.02*** (0.004)	-0.09*** (0.02)	0.07 (0.05)	0.12*** (0.01)	0.23*** (0.02)	-0.02 (0.05)			-0.007 (0.009)	-0.06*** (0.01)	-0.07*** (0.01)	-0.0003*** (0.0001)	-0.01*** (0.02)	
Bovine	-0.01* (0.01)			-0.02 (0.05)			0.04 (0.05)			-0.03*** (0.01)			-0.0003*** (0.0009)		
Chicken	0.01*** (0.002)	-0.006 (0.0004)	-0.02 (0.03)	-0.01 (0.01)	-0.06*** (0.01)	-0.07*** (0.01)	-0.03*** (0.01)			0.03*** (0.005)	0.09*** (0.01)	0.07*** (0.03)	-0.0002*** (0.0003)	-0.01*** (0.002)	
Other meat	-0.0002*** (0.000)	-0.001*** (0.0005)		-0.0003*** (0.0001)	-0.01*** (0.003)		-0.0003*** (0.0001)			-0.0002*** (0.0003)	-0.01*** (0.001)		0.001*** (0.00005)	0.02*** (0.003)	
Goat meat	-0.001 (0.002)	-0.007*** (0.003)	-0.06*** (0.02)	-0.03* (0.02)	-0.02*** (0.01)	-0.07*** (0.009)	0.03** (0.02)			0.01* (0.004)	-0.02*** (0.003)	0.02* (0.01)	-0.0004 (0.0003)	0.004*** (0.001)	
Log (expenditure)	-0.02*** (0.01)	0.04*** (0.01)	0.22*** (0.03)	0.35*** (0.07)	-0.1*** (0.03)	-0.17*** (0.03)	-0.08 (0.05)			0.005 (0.01)	0.20*** (0.03)	-0.07*** (0.02)	-0.001*** (0.0001)	-0.04*** (0.004)	
Lag (1)	-0.31*** (0.10)	0.07 (0.08)	-0.05 (0.08)	0.26*** (0.03)	0.04 (0.04)	-0.02 (0.07)	0.05 (0.04)			0.08 (0.15)	-0.03 (0.04)	0.02 (0.08)	0.14*** (0.25)	0.01 (0.08)	
R <sup>2</sup>	0.53	0.87	0.87	0.82	0.68	0.91	0.68			0.85	0.78	0.91	0.98	0.98	
R <sup>2</sup> ajust	0.39	0.77	0.8	0.64	0.43	0.86	0.35			0.70	0.62	0.86	0.95	0.97	
DW	1.4	1.29	1.54	2.09	1.24	2.1	1.77			1.36	1.30	1.5	1.36	1.25	

Source: Own calculation

Table 33 represents Hicksian (compensated) short term elasticities for six animal products (eggs, milk, bovine meat, chicken meat, goat/sheep meat and other meat) of India, Pakistan and Bangladesh respectively. For eggs, Pakistan has the largest absolute value (-0.37) followed by India (-0.03) and Bangladesh (-0.02). For milk, Pakistan has the largest absolute value (-0.20) followed by India (-0.08) and Bangladesh (-0.02). For bovine meat, we could calculate elasticity (-0.62) only for Pakistan due to problem of data availability. For poultry meat, Bangladesh has the largest absolute value (-0.38) followed by India (0.13) and Pakistan (0.15) while elasticities for India and Pakistan have positive signs. The difference between signs of three countries showed trend during past. In Pakistan and India, poultry sector has been evolved very quickly as result of growing demand and consumption. For goat/sheep meat, Pakistan has the largest absolute value (-0.99) followed by India (-0.33) and Bangladesh (-0.22). For other meat, India has the largest absolute value (0.22) followed by Pakistan (0.01) while both has positive signs.

**Table 33: Hicksian short term elasticities for animal products**

		Eggs	Milk	Bovine	Chicken	Other meat	Goat meat
Eggs	Pakistan	-0.37	0.24	-0.23	0.3	-0.01	0.06
	India	-0.03	0.15		-0.04	-0.01	-0.08
	Bangladesh	-0.02	0.03		0.06		-0.07
Milk	Pakistan	0.01	-0.2	0.14	0.01	0	0.04
	India	0.01	-0.08		0.01	0.01	0.06
	Bangladesh	0.01	-0.02		-0.01		0.02
Bovine	Pakistan	-0.04	0.55	-0.62	-0.17	0	0.28
	India						
	Bangladesh						
Chicken	Pakistan	0.34	0.36	-1.22	0.15	-0.01	0.38
	India	-0.02	0.08		0.13	-0.07	-0.12
	Bangladesh	0.08	-0.02		-0.38		0.32
Other meat	Pakistan	-0.17	0.38	-0.11	-0.16	0.01	0.05
	India	-0.02	0.21		-0.27	0.22	-0.14
	Bangladesh						
Goat meat	Pakistan	0.02	0.33	0.54	0.1	0	-0.99
	India	-0.05	0.53		-0.12	-0.04	-0.33
	Bangladesh	-0.07	0.04		0.26		-0.22

Source: Own calculation

The matrix of Allen substitution elasticities for different products is presented in table 34.

**Table 34: Matrix of Allen substitution elasticities**

		Eggs	Milk	Bovine	Chicken	Other meat	Goat meat
Eggs	Pakistan	-13.11	0.35	-1.35	12.28	-6.01	0.73
	India	-0.56	0.19		-0.45	-0.39	-0.95
	Bangladesh	-0.08	0.06		0.37	0.02	-0.34
Milk	Pakistan	0.35	-0.3	0.8	0.52	0.55	0.48
	India	0.19	-0.1		0.1	0.28	0.7
	Bangladesh	0.06	-0.05		-0.06		0.09
Bovine	Pakistan	-1.35	0.8	-3.6	-7.09	-0.67	3.13
	India						
	Bangladesh						
Chicken	Pakistan	12.28	0.52	-7.09	6.09	-6.62	4.25
	India	-0.45	0.1		1.56	-3.28	-1.46
	Bangladesh	0.37	-0.06		-2.4	-0.55	1.65
Other meat	Pakistan	-6.01	0.55	-0.67	-6.62	9.22	0.61
	India	-0.39	0.28		-3.28	10.12	-1.73
	Bangladesh						
Goat meat	Pakistan	0.73	0.48	3.13	4.25	0.61	-11.19
	India	-0.95	0.7		-1.46	-1.73	-4.12
	Bangladesh	-0.34	0.09		1.65	0.04	-1.14

Source: Own calculation

Table 35 is used to presents relations between different animal products. Milk and eggs are substitute products for three countries. Bovine meat is complement of all products except milk for Pakistan. Chicken meat is complement of all other meat products for three countries. The common relations are eggs-milk (S), goat meat-milk (S), goat meat-eggs (C), other meat-milk (S), other meats-eggs (C), other meats-milk (S) and other meat-chicken (C).

**Table 35: Matrix of substitution and compliments**

		Eggs	Milk	Bovine	Chicken	Other meat	Goat meat
Eggs	Pakistan		S	C	S	C	S
	India		S		C	C	C
	Bangladesh		S		S	S	C
Milk	Pakistan	S		S	S	S	S
	India	S			S	S	S
	Bangladesh	S			C		S
Bovine	Pakistan	C	S		C	C	S
	India						
	Bangladesh						
Chicken	Pakistan	S	S	C		C	S
	India	C	S			C	C
	Bangladesh	S	C			C	S
Other meat	Pakistan	C	S	C	C		S
	India	C	S		C		C
	Bangladesh						
Goat meat	Pakistan	C	S	S	S	S	
	India	C	S		C	C	
	Bangladesh	C	S		S	S	

**Source: Own calculation**

Long term Hicksian demand elasticities of India, Pakistan and Bangladesh are represented by table 36. For eggs, Pakistan has the largest absolute value (-0.28) followed by India (-0.03) and Bangladesh (-0.02). For milk, Pakistan has the largest absolute value (-0.28) followed by India (-0.08) and Bangladesh (-0.02). For bovine meat, we could calculate elasticity (-0.65) only for Pakistan due to problem of data availability. For poultry meat, Pakistan has the largest absolute value (0.16) followed by India (0.12) and Bangladesh (-0.01) while elasticities for India and Pakistan have positive signs. The difference between signs of three countries showed trend during past. In Pakistan and India, poultry sector has been evolved very quickly as result of growing demand and consumption. For goat/sheep meat, Pakistan has the largest absolute value (-0.81) followed by India (-0.31) and Bangladesh (-0.24). For other meat, India has the largest absolute value (0.22) followed by Pakistan (0.01) while both has positive signs.

**Table 36: Long term Hicksian elasticities**

		Eggs	Milk	Bovine	Chicken	Other meat	Goat meat
Eggs	Pakistan	-0.28	0.19	-0.18	0.23	-0.01	0.05
	India	-0.03	0.16		-0.04	-0.01	-0.08
	Bangladesh	-0.02	0.02		0.06		-0.06
Milk	Pakistan	0.01	-0.28	0.19	0.02	0	0.06
	India	0.01	-0.08		0.01	0.01	0.06
	Bangladesh	-0.02	0.02		0.06		-0.06
Bovine	Pakistan	-0.04	0.58	-0.65	-0.18	0	0.29
	India						
	Bangladesh						
Chicken	Pakistan	0.37	0.39	-1.33	0.16	-0.01	0.41
	India	-0.02	0.08		0.12	-0.07	-0.11
	Bangladesh	0.01	-0.02		-0.01		0.02
Other meat	Pakistan	-0.2	0.44	-0.13	-0.19	0.01	0.06
	India	-0.02	0.22		-0.27	0.22	-0.14
	Bangladesh						
Goat meat	Pakistan	0.02	0.27	0.44	0.08	0	-0.81
	India	-0.04	0.49		-0.11	-0.03	-0.31
	Bangladesh	-0.08	0.04		0.28		-0.24

**Source: Own calculation**

The expenditure elasticities are indicated on table 37. They are generally positive (normal goods) except for goat meat of Pakistan and India. For eggs, India has the largest value (2.39) followed by Bangladesh (0.79) and Pakistan (0.32). For milk, Pakistan has the largest value (1.52) followed by India (1.05) and Bangladesh (0.94). For bovine meat, we could calculate elasticity (0.56) only for Pakistan due to problem of data availability. For chicken meat, Pakistan has the largest absolute value (1.20) followed by Bangladesh (1.13) and India (0.58). For goat/sheep meat, Pakistan has the largest absolute value (-2.02) followed by Bangladesh (1.27) and India (-0.03). For other meat, India has the largest absolute value (1.47) followed by Pakistan (0.43). Eggs, other meat and milk are superior good in India ( $>1$ ) while milk and chicken are also superior good ( $>1$ ) in Pakistan. That means when income increases, Indian consumer buy more eggs, chicken, other meat and milk among all animal products. Likewise chicken and goat meat are superior products in Bangladesh. One surprising result is the fact that goat/sheep meat is “inferior good” in Pakistan and India (elasticities -2.02 and -0.03). This can be explained by the fact that in these countries, the poultry meat is preferred to cattle/sheep meat due to difference of price, so when income increased, people used more other animal product.

The Marshallian price elasticities for six (or five) products (eggs, milk, bovine meat, poultry meat, other meat and goat/sheep meat) of Pakistan, India and Bangladesh respectively are

presented in table 37. Like for Hicksian ones, these elasticities have not been calculated for a specific year but as mean values for the period 1991-2008. The values of the expenditure shares  $s_i$  and  $s_j$  appearing in share and elasticities equations have been replaced by their mean of the period. Concerning the Marshallian own price demand elasticities, Pakistan has the largest absolute value (-0.37) followed by Bangladesh (-0.19) and India (-0.14) for eggs. For milk, Pakistan has the largest absolute value (-1.25) followed by India (-0.89) and Bangladesh (-0.42). For bovine meat, we could calculate elasticity (-0.71) only for Pakistan due to problem of data availability. For chicken meat, Bangladesh has the largest absolute value (-0.56) followed by Pakistan (0.12) and India (0.08) while elasticities for India and Pakistan have positive signs. The difference between signs of three countries showed trend during past. In Pakistan and India, poultry sector has been evolved very quickly as result of growing demand and consumption. For goat/sheep meat, Pakistan has the largest absolute value (-0.81) followed by Bangladesh (-0.47) and India (-0.33). For other meat, India has the largest absolute value (-0.04) followed by Pakistan (0.01) while Pakistan has positive signs.

Milk is price elastic in Pakistan ( $>1$ ) while all other animal products in all three countries are relatively price inelastic ( $<1$ ). That means when one percentage of price of milk increases than Pakistan consumer decrease 1.25 percentage of its consumption. While for other products in three countries, consumer decreases less than one percentage of consumption of other product as result of increase of one percentage of its price.



**Table 37: Marshallian elasticities for animal products**

		Expenditure elasticity	Eggs	Milk	Bovine	Chicken	Other meat	Goat meat
Eggs	Pakistan	0.32	-0.37	0.03	-0.29	0.29	-0.01	0.04
	India	2.39	-0.14	-1.69		-0.23	-0.06	-0.27
	Bangladesh	0.79	-0.19	-0.31		-0.07		-0.22
Milk	Pakistan	1.52	-0.03	-1.25	-0.12	-0.02	0	-0.09
	India	1.05	-0.04	-0.89		-0.08	-0.02	-0.03
	Bangladesh	0.94	-0.2	-0.42		-0.16		-0.17
Bovine	Pakistan	0.56	-0.05	0.17	-0.71	-0.18	0	0.23
	India							
	Bangladesh							
Chicken	Pakistan	1.2	0.31	-0.46	-1.42	0.12	-0.01	0.27
	India	0.58	-0.05	-0.37		-0.08	-0.08	-0.16
	Bangladesh	1.13	-0.17	-0.5		-0.56		0.1
Other meat	Pakistan	0.43	-0.18	0.08	-0.19	-0.17	0.01	0.02
	India	1.47	-0.09	-0.92		-0.39	0.18	-0.26
	Bangladesh							
Goat meat	Pakistan	-2.02	0.08	1.72	0.88	0.15	0	-0.81
	India	-0.03	-0.04	0.56		-0.12	-0.04	-0.33
	Bangladesh	1.27	-0.36	-0.5		0.06		-0.47

**Source: Own calculation**

There are other many studies (Akmal 1994; Bouis 1992; Farooq et al.1999; Haq et al.2012) on Pakistan who calculated expenditure as well as price demand elasticities of one or several animal livestock products. First two authors<sup>50</sup> calculated expenditure and income elasticity for different income groups in rural and urban areas of Pakistan while last author<sup>51</sup> also calculated for rural and urban areas so we took their result for comparison with ours. Farooq et al.1999 used the data from farm house hold consumption. The expenditure elasticity for eggs calculated by them ranges from 0.23 to 2.31 and our value (0.47) falls within this range. The range of price elasticity for eggs by these authors is -0.14--1.08 and our value (-0.37) falls between this range. The range of their calculated expenditure elasticities for milk, bovine, chicken, other meat and goat meat are 0.25-1.55, 0.26-0.57, 0.28-1.18,0.35-0.90 and 0.21-1.75 respectively while our values are relatively higher with same signs except for goat meat (-3.03). The range of their calculated direct Marshallian elasticities for milk, bovine, chicken, other meat and goat meat are (-0.10)-(-1.01), (-0.07)-(-0.87), (-0.20)-(-1.20), (-1.16)-(-1.31) and (-0.15)-(-1.15) respectively while our values are relatively higher with same signs except for chicken meat (0.11) and other meat (1.01). We have

<sup>50</sup>Akmal 1994 and Bouis 1992

<sup>51</sup>Haq et al.2011

taken a long time period of 44 years so our results are a little bit different and used AIDS model like Farooq et al.1999 while other authors used different methodologies.

We also compared our results with other authors (Dastagiri 2004; Mittal 2006; Kumar et al.2011) for livestock products of India who calculated elasticities for one or several livestock products. Their calculated expenditure elasticities for eggs, milk, chicken, other meat and goat meat are 1.56, 0.043-1.50, 1.16, 0.32 and 2.26 respectively while our values are relatively higher or lower with same signs except of goat meat (-0.04). The range of their calculated direct Marshallian elasticities for eggs, milk, chicken, other meat and goat meat are (-1.8)-(-2.85), (-2.8)-(-2.9), (-0.32)-(-0.43), (-0.50)-(-3.17) and (-0.03)-(-3.33) respectively while our values are relatively higher or lower with same signs except of other meat. We have taken a long time period of 44 years so our results are a little bit different while other authors used the survey data.

We also compared our results with other authors (Pitt 1982; Ahmed et al.1993; Kumar et al.2012; Huq et al.2010; Wadud 2006) for livestock products of Bangladesh who calculated elasticities for one or several livestock products. The range of their calculated expenditure elasticities for eggs, milk, chicken and goat meat are 1.25-2.47, 1.79-2.52, 1.46-1.97 and 2.31-3.08 respectively while our values are relatively lower with same signs. The range of their calculated direct Marshallian elasticities for eggs, milk, chicken and goat meat are (-0.95)-(-2.21), (-0.25)-(-1.7), (-0.87)-(-0.91) and (-0.93)-(-1.18) respectively while our values are relatively lower with same signs. We have taken a long time period of 44 years so our results are a little bit different

For eggs in Pakistan, it is interesting to notice that uncompensated elasticity is (in absolute value) less than half of the compensated one (-0.82). It can be explained by the fact that if egg price increases (by example of 1%) this will have an effect on the whole “real” capacity of paying of consumer (a diminution which is equal to  $s_i * 1\%$ , where  $s_i$  is the share of good  $i$  in total expenditures). This apparent diminution of real income will induce a diminution of good  $i$  demand which is  $s_i * E_{Ri} * 1\%$  where  $E_{Ri}$  is the elasticity of income for good  $i$ . As for wheat  $s_i$  is important (about 0.03) and income elasticity also (0.78) the income impact is about 0.02 which is the difference between the two compensated and uncompensated direct price elasticities of egg. The same explanation can be found for other products and very generally Marshallian direct price elasticities are lower, in absolute values, than Hicksian elasticities.

## 4.5. Relationship between vegetal and animal food groups

Thus food is mainly divided into two categories i.e. vegetal and animal food. We have discussed these two categories in detail and also calculated the supply and demand elasticity for each product of each category. Now the most important question is the relationship between these two main groups of products (vegetal group and animal group). It means how consumers react to changes in price of vegetal or animal products in Pakistan, India and Bangladesh.

One important general problem for estimating demand for a large number of products having large number of coefficients which are to be statistically estimated together to calculate expenditure and Marshallian prices elasticities which are the main parameters classically used for simulations. When time series are used, to be able to estimate in one step all coefficients, it is necessary i) to have all data (consumption and prices) available on a large number of years and ii) to assume that during all these years there was no change in structure of consumer preferences. In our case we have complete data for only 1991 to 2007 (17 years) and we have a total of 12 products (7 for vegetal and 5 for animal foods) to take in account, so we used a classical two stage budgeting approach (see reference).

Following Edgerton (1997), we assume that the preference structure is such that, in the first stage, consumers choose how to spend their income among groups of products, such as food, housing, transportation, health services, education, etc. In the second stage, the level of expenditure in each group, as determined in the first stage, is allocated to the commodities in that group.

The model we have estimated for each of the two stages is the Almost Ideal Demand System (AIDS) in its linearized form (LA/AIDS) proposed by Deaton and Muelbauer (1980). At the first stage the two groups taken in account are vegetal and animal foods, at the second one the products taken in account are separately vegetal foods and animal foods. Expenditure, own-price and cross-price elasticities are derived from this demand system.

In the first stage, we have calculated the different elasticities for vegetal products (expenditure elasticity ( $EV_i^R$ ) of product  $i$  inside vegetal group relative to vegetal food expenditure  $VV$ , Hicksian ( $EV_{ij}^H$ ) and Marshallian ( $EV_{ij}^M$ ) elasticities of demand of product  $i$  relative to price of product  $j$  inside vegetal group in chapter 4.3) and, similarly, elasticities for animal products (expenditure elasticity ( $EA_k^R$ ) of product  $k$  inside animal group relative to animal food

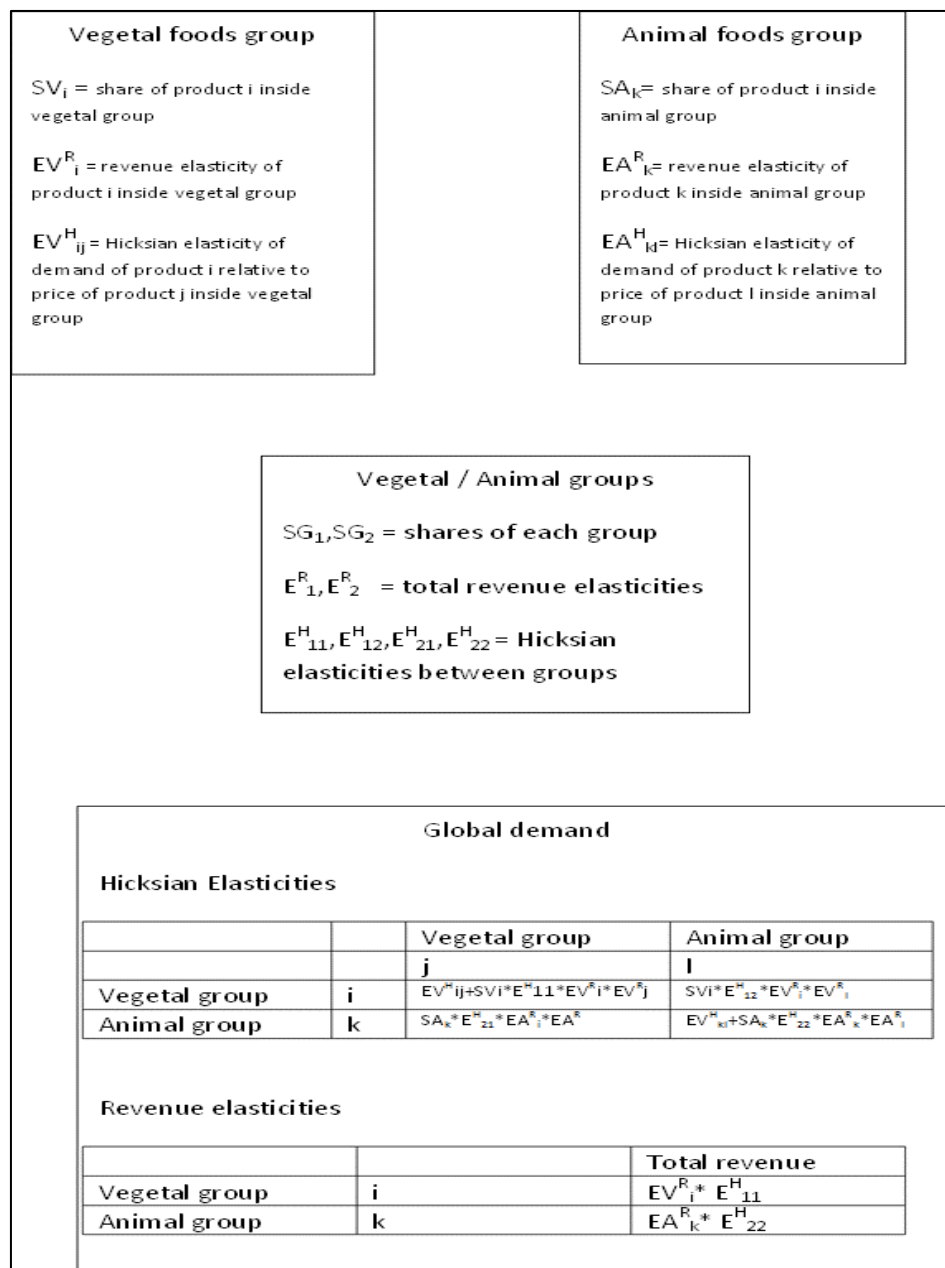
expenditure (VA), Hicksian ( $EA_{ki}^H$ ) and Marshallian ( $EA_{ki}^M$ ) elasticities of demand of product k relative to price of product i inside animal group in chapter 4.4)

In the second stage we have calculated the elasticities of demand for whole vegetal products and whole animal product relative to total food expenditure VT (=VV+VA) and mean prices of each group PV and PA respectively.

The general methodology and conditions of application are described in Okrent et al.2011.

Under the hypothesis of weak separation of preferences, it is possible to calculate the final elasticities of each product group (vegetal and animal) relative to total expenditure. The hypothesis of weak separation implies that there is no direct relationship between one specific product of one group and one other product of the other group. By example, in our case, it means that if the price of one animal product (milk for instance) varies it will change the price of the animal group (PA) and so change, of course, the demand of all animal foods, but also, in a same way, the demand for all vegetal products.

Authors like Michalek et al. (1992) and Edgerton (1997) showed that, under the two less restrictive conditions presented below, the two-stage budgeting system leads to an approximately correct budgetary allocation. The first condition states that the weak separation of preferences theorem must be respected; the second requires that the price index for each group is not too sensitive to changes in the utility function. Under these two conditions, it is possible to show that the relationships among elasticities in the two stages are maintained.



**Figure 26: Methodology to calculate total elasticities from animal and vegetal group by double budgeting**

The equations to be used for final calculation indicated by Carpentier et al., 2001 and cited by Okrent et al., 2011, are represented on Figure 26.

The Marshallian elasticities can be calculated from the Hicksian elasticities using standard formulas.

It appears that we have now to calculate for each country the elasticities between vegetal and animal groups. For that we used a LA/AIDS model with base data calculated during the preceding steps.

QV is the total quantity of vegetal products consumed by year and by capita

PV is the index of vegetal products prices

QA is the total quantity of animal products consumed by year and by capita

PA is the index of animal products prices

Like in previous chapters, shares of values to estimate are:

$$SV = PV * QV / (PV * QV + PA * QA) = a_1 + b_1 * \ln(PV) + c_1 * \ln(PA) + d_1 * \ln(DT/PT) + e_1 * SV(-1)$$

$$SA = PA * QA / (PV * QV + PA * QA) = a_2 + b_2 * \ln(PV) + c_2 * \ln(PA) + d_2 * \ln(DT/PT) + e_2 * SA(-1)$$

Where  $DT = DV + DA$  in total expenditure, and PT is the index of defined price linearized by

$$\ln(PT) = SV * \ln(PV) + SA * \ln(PA)$$

In fact as  $SV + SA = 1$ , one has one single equation to estimate for each country (the first was retained on vegetal products) and the coefficients of the second can be calculated from those of the first and using the constraints of symmetry and homogeneity.

It has generally:

$$a_1 + a_2 = 1, c_1 = -b_1, c_2 = -b_2, c_1 = b_2, d_1 + d_2 = 0, e_1 + e_2 = 0$$

The four coefficients for log prices are equal in absolute value. The different results of estimations for the three counties are indicated on tables 38 to 42.

**Table 38: Coefficients of equations for vegetal and animal food groups**

	Vegetal food		
	Pakistan	India	Bangladesh
<b>constant</b>	2.4***	1.24	1.10
	-0.37	-1.01	(0.62)
<b>vegetal food expenditure</b>	0.18***	0.21***	0.18***
	-0.02	-0.03	(0.05)
<b>animal food expenditure</b>			
<b>Log (expenditure)</b>	-0.34***	-0.13	-0.014
	-0.06	-0.18	(0.10)
<b>Lag (1)</b>	0.17	0.36***	0.01
	-0.1	-0.08	-0.17
<b>R<sup>2</sup></b>	0.97	0.92	0.91
<b>R<sup>2</sup> ajust</b>	0.96	0.9	0.90
<b>DW</b>	1.5	1.16	1.11

**Source: Own calculation**

Table 38 shows the coefficients of the one equations of the AIDS system for Pakistan, India and Bangladesh respectively. The R2 values for all three countries are more than 0.90. Generally all coefficients are significant. Concerning Durbin-Watson, values are generally near to 2 and always superior to 1.1. So we can consider that the forms of equations with a lagged variable correct well the autocorrelations between years. The significance of the different parameters at the probability levels of 10%, 5% and 1% are indicated on this table by one star (\*), two stars (\*\*) and three stars (\*\*\*) respectively. For the coefficients of the own price value in the equation of each category (in fact of each  $s_i$  which is the part of total expenditure due to this product) the sign is always negative (in accordance with theory) and the value is very generally significant at 5% probability. Many coefficients corresponding to cross effects are also significant.

Table 39 represents Hicksian (compensated) short term elasticities for both categories (vegetal and animal products) of Pakistan, India and Bangladesh respectively. Direct price elasticities of vegetal and animal food are negative for three countries, which show negative effect of price on their consumption. For vegetal food, Pakistan has the largest absolute value (-0.13) followed by Bangladesh (-0.06) and India (-0.01). It means when price of vegetal group increases then Pakistani consumer react more than Indian consumer. Cross price elasticity of animal products

group on vegetal products group is positive for three countries having same value. For animal food, Bangladesh has the largest absolute value (-0.12) followed by Pakistan (-0.10) and India (-0.02). It represents that Bangladeshi consumer reacts more to price of animal product as compared to other. Cross price elasticity of vegetal products group for animal products group is positive for three countries having same values.

**Table 39: Hicksian short term price elasticities for vegetal and animal groups**

		vegetal food	Animal food
vegetal food	Pakistan	-0.13	0.13
	India	-0.01	0.01
	Bangladesh	-0.06	0.06
Animal food	Pakistan	0.1	-0.1
	India	0.02	-0.02
	Bangladesh	0.12	-0.12

Source: Own calculation

From Hicksian elasticities matrix it is possible to calculate the Allen substitution matrix which is a symmetric matrix and indicates the intensity of relations between two products. When the sign is positive, products are substitutes and vice versa. When two products are complement then price decrease of one product increases other product consumption. A **substitute good**, in contrast to a complementary good, is a good with a positive cross elasticity of demand. This means a product's demand is increased when the price of another product is increased. Table 40 represents different relationships between vegetal food and animal food studied here. Our results indicated that vegetal food is substitute to animal food. That means when price of vegetal or animal food rises, consumption of animal or vegetal food also decreases.

**Table 40: Matrix of Allen substitution elasticities for vegetal and animal groups**

		vegetal food	Animal food
vegetal food	Pakistan	-0.4	0.2
	India	-0.01	0.03
	Bangladesh	-0.09	0.17
Animal food	Pakistan	0.2	-0.1
	India	0.03	-0.06
	Bangladesh	0.17	-0.34

Source: Own calculation



Long term Hicksian demand elasticities of Pakistan, India and Bangladesh are represented by table 41. The values of long term Hicksian direct price elasticities show the same signs of elasticities with higher absolute values. Otherwise all values of long term are smaller than short term elasticities. For vegetal food, Pakistan has the largest absolute value (-0.20) followed by Bangladesh (-0.06) and India (-0.01). Cross price elasticity of animal products group on vegetal products group is positive for three countries having same value. For animal food, Bangladesh has the largest absolute value (-0.11) followed by Pakistan (-0.05) and India (-0.01). Cross price elasticity of vegetal products group for animal products group is positive for three countries having same values. So consumer in long run reacts in the same way like short run. But these results show that Pakistan consumer prefer more animal products as compared to other countries.

**Table 41: Hicksian long term elasticities for vegetal and animal groups**

		vegetal food	Animal food
vegetal food	Pakistan	-0.2	0.2
	India	-0.01	0.01
	Bangladesh	-0.06	0.06
Animal food	Pakistan	0.05	-0.05
	India	0.01	-0.01
	Bangladesh	0.11	-0.11

**Source: Own calculation**

The table 42 expresses the Marshallian price elasticities for both groups (vegetal and animal product group) of Pakistan, India and Bangladesh respectively. Like Hicksian ones, these elasticities have not been calculated for a specific year but as mean values for the period 1991-2008. The values of the expenditure shares  $s_i$  and  $s_j$  appearing in share and elasticities equations have been replaced by their mean of the period. Concerning the Marshallian own price demand elasticities for vegetal food, Bangladesh has the largest absolute value (-0.71) followed by India (-0.60) and Pakistan (-0.12). For animal food, Pakistan has the largest absolute value (-1.10) followed by Bangladesh (-0.47) and India (-0.45).

The expenditure elasticities are also indicated on table 42. They are generally positive (normal goods) except of vegetal product group for Pakistan (-0.03). That means that Pakistani people

decrease their consumption of vegetal products and increase consumption of animal products when their expenditure increases. Concerning the expenditure elasticities for vegetal food, Bangladesh has the largest value (0.98) followed by India (0.81) and Pakistan (-0.03). For animal food, Pakistan has the largest absolute value (1.5) followed by India (1.4) and Bangladesh (1.04) which are highly elastic for three countries.

**Table 42: Marshallian elasticities for vegetal and animal groups**

		expenditure elasticity	vegetal food	Animal food
vegetal food	Pakistan	-0.03	-0.12	0.15
	India	0.81	-0.6	-0.25
	Bangladesh	0.98	-0.71	-0.27
Animal food	Pakistan	1.5	-0.43	-1.1
	India	1.4	-0.95	-0.45
	Bangladesh	1.04	-0.57	-0.47

Source: Own calculation

Our results concluded that in these countries, rising expenditure increase the consumption of animal products while their diet comprises of more vegetal products as compared to animal products. Our results shows that in all three countries taken here, animal food group is superior food ( $>1$ ), consumers prefer to buy more animal food when their income increase. Thus animal products are luxury products to some extent in low income countries<sup>52</sup>. While in Pakistan, vegetal food group is inferior ( $<0$ ), Pakistani consumer decreases consumption of vegetal food when his income rises. While on the other hand Pakistani consumer also decreases more than one percentage for consumption of animal food as result of one percentage increase of its price. While animal and vegetal foods are relatively price inelastic for India and Bangladesh

## **4.6. Analysis of results for human demand for all products taken together**

Thus food is mainly divided into two categories i.e. vegetal and animal food. We have discussed these two categories in detail and also calculated the supply and demand elasticity for each product of each category. Then demand for each group is also calculated .Now the most important question is the simultaneously effect on all the products of both categories taken together when income or price rises? If prices of one vegetal product increases then what would be effect on its consumption as well as on consumption of other animal products? It means how

<sup>52</sup>Lind et al. 2000

consumers react to changes in price of vegetable or animal products in Pakistan, India and Bangladesh. Hence income or price effect of all the products is calculated simultaneously.

The different results of estimations for the three countries are indicated on tables 43 to 46.

Table 43 represents Hicksian (compensated) short term elasticities for all products of Pakistan, India and Bangladesh respectively. Direct price elasticity of each product (except for other meat and chicken meat for India and Pakistan) is negative for three countries that show negative effect of price on their consumption. Which shows that price does not affect the consumption of other meat and chicken meat. All products are relatively inelastic except of goat meat (-1.02) for Pakistan.

Table 45 is used to represent different relationships between vegetal food and animal food studied here. Common relation for three countries are wheat-rice (C), sugar-rice (S), Wheat- corn (S), eggs-milk (S), vegetal oil-wheat (C) chicken-other meat (C) and Goat meat-milk (S). That means when price of wheat increases than consumption of rice also increases in three countries in these three countries because rice and wheat are crops of different season (kharif and Rabi) but staple food. Contrary price increase of eggs decreases consumption of milk in three countries (so substitute).

**Table 43: Hicksian short term elasticities**

		Rice	Pulses	Maize	Millet/Sorghum	Sugar	Vegetal oil	Wheat	Eggs	Milk	Bovine	Chicken	Other meat	Goat meat
Rice	Pakistan	-0.0433	0.0273	-0.0515	0.0137	0.2167	0.1319	-0.3159	0.0002	0.0221	0.002	0.0006	0	-0.0038
	India	-0.009			0.0027	0.0295	0.016	-0.0108	0.0007	0.005		0.0003	0.0002	0
	Bangladesh	-0.0982			0.0017	0.0001	0.0212	0.0099	0.0094	0.0098	0.0223	0.01		0.0138
Pulses	Pakistan	0.0281	-0.3499	-0.0537	-0.0755	0.1654	0.255	0.0503	-0.0002	-0.0205	-0.0019	-0.0006	0	0.0035
	India													
	Bangladesh													
Maize	Pakistan	-0.2143	-0.2167	-0.4567	-0.0848	0.1161	0.01	0.7643	0.0007	0.086	0.0079	0.0024	0	-0.0148
	India	0.0502		-0.1012	0.0491	-0.1934	-0.0793	0.2721	0.0003	0.002		0.0001	0.0001	0
	Bangladesh	0.4406		-0.937	0.1517	0.0666	0.0226	0.2321	0.0041	0.0094		0.0042		0.0058
Millet/Sorghum	Pakistan	0.0752	-0.4023	-0.1119	-0.3962	0.7255	0.426	-0.0454	-0.0024	-0.2833	-0.0259	-0.0078	-0.0001	0.0487
	India	0.1923		0.017	-0.1605	0.1046	-0.0226	-0.1344	0.0004	0.0029		0.0002	0.0001	0
	Bangladesh	0.031		0.2529	-1.3523	-0.5476	0.112	1.5581	-0.0094	-0.0216		-0.0096		-0.0133
Sugar	Pakistan	0.1423	0.1055	0.0183	0.0868	-0.633	-0.311	0.353	0.0021	0.249	0.0227	0.0069	0.0001	-0.0428
	India	0.0466		-0.0299	0.0468	-0.1635	0.0091	0.0865	0.0005	0.0035		0.0002	0.0001	0
	Bangladesh	0.3054		0.0038	-0.0187	-0.1489	0.0266	-0.2169	0.0085	0.0195		0.0087		0.012
Vegetal oil	Pakistan	0.0586	0.1099	0.0011	0.0345	-0.2102	-0.4523	0.1841	0.0024	0.287	0.0262	0.0079	0.0001	-0.0493
	India	-0.0397		-0.0154	-0.0127	0.0114	-0.1083	0.1552	0.0011	0.0077		0.0005	0.0003	0
	Bangladesh	0.1885		0.0017	0.005	0.035	-0.4092	0.0917	0.0153	0.0349		0.0156		0.0216
Wheat	Pakistan	-0.0847	0.0131	0.0492	-0.0022	0.1441	0.1112	-0.3195	0.0008	0.093	0.0085	0.0026	0	-0.016
	India	-0.0731		0.0306	-0.0437	0.0628	0.0895	-0.0844	0.0021	0.0149		0.0009	0.0006	0
	Bangladesh	0.0909		0.0089	0.0358	-0.1457	0.0468	-0.1245	0.0153	0.0351		0.0157		0.0217
Eggs	Pakistan	0.0003	-0.0003	0.0003	-0.0008	0.0056	0.0095	0.0051	-0.3658	0.2219	-0.2331	0.2958	-0.0067	0.0681
	India	0.01423		0.0003	0.00128	0.00345	0.00596	0.01998	-0.032	0.1124		-0.0394	-0.0098	-0.0764
	Bangladesh	0.0698		0.0001	-0.0002	0.0042	0.0058	0.0113	-0.0347	-0.0111		0.0429		-0.0882
Milk	Pakistan	0.0016	-0.0014	0.0015	-0.0037	0.0269	0.0459	0.0247	0.009	-0.3032	0.1281	0.0098	0.0006	0.0602
	India	0.00626		0.00013	0.00056	0.00152	0.00262	0.00879	0.007	-0.0962		0.0077	0.0053	0.0563
	Bangladesh	0.0836		0.0001	-0.0002	0.0051	0.0069	0.0136	-0.0058	-0.0643		-0.0287		-0.0103
Bovine	Pakistan	0.0006	-0.0005	0.0005	-0.0013	0.0099	0.0168	0.009	-0.0379	0.5126	-0.6211	-0.1722	-0.0008	0.2844
	India													
	Bangladesh													
Chicken	Pakistan	0.0012	-0.0011	0.0012	-0.0029	0.0212	0.0361	0.0194	0.3418	0.2785	-1.2236	0.1448	-0.0074	0.3908
	India	0.00346		0.00007	0.00031	0.00084	0.00145	0.00486	-0.0229	0.0716		0.128	-0.0702	-0.1175
	Bangladesh	0.1		0.0002	-0.0002	0.0061	0.0083	0.0162	0.0601	-0.0769		-0.4036		0.2899
Other meat	Pakistan	0.0004	-0.0004	0.0004	-0.001	0.0077	0.0131	0.007	-0.1679	0.3493	-0.1168	-0.1606	0.0102	0.0587
	India	0.00875		0.00018	0.00079	0.00212	0.00366	0.01228	-0.022	0.1904		-0.2716	0.2149	-0.1395
	Bangladesh													
Goat meat	Pakistan	-0.0021	0.0019	-0.002	0.0049	-0.0358	-0.061	-0.0328	0.0214	0.4655	0.5493	0.1062	0.0007	-1.0163
	India	-0.00017			-0.00002	-0.00004	-0.00007	-0.00024	-0.0454	0.5354		-0.12	-0.0369	-0.3326
	Bangladesh	0.1122		0.0002	-0.0003	0.0068	0.0093	0.0182	-0.1005	-0.0223		0.2356		-0.2592

Source: Own calculation

From Hicksian elasticities matrix it is possible to calculate the Allen substitution matrix which is a symmetric matrix and indicates the intensity of relations between two products. When the sign is positive, products are substitutes and vice versa. When two products are complement then price decrease of one product increases other product consumption. A **substitute good**, in contrast to a complementary good, is a good with a positive cross elasticity of demand. This means a product's

demand is increased when the price of another product is increased. Thus elasticities of substitution and compliments are presented (table 44)

**Table 44: Elasticities of substitutes and complements**

		Rice	Pulses	Maize	Millet/Sorghum	Sugar	Vegetal oil	Wheat	Eggs	Milk	Bovine	Chicken	Other meat	Goat meat
Rice	Pakistan	-1.316	0.854	-6.514	2.284	4.326	1.779	-2.574	0.01	0.048	0.018	0.038	0.014	-0.064
	India	-0.03		0.168	0.642	0.156	-0.133	-0.244	0.048	0.021		0.012	0.029	-0.001
	Bangladesh	-0.183		0.82	0.058	0.568	0.351	0.169	0.13	0.156		0.186		0.209
Pulses	Pakistan	0.854	-10.954	-6.785	-12.594	3.301	3.441	0.409	-0.009	-0.044	-0.016	-0.035	-0.013	0.059
	India													
	Bangladesh													
Maize	Pakistan	-6.513	-6.785	-57.747	-14.144	2.317	0.135	6.227	0.038	0.186	0.068	0.146	0.053	-0.247
	India	0.168		-6.366	1.067	-1.881	-0.971	1.921	0.019	0.008		0.005	0.012	0
	Bangladesh	0.82		-440.19	118.792	1.785	0.798	4.182	0.055	0.065		0.078		0.088
Millet/Sorghum	Pakistan	2.284	-12.594	-14.144	-66.076	14.483	5.749	-0.37	-0.127	-0.612	-0.224	-0.481	-0.174	0.813
	India	0.642		1.067	-3.49	1.017	-0.276	-0.949	0.028	0.012		0.007	0.017	0
	Bangladesh	0.058		118.795	-1059.281	-14.681	3.949	28.07	-0.126	-0.151		-0.18		-0.202
Sugar	Pakistan	4.326	3.302	2.317	14.483	-12.636	-4.197	2.876	0.111	0.538	0.197	0.423	0.153	-0.715
	India	0.156		-1.881	1.017	-1.591	0.111	0.611	0.034	0.015		0.008	0.021	0
	Bangladesh	0.568		1.785	-14.681	-3.993	0.938	-3.907	0.113	0.136		0.163		0.183
Vegetal oil	Pakistan	1.78	3.441	0.135	5.749	-4.197	-6.103	1.5	0.128	0.62	0.227	0.487	0.176	-0.824
	India	-0.133		-0.971	-0.276	0.111	-1.327	1.096	0.073	0.032		0.018	0.045	-0.001
	Bangladesh	0.351		0.798	3.949	0.938	-14.428	1.651	0.203	0.244		0.291		0.327
Wheat	Pakistan	-2.574	0.409	6.227	-0.37	2.876	1.5	-2.603	0.042	0.201	0.073	0.158	0.057	-0.267
	India	-0.244		1.921	-0.949	0.611	1.096	-0.596	0.141	0.062		0.034	0.087	-0.002
	Bangladesh	0.169		4.182	28.07	-3.907	1.651	-2.244	0.204	0.245		0.293		0.328
Eggs	Pakistan	0.01	-0.009	0.038	-0.127	0.111	0.128	0.042	-19.449	0.479	-2.015	18.171	-8.929	1.138
	India	0.048		0.019	0.028	0.034	0.073	0.141	-2.136	0.469		-1.528	-1.47	-3.029
	Bangladesh	0.13		0.055	-0.126	0.113	0.203	0.204	-0.461	-0.077		0.8		-1.338
Milk	Pakistan	0.048	-0.044	0.186	-0.612	0.538	0.62	0.201	0.479	-0.655	1.107	0.602	0.755	1.005
	India	0.021		0.008	0.012	0.015	0.032	0.062	0.469	-0.401		0.298	0.794	2.232
	Bangladesh	0.156		0.065	-0.151	0.136	0.244	0.245	-0.077	-0.449		-0.536		-0.156
Bovine	Pakistan	0.018	-0.016	0.068	-0.224	0.197	0.227	0.073	-2.015	1.107	-5.37	-10.578	-1.009	4.75
	India													
	Bangladesh													
Chicken	Pakistan	0.038	-0.035	0.146	-0.481	0.423	0.487	0.158	18.171	0.602	-10.579	8.899	-9.867	6.527
	India	0.012		0.005	0.007	0.008	0.018	0.034	-1.528	0.298		4.966	-10.538	-4.657
	Bangladesh	0.186		0.078	-0.18	0.163	0.291	0.293	0.8	-0.536		-7.53		4.395
Other meat	Pakistan	0.014	-0.013	0.053	-0.174	0.153	0.176	0.057	-8.929	0.755	-1.009	-9.867	13.653	0.98
	India	0.029		0.012	0.017	0.021	0.045	0.087	-1.47	0.794		-10.538	32.26	-5.531
	Bangladesh													
Goat meat	Pakistan	-0.064	0.059	-0.247	0.813	-0.715	-0.824	-0.267	1.138	1.005	4.75	6.527	0.98	-16.972
	India	-0.001		0	0	0	-0.001	-0.002	-3.029	2.232		-4.657	-5.531	-13.185
	Bangladesh	0.209		0.088	-0.202	0.183	0.327	0.328	-1.338	-0.156		4.395		-3.931

Source: Own calculation

**Table 45: Relations as substitutes and complements**

		Rice	Pulses	Maize	Millet/Sorghum	Sugar	Vegetal oil	Wheat	Eggs	Milk	Bovine	Chicken	Other meat	Goat meat
Rice	Pakistan		S	C	S	S	S	C						
	India			S	S	S	C	C						
	Bangladesh			S		S	S	S	S	S		S		S
Pulses	Pakistan	S		C	C	S	S	S						
	India													
	Bangladesh													
Maize	Pakistan	C	C		C	S	S	S		S		S		C
	India	S			S	C	C	S						
	Bangladesh	S			S	S	S	S						
Millet/Sorghum	Pakistan	S	C	C		S	S	C	C	C	C	C	C	S
	India	S		S		S	C	C						
	Bangladesh			S		C	S	S	C	C		C		C
Sugar	Pakistan	S	S	S	S		C	S	S	S	S	S	S	C
	India	S		C	S		S	S						
	Bangladesh	S		S	C		S	C	S	S		S		S
Vegetal oil	Pakistan	S	S	S	S	C		S	S	S	S	S	S	C
	India	C		C	C	S		S						
	Bangladesh	S		S	S	S		S	S	S		S		S
Wheat	Pakistan	C	S	S	C	S	S			S		S		C
	India	C		S	C	S	S		S					
	Bangladesh	S		S	S	C	S		S	S		S		S
Eggs	Pakistan				C	S	S			S	C	S	C	S
	India							S		S		C	C	C
	Bangladesh	S			C	S	S	S				S		C
Milk	Pakistan			S	C	S	S	S	S		S	S	S	S
	India								S			S	S	S
	Bangladesh	S			C	S	S	S				C		C
Bovine	Pakistan				C	S	S			S		C	C	S
	India													
	Bangladesh													
Chicken	Pakistan			S	C	S	S	S	S	S	C		C	S
	India								C	S			C	C
	Bangladesh	S			C	S	S	S	S	C				S
Other meat	Pakistan				C	S	S			S	C	C		S
	India								C	S		C		C
	Bangladesh													
Goat meat	Pakistan			C	S	C	C	C	S	S	S	S	S	
	India								C	S		C	C	
	Bangladesh	S			C	S	S	S	C	C		S		

Source: Own calculation

Table 46 is used to represent Marshallian elasticities for all products taken into analysis. That shows the same signs of Hicksian elasticities. All products are relatively inelastic except of milk

(-1.36) in Pakistan which means that Pakistan consumer reacts to price of milk more than Indian and Bangladeshi.

Table 46 also represents expenditure elasticities for all products. All products for Pakistan are normal goods except rice, corn, millet/sorghum, sugar, vegetable oils, wheat and goat meat. When expenditure or income rises, Pakistani consumer decreases the consumption of all above products which included almost all important vegetal products. So, Pakistani consumer decreases rapidly his consumption of vegetal products when expenditure or income increases. Milk and chicken are expenditure elastic for Pakistan that means when income increases, they also increased their consumption of these products. All products for India are normal goods except for goat meat. For India, eggs, wheat, milk and other meat are expenditure elastic which means that Indian consumer increases his consumption for animal products as well as of wheat with rise of expenditure. All products for Bangladesh are normal goods except for millet/sorghum. For Bangladesh, goat meat, chicken, wheat, vegetable oils and milk are expenditure elastic that means like Indian consumer, Bangladeshi consumer also increased consumption of wheat and vegetal oil with animal product. It can be concluded here that in India and Bangladesh, when income increases then consumption of wheat also increases but consumption of all animal products increases with rise of income.

When animal and vegetal products are taken all together then all vegetal products in Pakistan are inferior goods ( $<0$ ) except for millet/sorghum and pulses but chicken and milk are superior goods on the other hand. Eggs, milk, other meat and wheat are superior goods ( $>1$ ) in India while goat meat is inferior ( $<0$ ). Vegetal oils, chicken and goat meat are superior goods in India while on contrary, millet/sorghum is inferior good ( $<0$ ) in Bangladesh. As stated previously, when income increases by one percent then expenditure on superior good increases more than one percent and vice versa. While all products are relatively price inelastic for all three countries except for millet/sorghum for Bangladesh.

**Table 46: Marshallian and expenditure elasticities**

	expenditure elasticity	Rice	Pulses	Maize	Millet/Sorghum	Sugar	Vegetal oil	Wheat	Eggs	Milk	Bovine	Chicken	Other meat	Goat meat	
Rice	Pakistan	-0.005	-0.043	0.027	-0.051	0.014	0.217	0.132	-0.315	0.000	0.025	0.003	0.001	0.000	-0.003
	India	0.589	-0.185		-0.007	0.002	-0.045	-0.059	-0.118	-0.008	-0.136		-0.015	-0.004	-0.015
	Bangladesh	0.924	-0.594		0	-0.001	-0.013	-0.016	-0.042	-0.06	-0.11		-0.04		-0.047
Pulses	Pakistan	0.005	0.028	-0.35	-0.054	-0.076	0.165	0.255	0.05	0	-0.023	-0.002	-0.001	0	0.003
	India														
	Bangladesh														
Maize	Pakistan	-0.021	-0.214	-0.216	-0.457	-0.085	0.117	0.012	0.767	0.001	0.096	0.01	0.003	0	-0.014
	India	0.232	-0.019		-0.105	0.038	-0.217	-0.098	0.239	-0.003	-0.054		-0.006	-0.001	-0.006
	Bangladesh	0.388	0.232		-0.938	0.151	0.052	0.012	0.211	-0.025	-0.046		-0.017		-0.020
Millet/Sorghum	Pakistan	0.07	0.073	-0.405	-0.112	-0.397	0.722	0.421	-0.054	-0.004	-0.316	-0.034	-0.009	0	0.045
	India	0.344	0.089		0.011	-0.176	0.069	-0.051	-0.183	-0.005	-0.08		-0.009	-0.002	-0.009
	Bangladesh	-0.894	0.511		0.255	-1.351	-0.514	0.137	1.608	0.058	0.107		0.038		0.046
Sugar	Pakistan	-0.061	0.144	0.107	0.019	0.087	-0.63	-0.306	0.36	0.003	0.277	0.03	0.008	0	-0.039
	India	0.417	-0.078		-0.037	0.028	-0.206	-0.025	0.028	-0.006	-0.096		-0.011	-0.003	-0.011
	Bangladesh	0.807	-0.128		0.002	-0.02	-0.179	0.004	-0.262	-0.052	-0.096		-0.035		-0.041
Vegetal oil	Pakistan	-0.071	0.061	0.112	0.002	0.035	-0.207	-0.447	0.193	0.004	0.32	0.034	0.009	0	-0.045
	India	0.905	-0.311		-0.03	-0.054	-0.082	-0.182	0.027	-0.012	-0.209		-0.023	-0.006	-0.023
	Bangladesh	1.446	-0.588		-0.001	0.003	-0.019	-0.45	0.011	-0.093	-0.172		-0.062		-0.074
Wheat	Pakistan	-0.023	-0.084	0.014	0.049	-0.002	0.145	0.113	-0.317	0.001	0.104	0.011	0.003	0	-0.015
	India	1.749	-0.597		0.003	-0.124	-0.117	-0.053	-0.332	-0.024	-0.405		-0.044	-0.011	-0.044
	Bangladesh	1.452	-0.689		0.006	0.034	-0.2	0.006	-0.205	-0.094	-0.173		-0.062		-0.074
Eggs	Pakistan	0.473	-0.015	-0.015	-0.003	-0.004	-0.018	-0.026	-0.053	-0.375	0.003	-0.288	0.288	-0.007	0.040
	India	3.365	-0.994		-0.053	-0.154	-0.342	-0.269	-0.457	-0.082	-0.695		-0.126	-0.032	-0.161
	Bangladesh	0.819	-0.371		-0.002	-0.001	-0.026	-0.017	-0.034	-0.096	-0.129		-0.001		-0.142
Milk	Pakistan	2.284	-0.074	-0.074	-0.017	-0.017	-0.087	-0.123	-0.256	-0.034	-1.361	-0.136	-0.027	-0.001	0.019
	India	1.481	-0.437		-0.023	-0.068	-0.151	-0.118	-0.201	-0.015	-0.451		-0.03	-0.005	-0.077
	Bangladesh	0.982	-0.444		-0.002	-0.001	-0.032	-0.021	-0.041	-0.08	-0.205		-0.081		-0.075
Bovine	Pakistan	0.835	-0.027	-0.027	-0.006	-0.006	-0.032	-0.045	-0.094	-0.054	0.126	-0.718	-0.186	-0.001	0.234
	India														
	Bangladesh														
Chicken	Pakistan	1.794	-0.058	-0.058	-0.013	-0.014	-0.069	-0.097	-0.201	0.308	-0.552	-1.431	0.116	-0.009	0.283
	India	0.819	-0.242		-0.013	-0.037	-0.083	-0.065	-0.111	-0.035	-0.125		0.107	-0.076	-0.138
	Bangladesh	1.174	-0.531		-0.002	-0.002	-0.038	-0.025	-0.049	-0.028	-0.245		-0.467		0.212
Other meat	Pakistan	0.65	-0.021	-0.021	-0.005	-0.005	-0.025	-0.035	-0.073	-0.18	0.049	-0.192	-0.171	0.01	0.020
	India	2.069	-0.611		-0.033	-0.094	-0.211	-0.165	-0.281	-0.053	-0.306		-0.325	0.201	-0.192
	Bangladesh														
Goat meat	Pakistan	-3.035	0.098	0.099	0.022	0.023	0.116	0.164	0.34	0.078	1.871	0.9	0.156	0.003	-0.835
	India	-0.04	0.012		0.001	0.002	0.004	0.003	0.005	-0.045	0.545		-0.119	-0.037	-0.332
	Bangladesh	1.318	-0.596		-0.003	-0.002	-0.042	-0.028	-0.055	-0.199	-0.211		0.165		-0.346

Source: Own calculation

The comparison of our results with result of other authors<sup>53</sup> who took together vegetable and animal products for these countries is represented in table 47. These authors used household income and expenditure survey. Haq et al.2011 used LA-AIDS model for household data for rural and urban Punjab while all other authors used extended linear and food characteristics

<sup>53</sup>Bois et al.1992; Farooq et al.1999; Huq et al.2012 ; Seale et. al.2003 ; Akmal, 1994 for Pakistan, Pitt 1983; Ahmed et al.1993; Kumar et al.2012; Huq et al.2010 for Bangladesh and Mittal 2006; Kumar et al.2011 for india.



demand system. So present study took data for 40 years and used LA-AIDS approach by taking all the food products. For Pakistan our expenditure elasticities are positive like other authors (Bouis 1992; Farooq et al.1999; Haq et al.2011; Seale et. al. 2003; Akmal, 1994) except for rice, vegetal oils, wheat and goat meat but on the other hand our values are higher for other livestock products. That shows the change in dietary pattern of Pakistani consumer shifting their more expenditure to live stock products. When we compared our Marshallian direct price elasticities with these same authors then all signs are same except for chicken and other meat. That mean when chicken and other meat price increases then its consumption also increases.

**Table 47: Table of comparison with other authors for Pakistan**

	expenditure elasticity						direct price elasticity					
	farooq et al.1999	Huq et al.2011	Bouis et al.1992	Seale et. al.2003	Akmal 1994	our analysis	farooq et al.1999	Huq et al.2011	Bouis et al.1992	Seale et. al.2003	Akmal 1994	our analysis
Rice	0.26	0.86-1.01*	0.35-0.86*			-0.01	-0.23	-0.53--0.54*	-0.97--1.09*			-0.04
Pulses	0.60					0.01	-0.54					-0.35
Maize						-0.02						-0.46
Millet/Sorghum						0.07						-0.40
Sugar						-0.06						-0.63
Vegetal oil		0.65-0.73*	0.38-1.18*	0.53		-0.07		-0.40--0.61*	-1.03--1.31*	-0.43		-0.45
Wheat	0.51	0.75-0.77*	-0.06--0.12			-0.02	-0.61	-0.3--0.46*	-0.18--0.32			-0.32
Eggs			0.58-1.50*		0.235-2.31*	0.47			-1.03--1.08*			-0.14--0.96*
Milk	1.55	1.10-1.37*	0.68-0.67*	0.84	0.25-0.73*	2.28	-0.94	-0.75--0.99*	-0.94--1.01*	-0.68		-0.10--0.63*
Bovine			0.17-0.57*		0.26-0.37*	0.84			-0.71--0.87*			(-0.07)--(-0.56)*
Chicken			0.46-1.18*		0.28-1.7*	1.79			-1.10--1.20*			-0.20--1.32*
Other meat			0.35-0.90*			0.65			-1.16--1.31*			0.01
Goat meat			0.49-1.25*		0.21-1.75*	-3.04			-1.05--1.15*			-0.15--1.21*

Source: Own calculation

Table 48 is used to compare our results with results of other authors (Mittal 2006; Kumar et al.2011, Dastagiri 2004) for India. First two authors used QUAIDS approach for data from national sample survey (2004/2005) for different analysis groups and last author used classical regression method for data from national sample survey (1993/1994) for livestock products. So present study took data for 40 years and used LA-AIDS approach by taking all the food products. Our values of expenditure elasticities for all products have same signs except for goat meat (-0.04) but our values are relatively higher for other meat, milk, eggs and wheat which are expenditure elastic. That means when expenditure rises that their consumption also rises. Our values for Marshallian direct price elasticities have same signs except for chicken and other meat but other absolute values are relatively lower.

**Table 48: Table of comparison with other authors for India**

	expenditure elasticity				direct price elasticity			
	Kumar et al.(2011)	Mittal (2006)	Dastagiri (2004)	our analysis	Kumar et al.(2011)	Mittal (2006)	Dastagiri (2004)	our analysis
Rice	0.024			0.59	-0.25			-0.19
Pulses								
Maize				0.23				-0.1
Millet/Sorghum				0.34				-0.18
Sugar	0.062	0.82		0.42	-0.34	-0.73		-0.21
Vegetal oil	0.30	0.55		0.91	-0.50	-0.80		-0.18
Wheat	0.075			1.75	-0.34			-0.33
Eggs			1.56	3.37			-1.8--2.85	-0.08
Milk	0.043	1.19	1.50	1.48	-0.62	-0.78	-2.8--2.9*	-0.45
Bovine								
Chicken			1.16	0.82			-0.32--0.43*	0.11
Other meat			0.32	2.07			-0.50-3.17*	0.2
Goat meat			2.26	-0.04			-0.030--3.3*	-0.33

**Source: Own calculation**

Table 49 is used to compare our results with results of other authors (Pitt 1983; Ahmed et al.1993; Wadud 2006; Kumar et al.2012; Huq et al.2010) for Bangladesh. Ahmed et al.1993 and Huq et al.2010 used AIDS approach for data from household income and expenditure survey for different income groups. Kumar et al.2012 used QUAIDS approach for household income and expenditure survey 2005/2006. While Pitt 1983 used variable model of Tobin for data from household economic survey 1973/1974. So present study took data for 40 years and used LA-AIDS approach by taking all the food products. Our values of expenditure elasticities for all products have same signs but our values are relatively higher for chicken, goat meat, edible oils, and wheat which are expenditure elastic. That means when expenditure rises that their consumption also rises. Our values for Marshallian direct price elasticities have same signs but the values are relatively lower. Our results show that in long term, the consumption pattern in Bangladesh is more derived by expenditure as compared to price.

**Table 49: Table of comparison with other authors for Bangladesh**

	expenditure elasticity							direct price elasticity						
	pitt (1982)	ahmed et al.1993	kumar et al.(2012)	huq et al.2010	Scale et. al.(2003)	wadud 2006	our analysis	pitt (1982)	ahmed et al.1993	kumar et al.(2012)	huq et al.2010	Scale et. al.(2003)	wadud 2006	our analysis
Rice	0.94-1.19*	0.68	0.85				0.92	(-0.83)-(-1.30)*	-0.45	-0.62				-0.59
Pulses														
Maize							0.39							-0.94
Millet/Sorghum							-0.89							-1.35
Sugar		1.56	1.766				0.81		-1.15	-1.04				-0.18
Vegetal oil		0.91	0.78	1.76	0.54		1.45		-0.66	-0.69	-1.4	-0.44		-0.45
Wheat	(-0.10)-(-0.24)*	-0.22	1.34				1.45	(-0.06)-(-0.72)*	-1.29	-1.2				-0.21
Eggs		2.47	1.25				0.82		-2.21	-0.95				-0.1
Milk	1.90-2.52*	1.94	1.79	1.86	0.86		0.98	(-0.25)-(-1.08)*	-1.7	-0.96	-0.34	-0.7		-0.21
Bovine														
Chicken			1.97			1.46	1.17			-0.87			-0.91	-0.47
Other meat														
Goat meat			2.31			3.08	1.32			-1.18			-0.93	-0.35

**Source: Own calculations**

According to other studies (Mittal 2006; Kumar et al.2011; Chaterjee *et al.*2007), cereals in India are expenditure inelastic products but in our study all products are relatively expenditure inelastic except for other meats, eggs, milk and wheat. This implies that as expenditure or income level increases, the proportion of expenditure or income on other meats, eggs, milk and wheat is much higher than other products in our analysis. While all the cereals and animal products in our analysis are price inelastic (except for chicken and other meat) showing that the demand of staple food may not be affected adversely with increase in food price inflation (Kumar et al.2011).

For Pakistan, all the products (except for chicken and other meat) taken into analysis are price inelastic like other studies (Haq et al.2011; Bouis 1992). According to Haq et al 2011, wheat is staple food in Pakistan therefore price increase does not change much its consumption. Expenditure elasticities indicated that chicken and milk are expenditure elastic while goat meat, sugar, rice, corn, vegetal oil and wheat have negative signs that means when expenditure or income increases, consumer prefer to buy other expensive item and reduces to buy these products.

Whereas in Bangladesh all the products in our analysis are normal goods except for millet/sorghum while goat meat, chicken, milk, wheat and vegetal oils are expenditure elastic that means when expenditure raises than Bangladeshi consumer increases their consumption. But according to other studies (Huq et al.2010; Ali 2002), all cereals are expenditure inelastic except of wheat. The compensated own price elasticity indicated that all food items except for millet/sorghum are price inelastic. In Bangladesh, rice represents major part of food as staple product so here price inflation does not affect its consumption like India.

## 4.7. Conclusions

Total human consumption and consumption per capita in these three countries have changed significantly during the analysed period. According to the hypothesis in the introduction, changes in population, price and income explain a large part of these changes, as tends to show the significance of the coefficients of the estimated equations with three levels (vegetal products, animal products, vegetal products / animal products groups) and the fact that in almost all cases the signs of the direct elasticities are negative, in accordance with what is usually accepted in economic theory. Given the very large number of values in the different matrices of elasticities, it is naturally impossible to try to interpret or explain these numbers. However, we can make some general remarks.

Whereas for vegetal products, we used data available for 41 years for econometric estimates (1966 -2007), but for estimates of demand for animal products (and also for the two groups of vegetal / animals products) price data from the FAOSTAT database is available from 1991. So the number of available years was much shorter, thus it potentially limited the quality of the computed coefficients and required only limited number of products included in the application of systems. This has led us to exclude animal fats (ghee, butter, etc.) and fish (which have a high diversity) from our estimate.

Overall, our calculated values of price demand and income elasticities in various cases are different from other authors. As previously stated this can be largely explained by differences in methods (some old elasticity were calculated using independent equations for each product). They are biased and are therefore not consistent with modern economic methodology. Others estimated elasticities using panel data collected in each country by direct surveys of consumers. Figures published show very significant differences between elasticities calculated for different population groups (rural versus urban, different levels of per capita income, possibly different regions within the same country, etc.). In many cases, estimation methods are not specified (e.g. FAPRI).

The justification for choosing the values of price and income elasticities used in a partial equilibrium model is particularly with regard to developing countries where statistical data (especially for human consumption) are largely the result of mere estimates of international organizations. Indeed, we know that the values of elasticities may largely depend, in addition to

methodological differences, on time periods taken into account and the number of products included in the estimates (only food or all the "consumption" of households including housing, transport, appliances, cars, entertainment, etc.).

Values that we have calculated, like other authors, should be regarded as estimates of magnitude of certain behaviors of average consumer in each country. As previously stated figures in the various tables are tainted by error to the extent, in making these estimates, we had to use producer prices adjusted by fixed coefficients (specific to each product within each country) considered as proxy of real consumer prices for which no series of data is available for enough time period. In these circumstances, it is not possible to statistically test the relationship between producer and consumer prices. Insofar as in the three countries, a large part of consumption is the auto consumption (farm households) or local purchases (non-agricultural rural households) with short supply circuits, however we cannot say that this assumption is realistic. We cannot test the influence on the calculated elasticity values by certain food products (animal fat, fish, etc...) in this report which are not taken into account.

Despite the limitations of the results (especially for small products such as millet, sorghum, other meats, etc.) and the realization that improvements in these estimation procedures would be desirable (by actual consumers price, including more food products, longer data series, etc. ..), it became important to retain these values in this chapter for the construction of three PEM for reasons of consistency. These models are based almost entirely (such as estimates of this chapter) on FAO data and the conventional assumption of a linear relationship between consumer prices and producer prices. It must emphasize that the validity of these models such as elasticities calculated is largely dependent on the quality of the figures (especially for the price) provided by FAO.

# Chapter 5: Estimation of feed demand functions

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In these three countries, the animal feed is a sector relatively modest in terms of consumption of concentrates, that means, crop products used (cereals, pulses, oilseeds) or derived from industrial processing (milling, sugar processing, crushing, preparation of husked rice, etc. ..), but may play a much more important role in the future more than today, as a real competitor of the human diet. We can also say that constituting an additional outlet, it can have a positive role to stimulate supply and to develop products that are not used directly as food (brans, cakes, etc.).

Statistical data on the consumption of concentrate by animals are rare (and often inconsistent between various databases) and results from simple balance sheet calculations at the country level. As indicated below, it was necessary to combine different sources to reconstruct data for the products “feed but not food” not taken into account in the classical balances of FAO (brans, oil meals, molasses, etc.) and also to make some estimates of total demand of concentrates as function of livestock production.

Given the approximate nature of these outcomes and especially the total absence of price series for these products, it was not possible to do, as human demand, an econometric estimate on historical data. For obtaining all the values of price elasticities of demand, one original method based on the generation of pseudo-data had to be developed, so that these results can be incorporated into the three PEM.

In south Asian countries, feed crops used in animal feed are wheat, rice, maize, pulses, millet and sorghum while wheat and rice are mainly used for human consumption but their byproducts are used in feed (Khan, 2003; Pathak, 2003; Hutabarat et al., 2003). Hence this is also important to calculate feed demand elasticities. So in this chapter, methodology and results of feed demand elasticities are presented after description of generalities for three countries.

## **5.1. Generalities on the three South-Asia countries**

### **5.1.1 South-Asia**

#### **5.1.1.1. Evolution of the animal production in South-Asia**

According to FAOSTAT, over the period 2004-2008, the three countries produced about 8 Mt of meat, 3.5 Mt of eggs and 135 Mt of milk annually in average against 2.6 Mt, 0.32 Mt and 29 Mt over the period 1966 - 1970. This means that production of all meats increased more than 3 times (+5.4 Mt) during this period while production of eggs has been increased 10 times (+3.1 Mt) during this period. Likewise production of milk has been increased nearly 4 times (+106 Mt) during the same period (see table 50). By far India is the largest producer of all these products. For category of all meat, share of this country in the total of the three countries has increased from 66.3% in the early period to 74.4% in 2004-2008. Despite its strong growth (+3.4 Mt or 176%), augmentation in the country was much lower than Pakistan where with an increase of 1.7 Mt (393%), its share in the total of the three countries has increased from 16.9% to 26.9%. In Bangladesh there are also some increase (+0.32 Mt or 140%), but the pace of growth is lower than in the other two countries so its share in total has declined from 8.8% in the beginning period to just 6.8% in 2004 to 2008.

The share of different meats is significantly different depending on each country. In the Beginning period (1966 – 1970), the proportion of bovine meat (beef and buffalo) represented 64% of total meat in Pakistan and India against 61% in Bangladesh. In the end of the period (2004 to 2008), this category was still dominant but experienced a relative decline in its shares that have fallen to 56% in Pakistan, 45% in India and 35% in Bangladesh.

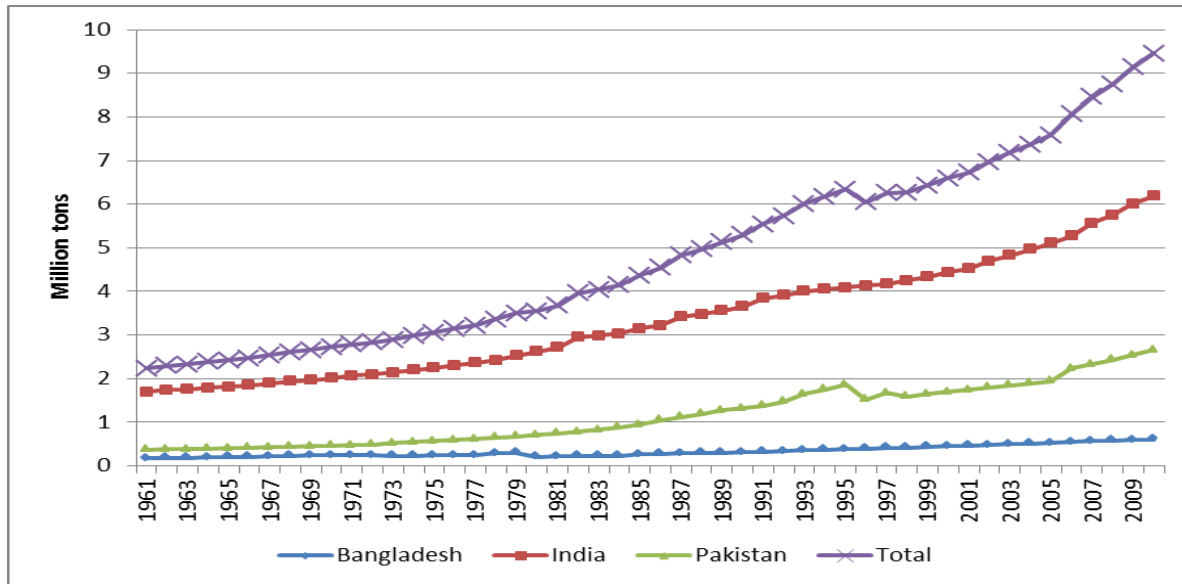
**Table 50: Evolution and repartition of animal products production**

	Average 1966-70				Average 2004-08				Variation				Evolution			
	Pakistan	India	Bangladesh	Total	Pakistan	India	Bangladesh	Total	Pakistan	India	Bangladesh	Total	Pakistan	India	Bangladesh	Total
Cattle meat	150	593	136	879	577	1000	184	1762	427	407	48	883	285%	69%	35%	100%
Buffalo meat	130	637	3	769	626	1385	5	2016	496	748	2	1247	383%	118%	85%	162%
Beef and Buffalo Meat + (Total)	280	1229	139	1648	1203	2385	189	3778	923	1156	51	2130	330%	94%	36%	129%
Sheep meat	66	145	1	212	155	256	3	414	89	111	2	202	134%	76%	319%	95%
Goat meat	70	242	30	342	299	518	162	980	229	276	132	638	329%	114%	438%	186%
Sheep and Goat Meat + (Total)	136	387	31	554	454	774	165	1394	318	387	135	839	233%	100%	435%	151%
Pig meat	0	162	0	162	0	405	0	405	0	243	0	243		150%		150%
Chicken meat	13	76	40	130	485	1573	138	2196	472	1496	97	2066	3629%	1959%	242%	1594%
Duck meat	0	12	12	25	5	37	39	81	4	25	27	57	894%	199%	229%	227%
Poultry Meat + (Total)	13	89	52	155	490	1610	177	2277	477	1521	125	2123	3533%	1712%	239%	1373%
Meat nes	10	66	6	82	19	159	14	192	9	93	8	110	93%	140%	136%	134%
Meat, Total + (Total)	439	1934	228	2601	2167	5334	546	8046	1727	3400	318	5445	393%	176%	140%	209%
Cow milk, whole, fresh	1940	8395	651	10986	10186	42977	812	53975	8247	34582	161	42989	425%	412%	25%	391%
Buffalo milk, whole, fresh	4956	11558	19	16533	20049	54231	31	74311	15093	42673	12	57779	305%	369%	65%	349%
Sheep milk, whole, fresh	20	0	13	32	33	0	30	63	14	0	17	30	69%		131%	94%
Goat milk, whole, fresh	150	615	331	1096	681	4021	1890	6592	531	3406	1559	5496	354%	554%	471%	502%
Milk, Total + (Total)	7066	20568	1013	28647	30950	101228	2762	134941	23885	80661	1749	106294	338%	392%	173%	371%
Hen eggs, in shell	11	255	30	296	444	2762	177	3383	433	2507	147	3087	3976%	983%	496%	1045%
Other bird eggs, in shell	1	0	22	23	7	0	75	82	7	0	53	60	1076%		240%	263%
Eggs Primary + (Total)	12	255	52	318	451	2762	252	3465	440	2507	200	3147	3822%	983%	387%	989%

Source: Calculations from FAOSTAT; Units: Thousands tons

This relative decline was mainly due to strong growth of production of poultry meat in all three countries which goes up from 3.1% to 22.6% in Pakistan, 4.6% to 31.2% in India and 22.9% to 32.5% in Bangladesh. Regarding the mutton and goat, which remained a traditional form of consumption in these three countries (particularly in Pakistan and Bangladesh for religious reasons), the relative share has decreased over time in Pakistan (21.0% at the end of period against 31.0% in early period) and India (14.5% against 21.0%). In Bangladesh, taking into account the lower growth of poultry meat as compared to the other two countries, the share of sheep and goats has increased from 13.6% to 30.2%. In India, where beef consumption is restricted from a religious point of view, the production of pork has increased by 0.24 Mt (150%), but its share of the total fell slightly from 8.4% to 7.6%. Finally in each country, there was a certain production of “other meats” representing less than 3% throughout in 1966-70 and declined during the period.



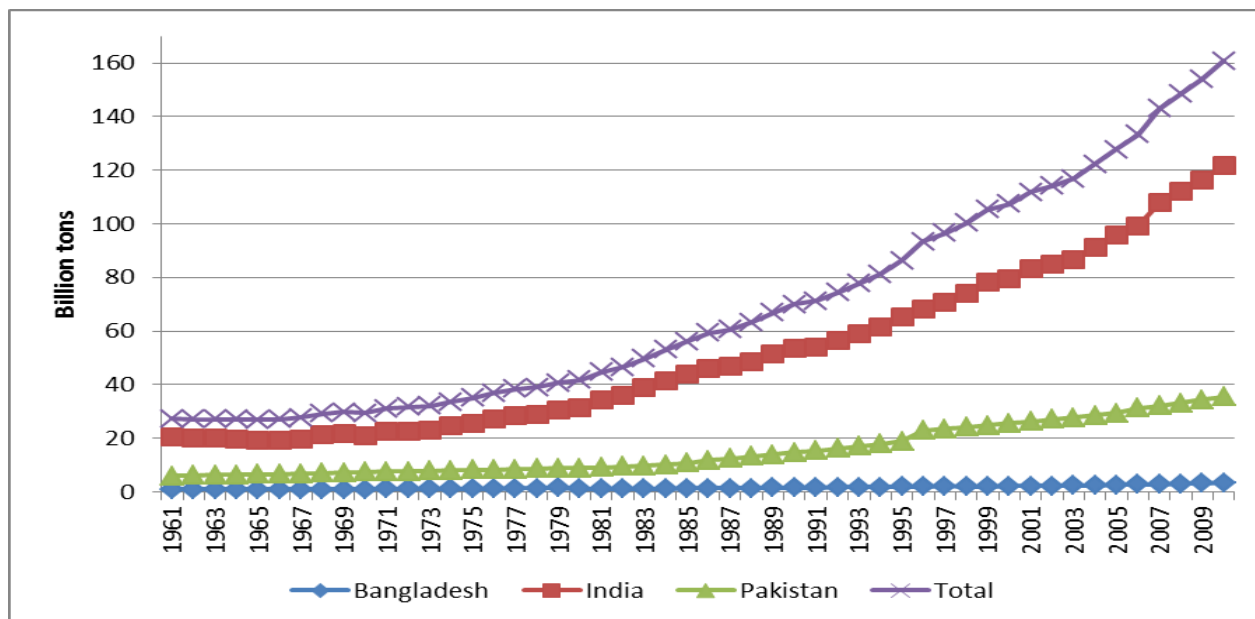


**Figure 27: Evolution of the total meat production in the three countries**

Source: Calculation from FAO data

Finally, it can be noted that within the meats, production of cattle and buffalo remained relatively balanced during the early period in Pakistan and India but has experienced some relative growth for the buffalo in the two countries. On the contrary, production more than 97% in Bangladesh was and is still based almost entirely on beef. Within the category sheep / goat meat, former representing 48.7% in Pakistan, 37.5% in India and 2.5 in Bangladesh, has declined over the benefit of goat meat.

Regarding milk, all three countries is a major producer in the world and their production has increased dramatically during the period (16 Mt or 371%). India that represented 71.8% of the total of the three countries from 1966 to 1970 showed an increase to 75.0% in 2006-2008 with a 5 times increases in tonnage. At the same time, the share of Pakistan has declined from 24.7% to 22.9% and share of Bangladesh declined from 3.5 to 2.1% (see figure 28).



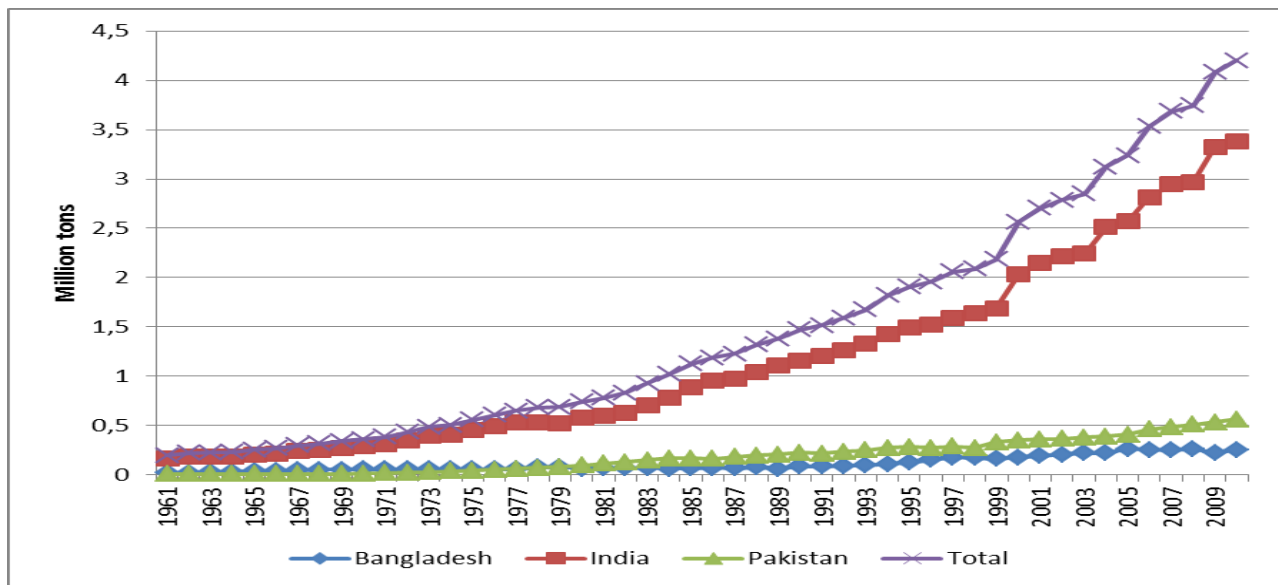
**Figure 28: Evolution of milk production in the three countries**

Source: Calculation from FAO data

According to FAOSTAT, sector of eggs production has been experienced a strong development in its production in all three countries, with 11 times increase over the period against 15 for the meat. India was and remains by far the largest producer with a relatively stable share of 80% of total production of these three countries over the period. On the other hand, production has increased 40 times in Pakistan during the period taken (its share of total production increased from 3.6% to 13.0%) while the increase in the Bangladesh (which was admittedly 4 times higher than Pakistan during early period (1966 to 1970) is "only" 390% and its share of the total production fell from 16.3 to 7.3% (see figure 29).

The most important point to emphasize concerning the production of animal products is the first considerable dynamism shown by the sector "poultry" for both the "broiler" and "layers"(representing currently up to nearly 95% of chicken in Pakistan and India while the duck is still having a significant place among broilers in Bangladesh: 22.3%) and the "eggs." The second important point is the considerable dynamism shown by the milk sector. The relative share of cows, buffalo, goats and sheep varies greatly depending on each country (particularly in the case of Bangladesh where almost all of the milk comes from goats), but the strength of each category was significant (5 times increase for milk of cattle and buffalo and 6 times increase for

goats milk). On the other hand, there was certain stagnation for sheep's milk with a decline in market share.



**Figure 29: Evolution of egg production in the three countries**

Source: Calculation from FAO data

Finally, it should be noted that in this thesis, for reasons of availability of certain data for production, consumption and prices in the FAOSTAT database, we could not take into account fish (farmed or caught in the sea, lakes and rivers) which nevertheless constitute an important contribution in terms of protein for the people of these three countries.

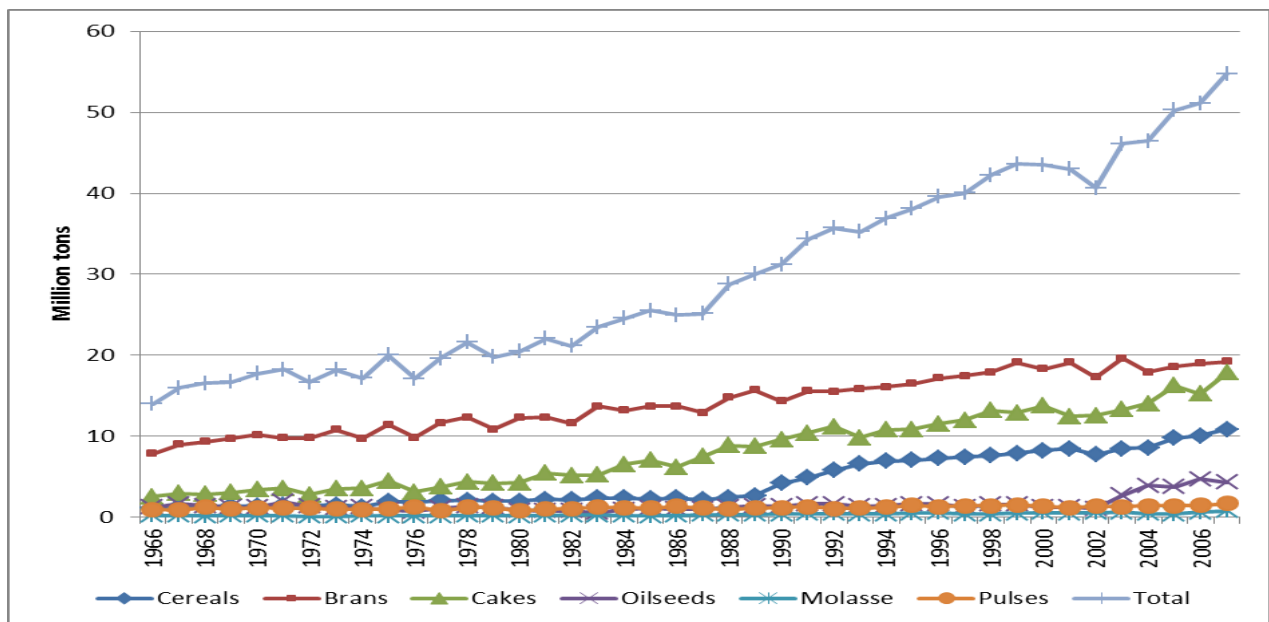
### 5.1.1.2. Evolution of consumption of concentrates as feed

These three countries primarily use available grass and forages to feed large and small ruminants while grains and by-products are more used in poultry farm (Khan, 2003; Pathak, 2003; Hutabarat et al., 2003). However, farmer used the traditional way to increase yields of animal products (milk, eggs) and accelerate the growth of animals (specially poultry) for their own consumption or for sale in local markets by giving them first a certain number of grains taken from their own crops (known as auto consumption or intra consumption) such as some cereals, some pulses or oilseeds (such as cotton) eventually non consumed for human consumption for reasons of quality or which are not subject to local marketing and secondly a number of by-products, with little or no value for human food, from local agricultural industries such as brans from the milling of wheat and rice processing, molasses from sugarcane (and in some cases beet)

and cake<sup>54</sup> from the oilseed crushing. The main objective of this operation is to produce oil used in food, but in each case there is a significant percentage (40 to 78%) of a by-product (cake or meal) more or less rich in protein particularly suitable for feed in countries where deficiency of protein products is important (with a particular situation for India). These four categories of products (cereals, cakes, oilseeds, pulses and molasses) will be referred to hereafter as the "concentrates".

The FAOSTAT database provides annual estimates from 1966 to 2007 on the consumption of these products in animal nutrition from national balance sheets. Insofar as these figures are actually balances of production trade, known consumption (in certain food and agricultural industries), it is clear that they are tainted by high uncertainty<sup>55</sup> and can be used for econometric estimates.

Overall for all three countries, consumption of concentrates increased from 14 Mt in 1966 to nearly 55 in 2007 by FAOSTAT, the last year for which statistics are available in this database.



**Figure 30: Evolution of total consumption of concentrates per product families**

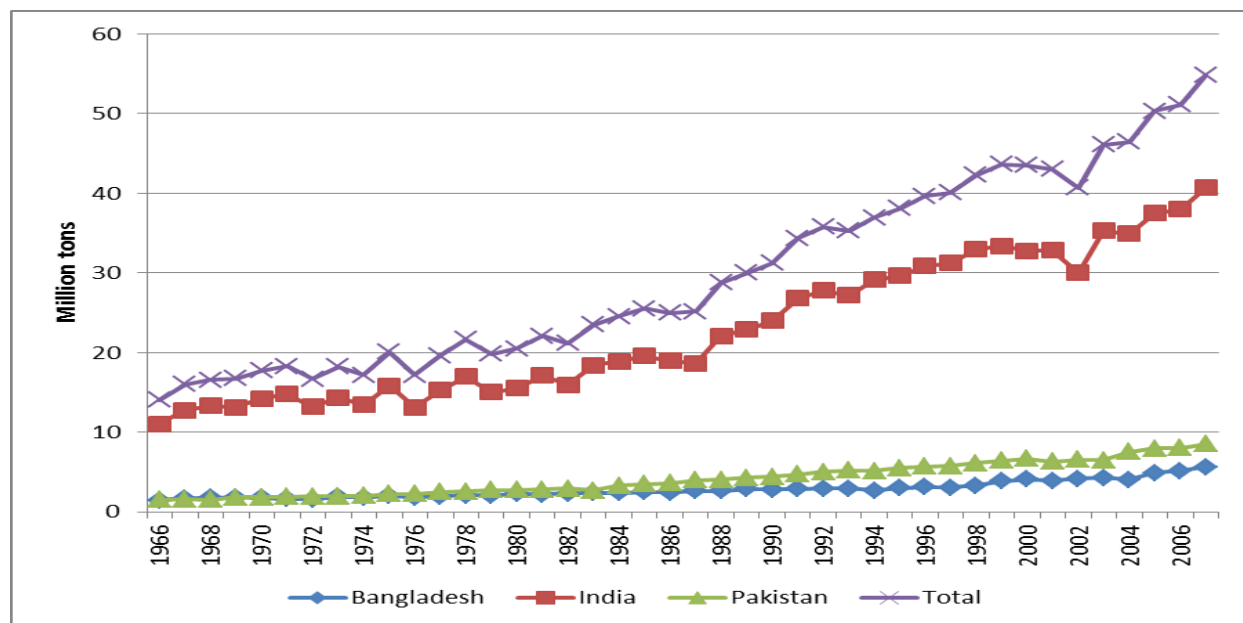
Source: Calculation from FAOSTAT data

<sup>54</sup> In all this report the words “cake” and “meal” are used indifferently to designate the residue rich in protein obtained by crush industry when oil is separated

<sup>55</sup>With regard to cereals, oilseeds and meals, PSD USDA database also provides annual digits of animal products consumption for these three countries which may be quite different from those of the FAO and on the other hand there are also sharp discontinuities for some years that seem to be better explained by changes in estimation method more than real change.

According to FAOSTAT, wheat and rice brans are always the first byproduct used with a share of 35% in 2007, but this place was 56% in 1966 that has steadily declined in favor of cereals (20% against 8 %) and meals (33% against 18%). All oilseeds grains fluctuates considerably from one year to another (between 3% and 1%), but was found in 2006 with 9% same percentage as in 1966. While molasses is often used at rates between 1 and 2%, legumes (pulses) have seen their place back strongly in recent years to be around 3% due to higher prices of these products and their high demand for food.

Overall between 1966 and 2007, 41 Mt of concentrates, 10 Mt of cereals and 3 MT of oilseeds were used in these three countries for animal feed where these demands for animal feed come naturally to compete with food for human (wheat flour, rice and vegetable oils). For other non-competing products with men, the increase was 11 Mt for bran and more than 15 MT for cakes. The result is a larger increase for meals (and to some extent bran) then for cereals; which is explained by the desire of farmers and feed manufacturers to rebalance compounds animal rations (especially poultry meat and eggs) by a higher intake of protein.

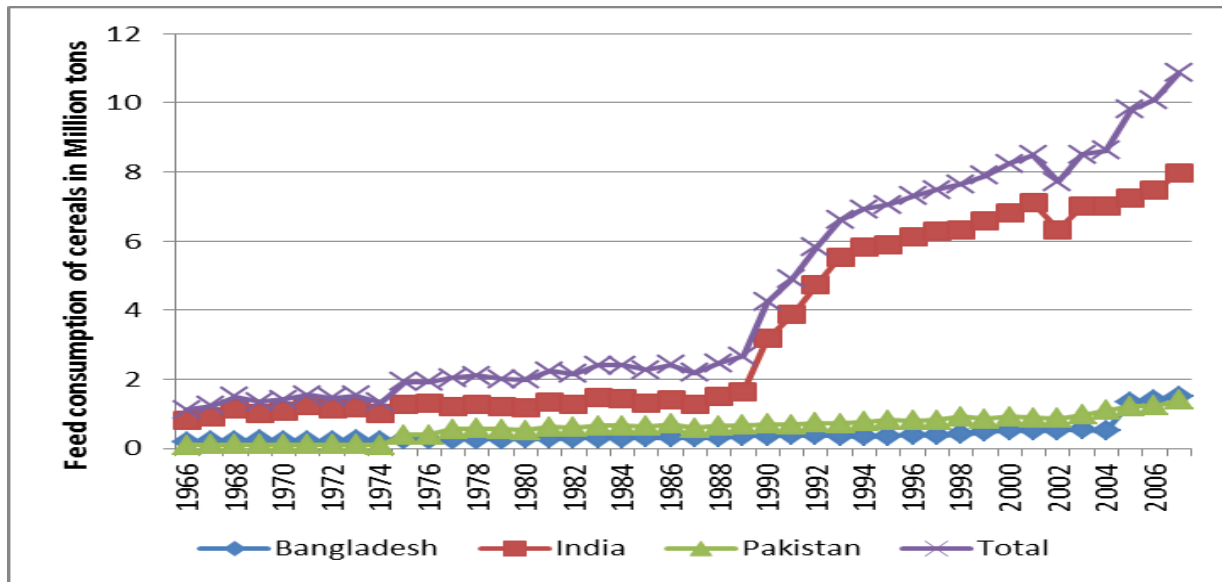


**Figure 31: Evolution of total consumption of concentrates by country**

Source: Elaboration from FAOSTAT data

Figure 31 shows the considerable weight of India in the total consumption of concentrates with 74% in 2007 against 79% in 1966. While Bangladesh's share remained virtually stable at 10% with significant annual fluctuations and Pakistan's share increased from 10% to nearly 16%. The

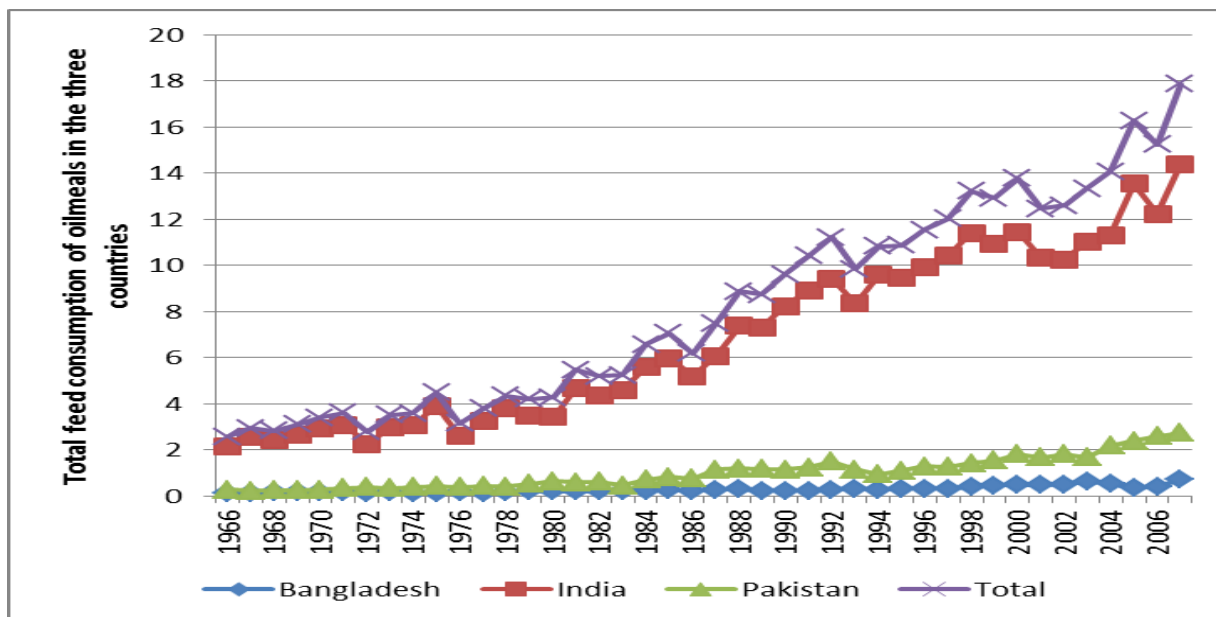
increased use of concentrates was therefore about 30 Mt in India, 7 Mt in Pakistan and 4 MT in Bangladesh, where distribution is much different according to families of products and countries. A similar importance of India in total consumption can be observed for cereals (Figure 32) and oil meals (Figure 33).



**Figure 32: Evolution of total feed consumption of cereals by country**

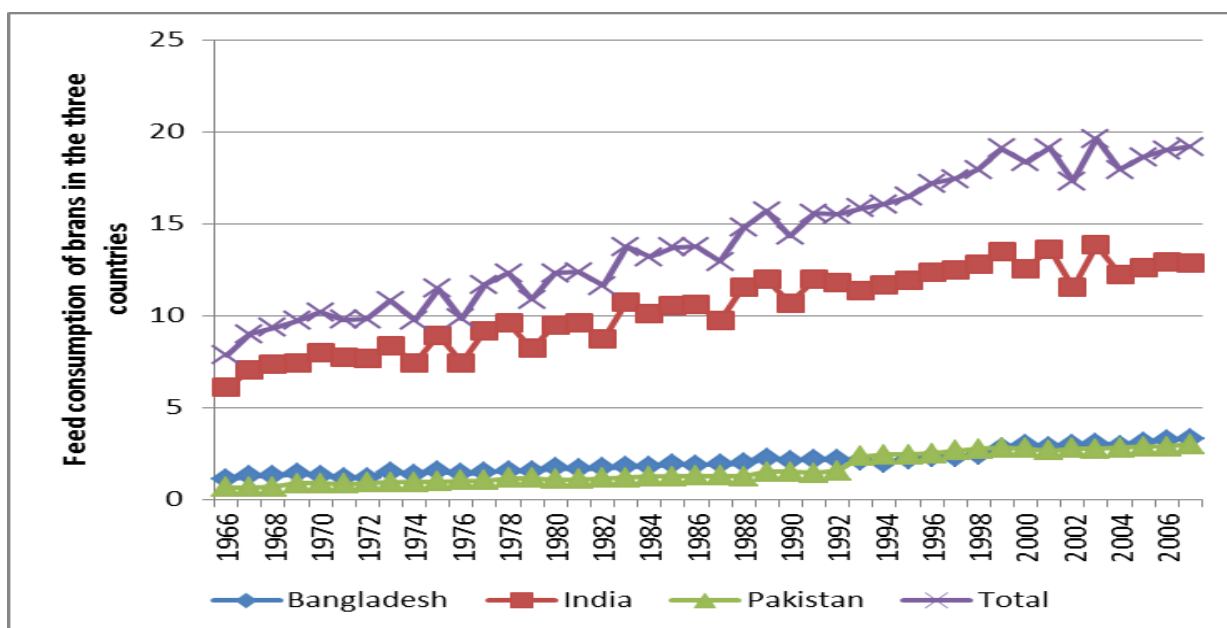
Source: Elaboration from FAOSTAT data

According to FAO data, up to 1988 there were very few cereals used in feed sector (less than 2.8 Mt), but during the 10 following years this tonnage was multiplied by 3 and continued to increase after to reach around 11 Mt in 2007. India alone represents the main part, but during the last years shares of Pakistan (13% in 2007) and Bangladesh (14%) increased notably.



**Figure 33: Evolution of total feed consumption of oil meals by country**

Source: Elaboration from FAOSTAT data



**Figure 34: Evolution of total feed consumption of brans by country**

Source: Elaboration from FAOSTAT data

## **5.1.2. Pakistan**

### **5.1.2.1. Evolution of the animal production in Pakistan**

Livestock contributes 51.8 percent to agricultural value added that is much more than the combined contribution of major and minor crops (45.5%). Livestock plays an important role in the economy of the country. Livestock sector contributed approximately 11.3 per cent to national GDP during 2008-2009. Gross value addition of livestock at current cost factor has increased from Rs. 1052 billion (2007-2008) to Rs. 1287 billion (2008-2009) showing an increase of 22.3 %. (Economic Survey of Pakistan, 2011). The value of livestock is 6.1% more than the combined value of major and minor crops. The contribution of fisheries and minor crops has also increased slightly. However, the contribution of forestry has been declined.

In Pakistan, from 1981-2000, the production of livestock products i.e., milk, beef and mutton increased with an overall average growth rate of 4.46% per annum, whereas the egg and poultry meat production growth rate was 8-11% per annum (Khan, 2003).

The upsurge in animal products prices has provided incentives for greater production and thus prospects for growth. Pakistan is endowed with many types of livestock such as buffalo, cattle, sheep, goat and poultry. There is quit a large indigenous livestock population, that is well adapted to local environmental conditions. The world's best dairy buffalo breeds i.e. Nili Ravi and Kundi are present in Pakistan. On the other side, the Sahiwal breed is one of the best local breed in Asia among the cows (Khan, 2003). There are also many types of sheep and goat breeds in different ecologies according to their suitability and the availability of feed resources.

According to FAOSTAT, the total buffalo population in 1981 was 22 million then increased to 25 million in 2007 with an overall growth of 3.90%. The total cattle population in 1981 was 15million but increased to 34 million in 2007 with an overall growth of 3.35%. The growth rate of buffalo is higher than cow because the people of Pakistan prefer buffalo milk compared to cow milk due to high butter fat in it.

According to FAOSTAT, the sheep population was 11.9 million in 1981 but decreased to10.1 million in 2007. The overall growth rate of sheep population is -0.66%. The goat population was 17.7 million in 1981and decreased to15 million in 2007 at growth rate of -0.66%. The goat and



sheep population decreased because the people of Pakistan prefer poultry meat due to its availability with cheap price.

Poultry has made progress at a significantly higher rate because of the introduction of commercial poultry and the establishment of scientific and commercial entrepreneurship in Pakistan. According to FAOSTAT, the population of poultry was only 68 million in 1981 but it had increased to 480 million by 2007 with an average growth rate of 8.10% during last twenty years. Milk production was 9.2million tons in 1981, increasing to 32.2 million tons that was obtained with an overall average growth rate of 5.14 Per cent.

Beef is commonly obtained from buffalo and cattle, primarily without any feedlot fattening. Beef production is considered to be a by-product of dairy activities. According to FAOSTAT, beef production in 1981 was 394 thousand tons, increasing to 1.34 million tons in 2007 with a 5.03% Per cent.

Mutton is obtained from sheep and goat, which are usually raised on conventional production systems and so far, no feedlot fattening has been introduced for systematic increase in mutton production. According to FAOSTAT, mutton production was 289 thousand tons in 1981, increasing to 407 thousand tons in 2007 that was achieved with an overall growth rate of 0.82 per cent.

Poultry meat production was only 53.6 thousand tons in 1981 but it is increased to 558 thousand tons at growth rate of 9.82%. This significance increase in poultry meat production was achieved with the advent of hybrids in broiler strains coupled with balanced feeding, proper management and health care.

According to FAOSTAT, egg production was 114 thousand tons in 1981, increasing to 486 thousand tons in 2007. This increase was achieved with a 5.98% growth rate.

#### **5.1.2.2. Evolution of feed resources in Pakistan:**

Feed resources available in Pakistan can be divided into two main categories as conventional feed resources and non-conventional feed resources (Younas et al. 2005). Conventional resources are grouped further into three categories: 1) green roughages, 2) dry roughages, 3) concentrates

Green roughages include fodder crops, range grasses including shrubs and forbs, sugar beets tops, sugarcane tops, silages and tree leaves. Even in advanced countries where grains are fed liberally

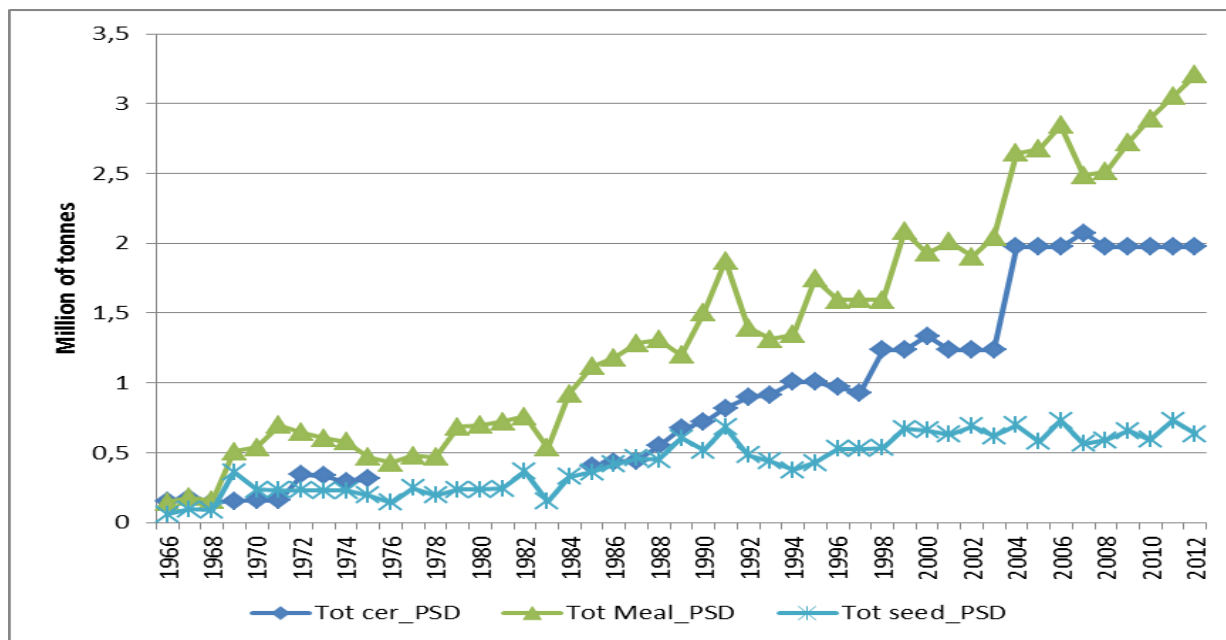
to the ruminants, forage still contributes about 75% of the nutrients whereas in the countries where grain feeding is not very common, ruminants derive more than 95% of their nutritional needs from roughage (Bulla et al 1977). Concentrates include cereal grains, oil seed cakes and meals, cereals brans and polishing, molasses and sugar beet pulp. Non-conventional feed resources have the potential to play a major role in meeting the feed shortage in the years to come. But we are more concerned with concentrates.

Concentrates are high in energy and protein, low in fibre and highly digestible. They are expensive part of animal feed and are used mostly in small quantities as supplements. These feeds include cereals, oil seeds and meals, cereals brans and polishing, molasses and sugar beet pulp. Habib et al., (1994) proposed that there are two types of concentrates common. First type is energy rich (carbonaceous) including cereal grains (wheat, maize, barley, oats, sorghum and rice), wheat bran, rice polishing, molasses (sugar cane and sugar beet molasses (sugar cane and sugar beet molasses), sugar beet pulp. Second type is protein-rich sources from plant origin include oilseeds (cottonseed, mustard seed, maize germ, sunflower, soybean, sesame,..), oilseed meals (cottonseed, soybean, maize gluten), maize gluten feed, maize gluten meal and from animal origin are blood meal, fish meal, meat meal and feather meal.

Non-conventional feed refers to those feeds which are not traditionally used in animal feeding but have the potential to be used as feed.

As PSD data are often used in world agricultural models, first it is interesting to examine the data concerning concentrates in feed utilization for Pakistan.

We sketched following graph (figure 35) that showed tremendous increase in utilization of total meals in animal feed from 500 thousand tons in 1975 to 2700 thousand tons in 2012. During last thirty years the poultry sector of Pakistan got boom and poultry feed mainly comprises soybean meal, rape seed meal. So with the boom of poultry sector, utilization of meals also increased tremendously. On the other hand, use of cereals also increased during last thirty years from 500 thousand hectares in 1996 to 2000 thousand hectares in 2009 that is also a worthwhile change. Cereals are also used in poultry feed as well as ruminants feed. The consumption of total oilseeds has also been increased from 250 thousand tons in 1975 to 900 thousand tons in 2009. Oilseed crops are less demanded in animal feed due to its composition (less proteins and more fibres).



**Figure 35: Evolution of concentrates used for feed in Pakistan according to PSD**

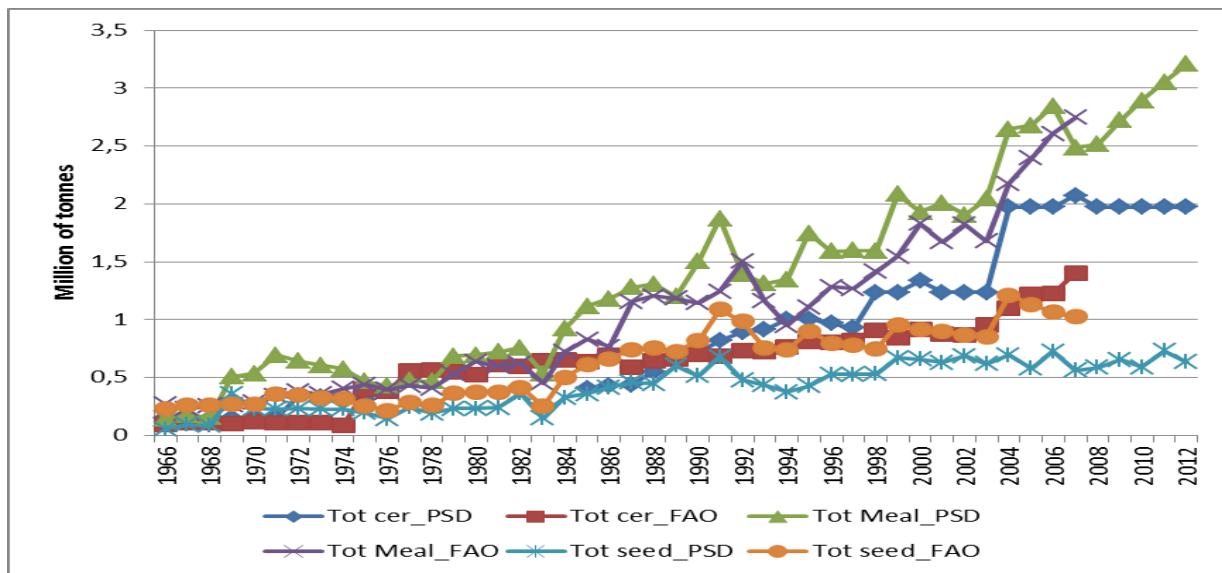
Source: Elaboration from PSD data

Now among the cereals, if we analyse the consumption of each cereal in animal feed during last 20 years then we came to know that corn (maize) is at first number because by-products of maize and maize itself are consumed in animal feed. The consumption of maize increased from 300 thousand tons in 1995 to 1500 thousand tons in 2009 (figure 35). It means that corn made more than 50% of total cereals used in animal feed. After corn, wheat makes contribution in animal feed that increased slightly from 100 thousand tons in 1995 to 400 thousand tons in 2009. After wheat, there are sorghum, barley and millet that are used traditionally for household animal rearing.

Among meals, cottonseed meals make more than 70% of total meal used in animal feed. The trend of line representing the consumption of sunflower seed is same as total meal. Utilization of cottonseed increased from 400 thousand tons in 1975 to 2700 thousand tons in 2009. After sunflower seed, it is rapeseed that increased from 100 thousand tons in 1975 to 500 thousand tons in 2009. Consumption of soybean and sunflower seed meal also increased after 1993 till 300 and 400 thousand tons respectively.

Among total oilseeds crops used in animal feed, cottonseed makes more than 70% of total oilseed. Consumption of cottonseed oil increased from 200 thousand tons in 1975 to 700 thousand tons in 2009. Before 1993, the total oilseed comprises of only cottonseed but after period, utilization of rapeseed increased till 500 thousand tons in 2009.

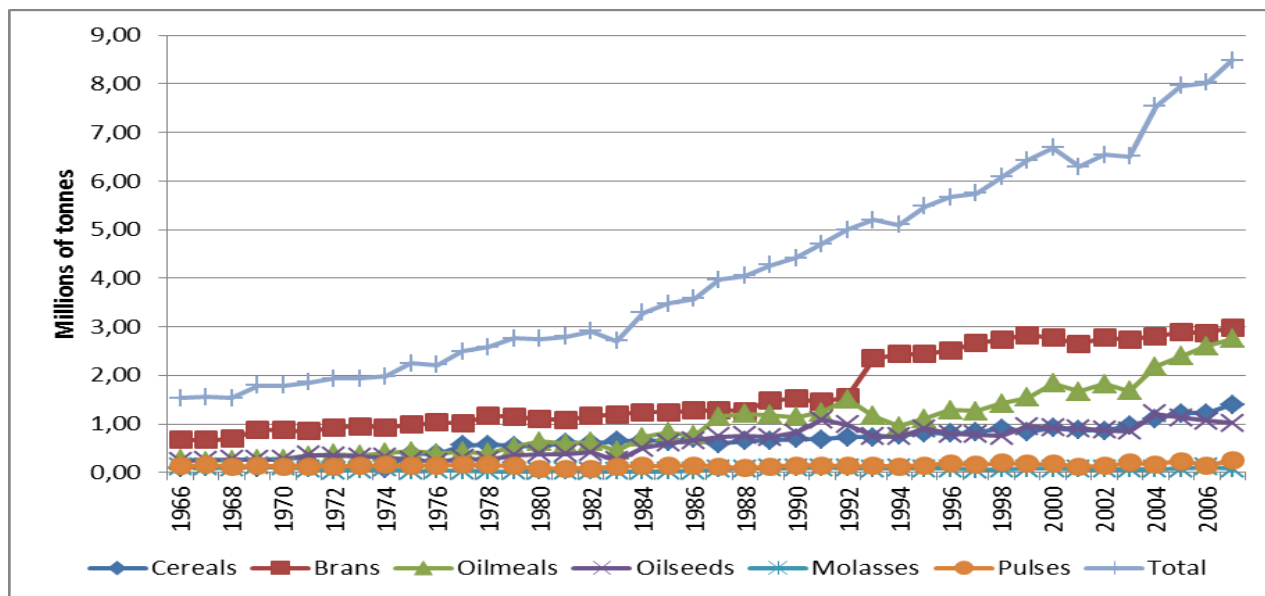
An important advantage of PSD database is to give more actualized data on the different items of national balance (up to 2012 against only till 2007 for FAO), but these data are limited to three families (cereals, oil meals and oilseeds). Due to the fact that FAO data are elaborate on a calendar year basis and PSD data on a standard crop year (October/august), it is normal that some differences appears. But as shown in the following graph, there are huge differences for these families (see figure 36).



**Figure 36: Comparison of PSD and FAO data for main feed families' uses in Pakistan**

Source: Elaboration from FAOSTAT and PSD data

The differences are very important; first for cereals (by instance 2.1 Mt according to PSD in 2007 and only 1.4 Mt according to FAO), but also for oilseeds (0.6 Mt for PSD for the same year against 1.0 for FAO). For oil meals the two sources give more proximate figures (2.5 Mt against 2.7) even for each year figures are significantly different. Contrary to FAO database, the main problem with PSD database is to give no information on other concentrates used in feed (brans, molasses, etc.). So we have choice to use FAO data even if we are conscious that these figures are only estimations not more reliable for econometric estimations.



**Figure 37: Evolution of feed concentrates used in Pakistan according to FAO**

Source: Elaboration from FAOSTAT data

### 5.1.2.3. Evolution of livestock feed industry

Khan, 2003 has divided feed industry of Pakistan into following major categories.

#### Local raw materials used without transformation

Feed crops in Pakistan are not only cultivated to feed animals but these are mainly cultivated to meet human dietary needs. Wheat, maize, sorghum, millet and barley are basically grown to meet human dietary needs and these are also used as components of animal feeds. The grains of these crops were used for livestock and rural poultry even before the development of commercial poultry feed industry. Maize grains are usually used up to 20% in poultry rations, however, when the maize prices increase it is substituted with other cereal grains or their by-products (Alvi, 2002). Wheat is also being used in poultry rations and also in commercial dairy farming systems. But in poultry feed industry, formulators are careful not to exceed the wheat use beyond 15 per cent because after 15% it has adverse effect i.e. lowered growth rate and increased fat contents in the dropping commonly known as pasting,

As sorghum does not exceed 5 per cent in commercial poultry feed. But millet is only used for poultry and livestock domestically but not for commercial poultry. By-products of rice (rice polish, rice bran and rice tips) are utilized in poultry or livestock feeding.

### Cereal processing industry:

These industries consist basically of flour mills and rice processing industries. Moreover, maize is also processed through wet milling but their number is few. Wheat flour mills produce wheat flour that is principle food for human in Pakistan, whereas its by-product is wheat bran which is mainly used as a ruminant feed ingredient, however, its use in poultry is not uncommon. Rice bran is another by-product of rice milling industries which is used in both livestock and poultry feeding. The by-products of maize industries include oil cakes, maize gluten 20 per cent and maize gluten 60% which are used in livestock and poultry feed. Maize oil cake and gluten 20% are exclusively used in livestock rations, whereas gluten 60% is mainly used in poultry rations.

### Oilseed extraction industry:

The by-products of the expeller extraction plants are called oilseed cake with more oil and fibre. Solvent extraction plants produce oilseed meals, which are comparatively low in fibre and oil but high in protein. The most commonly available oilseed cakes and meals used in livestock and poultry feeding are cottonseed cake/meal, rapeseed cake/meal, sesame cake/meal, sunflower cake/meal and soybean meal. The cakes are mainly used in livestock feeding whereas the meals are used in poultry feeding. Soybean meal, which is good source of protein and amino acid and is the preferred meat of poultry feed millers, is mainly imported from India and exclusively used poultry rations.

### Other industrial by-products:

The other miscellaneous industrial by-products are molasses, fish meal, guar meal and pulses.

### Raw materials imported

Vegetable protein sources are the major proteins in feed. Almost all vegetable protein sources are by-products of the solvent extraction industry. They vary in composition according to processing. Major vegetable protein sources used in poultry feeds are canola meal, sunflower meal, soybean meal which are imported.

Since 1997 canola seed has been imported for better utilization of the solvent extraction industry, as they were operational seasonally and in total only 180 days of the year.

#### **5.1.2.4. History and development of poultry industry in Pakistan**

The subsequent development of Pakistan's Poultry Industry can be divided into four phases (Pakistan Livestock Overview).

##### **The introductory period 1965-1970**

After realizing protein deficiency, Government encouraged poultry production by policies that exempted poultry producer from tax and by giving permission to import equipment. A number of catalytic forces shaped the early development of the poultry industry. Directorate of Poultry Production at Karachi was established for extension services.

##### **Institutional Development 1971-1975**

For coordination between government and industry activities, the Federal Poultry Board was established. Research services were offered through the Poultry Research Institute with the assistance of UNDP/FAO funds. This phase is characterized by both the greatest success of the poultry industry and its greatest failure. At the same time the clustering of production units led to large disease outbreaks and the lack of marketing facilities due to ban on export of poultry products limited industry growth.

##### **The Production Boom 1976-1980**

The nationalization of other industries contributing the entry of capital into poultry industry, particularly in the Punjab, resulted in the poultry production boom. The increase volume of production was forced through limited marketing channels. Serious financial setbacks to poultry farming in Pakistan culminated from discontinuation of poultry exports; disease problems; high relative prices of poultry feed; deteriorating feed quality; and limited supply of feed ingredients. Poultry farmers faced with financial problems and seeking remedial measures formed the Pakistan Poultry Association in 1979 on the advice of the Federal Poultry Board.

##### **Depression and Adjustment 1981-1990**

Disease problems posed a serious threat to the sound development and consolidation of the industry. Production showed a decreased growth or even depression during early 1980 particularly of increases in the Punjab, Baluchistan and NWFP. However, in the later part of 1980's starting from 1985 industry seemed to be readjusted with much rise in poultry number,

particularly for broilers. Faced with disease problems, lower productivity and numerous environmental and climatic difficulties, some of more successful farmers decided to produce under more modernized conditions and to establish their poultry farms in cooler, less polluted area of the country. The farmers also built houses with controlled environments for breeders, broilers and commercial layers.

### **1991 to now:**

The diseases like Hydro pericardium and Gumboro attacked the chicks of broiler, layer and parent flock that resulted in great mortality. With the passage of time efforts to reduce the incidence of these diseases and prophylaxes regarding vaccination and bio-security were done, this also resulted in establishment of new medicine companies and the importation of vaccines form abroad started. At national level institutes like Poultry Research Institute, Veterinary Research Institute and Agriculture University Faisalabad also done efforts to reduce these diseases.

There was depression in industry from 1995 to 1997 due to attack of diseases and ban on its serving in marriage ceremony ( demand) then in 1998 it started gradually improving and by increase in price of chick the companies got a great profit.

Now poultry industry is the most modern and well equipped industry in Pakistan.

## **5.1.3. India**

### **5.1.3.1. Evolution of animal production in India**

The livestock sector contributed over 5.26 per cent to the total GDP during 2006-07 and contributes about 31.7 per cent GDP from total agriculture and allied activities. In 2007-08, this sector contributed 104.8 million tons of milk, 53.5 billion eggs, 44 million kg wool and 2.6 million tons of meat. India ranks first in the world in milk production, which increased from 17 Mt) in 1950-51 to about 104.84 Mt by 2007-08 (economic survey of India 2011). The per capita availability of milk has also increased from 112 grams per day in 1968-69 to 252 grams during 2007-08, but it is still low compared to the world average of 265 grams/day. India produces more than 47.3 billion eggs per year, with per capita availability of 42 eggs per annum. As per the estimate provided by the Food and Agriculture Organization (FAO) for 2007, the annual chicken meat production in India is around 2.2 million tons.



According to FAOSTAT, the total buffalo population in 1981 was 6.1 million then increased to 10.2 million in 2007 with an overall growth of 2.06%. The total cattle population in 1981 was 9.8million but this slightly increased to 9.9 million in 2007 with an overall growth of 0.05%. The growth rate of buffalo is higher than cow because the people of Pakistan prefer buffalo milk compared to cow milk due to high butterfat in it.

According to FAOSTAT, the sheep population was 13.2 million in 1981and increased to22 million in 2007. The overall growth rate of sheep population is 2.07%. The goat population was 31.3 million in 1981and increased to53.4 million in 2007 at growth rate of 2.16%. The goat and sheep population decreased because the people of Pakistan prefer poultry meat due to its availability with cheap price. Beef is commonly obtained from buffalo and cattle, primarily without any feedlot fattening. Beef production is considered to be a by-product of dairy activities. Beef production in 1981 was 171 thousand tons, increasing to 242 thousand tons in 2007 with a 1.41% Per cent.

Poultry has made progress at a significantly higher rate because of the introduction of commercial poultry and the establishment of scientific and commercial entrepreneurship in India. According to FAOSTAT, the population of poultry was 149 million in 1981 but it had increased to 1502 million by 2007 with an average growth rate of 9.66% during last twenty years. Milk production was 34.3million tons in 1981, increasing to 107.9 million tons that was obtained with an overall average growth rate of 4.69 Per cent. India is the largest producer of milk in the world.

Mutton is obtained from sheep and goat, which are usually raised on conventional production systems and so far, no feedlot fattening has been introduced for systematic increase in mutton production. According to FAOSTAT, mutton production was 470 thousand tons in 1981, increasing to 797 thousand tons in 2007 that was achieved with an overall growth rate of 2.16 per cent.

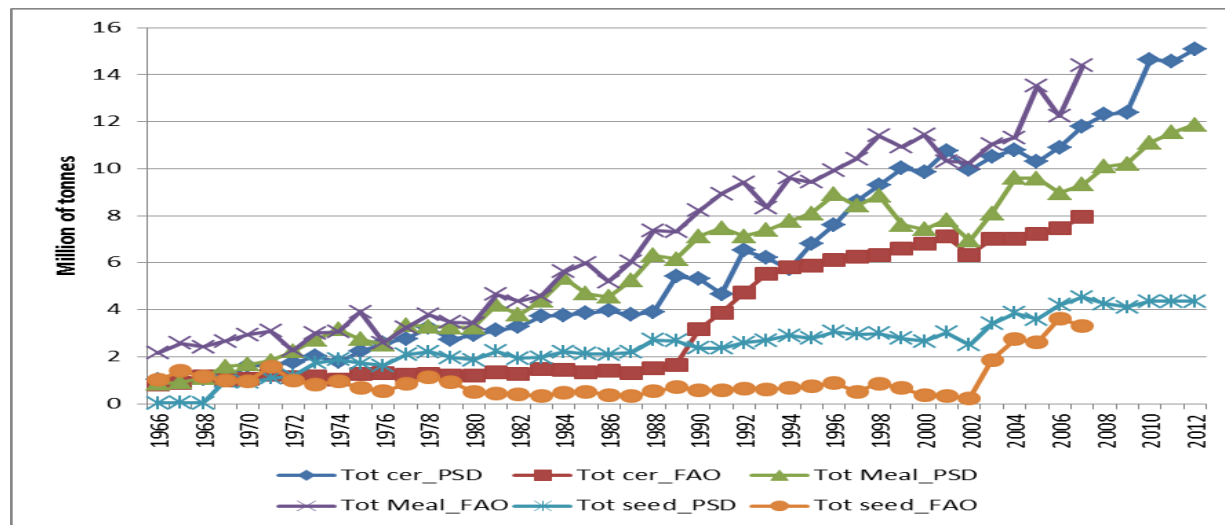
According to FAOSTAT, Poultry meat production was only 141 thousand tons in 1981 but it is increased to 1791 thousand tons at growth rate of 10.7%. India has the modern poultry industry with all equipment, pure line breeding and excellent feed quality. Egg production was 598thousand tons in 1981, increasing to 2947thousand tons in 2007. This increase was achieved with a 6.59% growth rate.

India is one of the most important livestock-rearing countries, with a large population of cattle, buffaloes, sheep, goats and other species of livestock. The country has 1/6 of the world's cattle and about 1/2 of the world's buffalo population (Government of India 2003). India ranks sixth terms of sheep and goat population. The pig population is about 12.79 million. The improved layer bird population is around 104 million<sup>56</sup>.

### 5.1.3.2. Evolution of feed resources in India

Like Pakistan, India has the same type of feed resources like conventional and non-conventional feed resources. Conventional resources are grouped further into three categories: 1) green roughages, 2) dry roughages, 3) concentrates. Our objective is to analyse concentrates.

For livestock feed, India does not depend on imports but is self-sufficient. Instead, India earns foreign exchange by exporting large quantities of solvent extracted meals. Concentrates includes cereals, cakes, meals and by products, etc. (Pathak, 2003).

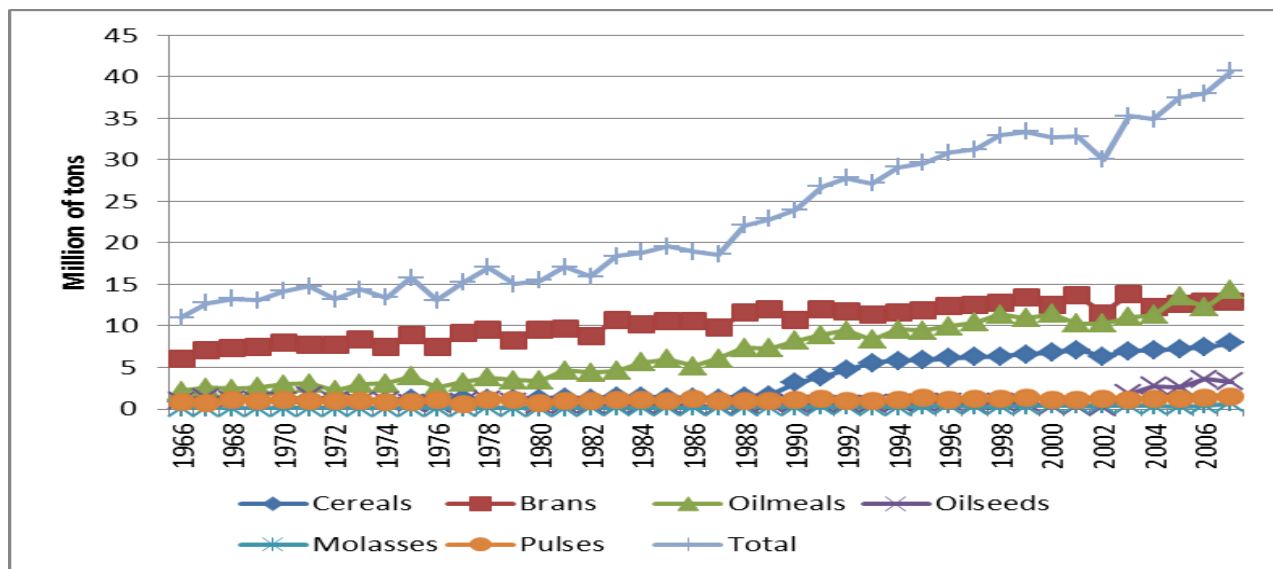


**Figure 38: Comparison of PSD and FAO data for the three main families of concentrates used in feed in India**

Source: Calculation from FAO and PSD

Like Pakistan, we observe huge differences between the two sources and decided to use FAO data which gives more families of concentrates.

<sup>56</sup>All India Poultry Year Book (2003–2004)



**Figure 39: Feed concentrate uses in India according to FAO**

Source: Calculation from FAO

Pathak, 2003 and Vaidya 2001 divided and explained the feed sources of India in following categories:

### **Cereals and grains**

Maize, sorghum and millet are commonly used in animal feeds. Wheat and rice are mainly retained for human consumption. India is one of the important consumers and producers of coarse cereals in the world. However, in contrast to animal feed use in developed countries it is a staple food for the poor in India and is a source of income and employment. Most of the coarse cereals in developed countries are used for cattle feed and some of the cereals like barley are processed for beer. Maize is a top ranking cereal in terms of global productivity. It is second to wheat in total production and has great significance as a human food, animal feed and industrial products. About half of the total world production of cereals is coarse cereals. Maize has been under the Technology Mission set up by the Government of India for promoting production technology and superior varieties of maize in the country since 1995. Sorghum is the most important cereal crop for poor people and grown for food, feed and industrial products. Sorghum grain can be nutritionally a better feed due to its high protein and fibre content.

### **Agro based industries and by-products**

India produces soybean, groundnut, rapeseed, sesame, cotton meal and sunflower meals for cattle and poultry feed. In cattle feed, in addition to these meals, others such as cottonseed and copra

are used as premium ingredients. India also exports a large quantity of meal. India has nearly 600 solvent extraction units.

### **Popular by-products**

They include wheat bran, rice bran and oil-extracted rice bran, tapioca, guar meal, safflower meal, maize gluten and molasses.

### **5.1.3.3. Evolution of livestock feed industry**

According to Vaidya 2001, livestock feeds are manufactured by industries under the banner of “Compound Livestock Feed Manufacturer’s Association of India” (CLFMA) and also some other small cooperatives. This association was formed in 1967 with the objective of helping the promotion of the concept of balanced feeding of animals in accordance with their nutritional requirements for deriving maximum output through productivity improvement. They have an installed capacity of over 5 million tons/year and produce over 3 million tons/yr. Other small industries in the unorganized sector produce 2 Mt/year, thus, making a total of 5 Mt/year against the demand of 42Mt/year. Many poultry industries have established their own feed milling facility and the required research and development to take care of the quality. Several State Agro-industrial Corporations have also started manufacturing the feeds. Demand for compound animal feeds was growing at a rate of 12% cent during many years.

CLFMA was formed in June 1967 as an association of feed manufacturers and associated industries such as ingredient suppliers, importers, feed additive manufacturers, consultants, hatcheries and milk cooperatives and feed machinery manufacturers. The objectives of CLFMA are to promote the concept of nutritionally balanced compound feed; to promote, assist, organize and coordinate scientific research in the field of animal nutrition; to conduct, assign, sponsor or co-sponsor surveys and studies; to collect, classify and circulate information related to animal feed to its members and government; to offer suggestions to government in formulating policies; and to impart training to livestock farmers, feed mill personnel, veterinarians, students and others. The office-bearers of CLFMA are elected and operate for a maximum of two years at one level.

Taneja (1999) remarked that “The compound feed industry, while helping with the optimal utilization of coarse grains, agro-industrial by-products such as de-oiled meals and other non-conventional raw materials, also provides nutritionally balanced and scientifically compounded

animal feed with high conversion efficiency, and therefore enables a greater quantity of animal products with less feed. This is of great significance in view of the shortage of feed in India.”

#### **5.1.3.4. History of Poultry Development in India**

Today poultry industry is the fastest growing sector of India's agriculture. To get the full impact of its rapid escalation, it would be interesting to trace the evolution of poultry development in India (Government of India 2003).

According to Government of India 2003, Poultry farming was mostly a backyard venture up to 1957. The first organized effort to develop poultry was made in that year when second Five Year Plan was launched. An All India Poultry Development Project was initiated. Their functions were also included promoting poultry farming extensively and provide training facilities to the officers of the neighbouring states. Along with it all the necessary equipment was also imported.

The middle and late seventies recorded a tremendous progress in the poultry industry. Central Avian Research Institute was established in 1979 to provide strong research support to the poultry industry both in the public as well as private sector. In the last four decades, poultry has come a long way from a backyard venture of the 'fifties to the modern, sophisticated dynamic agro-industry of today. Today India is the world's fifth largest egg producer and the eighteenth largest producer of broilers.

#### **5.1.4. Bangladesh**

##### **5.1.4.1. Evolution of animal production in Bangladesh**

The contribution of the livestock sub sector to GDP at constant prices was at 2.65 per cent and at 2.57 per cent (Bangladesh economic review, 2011) in 2009 and 2010 respectively. The growth of this sub-sector stood at 3.38 per cent and 3.54 per cent (provisional) in 2009-10 and 2010-11 respectively. Though the share of the livestock sub- sector in GDP is small, it contributes to meeting the daily protein requirements, cultivation, production and exports.

According to FAOSTAT, the total buffalo population in 1981 was 4.7 million then increased to 12.1 million in 2007 with an overall growth of 3.80%. The total cattle population in 1981 was 2.1million but this slightly increased to 2.6 million in 2007 with an overall growth of 0.77%. The

growth rate of buffalo is higher than cow because the people of Pakistan prefer buffalo milk compared to cow milk due to high butterfat in it.

According to FAOSTAT, the sheep population was 150 thousand in 1981 and increased to 470 thousand in 2007. The overall growth rate of sheep population is 4.67%. The goat population was 4.7 million in 1981 and increased to 24.1 million in 2007 at growth rate of 6.75%. The goat and sheep population decreased because the people of Pakistan prefer poultry meat due to its availability with cheap price.

Poultry has made progress at a significantly higher rate because of the introduction of commercial poultry and the establishment of scientific and commercial entrepreneurship in India. According to FAOSTAT, the population of poultry was only 71 thousand in 1981 but it had increased to 252 thousand by 2007 with an average growth rate of 5.18% during last twenty years. Milk production was 1.18 million tons in 1981, increasing to 2.89 million tons that was obtained with an overall average growth rate of 3.63%.

Beef is commonly obtained from buffalo and cattle, primarily without any feedlot fattening. Beef production is considered to be a by-product of dairy activities. According to FAOSTAT, beef production in 1981 was 124 thousand tons, increasing to 191 thousand tons in 2007 with a 1.74%.

Mutton is obtained from sheep and goat, which are usually raised on conventional production systems and so far, no feedlot fattening has been introduced for systematic increase in mutton production. According to FAOSTAT, mutton production was 25 thousand tons in 1981, increasing to 171 thousand tons in 2007 that was achieved with an overall growth rate of 8.08 per cent.

Poultry meat production was only 56 thousand tons in 1981 but it is increased to 189 thousand tons at growth rate of 4.97%. This significance increase in poultry meat production was achieved with the advent of hybrids in broiler strains coupled with balanced feeding, proper management and health care.

According to FAOSTAT, egg production was 66 thousand tons in 1981, increasing to 252 thousand tons in 2007. This increase was achieved with a 5.51% growth rate.

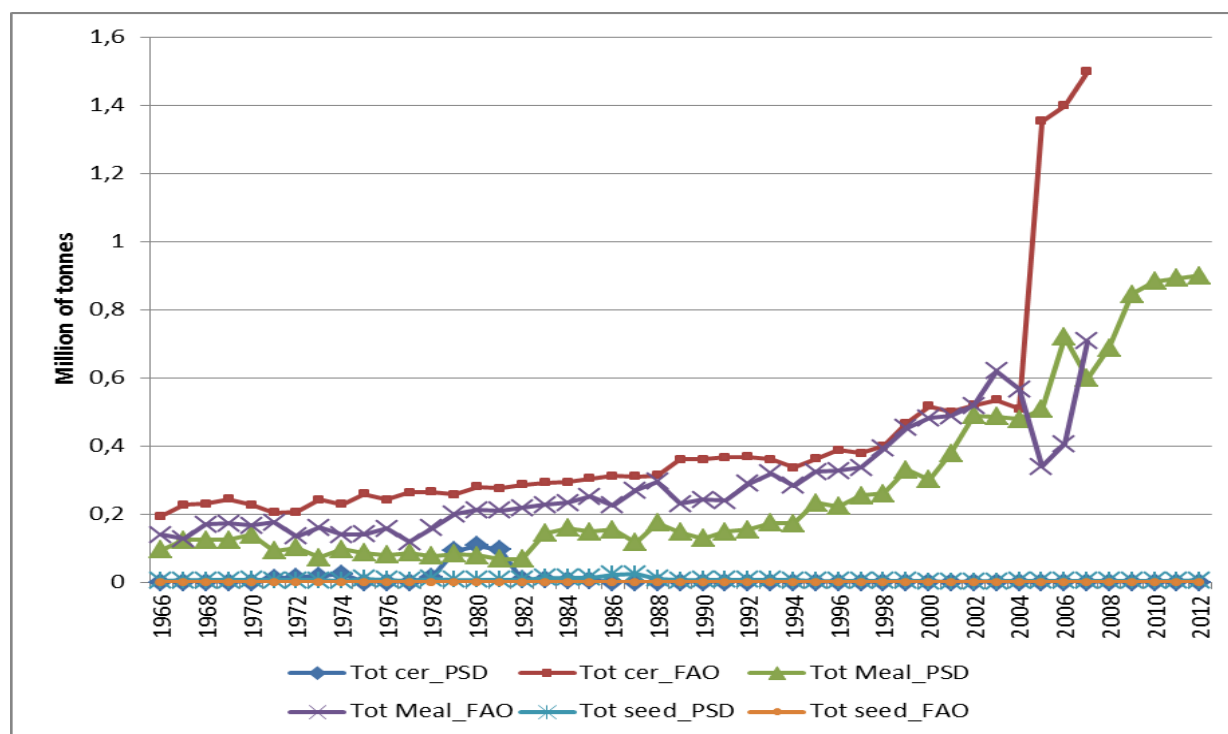
### 5.1.4.2. Evolution of feed industry in Bangladesh

Like Pakistan and India, Bangladesh has the same types of feed resources but roughage and concentrate are mainly used as feed in this country.

#### Dairy and cattle feed

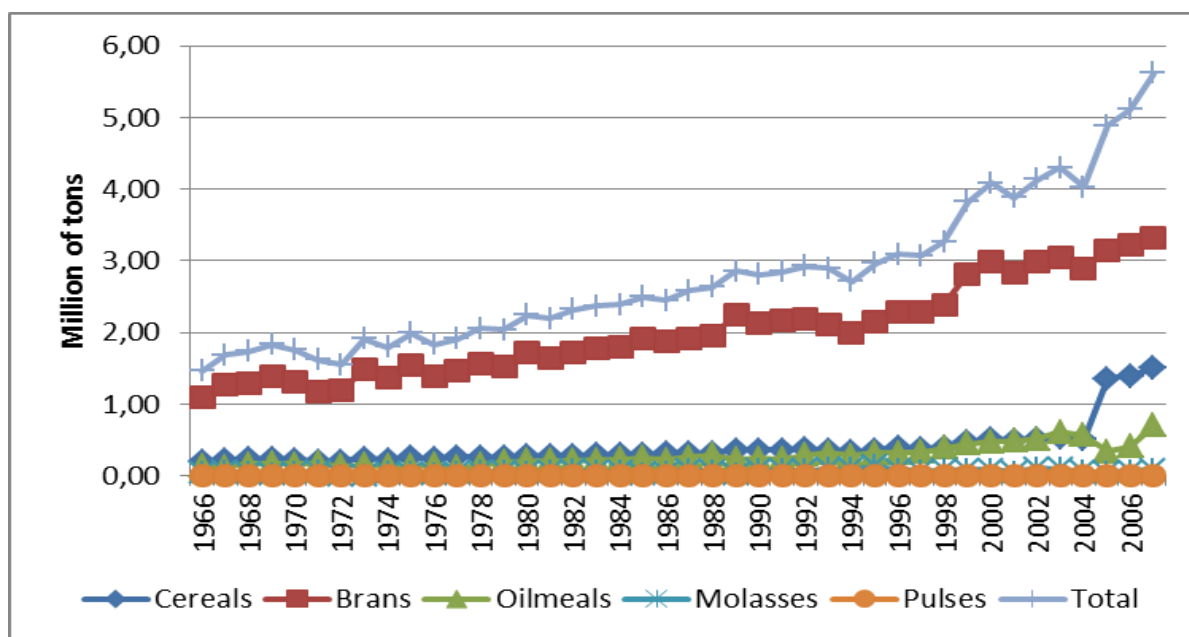
In Bangladesh, according to Hutabarat et al., 2003, there are majority of small dairy and cattle producers with 1- 20 animals so they used traditional method to feed their animals. They mostly used concentrates and vegetation cultivated in their own farms. Because of increasing demand for human food, land is intensively used for cereal production. Neither any grazing land nor spare land is available for growing fodder. This has resulted in shortage of green forage for ruminant livestock, and they are to live mainly on rice straw, which is deficient in protein and micronutrients. But the feed system is gradually coming more modern with better quality of feed. Further we could not find any publication that can explain the situation of animal feed in detail.

As for the two preceding countries, there are huge differences concerning concentrates used in feed in Bangladesh according to PSD and FAO



**Figure 40: Comparison PSD FAO Bangladesh**

Source: Elaboration from FAO and PSD data



**Figure 41: Utilizations of concentrates in Bangladesh according to FAO**

Source: Elaboration from FAO data

### 5.1.4.3. History of Poultry development in Bangladesh

Poultry industry is new in Bangladesh characterized with rapid industrialization and high growth rate. . It was reported in 1999 that there were 40 feed mills with 900 dealers within the private sector that were producing and distributing poultry feed all over the country (Latif 1999). Few of the feed mills are serious in maintaining the quality of products. On the other hand, farmers do not have access to adequate facilities to analyse and monitor the quality of the commercial feeds. In view of the limited availability and varying sources of different feed ingredients, the level of nutrients in the prepared feeds may differ from what is actually required. Poultry mainly subsists on post-harvest grains, sharing food crops with human and scavenging around homestead area. This situation has led to low productivity of livestock in the rural area. Under-nutrition due to inadequate or fluctuating nutrient supply is also a major constraint to animal production. Animals are traditionally raised in extensive system under ranged condition without any supplementation. It is often characterized by poor growth and high mortality. The strategy for improving livestock production has therefore been to maximize green forage production and to improve the efficiency of utilization of the available feed resources (crop residues and by-products) in a logical manner.



Two distinct poultry production systems exist in Bangladesh (Government of Bangladesh 2005). These are:

**a. Unorganized/ backyard/ traditional scavenging system.**

The unorganized/backyard/traditional scavenging system has some features which distinguish it from the commercialized intensive and semi-scavenging units. These backyard units require minimum inputs and directly contribute to the social and economic development of the family who rear them. They have little impact on environment and are highly integrated in the crop livestock system, which makes them sustainable under the prevailing socio-economic conditions. Women and children generally remain in charge of this poultry rearing system. Birds are left to scavenge during the day and put in improvised shelter at night. Low level of supplementation in the form of kura (rice bran) are provided in the morning and evening only. However, during the time of crop harvesting and processing, they get additional supplementation of grains. The level of production of these birds is very low compared to those under high inputs system. A scavenging hen lays, on average, 45 to 50 eggs per year; and mortality is high.

**b. Organized Commercial system.**

Commercial production systems use birds of improved genetic stock and rear them under improved management. Optimum performance of these birds can only be achieved if high quality inputs in optimum quantity are used. The current best commercial layer strains produce 280 to 290 eggs under improved management. Similarly, the best meat strains now reach the weight of more than two kg in six to seven weeks, a large improvement over past records

Increasing number of livestock and poultry farms in Bangladesh is constrained by high price of grains and cereal by-products. Protein concentrates, available in the market are imported by the feed millers, which are very expensive and small scale producers are not able to purchase these items to incorporate in poultry feed formulation. The chronic scarcity and high cost of protein supplements, such as fishmeal, soybean meal, oil cakes etc. and other cereal by-products (wheat bran, rice bran and broken rice) seriously affect performance and cost of livestock and poultry production.

It can be concluded from general description of these three countries that poultry sector of India and Pakistan is more developed as compared to Bangladesh. Among grains, maize and cottonseeds occupy first position in these countries while among by-products, brans and oilseed

meals occupy first position in three countries. In all three countries, there is also traditional system of animal rearing on farm level for their own uses.

## 5.2. Methodology used to estimate feed demand functions

### 5.2.1. Generalities

Due to the lack of long time series of annual prices for certain products, such as for cereals, molasses and most of meals as well as presence of high inaccuracy for data of various products (see differences between FAO and PSD), it is not possible to use a direct calculation of elasticities based on a translog model. We therefore adopted a two-step methodology defined below.

In the first step, total demand of concentrates is estimated by linear regression as a function of the annual change in production for the two families of products (poultry meat and eggs as one family, milk as other). These products are considered more likely to explain the increase in consumption of concentrates as feed because of having more or less complete early industrialization in countries taken here.

In a second step, we estimated a matrix of direct and cross price elasticity based on a theoretical model of nutritional formulation using standard compositions of various materials considered in this work and the nutritional constraints of different types of compound feed selected from the literature and by generating pseudo data (sets of ratios corresponding prices and consumption)

### 5.2.2. Estimation of the total demand for concentrated

For **Pakistan**, after testing the signification of coefficients of different types of equation and the possibility to interpret these values on zoo technic plan, we have taken following form of equation:

$$\text{TotCon}_t = a + b * \text{Trend} * \text{QVol}_t + c * \text{QMilk}_t + d$$

$\text{TotCon}_t$  represents the total consumption of concentrates (tons) in year t,  $\text{Trend}$  is a variable that is 1 in 1966 and increases by one each year,  $\text{QVol}_t$  is total production of poultry meat and

eggs (in tonnes) while  $QMilk_t$  is the total milk production (in tons). The resulting equation is as follows:

**Table 51: Estimation of parameters for total feed concentrates demand in Pakistan**

	estimateur	Standard error	Student	P Critic	
<b>a</b>	5.3936	0.8714	6.19	0	***
<b>b</b>	-0.0491	0.024	-2.044	0.0479	**
<b>c</b>	0.1272	0.0339	3.758	0.0006	***
<b>e</b>	786351	250520	3.139	0.0033	***

**Source: Own calculation**

In this equation the adjusted R2 is 0.98

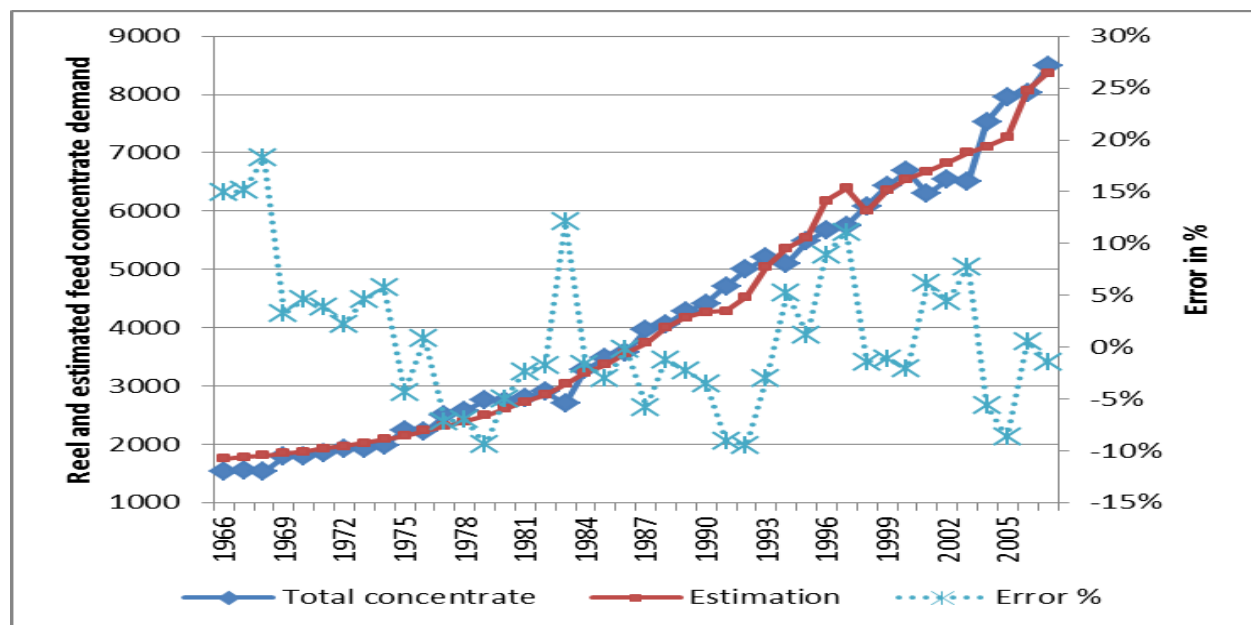
Different coefficients can be interpreted on a nutritional plan. For the initial year where  $Trend = 1$ ,  $a-b = 5.34$  that represents the average consumption of concentrates per unit of animal product (carcass weight for meat). This figure can be close to the index of consumption (consumption of feed per kilogram of body weight) in poultry meat production is currently around 2.1 in developed countries, or with a carcass yield of about 65 % consumption per kilogram of carcass weight of 3.2 kg / kg. For eggs, we can estimate compound feed consumption per kilogram of eggs in France that is 2 (against 3 before 25 years). The calculated parameters for 2007 (Trend equal to 42) indicate that consumption of feed per kilogram of carcass and eggs is 3.33 kg / kg, which indicated to have already very good technical performance for the poultry industry of Pakistan. In about 40 years the ratio have been improved by 38% due to a better feed value (energy and protein) of blended feeds and also genetic improvement of animals and a sharp decline in animal mortality.

The coefficient  $c = 0127$  can be interpreted as the average consumption of compound feed per kilogram of milk produced. It may appear relatively high, since a large part of dairy farming in Pakistan is traditional and based on grass and fodder, but this figure probably included statistical quantities of feed used for meat production of cattle and buffalo. Statistically it has not been possible to determine, as for poultry, a change in the ratio over time.

Constant equal to 786 kt concentrates corresponds to a stable amount used to complete the feed of other animals over time (and probably includes some losses and biases).

From this equation, it is possible to estimate the distribution of the total consumption of concentrates for each year. In 1966 only 8% of the total was devoted to poultry, against 49% in

milk and 45% to other animals. In 2007, it is estimated that approximately 42% is for poultry, against 9% in other animals and for milk remained practically stable.



**Figure 42: Real and estimated evolution of total consumption of concentrates in Pakistan**

Source: Own calculation; Unit: Thousand tons

The previous figures brought up significant differences at beginning of period (up to nearly 20%) but are much lower thereafter (mainly in the range -10%, +10%).

For India, an equation of the above form does not give interpretable results from a nutritional point of view. The calculated coefficient  $c$  was equal to 0.321kg/kg of milk which seems on a zoo technical point of view too intensive, and coefficient  $a = 3.77\text{kg/kg}$  and  $b = -0.08\text{ kg/kg/year}$  would indicate a non-realistic growth rate of feed efficiency per year of about 2.1%). This fact is probably due to some bias in total concentrate indicated in some years or to some effects of specific prices variations, which is not possible to test due to lack of data on prices. So we set a fixed coefficient equal to 3.5 kg of concentrates per kilogram of carcass meat and eggs (near to that calculated with preceding equation) and estimated allocation of the balance of concentrates to milk and other species.

The equation is:

$$\text{TotCon}_t = 3.5 * \text{QVol}_t + c * \text{QMilk}_t + d$$

And calculated parameters are:

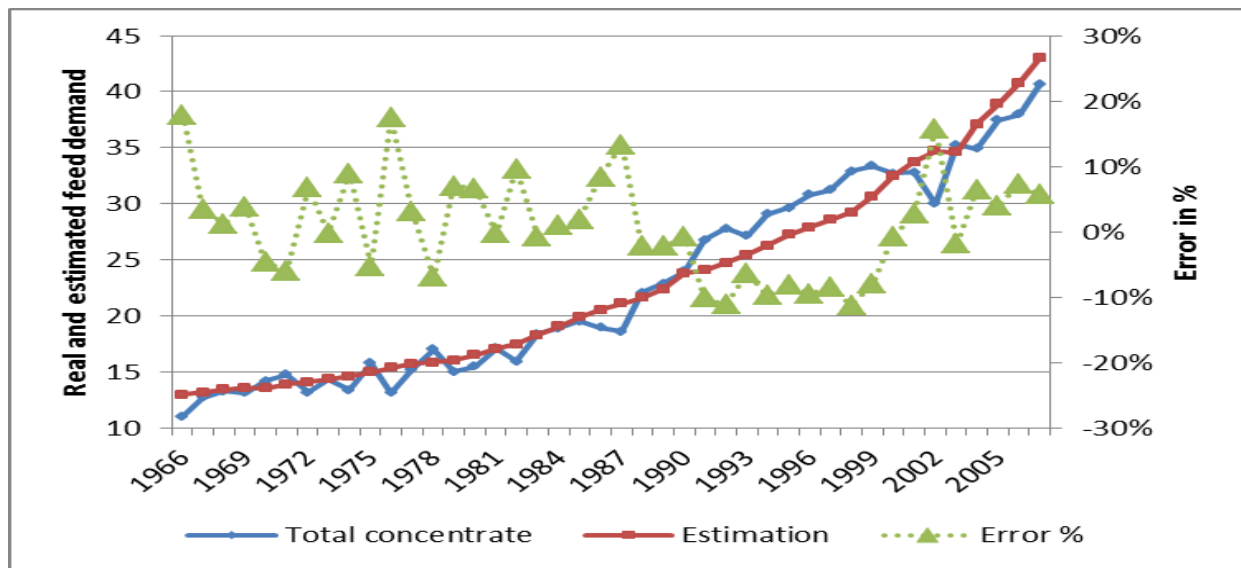
**Table 52: Estimation of parameters for total feed concentrates demand in India**

	estimator	Standard error	Student	P Critic	
constant	8645850	650950	13.28	0	***
c	0.169783	0.011514	14.75	0	***

Source: Own calculation

In this equation the adjusted R2 is 0.84.

The coefficient c (corresponding to Q\_milk) corresponds to an average and steady consumption of 0.169 kg of concentrate per kilogram of milk with the same remark as for Pakistan, and finally the coefficient (equal to 8.6 Mt) corresponds to the fixed consumption of other animals (and probably to the losses). From these coefficients, we can estimate that in 2007, poultry accounted for 39% of the total (against 8% in 1966), milk 41% (against 25%) and other animals 20% (against 67%).



**Figure 43: Real and estimated evolution of total consumption of concentrates in India.**

Source: Own calculation; Unit: Million tons

There is a pretty good proximity between the actual values and the estimated values with a tendency to average important deviations and a period of about 10 years (1990 to 2000) where the model tends to underestimate the reality systematically.

For Bangladesh, the form of equation used is:

$$\text{TotCon}_t = a * \text{QVol}_t + b * \text{Trend} + \text{const}$$

And the results are:

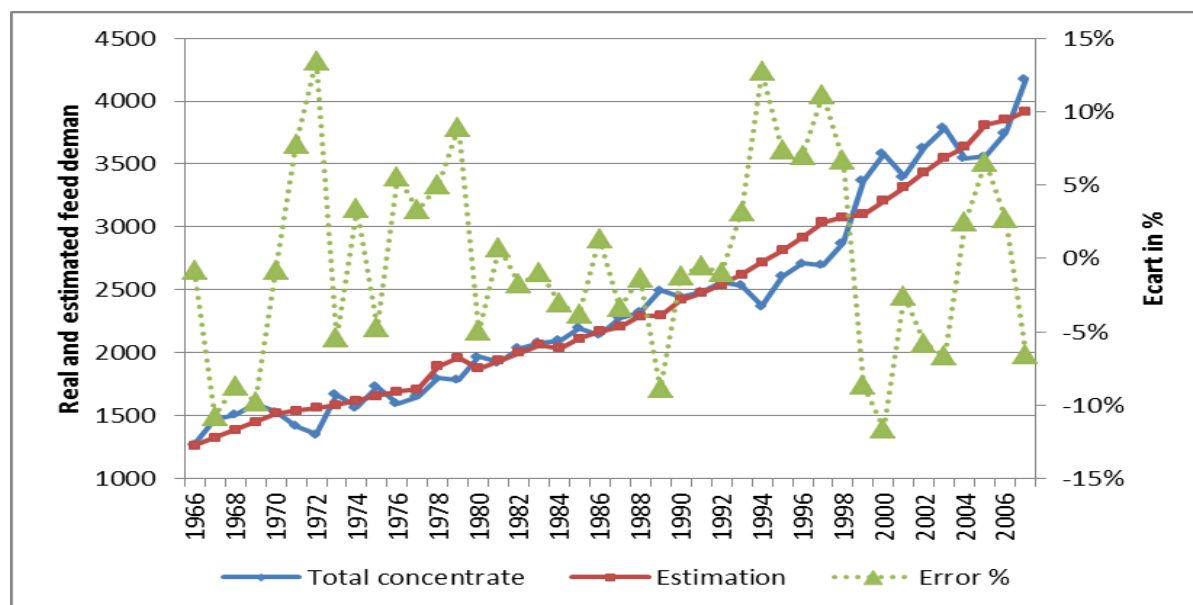
**Table 53: Estimation of parameters for total feed concentrates demand in Bangladesh**

	Estimator	Standard error	Student	P Critic	
const	810724	207392	3,909	0,0004	***
a	5,33221	1,69425	3,147	0,0032	***
b	44592,8	16302,9	2,735	0,0094	***

Source: Own calculation

In this equation the adjusted R2 is 0.96.

The direct introduction of Trend is explained by the fact that it was not possible to directly link the total consumption of concentrates with any animal production other than poultry, but globally these uses "others" have increased significantly over time. Thus the ratio of consumption to poultry appears to be fixed over time to 5.33 and corresponds to an index of average consumption of 7.61. These statistical results tend to show, that in Bangladesh, probably due to the fact that a lower part of poultry having a “rational feeding”, the conversion is less efficient. It seems also, that milk production which is mainly composed of goat milk and a small part of cow milk is not, so far, a significant consumer of concentrates, which is different from Pakistan and India. With these coefficients, we can calculate the share of poultry in the total consumption of concentrates is increased from 23% in 1966 to 36% in 2007.



**Figure 44: Real and estimated evolution of total consumption of concentrates in Bangladesh.**

Source: Own calculation

Figure 44 shows that the estimation is fairly satisfactory with the evolution of consumption in an error range of +10 to -10%.

These three equations will be used in the last chapter of thesis for the construction of scenarios.

### 5.2.3. Generation of pseudo data

A simplified version of FEEDSIM was used to generate pseudo-data for calculating the price and the substitution elasticity of demand (direct and cross) for the main ingredients used in animal feed in all three countries. This model is based on

1) A matrix of nutritional compositions (pork net energy, poultry metabolizable energy, digestible amino acids for pigs or poultry, net energy for ruminants (UFL and UFV), protein available to ruminants (PDIE, PDIN), cellulose, etc. ..) of a fifty raw materials conventionally used in compound feed. In the absence of specific information on the compositions of the main raw materials used in Southeast Asia, we chose a composition table that derives largely from the table published by INRA and AFZ in (<http://www.zootechnie.fr/fr/ouvrages-et-logiciels/tables-inra-afz.html>) which includes a large number of products including all those included in the model (cereals, cakes, pulses, bran, molasses, vegetable oils) but some values have been added (new raw materials such as Ukrainian sunflower meal and some by-products of wheat and corn from the European bioethanol industry) or adjusted to approximate the values actually used by French professionals of animal feed sector.

2) A set of vectors of "nutritional constraints" (minimum and / or maximum needs per kilogram of feed) for about forty nutrients (energy, essential amino acids "available", crude fibre, minerals, etc...). For each specific vector for one animal species and physiological age of the animal (growing broiler, broiler finisher, dairy cow complementary protein, supplementary cattle etc...) values used are derived as part from public research centre (INRA) and as large part from indications of nutritionists and trainers member of companies FEEDSIM AVENIR. As such, the specific values are of a confidential nature<sup>57</sup>.

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<sup>57</sup>The validity of the values chosen result from the many uses of the model that, particularly in the context of the barometer monthly tonnages can find the various regional raw materials actually used in food compounds of Grand-western France (Brittany, countries Loire, Normandy) known a posteriori either directly by some Public statistics (AGRESTE, FranceAgriMer) and / or professional or indirectly through some other indicators (activities of import port, providing various co-produced by Frenchcrushing factories (cakes ), milling (bran and from cereals) of starch and bioethanol (wheat-feed, corn gluten feed-, dregs), etc. ...

3) A set of vectors of "incorporation limits" (maximum or minimum) for specific raw materials (by example urea in cattle feed) or families of raw materials (cereals in chicken label) specific to each compound feed type and corresponding to nutritional criteria, technology or specifications of slaughterers or dealers.

In contrast to the standard FEEDSIM model, this simplified version uses a single vector of prices (for each raw material potentially usable) and does not include cost of transportation. Moreover, all the materials are assumed to be available in unlimited quantities.

Overall, the model is written as follows:

Economic function to minimize:

Cost for all compound feeds

$$\text{Min} \sum_{i=1}^n \sum_{j=1}^n X_{ij} * P_i$$

Where  $X_{ij}$  represents the quantity of ingredient  $i$  used in compound feed  $j$  and  $P_i$  is the price of this ingredient.

Under the constraints

$$\sum_{i=1}^n X_{ij} * C_{in} >< B_{jn} * T_j$$

Where  $C_{in}$  represents the content of the ingredient  $i$  for the nutrient  $n$ ,  $B_{jn}$  is the need (minimum or maximum) per kilo of nutrient  $n$  in the compound feed  $j$  and  $T_j$  is the tonnage manufactured of compound feed  $j$ .

And

$$X_{ij} >< L_{ij} * T_j$$

Where  $L_{ij}$  is the percentage (minimum or maximum) of incorporation of ingredient  $i$  in the compound feed  $j$ <sup>58</sup>.

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<sup>58</sup> In practice, the constraints on incorporation concerning families of raw materials are included in the nutritional constraints.



The software GAMS is used to write the model and the solver CPLEX is used to optimize the economic function when it is linear (as well as constraints) and the solver COUENNE is used when it is nonlinear in the model.

### The nutritional constraints

Regarding the nutritional constraints, we incorporated the data published by the Bureau of Indian Standard (BIS) consulted on its internet site into the matrix FEEDSIM

**Table 54: Nutritional constraints for broilers compound feed according to BIS**

Characteristic	Broiler starter feed	Broiler finisher feed	Chick feed	Growing chicken feed	Laying chicken feed	Breeder layer feed
Moisture ( <i>maximum %</i> )	11	11	11	11	11	11
Metabolizable energy ( <i>minimum cal/kg</i> )	2 800	2 900	2 600	2 500	2 600	2 600
Crude protein (N x 6.25) ( <i>maximum %</i> )	23	20	20	16	18	18
Crude fibre ( <i>maximum %</i> )	6	6	7	8	8	8
Acid-insoluble ash ( <i>maximum %</i> )	3.0	3.0	4.0	4.0	4.0	4.0
Salt (as NaCl) ( <i>maximum %</i> )	0.6	0.6	0.6	0.6	0.6	0.6
Calcium (Ca) ( <i>maximum %</i> )	1.2	1.2	1.0	1.0	3.0	3.0
Available phosphorus ( <i>minimum %</i> )	0.5	0.5	0.5	0.5	0.5	0.5
Lysine ( <i>maximum %</i> )	1.2	1.0	0.9	0.6	0.65	0.65
Methionine ( <i>maximum %</i> )	0.50	0.35	0.3	0.25	0.30	0.30
Methionine + cystine ( <i>g/100 g</i> )	0.9	0.7	0.6	0.5	0.55	0.55
Manganese ( <i>mg/kg</i> )	90	90	90	50	55	90
Iodine ( <i>mg/kg</i> )	1	1	1	1	1	1
Iron ( <i>mg/kg</i> )	120	120	120	90	75	90
Zinc ( <i>mg/kg</i> )	60	60	60	50	75	100
Copper ( <i>mg/kg</i> )	12	12	12	9	9	12
Vitamin A ( <i>IU/kg</i> )	6 000	6 000	6 000	6 000	8 000	8 000
Vitamin D3 ( <i>IU/kg</i> )	600	600	600	600	1 200	1 200
Thiamine ( <i>mg/kg</i> )	5	5	5	3	3	3
Riboflavin ( <i>mg/kg</i> )	6	6	6	5	5	8
Pantothenic acid ( <i>mg/kg</i> )	15	15	15	15	15	15
Nicotinic acid ( <i>mg/kg</i> )	40	40	40	15	15	15
Biotin ( <i>mg/kg</i> )	0.2	0.2	0.02	0.15	0.15	0.20
Vitamin B12 ( <i>mg/kg</i> )	0.015	0.015	0.015	0.01	0.010	0.01
Folic acid( <i>mg/kg</i> )	1.0	1.0	1.0	0.5	0.5	0.5
Choline ( <i>mg/kg</i> )	1 400	1 000	1 300	900	800	800
Vitamin E( <i>mg/kg</i> )	15	15	15	10	10	15
Vitamin K ( <i>mg/kg</i> )	1.0	1.0	1.0	1.0	1.0	1.0
Pyridoxine ( <i>mg/kg</i> )	5	5	5	5	5	8
Linoleic acid ( <i>g/100 g</i> )	1	1	1	1	1	1

Source: BIS. Poultry feeds - specifications, fourth revision.

One considers in the conventional way that all micronutrients and vitamins are included in the "premix" or "pre-mix" which is systematically incorporated to 1% in all feeds. These parameters are not involved in the nutritional constraints concerning raw materials outside premix.

The Compound Livestock Feed Manufacturers' Association (CLFMA) has prepared its own specifications, which are shown in Table 55.

**Table 55: Nutritional constraints for compound feed according to CLFMA**

Characteristic	Dairy special feed	Type I feed	Type II feed	Type III feed	Chick feed	Grower feed	Layer feed I	Layer feed II	Broiler starter feed	Broiler finisher feed	Breeder chick feed	Breeder grower feed	Broiler breeder feed	Layer breeder feed	Broiler male breeder feed
Moisture ( <i>maximum</i> %)	12.0	12.0	12.0	12.0	12	12	12	12	12	12	12	12	12	12	12
Crude protein (on dm basis) ( <i>minimum</i> %)	22.0	20.0	18.0	16.0	18	14	16	14	20	18	18	14	16	16	14
Undegraded protein ( <i>minimum</i> %)	8.0	--	--	--											
Crude fat ( <i>minimum</i> %)	3.0	2.5	2.5	2.0											
Crude fibre ( <i>maximum</i> %)	7.0	7.0	12.0	14.0	7	8	8	10	6	5	5	7	7	7	7
Acid-insoluble ash ( <i>maximum</i> %)	3.5	4.0	4.5	5.0	4	4	4	4	4	4	4	4	4	4	4
Fat ( <i>maximum</i> %)					2	2	2	2	3	3	3	3	3	3	3
Metabolizable energy ( <i>minimum</i> cal/kg)					2600	2300	2500	2300	2600	2700	2600	2400	2500	2500	2400

**Source:** CLFMA Standards for dairy and poultry compound Feeds.

It is also specified on the website: "The specifications of both BIS and CLFMA are only guidelines and their use as standards is not compulsory. The animal feed business is competitive and feed manufacturers therefore endeavour to produce feed of the highest possible quality. "

### **Types and tonnages of concentrates used in different animal species**

Given the nutritional data available, it was assumed that the nutritional constraints of formulation indicated for India also applied with little change in Pakistan and Bangladesh. For each country, we chose six types of compound feed: feed that is rich in protein for dairy cattle "intensive", a supplementary fodder feed used for meat of large and small ruminant, two types of feed for broiler (starter and finisher) and two types of feed for layers (youth and adult).

In the absence of reliable and comprehensive data on the production of industrial compound feed and assignments using various raw materials for animal categories in each country, we selected an estimation method  $TE_j$  for tonnages 'formulated' by the industry and in the farm from the

equations of precedent paragraph for broad categories (milk, poultry meat, egg, etc.) and technical coefficients for the distribution of feed between growth and finishing.

### Use of raw materials and prices

Regarding the tonnage of raw materials consumed in 2007 for animal feed, we started from FAO statistics and it gives the following basic data:

Regarding the bran of rice and wheat, the three countries have extremely important tonnages that are not found in the results of the formulation model regardless of the prices used for this product. This is due to the high content of cellulose of this ingredient and therefore its low energy value leads to a situation where its incorporation is limited by the energy constraints in compound feed for poultry and ruminants. It has been assumed that the constant parts of the total use of concentrates used in each country corresponded to tonnages of bran (0.789 Mt for Pakistan, 8.646 Mt for India and 0.930 Mt for Bangladesh) distributed directly by farmers for their animals regardless of the price level of this product. Therefore, it is not taken into account for the formulation and calculation of elasticities.

**Table 56: Estimation of consumption of concentrates in feeds in 2007**

	<b>Pakistan</b>	<b>India</b>	<b>Bangladesh</b>	<b>Total</b>
<b>Maize</b>	721	4700	56	5477
<b>Millet</b>	153	203	0	356
<b>Sorghum</b>	9	86	0	95
<b>Wheat</b>	466	910	0	1376
<b>Briz rice</b>	0	1929	1491	3420
<b>Other cer</b>	54	123	0	177
<b>Brans</b>	2989	12885	3323	19197
<b>Cottonmeal</b>	1259	2448	8	3715
<b>Rapemeal</b>	609	2820	195	3624
<b>Soymeal</b>	428	1436	311	2175
<b>Sunmeal</b>	318	605	0	924
<b>Other meal</b>	134	7083	192	7409
<b>Molasse</b>	81	656	87	824
<b>Pulses</b>	244	1465	1	1710
<b>Cottonseed</b>	1024	3277	0	4301
<b>Other seed</b>	0	25	0	26
<b>Total</b>	8488	40650	5666	54804

Source: Estimations from FAO data; Unit: Thousand tons

For bran, tonnages are not included in direct off formulation.

An adjustment must be made on data  $T_j$  for tonnage of feed 'formulated'. Raw materials considered in this thesis (cereal, cake, protein, derived from cereals) are only one part of concentrated raw materials actually used in animal feed. Particular it lacks minerals, industrial amino acids, animal or vegetable fats which are essential for the rations for balancing nutritional level.

We then proceeded as follows:

The tonnage used in the model for each of the six types of "compound feed" is calculated by the formula:

$$T_j = \text{tonnage of equivalent compound feed} * \text{Sum of compound feed tonnages of raw materials used in each country} / \text{Sum of compound feed tonnage equivalent} * \text{ALPHA}$$

The coefficient ALPHA (near 1.15) is calculated for each country so that the sum of the tonnages calculated by the model in the baseline of cereals, cakes, protein, and all products will be equal to the sum of these raw materials listed in Table 56.

Regarding prices, the FAOSTAT database only provides value (at farmer level) for cereals, pulses and oilseeds (depending on the country) but no figures on the price of co-products (cakes, bran etc.). Moreover, even for cereals it is clear that the products used in animal feed are inferior to those used for human food and therefore are not valued at the same price but at a lower unknown price. Method to estimate these prices from unit values in U.S. \$ of imports (or exports) converted into local currency proved unenforceable to the extent that trade is often (for some products and for some years) very low and therefore the unit price of the trade cannot be considered representative of the market price.

We therefore used an indirect method that consisted 1) to base on precise figures published for Pakistan by Shah. et al. which refer to the year 2009 and Rasool et al. (2006) providing feed price series until 2005, 2) to use for commodity crops, prices quoted by FAO for the reference year 2007 affected a reduction coefficient and 3) to calculate the price of the other ingredients so that the ingredients consumption calculated by the model for each country are as close as possible to the figures in the table 56. It is important to note that the incorporation of raw materials formulation does not depend on absolute price levels, but on their relative values.

These two tables from Shah et al.2010 were used to make estimations on main feed ingredients in Pakistan, even if they are only indicatives at two different locations.

**Table 57: Estimation of various ingredients prices for Pakistan in 2009 at rainfed sites**

inputs	prices Rs. Kg	percent share		
		inputs		cost
Maize gluten 30% protein	15	40.5		30.45
Rapeseed cake	24.77	5		6.21
Cotton seed cake (CSC)	23.97	14		16.82
Wheat bran	16.97	19		16.16
Maize cake	25	20		25.06
Dicalcium phosphate (DCP)	36	1		1.80
Rapeseed oil	140	0.5		3.51

Source: Shah et al.2010; Unit: Pak Rupees per kg

**Table 58: Estimation of various ingredients prices for Pakistan in 2009 at irrigated sites**

inputs	prices Rs. Kg	percent share		
		inputs		cost
Maize gluten	13	15		10.97
Rapeseed cake	21.5	5		6.05
Cotton seed cake	20	47.5		53.44
Wheat bran	17.4	15		14.64
Maize cake	21.3	10		11.95
Salt	2	1.3		0.14
Molasses	8	6.3		2.81

Source: Shah et al.2010; Unit: Pak Rupees per kg

**Table 59: Estimation of evolution of different prices for animal feed in Pakistan**

Ingredient	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05 Jan	05-06 Jan
Broken rice	5.12	7.45	7.32	7.12	7.06	7.94	8.41	8.60	10.50	11.22
Maize	4.67	5.98	6.99	6.87	6.80	7.36	7.72	7.80	10.00	8.90
Wheat	4.91	7.17	6.34	6.99	6.93	6.99	8.07	8.70	11.87	11.41
Rice polish	1.87	3.55	3.63	3.27	3.86	5.40	5.53	4.86	6.00	6.65
Molasses	0.79	1.20	0.62	0.70	1.62	2.38	2.11	1.25	4.00	4.16
Rice bran	1.86	2.38	N.A	1.80	2.77	4.54	2.98	3.36	N.A	N.A
Wheat bran	N.A	N.a	N.A	N.A	4.72	4.19	4.48	5.50	N.A	N.A.
Sorghum	5.00	N.A	6.42	N.A	7.26	5.99	N.A	6.42	N.A	N.A.
Guar meal	8.77	N.A	6.41	7.46	9.44	7.40	9.80	11.64	10.00	11.10
Cotton seed meal	7.08	8.42	N.A	6.55	8.99	N.A	N.A	N.A	N.A	N.A.
Rapeseed meal	4.70	4.94	5.54	5.77	6.42	8.31	7.52	7.18	7.00	7.04
Fish meal	N.A	N.A	15.92	18.74	21.16	20.24	19.47	23.70	23.75	21.46
Poultry byproduct meal	7.41	8.80	7.77	8.96	11.04	11.24	12.25	13.16	14.50	14.60
Sunflower meal	4.75	N.A	4.30	3.97	7.66	8.23	7.17	7.37	7.37	6.95
Corn gluten 60%	13.80	16.08	12.56	14.69	16.90	14.44	15.35	16.14	16.15	17.15
Canola meal	N.A	7.51	6.42	5.49	7.55	8.92	8.79	9.67	11.00	10.95
Indian SBM	14.21	14.72	9.96	14.70	19.35	15.28	16.94	19.43	17.70	17.52
Bone meal	5.97	7.40	7.37	6.85	6.64	6.50	6.30	N.A	N.A	N.A.
Lysine	111.82	132.0	117.65	66.50	94.30	105.0	111.92	224.0	120	110
DI Methionine	122.0	129.0	180.0	119.0	133.0	N.A	126.0	N.A	165	145
Hydroxy-Methionine	123	129.00	299.0	137.36	166.0	133.0	133.0	190.0	N.A.	N.A.
Feed cost per 50 kg bag (broiler starter crumbles)	475	504	519	549	574	604	634	669	694	709

Source: Rasool et al. (2006); Unit: Pak rupees per kg

The price vectors ( $P_i$ ) per country used for the calculation of basic situations, and then the pseudo-data are as follows:

**Table 60: Estimated prices in 2007 in local currency per kg**

	Pakistan	India	Bangladesh
Maize	13.20	8.00	11.49
Millet	11.52	7.10	
Sorghum	15.30	9.37	11.75
Wheat	11.84	7.70	17.61
Briz rice		8.26	11.90
Other cer	5.11	5.50	6.35
Brans	3.91	5.16	3.60
Cottonmeal	7.22	7.05	10.30
Rapemeal	8.96	7.14	9.73
Soymeal	20.21	18.90	19.60
Sunmeal	3.67	5.42	0.00
Other meal	6.00	6.62	8.23
Molasse	4.57	2.80	6.63
Pulses	9.54	7.08	13.33
Cottonseed	12.50	5.54	
Other seed	45.50	24.89	

Source: Own estimations; Unit: Rupees per kg

**Table 61: Estimation of prices ratios compared to maize**

	Pakistan	India	Bangladesh
Maize	100.00	100.00	100.00
Millet	87.27	88.69	
Sorghum	115.91	117.11	102.29
Wheat	89.70	96.21	153.32
Briz rice		103.15	103.60
Other cer	38.68	68.72	55.28
Brans	29.65	64.43	31.33
Cottonmeal	54.69	88.02	89.68
Rapemeal	67.90	89.25	84.75
Soymeal	153.08	236.18	170.65
Sunmeal	27.77	67.74	
Other meal	45.45	82.67	71.67
Molasse	34.58	34.95	57.72
Pulses	72.27	88.51	116.01
Cottonseed	94.70	69.28	
Other seed	344.70	311.05	

**Source: Own estimations; Unit: Percentage basis 100 for maize**

It should be noted that these prices are simple estimates designed to calculate the matrices of elasticities.

We performed 100 iterations of the model. For the calculation of the iteration n a vector of prices of all raw materials included in each country is defined by:

$$PP_{i,n} = P_i * ALEA_{i,n}$$

Where  $P_i$  is the reference price and  $ALEA_{i,n}$  is normal independent random variable with mean 1 and standard deviation 0.10 as well as different for each product.

The prices of all other ingredients were kept unchanged.

Prices and quantities used of each raw material correspond to each of the 100 passages which were stored in an Excel file to be processed by GRETL

From the  $X_{ij}^*$  provided by the solver for each price vector  $P_i$ , we can calculate:

- For each formula  $I_{ij} = X_{ij}^* T_j$  that is the percentage of incorporation of each ingredient in each compound feed
- For all compound feeding stuffs:

$$IM_i = \frac{\sum_{j=1}^n X_{ij}^* T_j}{\sum_{j=1}^n T_j}$$

that is the average rate of incorporation of ingredient i in all compound feed.

Here we will focus on the total consumption of each raw material.

$$Xt_i = \sum_{j=1}^n X_{ij}$$

Or, equivalently to  $IM_i$  (average rates of incorporation) which obviously depend on either tonnage or tonnage distribution of different types of food compounds (considered fixed) and on the vector price  $p_i$  as a variable.

#### 5.2.4. Estimation of prices and substitution elasticities

We can write:

$$Xt_i = f(P_i)$$

We can assume that the total demand function of each ingredient is derived from a cost function of the form:

$$\ln C = \beta_0 + \beta_i \ln P_i + \frac{1}{2} \sum_{j \neq i} \beta_{ij} \ln P_i * \ln P_j$$

Where  $\beta_{ij}$  are subject to constraints of symmetry and homogeneity. In practice, we estimate the  $N_i - 1$  that is share of total cost ( $N_i$  is the number of raw materials taken into account):

#### Equation 13: Formula to calculate share of total expenditure

$$S_i = xti * \frac{Pi}{C} = \partial \ln(C) / \partial \ln(P_i) = \beta_i + \sum_{j \neq i} \beta_{ij} \ln(P_j)$$

By the method Full Information Maximum Likelihood (FIML) method or the Seemingly Unrelated Iterative (SUR) which are equivalent and provide results independent of the equation eliminated. The software used is GRET. The direct and cross price elasticities are typically calculated by the formulas:



**Equation 14: Formula to calculate direct and cross price elasticities**

$$E_{ii} = \frac{\partial \ln(xt_i)}{\partial \ln(P_i)} = (\beta_{ii} + S_i S_i - S_i) S_i$$
$$E_{ij} = \frac{\partial \ln(xt_i)}{\partial \ln(P_j)} = (\beta_{ij} + S_j S_i) S_i$$

And Allen elasticities of substitution  $A_{ij}$  (symmetric matrix) are calculated by the formula:

**Equation 15: Formula to calculate Allen elasticities of substitution**

$$A_{ij} = E_{ij} / S_j$$

It is supposed here that 1) implemented policy is constant and does not change 2) structure of milk production is constant 3) animals (cow and buffalo) eat same quantity of concentrates 4) other products (not taken here) like fish meal, forage, pasture and maize gluten do not have interaction with products taken here.

### **5.3. Analysis of main results**

One can check that according to the theory all price elasticities of demand are negative. The results of calculation of direct and cross price elasticities for all raw materials are presented in table 62.

In Pakistan, the feed industry is more developed than Bangladesh so results are quite different from Bangladesh. In Pakistan, direct price elasticity of feed demand for other cereals, total bran and total molasses are relatively high elastic to their price ( $>1$ ). So their consumption as feed is relatively high affected by price changes while price elasticity of others (maize, sorghum, millet, cottonseed, rapeseed cake, cotton cake, palmkernel cake and soybeans cake) are relatively inelastic ( $<1$ ) so their demand for feed is less affected by price changes.

In India, the feed industry is more developed than Pakistan and Bangladesh so the results for India is quite different from other countries. In India, direct price elasticity for other cereals, millet, total bran, total molasses, cotton cake, pkern cake and other cakes are price elastic ( $>1$ ).

So their demand for feed is more changed with price changes while other raw materials (maize, sorghum, cottonseed, rapeseed cake and rice) are relatively price inelastic ( $<1$ ) so their demand for feed is less affected by their price changes. We can see that the major raw materials used as human food like wheat and rice are relative inelastic. There may be one reason that these two products are directly consumed by animals on the farm by farmers in traditional method.

For Bangladesh, direct price elasticities of feed demand for rice, palm kernel meal (assimilated to “other cakes”), cotton cake, rapeseed cake, total pulses, sorghum, maize and other cereals are highly elastic ( $>1$ ). While for other (total bran, total molasses and soybean cake), direct price elasticity is relatively inelastic ( $<1$ ). It suggests that consumption of total bran, total molasses and soybean cake as feed is less affected by their price changes or these raw materials are used as necessity.

Total pulses, sorghum, rice, maize and other cereals are highly elastic to price and their consumption is affected rapidly by their price changes. So we can say that all those products which are also used in human food are more elastic to price for their consumption as feed. For maize, the price elasticity for Bangladesh is highly elastic (-4.5) but for other two countries, it is relatively inelastic.

**Table 62: Price elasticities of demand for the different ingredients**

	Other cereals	Wheat	Maize	Sorghum	Millet	Total brans	Cottonseed	Total molasses	Total pulses	Rapecake	Cottoncake	Pkerncake	Soybean cake	Othercakes	Rice	Otherseeds	
Other cereals	Pakistan	-3.52	0.54	-0.18	0.67	1.36	0.56	0.15	-0.14	-0.74	0.39	0.87	0.80	0.70			
	India	-6.15	1.50	-1.61	2.29	2.11	0.49	0.63	0.56	-1.91	0.21	0.43	0.80	0.24	-0.73	0.96	
	Bangladesh	-2.51		0.63	0.05		0.77		0.12	0.10	0.50	0.30	0.94	-1.24		0.36	
Wheat	Pakistan	0.06	0.21	0.87	0.83	0.18	-0.01	0.09	0.10	0.15	0.17	-0.03	-0.13	0.05	-2.54		
	India	0.16	0.54	-0.62	0.53	0.29	0.38	0.13	0.02	0.45	-0.50	-0.01	-0.49	0.15	0.06	0.14	-1.22
	Bangladesh																
Maize	Pakistan	-0.02	0.77	-0.32	-1.34	0.04	0.20	0.10	0.02	-0.16	0.15	-0.07	0.24	0.22	0.17		
	India	-0.18	-0.66	-0.54	-0.41	0.66	0.45	0.10	-0.02	-1.06	-0.07	0.17	0.46	0.39	-0.61	0.21	1.11
	Bangladesh	0.26		-4.49	1.66		-0.05		0.11	0.40	-0.03	-0.30	0.18	0.10		2.16	
Sorghum	Pakistan	0.16	1.75	-3.22	-0.31	-0.09	0.04	0.10	0.03	-0.21	0.36	0.18	-0.03	-0.11	1.36		
	India	0.45	1.01	-0.73	0.49	-0.85	-0.70	-0.03	0.33	0.01	1.63	0.17	-1.05	-0.73	-0.98	1.11	-0.14
	Bangladesh	0.03		2.20	-5.05		0.05		0.09	0.16	0.39	0.07	0.05	-0.19		2.21	
Millet	Pakistan	0.38	0.45	0.11	-0.11	-0.86	-0.20	0.08	0.02	0.08	-0.01	0.06	-0.04	-0.32	0.38		
	India	0.48	0.63	1.33	-0.97	-1.54	-1.18	-0.05	0.17	1.01	0.15	0.04	-0.10	-0.26	1.23	-0.07	-0.85
	Bangladesh																
Total brans	Pakistan	0.23	-0.04	0.82	0.06	-0.29	-1.65	0.11	0.12	-0.49	0.30	-0.02	-0.22	0.78	0.27		
	India	0.11	0.83	0.90	-0.79	-1.18	-1.06	0.30	0.04	0.51	0.43	-0.22	-0.32	1.03	0.06	-0.53	-0.10
	Bangladesh	0.11		-0.02	0.01		-0.13		0.00	0.00	0.07	-0.02	-0.04	0.05		-0.03	
Cotton seed	Pakistan	0.03	0.15	0.19	0.07	0.05	0.05	-0.92	0.01	0.02	0.07	0.04	0.01	0.23	0.01		
	India	0.07	0.14	0.11	-0.02	-0.03	0.15	-0.93	-0.01	0.08	0.00	0.08	0.02	0.26	0.09	0.02	-0.03
	Bangladesh																
Total molasses	Pakistan	-0.76	4.76	1.22	0.60	0.34	1.61	0.27	-1.14	-11.29	1.13	-2.95	1.49	3.62	1.11		
	India	0.76	0.20	-0.23	2.29	1.05	0.24	-0.10	-2.24	-4.58	0.59	-0.65	0.30	2.83	0.69	1.67	-2.81
	Bangladesh	0.25		0.58	0.34		-0.07		-0.93	-0.12	-0.07	-0.09	0.16	-0.46		0.40	
Total pulses	Pakistan	-1.42	2.52	-3.06	-1.69	0.52	-2.24	0.18	-3.99	12.69	-8.74	-1.20	4.17	-0.43	2.71		
	India	-1.31	2.94	-6.46	0.04	3.05	1.53	0.49	-2.28	6.27	-10.31	0.68	6.96	-0.94	3.64	-5.05	0.75
	Bangladesh	0.12		1.18	0.35		0.02		-0.07	-5.25	-0.43	0.37	0.76	1.93		1.03	
Rapeseed cake	Pakistan	-0.23	0.24	0.24	0.24	-0.01	0.12	0.07	0.03	-0.73	-0.78	0.19	-0.30	0.63	0.29		
	India	0.02	-0.36	-0.04	0.61	0.05	0.14	0.00	0.03	-1.12	-0.67	0.45	-0.29	0.68	0.43	-0.07	0.14
	Bangladesh	0.06		-0.01	0.09		0.06		0.00	-0.05	-1.54	0.81	-0.03	0.68		-0.08	
Cotton cake	Pakistan	0.15	-0.11	-0.27	0.29	0.08	-0.02	0.09	-0.21	-0.24	0.45	-0.75	-0.49	0.65	0.37		
	India	0.02	-0.01	0.17	0.09	0.02	-0.11	0.08	-0.05	0.11	0.68	-1.07	-0.63	0.36	0.12	0.25	-0.04
	Bangladesh	0.05		-0.13	0.02		-0.03		-0.01	0.05	1.09	-1.29	0.03	0.25		-0.04	
Pkerncake	Pakistan	0.61	-0.79	1.68	-0.09	-0.10	-0.36	0.04	0.19	1.51	-1.29	-0.87	-0.68	0.62	-0.45		
	India	0.23	-2.54	2.20	-2.84	-0.25	-0.76	0.07	0.12	5.46	-2.06	-2.99	-1.42	1.81	0.71	0.48	1.78
	Bangladesh	0.67		0.32	0.06		-0.19		0.05	0.45	-0.14	0.13	-1.40	-0.08		0.14	
Soybean cake	Pakistan	0.05	0.03	0.15	-0.03	-0.08	0.12	0.09	0.04	-0.02	0.26	0.11	0.06	-0.69	-0.10		
	India	0.03	0.06	0.14	-0.15	-0.05	0.18	0.09	0.08	-0.06	0.36	0.13	0.14	-1.00	-0.33	0.37	0.01
	Bangladesh	-0.16		0.03	-0.05		0.05		-0.03	0.21	0.69	0.19	-0.01	-0.93		0.01	
Other cakes	Pakistan	0.44	-14.26	1.11	3.63	0.86	0.41	0.02	0.13	0.89	1.17	0.60	-0.41	-0.97	6.39		
	India	0.05	0.10	-1.03	-0.93	1.03	0.05	0.14	0.10	1.01	1.09	0.21	0.25	-1.54	-2.15	0.04	1.59
	Bangladesh																
Rice	Pakistan																
	India	-0.07	0.13	0.19	0.55	-0.03	-0.23	0.02	0.12	-0.73	-0.10	0.22	0.09	0.90	0.02	-0.54	-0.55
	Bangladesh	0.16		2.40	1.85		-0.09		0.09	0.39	-0.27	-0.11	0.09	0.05		-4.55	
Otherseeds	Pakistan																
	India	0.32	-3.91	3.32	-0.23	-1.26	-0.14	-0.07	-0.69	0.36	0.65	-0.12	1.11	0.04	2.80	-1.85	-0.33
	Bangladesh																

Source: Own calculation

Table 63 is used to present elasticities of substitutions for all different products. When the sign is positive, products are substitutes and vice versa. When two products are complement then price decrease of one product increases other product consumption. A **substitute good**, in contrast to a

complementary good, is a good with a positive cross elasticity of demand. This means a product's demand is increased when the price of another product is increased.

**Table 63: Elasticities of substitution for the different products**

	Other cereals	Wheat	Maize	Sorghum	Millet	Total brans	Cottonseed	Total molasses	Total pulses	Rapecake	Cottoncake	Pkerncake	Soybean cake	Othercakes	Rice	Otherseeds	
Other cereals	Pakistan	-223.34	3.86	-1.16	10.10	24.02	14.68	1.73	-48.13	-90.30	-14.72	9.49	38.40	3.34	28.23		
	India	-689.66	17.50	-20.20	50.81	53.42	12.31	8.01	85.20	-146.46	1.71	2.62	25.60	3.59	5.09	-8.07	35.92
	Bangladesh	-70.05		34.35	37.37		-0.27		9.09	18.40	-0.13	-2.00	4.99	0.50		9.79	
Wheat	Pakistan	3.86	1.50	5.50	12.54	3.19	-0.29	1.06	34.10	18.07	1.69	-0.76	-5.64	0.21	-102.29		
	India	17.50	6.27	-7.74	11.79	7.39	9.71	1.60	2.37	34.34	-4.15	-0.07	-29.65	0.65	1.20	1.57	-45.62
	Bangladesh																
Maize	Pakistan	-1.16	5.50	-2.03	-20.27	0.72	5.16	1.17	7.68	-19.30	1.49	-1.69	10.57	0.91	7.00		
	India	-20.20	-7.74	-6.82	-9.21	16.66	11.34	1.32	-2.94	-81.23	-0.56	2.14	27.65	1.75	-12.95	2.33	41.72
	Bangladesh	34.35		-104.58	38.24		0.26		7.08	7.26	1.92	0.49	1.23	-0.94		1.10	
Sorghum	Pakistan	10.10	12.54	-20.27	-4.74	-1.65	0.97	1.11	9.12	-25.65	3.68	4.42	-1.31	-0.46	54.90		
	India	50.81	11.79	-9.21	10.89	-21.56	-17.60	-0.35	50.85	0.96	13.58	2.09	-63.14	-3.29	-20.70	12.21	-5.10
	Bangladesh	37.37		38.24	-78.70		-0.48		6.86	17.89	-1.32	-0.76	2.38	0.25		6.18	
Millet	Pakistan	24.02	3.19	0.72	-1.65	-15.29	-5.19	0.85	6.07	9.14	-0.12	1.42	-1.78	-1.33	15.19		
	India	53.42	7.39	16.66	-21.56	-39.07	-29.93	-0.66	26.58	77.07	1.24	0.46	-6.19	-1.18	26.11	-0.72	-31.75
	Bangladesh																
Total brans	Pakistan	14.68	-0.29	5.16	0.97	-5.19	-43.55	1.22	42.62	-59.27	3.08	-0.48	-9.51	3.27	10.74		
	India	12.31	9.71	11.34	-17.60	-29.93	-26.66	3.79	6.10	38.78	3.55	-2.82	-19.25	4.60	1.36	-5.88	-3.56
	Bangladesh	-0.27		0.26	-0.48		-0.70		-0.35	0.09	0.35	-0.15	-1.04	0.25		4.13	
Cotton seed	Pakistan	1.73	1.06	1.17	1.11	0.85	1.22	-10.33	3.06	2.01	0.74	1.06	0.43	0.97	0.23		
	India	8.01	1.60	1.32	-0.35	-0.66	3.79	-11.96	-1.28	6.25	0.01	1.00	0.92	1.15	1.84	0.26	-0.95
	Bangladesh																
Total molasses	Pakistan	-48.13	34.10	7.68	9.12	6.07	42.62	3.06	-395.12	-1380.00	11.45	-72.35	65.62	15.11	44.57		
	India	85.20	2.37	-2.94	50.85	26.58	6.10	-1.28	-344.73	-350.60	4.88	-8.14	18.04	12.66	14.64	18.38	-105.34
	Bangladesh	9.09		7.08	6.86		-0.35		-74.67	-5.41	-0.34	-0.58	4.25	-2.35		9.60	
Total pulses	Pakistan	-90.30	18.07	-19.30	-25.65	9.14	-59.27	2.01	-1380.00	1550.86	-88.84	-29.45	183.95	-1.81	109.06		
	India	-146.46	34.34	-81.23	0.96	77.07	38.78	6.25	-350.60	480.37	-85.75	8.57	418.02	-4.21	77.31	-55.62	27.90
	Bangladesh	18.40		7.26	17.89		0.09		-5.41	-242.03	-2.13	2.46	20.64	9.78		4.48	
Rapeseed cake	Pakistan	-14.72	1.69	1.49	3.68	-0.12	3.08	0.74	11.45	-88.84	-7.90	4.54	-13.11	2.64	11.85		
	India	1.71	-4.15	-0.56	13.58	1.24	3.55	0.01	4.88	-85.75	-5.55	5.67	-17.13	3.02	9.07	-0.80	5.38
	Bangladesh	-0.13		1.92	-1.32		0.35		-0.34	-2.13	-7.68	5.43	-0.71	3.43		2.46	
Cotton cake	Pakistan	9.49	-0.76	-1.69	4.42	1.42	-0.48	1.06	-72.35	-29.45	4.54	-18.37	-21.46	2.71	14.78		
	India	2.62	-0.07	2.14	2.09	0.46	-2.82	1.00	-8.14	8.57	5.67	-13.43	-37.64	1.60	2.62	2.74	-1.56
	Bangladesh	-2.00		0.49	-0.76		-0.15		-0.58	2.46	5.43	-8.68	0.84	1.26		1.99	
Pkerncake	Pakistan	38.40	-5.64	10.57	-1.31	-1.78	-9.51	0.43	65.62	183.95	-13.11	-21.46	-30.16	2.57	-18.13		
	India	25.60	-29.65	27.65	-63.14	-6.19	-19.25	0.92	18.04	418.02	-17.13	-37.64	-84.99	8.09	15.15	5.31	66.53
	Bangladesh	4.99		1.23	2.38		-1.04		4.25	20.64	-0.71	0.84	-38.09	-0.39		25.57	
Soybean cake	Pakistan	3.34	0.21	0.91	-0.46	-1.33	3.27	0.97	15.11	-1.81	2.64	2.71	2.57	-2.87	-4.06		
	India	3.59	0.65	1.75	-3.29	-1.18	4.60	1.15	12.66	-4.21	3.02	1.60	8.09	-4.50	-6.91	4.04	0.18
	Bangladesh	0.50		-0.94	0.25		0.25		-2.35	9.78	3.43	1.26	-0.39	-4.71		-6.30	
Other cakes	Pakistan	28.23	-102.29	7.00	54.90	15.19	10.74	0.23	44.57	109.06	11.85	14.78	-18.13	-4.06	257.41		
	India	5.09	1.20	-12.95	-20.70	26.11	1.36	1.84	14.64	77.31	9.07	2.62	15.15	-6.91	-45.70	0.40	59.42
	Bangladesh																
Rice	Pakistan																
	India	-8.07	1.57	2.33	12.21	-0.72	-5.88	0.26	18.38	-55.62	-0.80	2.74	5.31	4.04	0.40	-5.90	-20.38
	Bangladesh	9.79		1.10	6.18		4.13		9.60	4.48	2.46	1.99	25.57	-6.30		-96.30	
Otherseeds	Pakistan																
	India	35.92	-45.62	41.72	-5.10	-31.75	-3.56	-0.95	-105.34	27.90	5.38	-1.56	66.53	0.18	59.42	-20.38	-12.22
	Bangladesh																

Source: Own calculation

Table 64 is used to presents the different relationship between different products. The common relationships are maize-total brans (S), rapeseed cake-total brans (S), cotton cake-total brans (C), pkern cake-total brans (C), soybean cake-total brans (S), other cakes-total brans (S), rapeseed cake-cotton cake (S), rapeseed cake-pkern cake (C), rapeseed cake-soybean cake (S), rapeseed cake-other cakes (S) and cotton cake-soybean cake (S).

**Table 64: Elasticities of substitution for the different ingredients**

		Other cereals	Wheat	Maize	Sorghum	Millet	Total brans	Cottonseed	Total molasses	Total pulses	Rapecake	Cottoncake	Pkerncake	Soybean cake	Othercakes	Rice	Otherseeds
Other cereals	Pakistan		S	C	S	S	S	S	C	C	C	S	S	S	S		
	India		S	C	S	S	S	S	C	C	C	S	S	S	S	C	S
	Bangladesh			S	S		C		S	S	C	C	S	S		S	
Wheat	Pakistan	S		S	S	S	C	S	S	S	S	C	C	S	C		
	India	S		C	S	S	S	S	S	S	C	C	C	S	S	S	C
	Bangladesh																
Maize	Pakistan	C	S		C	S	S	S	S	C	S	C	S	S	S		
	India	C	C		C	S	S	S	C	C	C	S	S	S	C	S	S
	Bangladesh	S			S		S		S	S	S	S	S	C		S	
Sorghum	Pakistan	S	S	C		C	S	S	S	C	S	S	C	C	S		
	India	S	S	C		C	C	C	S	S	S	S	C	C	C	S	C
	Bangladesh	S		S			C		S	S	C	C	S	S		S	
Millet	Pakistan	S	S	S	C		C	S	S	S	C	C	C	C	S		
	India	S	S	S	C		C	C	S	S	S	S	C	C	S	C	C
	Bangladesh																
Total brans	Pakistan	S	C	S	S	C		S	S	C	S	C	C	S	S		
	India	S	S	S	C	C		S	S	S	S	C	C	S	S	C	C
	Bangladesh	C		S	C				C	S	S	C	C	S		S	
Cotton seed	Pakistan	S	S	S	S	S	S		S	S	S	S	S	S	S		
	India	S	S	S	C	C	S		C	S	S	S	S	S	S	S	C
	Bangladesh																
Total molasses	Pakistan	C	S	S	S	S	S	S		C	S	C	S	S	S		
	India	S	S	C	S	S	S	C		C	S	C	S	S	S	S	C
	Bangladesh	S		S	S		C			C	C	C	S	C		S	
Total pulses	Pakistan	C	S	C	C	S	C	S	C		C	C	S	C	S		
	India	C	S	C	S	S	S	S	C		C	S	S	C	S	C	S
	Bangladesh	S		S	S		S		C		C	S	S	S		S	
Rapeseed cake	Pakistan	C	S	S	S	C	S	S	S	C		S	C	S	S		
	India	S	C	C	S	S	S	S	S	C		S	C	S	S	C	S
	Bangladesh	C		S	C		S		C	C		S	C	S		S	
Cotton cake	Pakistan	S	C	C	S	S	C	S	C	C	C		C	S	S		
	India	S	S	S	S	S	C	S	C	S	S		C	S	S	S	C
	Bangladesh	C		S	C		C		C	S	S		S	S		S	
Pkerncake	Pakistan	S	C	S	C	C	C	S	S	S	C	C		S	C		
	India	S	C	S	C	C	C	S	S	S	C	C		S	S	S	S
	Bangladesh	S		S	S		C		S	S	C	S		C		S	
Soybean cake	Pakistan	S	S	S	C	C	S	S	S	C	S	S	S		C		
	India	S	S	S	C	C	S	S	S	C	S	S	S		C	S	S
	Bangladesh	S		C	S		S		C	S	S	S	C		C		
Other cakes	Pakistan	S	C	S	S	S	S	S	S	S	S	S	C	C			
	India	S	S	C	C	S	S	S	S	S	S	S	S	C		S	S
	Bangladesh																
Rice	Pakistan																
	India	C	S	S	S	C	C	S	S	C	C	S	S	S	S		C
	Bangladesh	S		S	S		S		S	S	S	S	S	C			
Otherseeds	Pakistan																
	India	S	C	S	C	C	C	C	C	S	S	C	S	S	S	C	
	Bangladesh																

Source: Own calculation

## 5.4. Conclusions

Despite the unreliability of statistical data used to describe and model the feed sector in the concerned three countries, it seems possible to draw some general conclusions.

We must first note the strong development of consumption of concentrates in animal feed. For all three countries, the tonnage reached about 55 Mt in 2007, more than double of the existing twenty years earlier. The distribution of these consumptions is very different from what is generally observed in Europe and mainly in developed countries because of the importance of rice and wheat bran (35% of total) and oilseeds used in the state (about 10%), cereals and cakes, major ingredients in developed countries representing less than 50%. The important and strong place of by-products less in energetic and protein (bran, molasses, etc.) but rich in cellulose leads to concentrates which are "average" rich in energy and protein and therefore could induce consumption indices (including for poultry) quite low. Among the differences between countries, it should be noted that in Pakistan, according to FAOSTAT, no tonnage of broken rice has ever been used in animal feed unlike the other two countries, which seems surprising.

Despite this, it was possible for each country to establish a statistical relationship between total demand of concentrates and some animal production. Statistical estimates show that the most concerned two sectors are always poultry (meat and eggs) on one hand and, except for Bangladesh, the milk. The calculated coefficients, although approximate can be interpreted in terms of consumption indices for poultry products (kg feed per kg of animal product) or in terms of kg of concentrate per kilogram of milk which are added to fodder in more intensive milk farms. For the three countries in statistical estimates, it remains an important constant term that can be assigned to a specific animal species and can be interpreted as a tonnage of concentrates, more or less fixed, which is given as food supplement to all animals regardless of their productivity (yields of eggs and milk). It would be interesting to distinguish in this analysis between the raw materials that are used in areas of more or less industrial compound feed and others, which is used directly by farmers, but such estimates exist only very occasionally, e.g. for Pakistan and could not be subjected to statistical estimates, the tonnages of the various types of compound feed themselves are only partially known in the three countries.

The original methodology used to calculate demand estimates was used to calculate values that seem consistent with the traditional nutritional bases (substitute products are generally raw

materials having compositions neighbouring protein, energy and cellulose) and complementary products are products of composition "opposite" (high protein versus high energy). However, this rule is not always true, because of the statistical uncertainties on the one hand, and secondly the fact that i) many products are intermediate (both rich in energy and protein) and that the calculated elasticities are aggregate elasticities including both poultry and cattle feed and the interactions between ingredients may be opposed in both species.

Finally we can note that all direct elasticities are negative as economic theory predicts except for some minor products where they are positive. This is explained by the simplified procedure for estimating the translog model, but precisely these products are very minor, this should not significantly alter the results of the simulations with the PEM. Matrices of elasticities in this chapter have been incorporated as such in these models.

# Chapter 6: Market Equilibrium Models for crops and building scenarios for 2025

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This chapter is the heart of the thesis insofar as it incorporates all analysis and estimates calculated in the three previous chapters. Which described and modelled i) the behaviour of supply of agricultural products in the three countries (Chapter 3) with the different aspects of substitution between crops through the mechanisms of allocation of the total available surface area (exogenous parameter ) as function of the price and yield (exogenous), ii) the behaviour of human demand for food for all animal and vegetable products (Chapter 4) with the relationship between the total population (exogenous), prices and income represented by various matrices of direct and cross elasticities and after the relations at level of animal demand (Chapter 5) and livestock production (exogenous), total demand for concentrates and relations with the specified price as matrices of elasticities

In this chapter, taking into account all these factors and parameters, the goal is to present a model to represent and analyse relationships between various levels of each product chain (supply, human demand, animal demand) and therefore mechanisms that are involved, taking all parameters of substitution / complementarity between products, in determining the domestic price of each product, considering that in the current version of these models, we retained the hypothesis of "small country" i.e. non influence of these situations on the global context. Determination of price changes in response to changes of some exogenous parameters is the priority of PEM insofar as from the knowledge of these, it is possible to calculate the variation of all other endogenous variables for each product (surfaces, production, human demand, and animal demand). It is also possible in such models to introduce the relations between certain exogenous variables (tonnage processed of some crops and corresponding by-products production), certain relationships between price (oilseeds, oils and meals).

From the calculation of the various endogenous variables, it is also possible to calculate with such models the values of some "indicators" that are interesting for synthetic analysis of agricultural policies such as per capita consumption levels of protein and calories, balances on



trade value, the total expenditure on human food and per capita etc. ..., these indicators can be combinations of linear or non-linear variables calculated in the model.

## 6.1. Methodology used to construct the models

Three partial equilibrium models have been developed to represent and calculate the price changes, production (areas) and consumption changes (human and animal) when some exogenous variables (population, per capita income, etc.) are modified.

In the form of equation it is supposed that supply of each agricultural product is equal to sum of human agricultural demand, animal agricultural demand, quantity of transformation, residual demand and net trade of this agricultural product.

$$OF_i P_j, X_{ik} = DH_i P_j, Y_{ik} + DA_i P_j, Z_{ik} + TR_i U_{ik} + DR_i V_{ik} + EL_i$$

Where i and j = number of vegetable crops or ingredient

k= number of exogenous variables

$OF_i$  = Quantity supplies of agricultural product of crop or ingredient i

$DH_i$  = Human demand of crop or ingredient i

$DA_i$  = Animal demand of crop or ingredient i

$TR_i$  = Quantity transformed of crop or ingredient i

$DR_i$  = Residual demand (seed, waste etc.) of crop or ingredient i

$EL_i$  = Net exterior trade (exports – imports) of crop or ingredient i. it may be positive if crop i is exported or negative if crop i is imported.

$X_{ik}, Y_{ik}, Z_{ik}, U_{ik}, V_{ik}$  = exogenous variables

As indicated in chapter 1, the above equation can be written in term of variations and simplified form:

$$\Delta OF_i = \Delta DH_i + \Delta DA_i + \Delta TR_i + \Delta DR_i + \Delta EL_i$$

$\Delta OF_i$  = variations of supply of crop or ingredient i

$\Delta DH_i$  = variations of human demand of crop or ingredient i

$\Delta DA_i$  = variation of animal demand of crop or ingredient i

$\Delta TR_i$  = variation of demand for transformation of crop or ingredient i

$\Delta DR_i$  = variation of residual demand of crop or ingredient i

$\Delta El_i$  = variations of external trade of crop or ingredient i

Equation 1 can also be written theoretically for marginal variations of prices and exogenous variables for crops in a simplified matrix form:

$$EO - \beta * EDH - \gamma * EDA * dP_i \quad P_i = dX_{ik}, dY_{ik}, dZ_{ik}, dU_{ik}, dV_{ik}$$

Where  $dP_i$   $P_i$  is the vector of relative variations of prices, EO is the price elasticity matrix of supply, EDH and EDA are the price elasticity matrices of demand for food and feed and  $dX_{ik}, dY_{ik}, dZ_{ik}, dU_{ik}, dV_{ik}$  are the variations of exogenous parameters. The significance of vectors  $\beta$  and  $\gamma$  will be indicated later.

Globally the model takes in account for each country 33 products (crops and by-products), but, of course, some of them can be neither produced and/or nor used in one or two of these countries:

### **Crops (13 products):**

Cereals (6): Wheat, Rice, Maize, Millet, Sorghum, Other cereals

Pulses (1): Total pulses

Cultures scribers (1): Total sugar crops

Oilseeds (5): Soybean, Sunflower seed, Rapeseed, Cottonseed, Other seeds

### **Byproducts from crop processing (13)**

By-products from sugar refinery (2): Total sugar, Total molasses

By-products from crushing industry (10):

Vegetal oils; Soybean oil, Sunflower oil, Rapeseed oil, Cotton oil, other oils

Cakes and meals: Soybean cake, Rapeseed cake, Sunflower cake, Cotton cake, Other cakes

By-products from cereals industries (1): Total brans,

### **Animal products (7)**

Meat (5): Bovine meat, Ovine meat, Pig meat, chicken meat, other meats

Eggs (1): Total eggs,

Milk (1): Total milk

Now we explain how different categories of product at different levels are calculated in our PEM:

### **The byproducts**

Among the vegetal products, it is important to distinguish between crops (13 products) and by-products (13 products), which are derived from these crops in operations of transformations with coefficients that can be regarded as fixed.

In the partial equilibrium model, the variation of production of each by-product  $i$  in each country obtained from the crop  $j$  can be written as:

$$\Delta \text{PROD}_i = \text{CT}_{ij} * \Delta \text{TR}_j$$

Where  $\text{CT}_{ij}$  is the technical coefficient of mass yield.

### **The crops**

Regarding the production of various crops  $i$ , which are calculated from surface variations, yield, price and appropriate subsidy can be written as:

$$d\text{AREA} = \Delta \text{AREA} \quad \text{AREA} = d\text{AREA\_EXO} + \text{EO} * d\text{PB} = d\text{SURF\_EXO} + \text{EO} * (d\text{YIELD} + d\text{P\_P} + d\text{SUB\_P})$$

In this vector equation:

$d\text{AREA}$  represents the percentage change in the surface of each culture between reference period or base period and the simulated situation

$d\text{AREA\_EXO}$  represents the exogenous variation in percentage of the total area in each country devoted to the 13 crops considered (expansion effect)

$\text{EO}$  is the matrix of gross product elasticities of supply for main crops (substitution effects)

$d\text{YIELD}$  is the percentage change in yield for each crop (as exogenous)

$d\text{P\_P}$  is the percentage change in the producer prices of different crops

$dSUB\_P$  is possible percentage subsidy paid directly by each government to producers for one or more crops

The percentage variation of production for each crop  $dPROD$  is given by:

$$dPROD = dYIELD + dAREA$$

### **The seeds uses**

Variations of seed uses for each crop are considered proportional to the surface variations of this crop

$$dSEED = dAREA$$

### **The production of animal products**

Variations of animal products as a percentage  $dPROD$  are exogenous and defined by:

$$dPROD = dPRODANI$$

### **The human demand**

Variation of human demand in percentage is:

$$dDH = dPOP + EDHP * (dP\_C + dSUB\_C) + EDHR * (a * dGDP + dSUB\_T)$$

Where

$dPOP$  is the percentage change in population

$EDHP$  is the matrix of price elasticity of human demand

$dP\_C$  is the percentage change in consumer prices

$dSUB\_C$  is possible percentage subsidy paid to consumers for certain specific products

$EDHR$  is the matrix of income elasticity of human demand for products

$dGDP$  or PDD is the percentage change in GDP per capita

$a$  is a coefficient (between 0 and 1) that expresses the proportion of the increase in GDP per capita which is associated with the increased demand for food.

$dSUB\_T$  is possible percentage subsidy that is paid to consumers to increase their purchases for plant and animal foods without specific assignment.

### **The animal demand**

The animal demand for different products is calculated in two stages:

The first stage relates to the total concentrates demand for each country

$$\Delta CON = f(\Delta PRODANI)$$

Where  $\Delta CON$  is the change of the total demand for concentrates in tonnage for animal feed. The function  $f(\Delta PRODANI)$  is specific for each country that corresponds to estimates presented in chapter 5 that links consumption of concentrates to production of various animal products  $PRODANI$  (effects of demand growth)

The second is evolution of  $INC$  (various ingredients within the total concentrate).

$$dINC = EDA * dP_A$$

Where

$dINC$  is the percentage change in the proportion of each ingredient in the total concentrates

$EDA$  is the matrix of price elasticity of animal demand

$dP_A$  is the percentage change in the purchase price of the various ingredients for animal feed.

Variation of consumption of each ingredient is:

$$\Delta DA = CON^0 + \Delta CON * INC^0 * 1 + dINC - CON^0 * INC^0$$

Where  $INC^0$  and  $CON^0$  are the initial shares of each ingredient and the initial total demand for concentrates in tonnage respectively in the total consumption. With small variations, the equation can be written:

$$\Delta DA \approx INC^0 * (\Delta CON + CON^0 * dINC)$$

### **The foreign trade balance**

The variation of trade can be either exogenous (when the objective of the simulation is to calculate equilibrium prices corresponding to a public policy concerning external trade) or endogenous when in the simulation some hypotheses on prices evolution (by example in relation with world prices). In each case external trade balance is used to equilibrate the model and assure

the equality for each product between the supply and the utilizations (the sum of human and animal demand).

### **The prices**

To calculate the equilibrium price for each product in each country, it is necessary to establish a relationship between the prices at all three levels of the industry. In general, it can be assumed:

$$dP_C = b * dP_P$$

And

$$dP_A = c * dP_P$$

It means that the price changes at the consumer level and at the feed industry level are proportional to price changes at the producer level. The simplest hypothesis is that b and c are equal to 1.

Regarding oilseed products (seed, oil and meal), there is a particular situation as the seeds are, mainly, for crushing while the value of the two co-products (oil and cake) which in practice determine their price. In fact the important factor for the crusher in the demand of each seed (in quantity and nature of the specific seed) is the crush margin which can be written:

$$MT = d^h * P^h + d^t * P^t - P^g$$

Where  $d^h$  and  $d^t$  are the mass yields of oil and meal for grain  $g$ .  $P^h$ ,  $P^g$  and  $P^t$  are the prices of oil, seed and meal respectively.

Generally crushing margins are low compared to the prices of different products and correspond to a large extent to cover the cost of crushing (depreciation of plant, energy and fluids, labour, etc.). Moreover, analysis of time-series data on long prices shows that there is cointegration between the prices of these three products and so that in equilibrium:

$$\Delta P^g = d^h * \Delta P^h + d^t * \Delta P^t$$

Regarding sugar plants, the same relationship exists between the price of the crop and that of sugar and molasses.

This reduces the number of independent price to be calculated in each simulation.

For cereals (wheat and rice), there exists an influence of price of co-product (bran) on the price of grain, but it can be considered negligible compared to the price of the main product (wheat flour or rice).

## **6.2. The initial situation of the three countries**

These initial situations were constructed and completed for each country from national food balance sheets elaborated by the FAO (sub-base FOOD BALANCE SHEETS, category: Food Balance Sheets).

1) For by-products unused in food (cakes, bran), these were constructed from production and foreign trade statistics (FAO sub-base FOOD BALANCE SHEETS, Category: Commodity Balances).

2) For surfaces and yields, these were constructed from production statistics (sub-base FAO PRODUCTION, Category: Crops).

These statistics are very detailed in terms of products, we have aggregated them into 32 categories of products corresponding to cereals, oilseeds, pulses, sugar plants and animal products (and by-products) and secondly those which are not part of this field (fruits, vegetables, tea, etc.).

From these figures for the total of the three countries appearing on a detailed form (Table 65) and on a synthetic form (Table 66) it is possible to draw some general characteristics<sup>59</sup>.

---

<sup>59</sup> The same tables for each of the countries are presented in Annex A

**Table 65: General detailed balance of main agricultural products for the total of the three countries**

	Population	Area	Yield	Production	Trade balance	Food	Feed	Seeds	Process	Variation of Stocks	Other uses
Population	1525264										
Wheat		37191	2.84	105566	-5388	90811	1451	4212	2	-11331	3147
Rice		56157	2.28	127896	4842	110756	3377	2790	351	26	5806
Maize		9393	2.20	20671	2136	8760	4863	886	15	-100	3911
Millet		10908	0.84	9118	170	7862	288	352	0	0	446
Sorghum		7779	0.95	7404	78	6489	95	235	0	0	507
Other cereals		867	2.05	1774	22	1314	205	101	100	0	32
Total pulses		22760	0.68	15468	-4846	17266	1662	764	0	0	622
Total sugar crops		5595	60.84	340400	0	17742	5701	19756	297921	5000	4280
Soybean		9770	1.03	10110	-145	1470	0	553	6780	-1000	452
Sunflower seed		1800	0.73	1320	-155	0	0	21	1615	161	0
Rapeseed		6779	1.12	7625	-592	548	0	44	7643	300	282
Cottonseed		13429	0.93	12426	2	0	4066	341	6953	0	1064
Others seeds		11454	1.48	16904	487	7024	24	294	9209	581	447
Total sugar				32023	-4000	32035	185	0	265	-1816	1722
Total molasses				8163	922	0	494	0	7747	1000	0
Soybean oil				1206	-1565	1851	0	0	0	-60	860
Sunflower oil				542	-518	1011	0	0	0	-5	44
Rapeseed oil				2700	-43	2672	0	0	0	-5	66
Cotton oil				1240	-5	1166	0	0	0	-18	61
Other oils				3530	-9016	6617	0	0	0	-381	5548
Soybean cake				5424	2541	0	2883	0	0	0	0
Rapeseed cake				4611	977	0	3634	0	0	0	0
Sunflower cake				727	17	0	710	0	0	0	0
Cottoncake				3477	2	0	3475	0	0	0	0
Other cakes				7409	341	0	7462	0	0	409	16
Total brans				24456	122	0	18418	0	5916	0	0
Bovine meat				4149	571	3578	0	0	0	0	0
Ovine meat				1464	60	1404	0	0	0	0	0
Pig meat				350	-1	351	0	0	0	0	0
Chicken meat				2917	1	2916	0	0	0	0	0
Other meats				206	1	197	0	0	8	0	0
Total eggs				4083	79	3388	0	198	0	-10	408
Total milk				148533	-70	119533	21299	0	0	0	7771
Total		193883		933892	-12973	446761	80292	30547	344524	-7248	37492

Source: Calculation from different data of FAO, Unit: Thousands people, ton/ha, thousands hectares, thousands tons



**Table 66: General synthetic balance of main agricultural products for the total of the three countries**

	Area	Yield	Production	Trade balance	Food	Feed	Seeds	Process	Variation of Stocks	Other uses
Total cereals	122294	2,23	272430	1860	225992	10280	8576	468	-11405	13849
Total oilseeds	43232	1,12	48385	-403	9042	4090	1253	32200	42	2245
Total pulses	22760	0,68	15468	-4846	17266	1662	764	0	0	622
Total sugcrops	5595	60,84	340400	0	17742	5701	19756	297921	5000	4280
Total vegal crops	193881	3,49	676683	-3389	270042	21733	30349	330589	-6363	20996
Total meat			9086	632	8446	0	0	8	0	0
Total eggs			4083	79	3388	0	198	0	-10	408
Total milk			148533	-70	119533	21299	0	0	0	7771
Total vegetal oils			9218	-11147	13317	0	0	0	-469	6579
Total cakes			21647	3878	0	18163	0	0	409	16
Total sugar			32023	-4000	32035	185	0	265	-1816	1722
Total molasses			8163	922	0	494	0	7747	1000	0
Total brans			24456	122	0	18418	0	5916	0	0
Total	193882		933892	-12973	446761	80292	30547	344524	-7248	37492

**Source: Calculation from different data of FAO, Units: Thousands hectares, ton/ha, thousands tons**

On these tables, it appears some important points:

1) A total of 336 Mt of products (excluding sugar plants) was produced from 187 Mha. Cereals with a total of 272 Mt (81% of total tonnage and 65% of the area) come clearly in first place with a particular weight in terms of tonnage and surfaces for rice and wheat. In term of surface area, maize, sorghum and millet are similar levels, but having yield two times more than the other two products, maize represents much larger tonnage. Oilseeds with 48 Mt and 43 Mha come in second place in all crops (23% of the area and only 21% of the production due to significantly lower yields as compared to rice, wheat or corn). Among these oilseeds, cotton, soybean and rapeseed show an important part (but very different depending on the country) and it should be also noted other important oilseeds with significant part (sesame, castor, etc.) that are not presented with detail in this work. The pulses, making together a large number of different crops with yields for different food and feed uses, represent only 12% of the area and about 7% of production, again due to low yields.

Sugar crops (mainly sugar cane is 5.6 Mha and 340 Mt, but this size cannot be compared directly with tonnages of other crops to the extent that its moisture content is very different from that of other products.

2) In terms of trade, the zone formed by the three countries had a deficit of 3.4 Mt for vegetal products in the state corresponding to a surplus of 1.9 Mt of cereals (its rice and corn that are more to compensate the 5.4 Mt deficit of wheat), but a very large deficit of 4.9 Mt in pulses. Despite the export of certain "Otherseeds" , this zone is characterized by slight deficit for all oilseeds (-0.4 Mt in total consisting mainly for rapeseed, soybean and sunflower)

3) The year 2009 is special because it was characterized by an important stocking of cereals (11.4 Mt consisting mainly of wheat). This stocking, after two years of high prices on world markets has limited the increase in human consumption.

4) Of the 259 Mt of cereals which were consumed in 2009 by the three countries, 226 went to food, 10 Mt in animal feed, 9 Mt were consumed as seeds (including losses), 14 in the not food uses (agricultural alcohol, industrial starch, biofuels, other), and 0.4 have been converted for not identified uses. Although undergone primary processing (production of flour from wheat and extraction of bran from rice), these products expressed as equivalent to grain are considered directly consumed in the balance FAO. For oilseeds, one part of the production was used directly for human consumption (including soybean and other seeds) or animal feed (especially cotton) and seed but most (32 of 49 Mt) was transformed into oil and meal in mills.

5) From these diverse crops (and some imports), these three countries produced nearly 22 Mt of meal, more than 9 million tons of vegetable oils, 32 Mt of sugar, 8 Mt of molasses while 24 Mt of rice and wheat bran. Whereas for the meals, there was an overall surplus of nearly 4 Mt, there is a very important deficit for vegetal oils (-11 Mt for oils of palm, soybean and sunflower) which corresponds to more than 80% for consumption as food. For these vegetal oils, it should be noted that significant tonnage of products (6.6 Mt) go to non-food industries uses such as soap, paints, varnishes, lubricants, etc. While the sugar deficit is important (4 Mt) and the molasses like bran has a surplus.

6) In animal products, domestic consumption is very close to domestic production with the exception of beef for which there is a surplus of 0.6 Mt correspond approximately to 13% of the production of the meat (this balance being almost entirely imputable to India). For the poultry industry, foreign trade is very low and domestic consumption is almost equal to domestic production. From detailed tables for each country (annex b) , it is possible to calculate the technical coefficients relating the amount of each by-product obtained from the quantity of each

crop used in the implementation process for transformation industry in each country (see table 67).

**Table 67: Technical coefficients for different byproducts**

		MEAL	OIL	BRANS	SUGAR	MOLASSE
Wheat	Pakistan			0.150		
	India			0.150		
	Bangladesh			0.150		
Rice	Pakistan			0.127		
	India			0.088		
	Bangladesh			0.125		
Total sugar crops	Pakistan				0.101	0.036
	India				0.108	0.026
	Bangladesh				0.154	0.018
Soybean	Pakistan	0.800	0.178			
	India	0.800	0.178			
	Bangladesh	0.800	0.178			
Sunflowerseed	Pakistan	0.450	0.328			
	India	0.450	0.340			
	Bangladesh	0.450	0.340			
Rapeseed	Pakistan	0.620	0.350			
	India	0.600	0.357			
	Bangladesh	0.621	0.297			
Cottonseed	Pakistan	0.500	0.179			
	India	0.500	0.178			
	Bangladesh	0.500	0.174			
Otherseeds	Pakistan	0.445	0.318			
	India	0.833	0.391			
	Bangladesh	0.255	0.201			

Source: Calculation from FAO data for year 2009; Unit: Percentage

For wheat, due to the absence of precise information, 15% ratio is retained between the amount of wheat used for human consumption and the production of wheat bran. The ratio for rice is obtained by dividing the total production for bran of each country by the amount of milled rice used for human consumption.

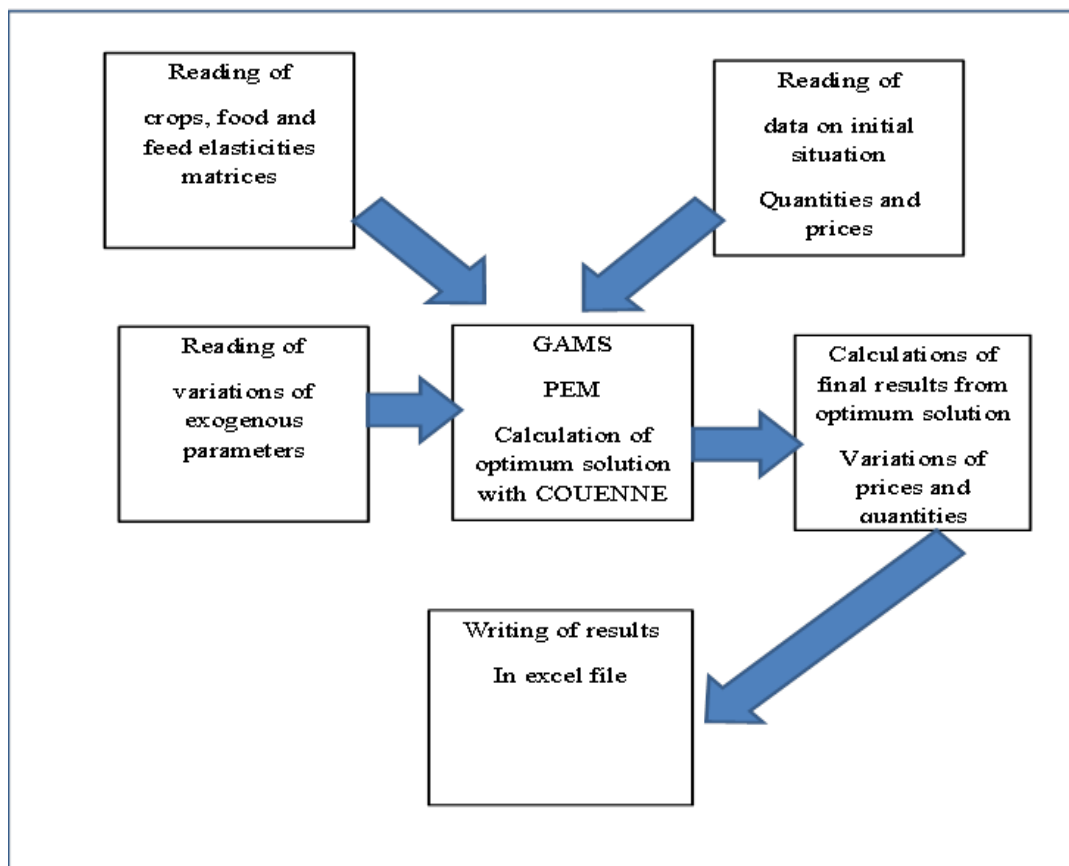
For sugar (total) and molasses (total), coefficients are obtained by dividing the total production of these products by the total amount of sugar crops (cane and beet) as shown in the transformed

balance. For each oilseed, technical coefficients for the meal and oil are obtained by dividing the production of each of these commodities by the quantity of seeds corresponding transformed.

### 6.3. The structure and the operating mode of the model.

The model has been implemented in GAMS<sup>60</sup> and used the solver COUENNE<sup>61</sup>. The logical tasks performed by the program (Figure 45) are 1) reading of data, 2) calculation of optimum solution, 3) writing of results in an excel file.

**Figure 45: Logical tasks of the PEM model**



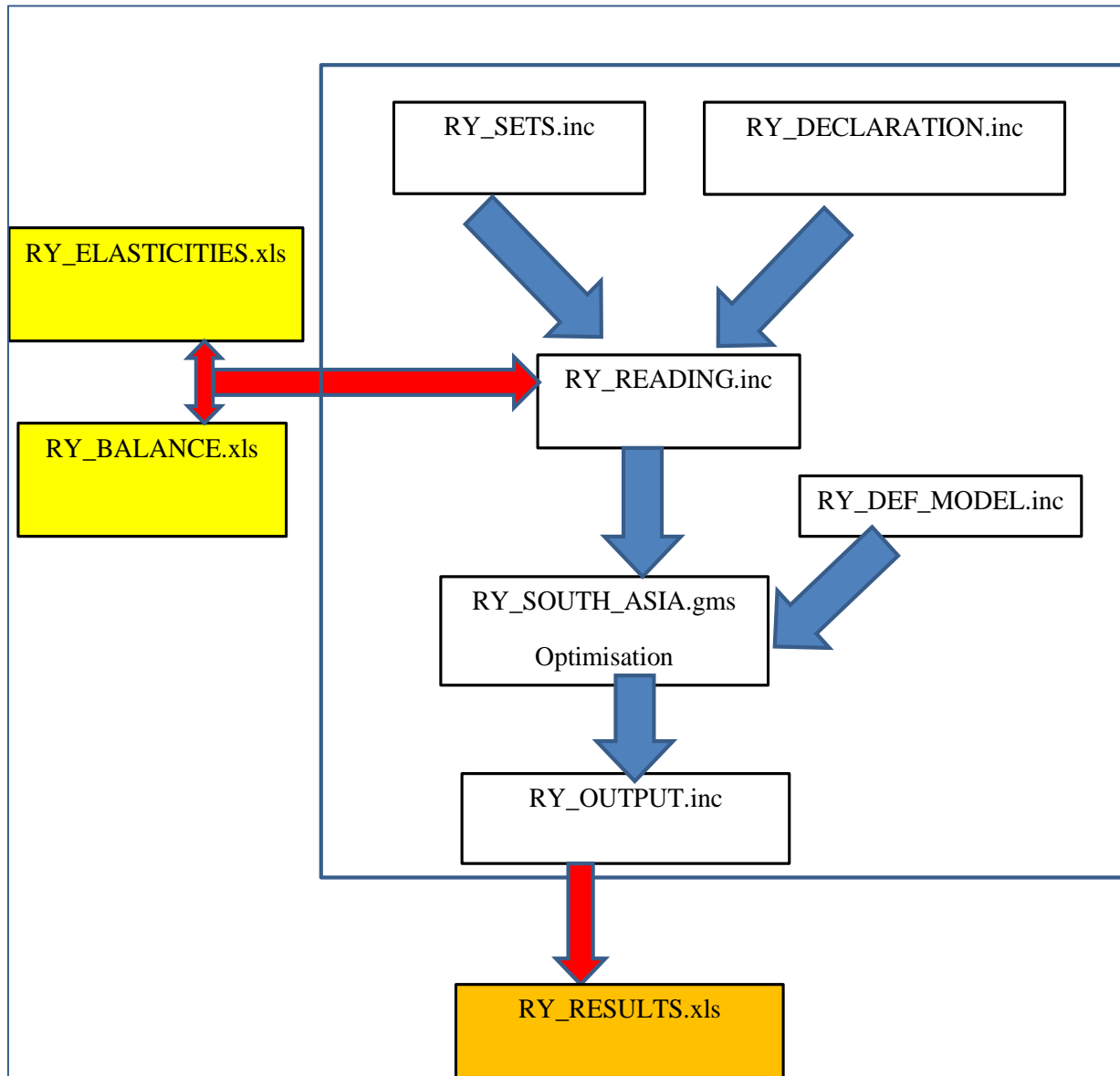
<sup>60</sup> General Algebraic Modeling System (GAMS), <http://www.gams.com/>

<sup>61</sup> COUENNE is an Open Source code for solving Global Optimization problems. It is part of the COIN-OR infrastructure for Operations Research software. This program contains Ipopt, a library for large-scale non-linear optimization. Ipopt is released as open source code under the Common Public License (CPL).

### 6.3.1. Organization, structure and syntax for the GAMS programs

The different tasks indicated on Figure 46 are performed by six programs written in GAMS language.

**Figure 46: The tasks performed by the different GAMS programs**



**The program RY\_SETS.inc** defines all the collections (SETS) of names used in the different programs for countries, products, posts (area, productions, etc.).

For example:

```
SET COUNTRY /PAK, IND, BAN/ ;  
SET PRODUCT / Wheat, Rice, ...../;
```

**The program RY\_DECLARATION.inc** defines the names of all the “PARAMETERS” used in the different programs. By definition in GAMS, the name “PARAMETERS” are exogenous variable which are read in outside files or calculated inside the programs and differ from “VARIABLES” which are endogenous and calculated by the solver in optimization procedure. All parameters must be previously defined (names and SETS on which the different arguments are defined)

For example:

```
PARAMETERS  
PRICE_PROD (COUNTRY, PRODUCT)  
PRICE_FEED (COUNTRY, PRODUCT)  
;
```

After declaration<sup>62</sup>, parameters have to be initialized either by reading values from external files, either by calculating them from other parameters or, after optimization, by calculating them from variables.

**The program RY\_READING.inc** reads the different parameters from the two excel files RY\_ELASTICITIES.xls and RY\_BALANCES.xls. The structure of these two input data files will be described hereafter. After reading, this program makes several verifications, aggregations and other calculations.

The syntax for reading values of the parameter PRICE\_PROD(COUNTRY,PRODUCT) in the file RY\_BALANCE.xls is:

```
$libinclude xlexport PRICE_PROD RY_BALANCE.xls sheet!init:final;
```

sheet!init:final represents the name of the sheet to be read and the location of data (from cell init (example a4) to cell final (example q35)). The sheet must contain in correct place the names of the first argument in columns and the names of the second in columns.

---

<sup>62</sup> Of course parameters can have more than two arguments

**The program RY\_DEF\_MODEL.inc** contains 1) the declaration of the different variables, 2) the definition of the objective function and the constraints equations, 3) the name and the structure of the model with this syntax:

Part 1

```
VARIABLE  
EVOL_AREA (COUNTRY,PRODUCT)  
FUNC_OBJ  
;
```

Part 2

```
EQUATIONS  
EQ_FUNC_OBJ  
EQ_EVOL_AREA(COUNTRY,PRODUCT)  
;  
EQ_FUNC_OBJ..  
FUNC_OBJ =E= SUM(.....);  
EQ_EVOL_AREA(COUNTRY,PRODUCT)..  
EVOL_AREA (COUNTRY,PRODUCT) =E= SUM(.....);
```

Part 3

```
MODEL MOD_SOUTH_ASIA /EQ_FUNC_OBJ, EQ_EVOL_AREA,...../  
Or  
MODEL MOD_SOUTH_ASIA /ALL/;
```

**The program RY\_SOUTH\_ASIA.gms** is the main program from which all other programs are called:

After definition of some options, the main program contains the different elements:

```
.....  
$include RY_SETS.inc  
$include RY_DECLARATIONS.inc  
$include RY_READING.inc
```

Some intermediary calculations and definition of the exogenous variations for the specific simulation are also made in this program.

```
$include RY_DEF_MODEL.inc  
OPTION NLP = COUENNE ;  
SOLVE MOD_SOUTH_ASIA minimizing FUNC_OBJ using NLP;  
$include RY_WRITING.inc
```

**The program RY\_OUTPUT.inc** gets the values of the different variables after optimization and calculates some new parameters of interest which are written in the excel as RY\_RESULT.xls.

The general syntax is:

```
$libinclude xlexport EVOL_AREA.l RY_RESULTS.xls evol!init:final;
```

Where variable.l indicates the value of calculated variable at level (the other main option being variable.m which is the marginal value).

### **6.3.2. Organization and contents of the different excel files**

The PEM used three excel files.

#### **RY ELASTICITIES.xls**

This files contains four sheets, the first one (ES\_price) gives the direct and cross gross product elasticities for all crops (as calculated at chapter 3 of the report), the second (EDH\_rev) gives the food demand expenditure elasticities for vegetal and animal products considered together (as calculated in chapter 4), the third (EDH\_price) gives the Marshallian cross and direct price elasticities for vegetal and animal products considered together (as calculated in chapter 4), the fourth (EDA\_price) gives the cross and direct price elasticities for feed products (as calculated in the chapter 5).

#### **RY BALANCE.xls**

This file contains four sheets. The first one (balance) contain for each country the “food balance sheet” elaborated by FAO for year 2009 in the form available in FAOSTAT database. This “food balance sheet” contains a greater number of products which are taken in the model. Some have been eliminated (vegetable, fruits, etc.) because considered as having no interaction with products selected in the model, some other have been aggregated (by example palm oil, groundnut oil,



etc.) to form the family of products “Other oils”. In FAO balance sheet, there is no information on “specific feed products” such as brans, and oilseeds cakes. These balance sheet for 2009 have been calculated and included in the same sheet of the excel file. The sources of data used were FAO data on production and external trade of each country for 2009. It was considered that the totality of the quantity of each product available in each country (production plus importations less exportations) was used as feed.

The second sheet of this excel file (SRP) contains the values of cultivated areas, yields and productions for each country and each crop in 2009. This information came from a different sub-database of FAOSTAT. In some cases the figure for production of some crops was different from the figure indicated in balance sheet. In those cases, for having coherent initial data, for production the figure used in the model was that coming from “balance” sheet and for area the figure given in the “SRP” sheet. The yield we recalculated inside GAMS program, but adjustments were generally moderate.

The third sheet (price) gives the prices for each product in each country at the three levels: production (PRICE\_PROD), feed industry and breeders (PRICE\_FEED) and consumers (PRICE\_CONS). As in preceding parts of this report, the lack of data on prices and their low reliability was a main problem and a lot of these prices had to be estimated from different sources available in publications or online sites. A large effort has been done to make them as coherent as possible.

The last sheet (NUTRI) contains the values of contents for each food and feed product in term of kilocalories per kilo of product and in term of protein in grams per kilo. Supposed to be common to the three countries, these values are calculated from “food balance sheets” (which give the average quantity used in kg/capita/year and the corresponding quantity of kcal (in kcal/capita/day) and protein (in grams/capita/day) provided to human nutrition for each product).

### **RY RESULTS.xls**

This file is reinitialized to zero at each calculation of the model by creating a new copy of the RY\_MODEL\_RESULTS.xls.

It contains 8 sheets. The four first ones have the same structure (init, final, var, evol) and present the value of each post of the balance (population, price, area, production, balance of external trade (exportations less importations), food utilization, feed utilization, variations of stocks,

transformation/processing (in particular oilseed crushing and sugar industry), seeds, other uses for each country (and also for the sum of them). Two other parameters are indicated in these sheets (consumption per capita and per year, percentage of each product in total food consumption).

The sheet “**init**” reminds the initial values of each parameter, the sheet “**final**” give the final values of each parameter corresponding to the calculated scenario corresponding to chosen variations of exogenous parameters. The sheets “**var**” and “**evol**” indicates the differences between final and initial values in absolute quantities and in percentage.

The sheet “**PRICE**” gives the initial, final, variation and evolution of producer, consumers and feed prices for each product and each country.

The sheet “**INDICATORS**” gives the value of some aggregated indicators with initial, final, variations and evolutions of them.

These indicators, for which initial, final, variation, and evolution are calculated for each country, are:

- 1) Values of vegetal production, value of animal production and value of total production at producers prices
- 2) Values of total expenditure for vegetal foods, animal foods and total foods expressed at national level and by capita
- 3) Value of total concentrates as feed consumption expressed at feed prices.
- 4) Value added at animal production level. This is the difference between the value of animal production and the cost of animal feeding. Of course this indicator is only an approximation of real value added because costs such as employment, housing, veterinary products, etc. are not taken in account due to lack of data.
- 5) Value of the external trade balance for vegetal products, animal products and total expressed at national level and equal to the sum of trade balance in quantity multiplied by the corresponding producer prices.
- 6) Cost of subvention given to producers or consumers (for vegetal, animal product and the total respectively) first at national level then expressed in values per capita.
- 7) The level of kilocalories and protein intakes (expressed at national level and by capita) given by vegetal foods, animal foods and total.

The sheet “**EFFECTS**” gives decomposition of different “effects” in variation of areas (price effects and eventually subvention effects) and variations of food demand (prices effects, income effects and eventually subvention effects).

The sheet “**FEED**” gives decomposition of effects in feed demand of variations of animal production and prices effects for each concentrate.

The sheet “**ELAST**” reminds the values of the different elasticities for verification purpose.

## 6.4. The different scenarios calculated for 2009

### 6.4.1. Definition of the different scenarios

When a PEM has been elaborated, it is interesting to analyse the impact of marginal variations of main exogenous parameters on the different calculated variables (scenarios SC1 to SC5) for 2009. Some specific scenarios corresponding to simplified public policies of intervention in form of subventions given either to producers or consumers have been calculated (SC10, SC11, SC12 and SC20, SC21, SC22). The definitions of the scenarios are presented on Table 68.

**Table 68: Definition of the hypotheses for the different scenarios**

	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
Specification of scenario	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
Constraints on specific products														
For all countries														
Variation of solde														
Total milk (kt)	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500			
Total Sugarcrops (kt)	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100			
Total brans (kt)	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000			
Constraints on other products														
Pakistan (kt)	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500			
India (kt)	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000			
Bangladesh (kt)	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500			
Constraints on all products														
Pakistan (kt)												2500;+2500	-2500;+2500	-INF;+INF
India (kt)												7500;+7500	-7500;+7500	-INF;+INF
Bangladesh (kt)												2500;+2500	-2500;+2500	-INF;+INF
Sum of the three countries													-5000;+5000	-INF;+INF

Source: Own definitions

One important point is to justify the choice to let some flexibility in adjustments of external trade for each country. As indicated previously with 32 different products (crops and by-products), a PEM implies to solve a system of 32 simultaneous equations where the unknown variables are 1)

variations of prices, and 2) variations of external trade. From a theoretical point of view such a linear system has always a solution for the 32 variations of trade balance if variations of prices are fixed or for the 32 variations of prices if the 32 variations of external trade are fixed. In fact in our specific case, the model includes some other equations such as relations between variations of prices for oilseeds products (seeds, cake and oil) and sugar products (sugar cane, sugar and molasses). Much more important, even if one single solution on prices variations exist always, there is mathematic point of view, when trade balances for all products are fixed, the different values calculated for variations of prices, and variations of other parameters (by example areas, productions, food consumptions, etc..) may not be acceptable from an economic point of view. A price cannot become negative (neither areas nor food consumptions etc.), so variations of different variables calculated by the model had to be constrained. For instance diminution of every price has to be lower than 100% in percentage, diminution of production (in quantity) has to be less than initial production, etc. All these aspects concern logical limits to diminution of some variables. There are also some limits concerning increases of some variables (for instance imports of fluid milk or sugar crops) for which transportation on long distance is very expensive and for which there is no real international market.

So in the specific PEM developed here, situation is an intermediary. If the model is run with variations of balance trade fixed equal to zero for all products, it is observed that there is no “acceptable” set of solutions from an economic point of view. So some flexibility had to be given to these variables for getting “acceptable” results, but in this case it has been demonstrated that the solution is not unique and, more, there is infinity of sets of solutions. The best way to deal with this problem is to define a proper objective function which can be optimized. It is generally admitted in literature that small variations of exogenous parameters must induce small variations of prices in absolute value (either positively or negatively). This marginal hypothesis is coherent, as was explained previously, with the conditions of utilization of elasticities matrices. Finally the objective function included in the model is:

*FUNC\_OBJ=E=SUM ((COUNTRY, PRODUCT), POWER (DPRICE\_PROD (COUNTRY, PRODUCT),2));*

For simplification of calculation made by the solver, as frequently done in this case, the function *ABS(DPRICE\_PROD(COUNTRY,PRODUC))* which is not continuous has been replaced by

POWER(DPRICE\_PROD(COUNTRY,PRODUC),2) which has better mathematical properties and is nearly equivalent in term of results of optimization. In fact this objective function is no more linear (it is quadratic in prices variations) and the model must be solved with a specific more elaborated solver such as COUENNE which is available through GAMS.

#### **6.4.2. Analysis of the main results for the different scenarios**

The 13 scenarios are defined in table 88 of Annex C for main variables (price, area, production, external trade, food consumption, feed utilizations) then results of variation of production for all products in all scenarios are presented in tables 89, 90 and 91 for Pakistan, India and Bangladesh respectively. Results of variation of prices for all products in all scenarios are presented in table 92, 93 and 94 for Pakistan, India and Bangladesh respectively. Likewise Results of variation of surface areas for all products in all scenarios are presented in tables 95, 96 and 97 for Pakistan, India and Bangladesh respectively. Results of variation of external trade for all products in all scenarios are presented in tables 99, 100 and 101 for Pakistan, India and Bangladesh respectively.

Tables 103, 104 and 105 represent results of variation of food consumption for all products in all scenarios for Pakistan, India and Bangladesh respectively. Likewise tables 107, 108 and 109 represent results of variation of feed consumption for all concentrates in all scenarios for Pakistan, India and Bangladesh respectively. Results of variation of food consumption per capita for all products in all scenarios are presented in tables 111, 112 and 113 for Pakistan, India and Bangladesh respectively while table 114 represents results of variation of food expenditure for all products in all scenarios for three countries. Then results of variation of public cost of subsidy , variation of external trade, variation of calorie and variation of protein for all products in all scenarios are presented by tables 116, 117, 118 and 119 respectively. These tables are presented in Annex C.

#### **Scenario SC1: Population of each country increased by 5%**

For **Pakistan**, this increase of 8.5 million people (5% of population) implies limited increases of prices for wheat, millet, all oilseeds and vegetal oils, and for main animal products, reversely prices of other crops (in particular pulses and sugar crops) decrease. These contradictory evolutions of prices are due to some substitutions in areas cultivated (those of wheat, millet and rapeseed increase due to relative price rise of these crops) and those of rice and sugar crops regress slightly. The value of total agricultural production increased by 1.1% (-0.2% for

agricultural products and +2.8% for animal products). The food expenditure may increase by 4.8% at national level but may decrease by 0.2% per capita. Total human consumption per capita may increase slightly by 7.2 kg with an increase of maize, pulses, sugar, beef and diminution for milk and slightly for vegetal oils. Intakes of kilocalories per capita fell by 0.4% (+0.2 for vegetal products and -3.4% for animal products). For proteins, the overall decline is 1.0% (+0.48 for vegetal products and -3.1% for animal products). An overall population increase not accompanied by an increase in the production of animal products led to deterioration of calorie and protein intake in the country.

Overall demand of concentrates for feed is only slightly affected in this scenario because there is no change in the production, but the effects of substitution between feed ingredients, due to prices modifications, led to a slight increase in use of corn and molasses but also to a decrease of utilization for pulses. That benefits to human consumption.

In terms of trade balance, there is degradation in tonnage of 1.7 Mt which concerns mainly wheat, sugar, molasses and beef. In terms of value, the balance already negative worsens by 31%, this is almost entirely due to vegetal products (resulted as increased imports of wheat and sugar) while values of animal products net trade, very low in the initial situation remains practically unchanged.

For **India**, with a population increase of 64.4 million people (5% increase of population), the price changes are significantly larger than in Pakistan. Prices of rice, corn, sugarcane, sugar and various meats increase significantly, while prices of wheat, other cereals, pulses, soybean and milk decrease. These changes are partially due to substitutions between surfaces that lead to a total area increase of more than 2.1 Mha due to area increases of pulses and rapeseed more than in maize, rice and sorghum. Surface areas of wheat, sugar cane and cotton decline slightly. The total value of agricultural production increases by 2.7% (+4.8 for vegetal crops and -0.9% for animal products) due to both changes in land use and price changes.

Food expenditures increase by 2.5% at the national level, but decrease by 2.4% per capita (with -0.5% for plant products and -6.2% for animal products). Human consumption per capita increases slightly by 10kg/capita/year with a setback for all animal products and also a slight decrease for sugar and all vegetal oils. Per capita consumption decreases by 4.8 kg / capita / year for all cereals due to strongest regressions being attributable to wheat and rice. For feed, taking into

account substitution effects related to price changes, there is a reduction in total use of concentrates by 1.6 Mt, with a sharp increase of corn, soybean meal and "other meal" and a significant decrease in pulses, wheat, rice and bran.

For the external trade balance, there is a decrease of 1.6 Mt mainly due to rice, millet, sugar and "other meal" who see their initial surplus or deficits reduced by 1 Mt (which is the maximum allowed in this scenario). On the contrary, external trade balance improves by 1Mt for pulses and rapeseed meal. So taking values, the overall deficit decreased by 3.2% (2.8% degradation for vegetal products and amelioration of 7.0% for animal products), especially due to the development of potentially exportable excess eggs.

Availability of calories per capita decreases overall by 3.5% (-3.3% for vegetal products and -5.4% for animal products) while for protein, availability per capita decrease by 3.0% (2.3% for vegetal products and 5.6% for animal products). Such as in Pakistan, for India, this scenario implies a deterioration of the nutritional situation of the country with a focus on consumption of vegetal calories and proteins.

In **Bangladesh**, with a population increase of 7.4 Million people (5% increase of population), impacts on prices are generally very limited, however, with some increase in the price of rice and, to a lesser extent, those of milk, meat and poultry eggs. Given the low price variations of different crops, the surfaces change very little with only +4000 ha for maize. The value of total agricultural production increases by 3.9% (+4.8% for crops and +1.7% for livestock products). Per capita consumption regresses slightly by 8kg/capita/year mainly due to the slight decline in rice intake due to higher relative price of this product. Total food expenditures per capita change very little (+0.1%) with an increase in vegetal products (+0.5%) and a decline in animal products (-1.7%).

The external trade balance decreases very slightly in tonnage, and worsens by 2.4% in value with almost equal percentages for vegetal and animal products.

For levels of caloric and protein intakes, there is a significant degradation by 3.3% and 3.0% respectively for all products, declines spreading roughly equally between vegetal and animal products. Unlike the other two countries, there is no significant change in contributions between vegetal and animal products, the ration at the very initial situation being mainly based on vegetal sources.

### **Scenario SC2: Total food expenditure per capita increased by 5%**

For **Pakistan**, in this scenario, price changes are very small and are mainly due to wheat (+1.8%) and milk (+7.8%). Cultivated land change slightly with an increase in the total area of only 12000 ha due to almost entirely to wheat. The total value of agricultural production increases by 2.9% and the per capita food expenditure increases by 4.7% (+1.8% respectively for vegetal products and +6.8% for animal products). The per capita consumption increases overall very slightly by 2kg/capita/year due to vegetal and animal products. The external trade balance decreases slightly in tonnage (mainly due to sugar), but worsens more significantly in value (+8.3%). About the food situation, there is an increase of 0.9% of total calorie intake (+0.9% for vegetal products and +0.8% for animal products) and an increase of 0.5% for protein intake.

For **India**, the price changes are generally very low except for milk (+7.5%) for rice (+7.3%) and to a lesser extent wheat (+3.3%). The total cultivated area increases slightly by 143000 ha under the main influence of increase in wheat, rice and pulses, while soybean records a decline to its lower relative price. The value of agricultural production increases by 4.6% (of which +6.2 for animal products due to the price effect). The external trade balance improves by about 440000 t primarily due to improved results for wheat, rice, pulses and other cakes, which offset more than the deterioration for sugar, millet and soymeal. Value in the trade balance deteriorates by 1.6%. For calories and proteins intake, there is increase per capita of 0.4% and 0.3% respectively.

For **Bangladesh**, among vegetal products only rice price shows an increase by 5.5% while all animal products are experiencing from a limited increase from 1.0% for poultry meat and eggs to 2.5% for milk. Given these very small price changes, the surface does not change practically (only 4000 ha for maize). The total value of agricultural production increases by 4.0% mainly due to price effects (+4.9 and +1.7 for vegetal and animal products respectively). The balance of foreign trade in tonnage varies very little with only a slight overall improvement in the balance of rice and a slight degradation for wheat and milk. In value, the overall balance was already negative, worsens by 2.4%. About nutritional level, there is an increase of 1.2% and 1.1% per capita intake of calories and proteins, which is slightly higher than for Pakistan and India. This is explained by an increase in per capita consumption of 3.1 kg / capita / year mainly in the form of rice, sugar and milk.

### **Scenario SC3: Total cultivated area increased by 5%**



In **Pakistan**, the total cultivated area increases by 1.1 Mha (including 530,000 ha for wheat and 170,000 for cotton). The prices of vegetal products fell by almost 10% for wheat and rice (and even more than 21% for sugar crops). Given the substitution effects at the level of human consumption, animal products prices change slightly (especially -1.3% for sheep meat and +2.5% for milk). Despite the increase of 5% of the area, the value of total agricultural production decreases by 0.9% due to the price effects (the decrease is 2.8% for vegetal products while increases by 1.7% for animal products). The total food expenditure fell by 0.7%, despite the increase of 3.3 kg / capita / year for food consumption with more wheat in the diet (+4.3 kg / capita / year).

The external trade balance improves by 1.3 Mt especially due to the improvement in the balance of wheat, rice, and pulses. In value terms, the foreign trade deficit decrease significantly by 15.8%. At nutritional level, intake of calories and proteins per capita grows by 1.2% and 1.3% respectively.

In **India**, the total increase of surface by 8.3 Mha (5% of initial surface cultivated) is accompanied by an increase for all crops, the largest increases being for rice, millet and pulses and especially oilseeds. The corresponding increase in production allows lower prices of virtually all vegetal products (-13.6% for rice) with the exception of cotton seed and sugar crops (and sugar). The external trade balance improves by 4.8 Mt in tonnage (with a breakdown for wheat and instead a strong increase for all other grains, cotton, sugar, total oil and meal) and by 18.5% in value (marked improvement for vegetal products, but slight deterioration of 4.2% for animal products). About nutritional level, there is an improvement of 1.5% for calories and 1.5% for protein, with improvement rates slightly higher than those observed in Pakistan. In **Bangladesh**, the total area increases by 630,000 ha (5% of surface cultivated) almost entirely due to the rice. Food consumption per capita increases by 5.1 kg / capita / year mainly in the form of rice. Nutritional intake of calories and proteins per capita improves significantly more than other two countries (+2.2% and +2.0% respectively). The external trade balance improves by 0.5 Mt in tonnage and 1.0% in value.

#### **Scenario SC4: Yield of each crop increased by 5%**

In **Pakistan**, this scenario leads to moderate effects on prices practically limited to wheat (-7.6%) and rice (-1.6%) and in the opposite direction to sugar crops (+2.1%). Surfaces for different crops

change very little and an increase of production is due to variations in yield that allows improving the external balance of 1.7 Mt particularly pronounced for wheat, rice, pulses, and sugar. The value of foreign trade deficit decreases by 22%. At nutritional level, intake of calories and proteins per capita grow by 0.7% and 1.1% respectively.

In **India**, there are important price variations more than in Pakistan, both to decrease (-20.1% for rice, -13.3% for sugar crops) and to increase (greater than 10% for sorghum, cottonseed and soybean). The trade balance improves by 4.0 Mt with a net increase for rice, millet, sugar and all the cakes, which compensate the degradation of wheat and pulses. In value, external trade deficit decreases by 9.9%. The increase in consumption by 4.5 kg / capita / year allows a significant increase in calorie and protein intake by 1.9% and 1.7% respectively.

In **Bangladesh**, the prices change very slightly with the exception of the rice which fell by 4.6%. The trade balance improved by 0.5 Mt almost entirely due to the rice that passes a slight initial deficit to a surplus of more than 0.4 Mt. Worth of the deficit decreases by 0.9%. Consumption per capita rises by 5.2 kg / capita / year (of which +4.4 for rice), which allows an improved intake of calories and proteins by 2.2% and 2.0% respectively.

#### **Scenario SC5: Production for each animal product increased by 5%**

In **Pakistan**, this increase of livestock does virtually no change in crop prices, but a slight decrease in the prices of meat, eggs and a steeper decline in milk prices (-4.0%). The external trade balance hardly changes at all, but slight gains in balance for animal products and sugar is almost compensated by the damage balances on oilseeds meals. Value of external deficit improves by 7.1%, while the deficit of vegetal products improves by 7.1%, the surplus for animal products increases by 1.7%. Per capita consumption rise be 9.0 kg / capita / year mainly due to milk (+9.8 kg / capita / year) and allows a slight improvement in calorie intake (+0.3%) and a larger increase in protein (+1.6%). The increase in animal production requires the use of 0.4 Mt of concentrates, most of which being essentially brans and cakes.

In **India**, milk prices fell by 15.6% whereas among the crops, wheat price increases by 9.4% while other crops decrease slightly. The external trade balance deteriorates by 5.1 Mt mainly due to wheat, rice, pulses and sugar degradations of trade which are not offset by increases in tonnage for trade balance of animal products, so value of the total deficit increases sharply by 19.2%. Per capita consumption increases by 9.1 kg / capita / year mainly due to milk (+4.6 kg / capita / year)

and wheat (+2.5 kg / capita / year). At nutritional level, intake per capita increase by 2.5% for both calories and protein.

Regarding the feed, concentrates requirements increase by 1.7 Mt and are satisfied primarily by an increase in uses of pulses, brans and cottonseeds whereas various cereals are little affected.

In **Bangladesh**, the prices of animal products decrease significantly for meat and eggs while sharper for milk (-10.3%). The per capita consumption increases by 6.8 kg / capita / year, this evolution being mainly due to rice (+4.6 kg / capita / year) and marginally to various animal products. Calorie and protein intakes per capita grow by 2.7% and 2.6% respectively. The foreign trade balance decreases by 0.7 Mt (due to mainly rice) and worsens in value by 2.3%.

**Scenarios SC10: Subvention of 10% of initial producer price given to producers for all crops, SC11: Subvention of 10% for rice, SC12: Subvention of 10% for Wheat**

As anticipated, a uniform subsidy of 10% paid to the producers for all crops has no effect in terms of price changes and of the various balance sheet items (production, areas, etc.) since this policy involves no substitution between crops and the total area cultivated is considered unchanged. The measure ameliorates by a 10% gross products of farmers (and therefore more gross margins), which suggests that in reality the producers could use some of these additional margins for investing in improved seeds, fertilizers and irrigation forms, which would improve yields, but this factor is not taken into account in the formulation of our simplified model.

When subsidies are limited to rice producers (SC11), in **Pakistan**, there are slight variations on price; i.e. lower prices of rice and sorghum, and slight increases for price of wheat and sugar crops which are explained by slight variations in surfaces. In **India** and **Bangladesh**, price fluctuations for all the products are practically nil, although in India there is some variation of surfaces (+160 000 ha for rice, +240 000 for pulses, but -470,000 ha for soybean, partially compensated by an increase in rapeseed). Overall in Pakistan, the total area fell by 25 000 ha but area of rice increases slightly by 20 000 ha. For all three countries, the impact on food consumption and intake of calories and proteins is virtually zero.

For a producer subsidy of 10% limited to wheat (SC12), the impacts on prices are virtually nil in **Pakistan** and **Bangladesh**, but significant, though still very low in **India**. Reallocations of surface, especially for wheat, are virtually nil (Bangladesh) or extremely low (Pakistan), but more important in India (460 000 ha), where it is accompanied by an increase of soybean, the

complementary crop in this country, and a decline in sorghum, canola and pulses, substitutes crops. In terms of human consumption, the impacts are virtually non-existent in Pakistan and Bangladesh, but slightly favourable in India (+0.1% for calories and +0.2% for protein).

Overall, it therefore appears that the aid paid to producers, irrespective of the form (global, rice, and wheat) has a positive impact on farmers' incomes, but it is not a lever (except perhaps for livestock, but in the model these products are exogenous) for significantly improving the food security of these countries. It is clear that, even if these kinds of scenarios were not calculated, higher support prices for both crops (that results in simultaneously increasing prices to producers and consumers) might even have an adverse effect at the nutrition of people in these three countries.

**Scenarios SC20: Subvention of 10% of initial consumer price given to consumers for all food products, SC21: Subvention of 10% for rice, SC22: Subvention of 10% for Wheat**

The attribution of a direct consumer subsidy for all products (SC20) would have generally very limited effects on all prices except in **Pakistan** for milk (+15.8%), wheat (+3.0%) and beef (+1.6%), in **India** for milk (+15.0%), rice (+14.6%) and wheat (+3.6%), and finally in **Bangladesh** where would be increases of 11.5% for rice, 10.1% for milk and between 3.5 and 4.1% for other animal products. In terms of nutritional impact, the calorie intake per capita would increase by 1.7% in Pakistan, 0.7% in India and 1.3% in Bangladesh. In terms of Proteins, the improvements would be 0.9%, 0.5% and 1.0% respectively. In each country, due to some price increases and global food demand progression, there would be an increase in the value of agricultural production (+5.8%, +9.4% and +9.3% respectively), largely due to the animal sector and more particularly to the dairy production (favourable factor to farmers) but at the same time a decline in value of the balance of trade (16.5%, 2.4% and 3.0% respectively in the three countries). Food expenditures per capita would increase by 9.4% in Pakistan (+13.6% for animal products), 9.4% in India (+12.9% for animal products) and 9.3% in Bangladesh (+9.4% for animal products) respectively.

Subsidy limited to rice (SC21), would have price effects virtually nil in Pakistan, limited to a few products (+4.3 for rice, +4.4% for wheat and milk) in India and (+4.7% for rice, + 2.2% for milk) in Bangladesh. The consequences on changes in surfaces would also be low or zero (just slightly increase of surfaces for wheat and rice in India and decrease for sugar crops). At nutritional level,

intake of calories increase by 0.3% in Pakistan, 0.3% in India and 2.4% in Bangladesh while proteins intake would increase by 0.5%, 0.3% and 2.2% respectively. In the same time, the value of the agricultural production would increase by 0.1% in Pakistan 2.7% in India and 3.4% in Bangladesh, while the worth of trade balance would deteriorate by 0.6%, 2.3% and 3.5% respectively.

Regarding the subsidy limited to wheat (SC22), the price effects are virtually non-existent in Bangladesh, limited to wheat (+1.4%) and milk (+1.4%) in Pakistan and to rice (+1.9%) and milk (+2.0%) in India. Impacts on surfaces in the three countries are zero or extremely low. At nutritional level, per capita daily intake of calories and proteins would increase slightly in Pakistan (+0.7% and +1.2% respectively), India (+0.3% and +0.4%) and Bangladesh (+0.5% and +0.4%). The worth of agricultural production in Pakistan increase slightly (+1.0%) and in India (+1.2%) but is unchanged in Bangladesh. Total food expenditures in each country rise 1.2%, 1.2% and 0.5% respectively. And the trade deficit worsens significantly in Pakistan (+2.6%) and in Bangladesh (+1.2%) but low in India (+0.3%).

Overall it appears that the three proposed policies to give subsidy to consumers can have some good improvement effects on nutrition, but also, in supplement to the cost for public authorities, they all have adverse effects on external trade and, given the price increase of certain products, they increases cost of food for consumers. Finally, even if subventions are given to consumers, the benefice of this aid is shared within the country between consumers and producers, and profits also to “rest of the world” through development of imports.

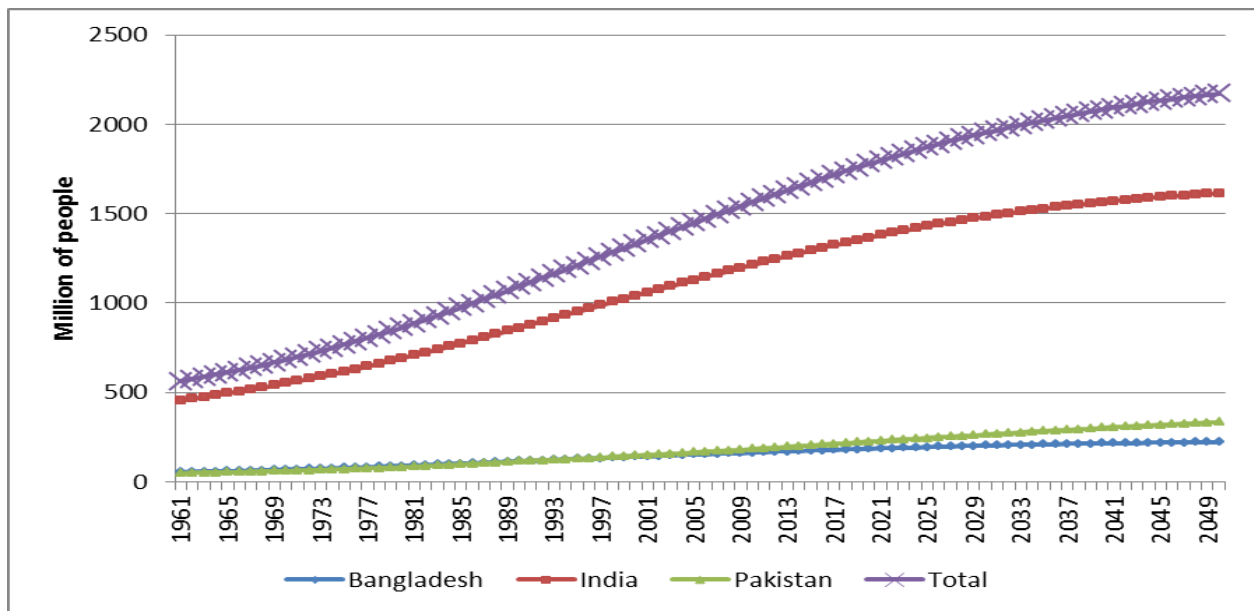
## **6.5. The different scenarios calculated for 2025**

### **6.5.1. The exogenous parameters for the construction of the baseline 2025.**

The construction of a trend scenario for 2025 requires the prior calculation of estimates on the various exogenous parameters which are to be taken into account by the model GAMS.

#### **Evolution of populations.**

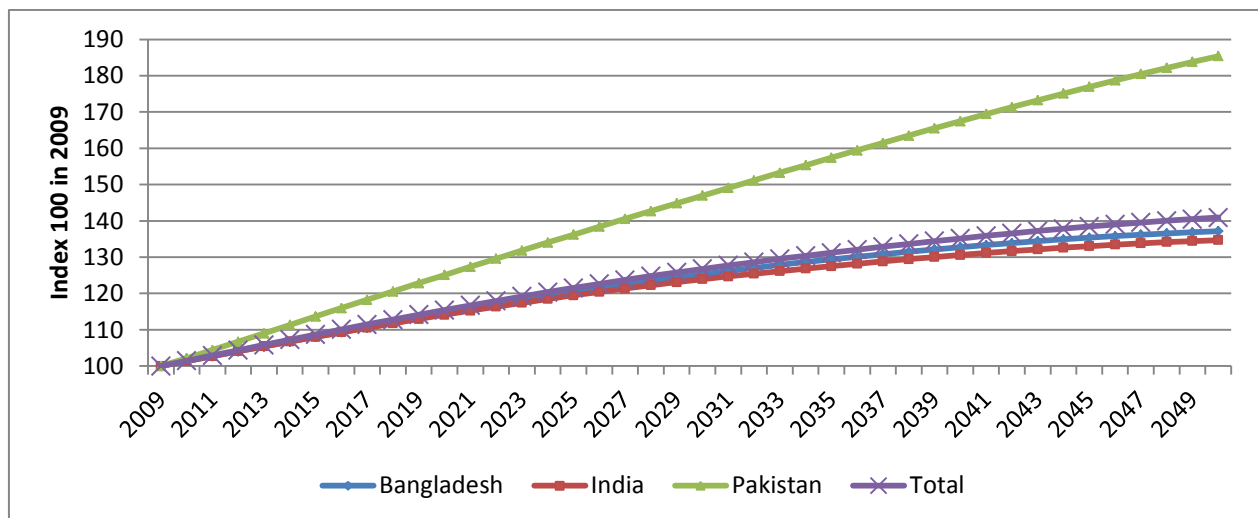
The population of these three countries has considerably increased between 1960 and 2009 and should continue to do so over the next 40 years. According to forecasts by the World Bank, this population would reach 2.17 billion in 2050 against 1.54 in 2009. This should be due to augmentation of 416 million in India, 154 million in Pakistan and "only" 60 million in Bangladesh. As shown in Figure 47. Despite a slowdown in the growth rate compared to previous decades (particularly in India), growth remains strong in all three countries.



**Figure 47: Evolution of the total population in the three countries.**

Source: Calculation from World Bank data

According to these projections, when we took the index 100 in 2009, the reference year for the partial equilibrium model (Figure 48), it would be 135 in 2050 for India, 137 for Bangladesh and the level even higher in Pakistan (185) and the total of the three countries is 141.



**Figure 48: Provisions for population evolution of the three countries (index 100 in 2009)**

Source: Calculation from World Bank data

Between 2009 and 2025, the year of scenarios calculation, the total population is expected to increase by 332 million (233 in India, 66 in Pakistan and 33 in Bangladesh). In percentage for these three countries, progressions are 20%, 36% and 20% respectively.

### **Evolution of GDP and food expenditure per capita**

According to the latest forecasts from the USDA / ERS (International Macroeconomic Data Set, baseline for 2030<sup>63</sup>, <http://www.ers.usda.gov/data-products/international-macroeconomic-data-set.aspx>), the GDP per capita for these countries in 2005 constant dollars should increase from 737\$ in 2009 to 1113 in 2025 (+51%) for Pakistan, from 978\$ to 2613\$ for India (+167%) and from 495\$ to 965\$ for Bangladesh (+95%).

<sup>63</sup> The International Macroeconomic Data Set provides data from 1969 through 2020 for real (adjusted for inflation) gross domestic product (GDP), population, real exchange rates, and other variables for the 190 countries and 34 regions that are most important for U.S. agricultural trade. The data presented are a key component of the USDA Baseline projections process, and can be used as a benchmark for analyzing the impacts of U.S. and global macroeconomic shocks. The data for the Baseline projections are updated once a year to reflect the assumptions used for the Baseline. The historical data will be revised several times a year as the underlying data evolve.

To estimate the impact of these changes of real per capita GDP<sup>64</sup> growth on food consumption expenditure, it is necessary to know the relationship between these two variables. It is therefore estimated for each country the following equation:

$$\text{Log ConsAlim} = a + b * \log(\text{GDP tete})$$

Where, the total food consumption (for animal and plant products included in the model) is expressed in current local currency.

For Pakistan, a coefficient  $b = 0.88$  (adjusted  $R^2 = 0.97$ ) is calculated. This indicates that when the GDP per capita increases by 1% then total food expenditure increases by 0.88%. For India, the coefficient  $b$  is 0.65 (adjusted  $R^2 = 0.97$ ) and for Bangladesh, it is 0.80 (adjusted  $R^2 = 0.96$ ). These estimations were made on the relatively short period 1991 - 2007 for which we had estimations of total vegetal and animal food expenditures (cf. Chapter 4). Those coefficients indicates that while in India there is a diversification of expenditure towards other sectors than food, in other two countries it is still increasing demand for food which absorbs most of the income growth.

Using these coefficients, it is possible to estimate that food expenditure for products taken in account in this thesis should increase between 2009 and 2025 by 45% for Pakistan ( $51\% * 88\%$ ), by 108% for India and by 76% for Bangladesh.

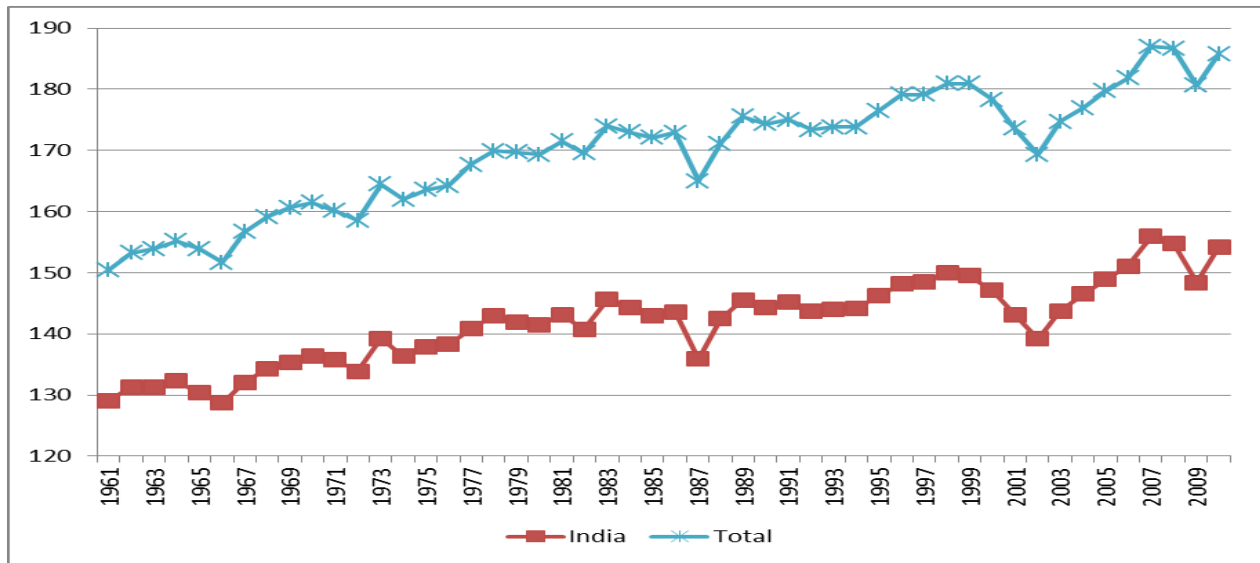
### **Evolution of total area cultivated for main crops**

Between 1961 and 2010, the total area under cultivation for various crops taken into account has increase from 150 to 185 Mha (26%) or a total increase of 35 Mha mainly attributed to India (25 Mha) while in Pakistan, it is less (+6.7 Mha) than India but more than Bangladesh (+3.6 Mha). In percentage, it is Pakistan which has been characterized by the highest growth (+55%), followed by Bangladesh (38%) and only 19% in India.

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<sup>64</sup> Real Gross Domestic Product (GDP) is an inflation-adjusted measure that reflects the value of all goods and services produced in a given year, expressed in base-year prices. Often referred to as "constant-price", "inflation-corrected" GDP or "constant dollar GDP".

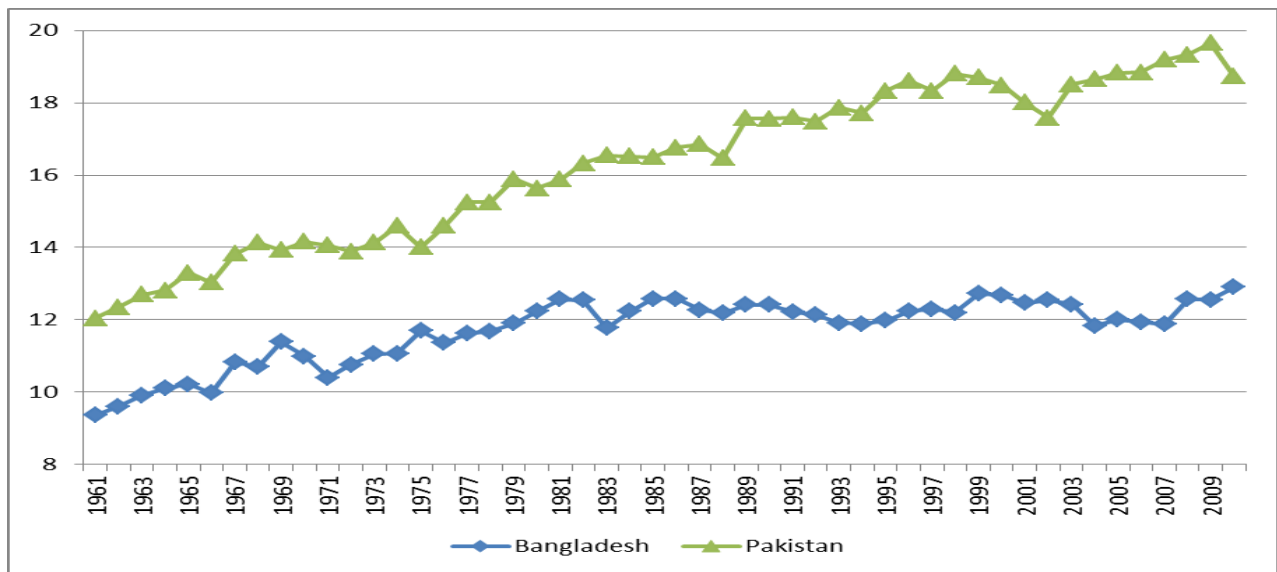




**Figure 49: Evolution of total area for India and total of the three countries**

Source: Own calculation; Unit: Million hectares

Besides the weight of India, the other important point is the slowdown increase of total area, decade by decade, from the early 60s for Pakistan and Bangladesh. For India on the contrary, there was a strong increase over the last decade, but nothing to suggest that this situation will continue unabated.



**Figure 50: Evolution of total area for Pakistan and Bangladesh**

Source: Own calculation from FAOSTAT; Unit: Million hectares

**Table 69: Evolution of total crops area per period**

Years	Bangladesh	India	Pakistan	Total
1961_70	1.63	7.22	2.11	10.96
1970_80	1.25	5.19	1.48	7.92
1980_90	0.18	2.88	1.92	4.98
1990_00	0.27	2.75	0.93	3.95
2000_10	0.23	7.06	0.23	7.52
Total	3.55	25.10	6.67	35.32

Source: Own calculation from FAO data; Unit: Million hectares

To make assumptions in the baseline scenario on the evolution of the total cultivated area in each country in 2025, we calculated regression of this variable as a function of Trend (variable increases by 1 for each year and is equal to 1 in 1961) with the functional form:

$$\text{Log AreaTot} = a + b * \log(\text{Trend})$$

The graphs of evolutions and the estimated extrapolations calculated on period 1980 - 2010, for each country and for the total<sup>65</sup>, are given in annex B

**Table 70: Extrapolation to 2025 of total cultivated area for each country for main crops**

Years	Bangladesh	India	Pakistan	Total
1961-70	1.63	7.22	2.11	10.96
1970-80	1.25	5.19	1.48	7.92
1980-90	0.18	2.88	1.92	4.98
1990-00	0.27	2.75	0.93	3.95
2000-10	0.23	7.06	0.23	7.52
Total	3.55	25.10	6.67	35.32

Source: Own calculations; Units: Million hectares, percentage

It is important to compare these hypotheses for evolution of the total areas by country between 2009 and 2025 for the 11 crops taken in account here (rice, wheat, millet, sorghum, maize, barley, sugar cane, pulses, cotton, rapeseed, and soybean) with other outlooks previously published.

<sup>65</sup> The line corresponding to “total” may differ slightly from the sum of the three countries as it is a direct estimate.

The annual Outlook elaborated by FAPRI is a source internationally recognized and it gives information on many agricultural products and countries. The last publication was diffused in 2012 (<http://www.fapri.iastate.edu/outlook/2012/> ,FAPRI-ISU 2012 World Agricultural Outlook) and give outlooks up to 2021, but no detail is given for very important products concerning South Asian countries (for instance rice and cotton). A special work has been published in 2011 (<http://www.fapri.iastate.edu/outlook/2011/>, FAPRI-ISU 2011 World Agricultural Outlook) with outlooks for 2025, but without details for some products. For these products previsions are available in 2010 (<http://www.fapri.iastate.edu/outlook/2010/>, FAPRI 2010 U.S. and World Agricultural Outlook) but outlooks concern only year 2019. To get estimations for 2025, linear extrapolations of published data on period 2010-2019 were calculated for 2025 and associated with results on other products published by FAPRI in 2012.

For **Pakistan**, FAPRI considers 7 crops (Barley, Corn, Sorghum, Sugar Beet, Sugarcane, Wheat, Rice, and Cotton) and anticipate that total area could increase from 17.3 Mha in 2009 to 17.5 in 2025 (+0.223 Mha or +1.3%). Considering the crops not taken in account in FAPRI outlook, we retain for trend scenario an intermediate figure of +0.4 Mha (+2%) of total area evolution between 2009 and 2025.

For **India**, FAPRI considers 9 crops (Corn, Peanut, Rapeseed, Sorghum, Soybeans, Sugarcane, Wheat, Rice, Cotton) and anticipate that total area could increase from 117.5 Mha in 2009 to 135.3 in 2025 (+17.9 Mha or +15.2%). The main crops explaining the difference of 30.9 Mha in 2009 with our figure (cf.

Table 70) are total pulses (20.7 Mha in 2009) and millet (10.0 Mha) not taken in account by FAPRI. The hypothesis of FAPRI seems very optimistic and the calculated value of

Table 70 too small compared to evolution of the 10 last years, so we retain for the trend scenario an evolution of 10 Mha (+6.5%) for total Indian area.

For **Bangladesh**, the only crop taken in account by FAPRI is rice with a hypothesis of evolution of 0.56 Mha (+4.8%) from 11.6 Mha in 2009 to 12.2 in 2025. With other products taken in account in our figure having tendency to regress, we retain a trend hypothesis of evolution of total area of 1% or +0.12 Mha.

### **Evolution of yields**

The results of calculations on period 1980-2010 are presented in Table 71 and the curves are shown in Annex B

**Table 71: Extrapolation to 2025 of yields for each crop of each country**

	Pakistan				India				Bangladesh			
	2025	2009	var	evol	2025	2009	var	evol	2025	2009	var	evol
Wheat	3	2.66	0.34	12.80%	3.56	2.91	0.65	22.50%	2.07	2.15	-0.08	-3.60%
Rice Paddy	3.37	3.58	-0.21	-5.80%	3.91	3.19	0.72	22.50%	5.05	4.2	0.85	20.20%
Barley	1.1	0.95	0.16	16.60%	2.72	2.17	0.55	25.50%	0.83	0.86	-0.03	-3.80%
Maize	3.13	3.49	-0.35	-10.10%	2.58	2	0.58	29.10%	8.47	5.68	2.78	49.00%
Millet	0.53	0.62	-0.09	-13.80%	1.19	0.84	0.35	41.40%	0.62	0.38	0.24	62.00%
Sorghum	0.63	0.62	0.01	0.90%	0.95	0.96	-0.01	-1.40%	1.74	1.33	0.41	30.60%
Total cereals	2.96	2.79	0.17	6.20%	3.28	2.57	0.71	27.50%	4.91	4.14	0.76	18.50%
Soybean	1.34	0.61	0.73	120.80%	1.34	1.02	0.31	30.50%	2.18	1.47	0.71	48.70%
Groundnut	0.77	0.61	0.16	25.70%	1.24	1.01	0.23	22.80%	1.43	1.45	-0.02	-1.40%
Rapessed	1.11	0.81	0.3	36.40%	1.43	1.14	0.28	24.70%	0.92	0.87	0.05	6.00%
Sugarcane	55.98	48.62	7.36	15.10%	75.59	64.49	11.11	17.20%	38.37	41.44	-3.07	-7.40%
Pulses	0.63	0.66	-0.04	-5.30%	0.72	0.68	0.05	6.80%	0.92	0.87	0.05	6.00%
Seed cotton	2.81	2.04	0.77	37.90%	1.45	1.23	0.22	17.60%	3.7	2.77	0.93	33.60%
Cotton seed	1.74	1.33	0.41	30.80%	0.94	0.8	0.14	17.60%	2.46	1.85	0.61	33.00%
Cotton lint	0.89	0.68	0.21	30.70%	0.46	0.39	0.07	17.60%	1.23	0.92	0.31	33.20%

Source: Own calculation from FAO data, Units: ton/ha, percentage

As it can be seen on the different figures of annex B representing historical evolutions of yields and extrapolation curve, in some cases the values calculated for 2025 can be problematic because of impact of some apparently aberrant points. So it is interesting to compare these extrapolations with outlooks published by other authors. We used the FAPRI publications of 2011 and 2012 like for total area by country for main crops.

**Table 72: Comparison of yields extrapolations for 2025 with FAPRI outlook and historical data for Pakistan.**

	2009	2009	2025	2025	evolution	evolution	evolution/year	evolution/year	evolution/year "1968" "2006"
	FAO	FAPRI	own extrapolation	FAPRI	own extrapolation	FAPRI	own extrapolation	FAPRI	FAO
Wheat	2.66	2.66	3.00	3.15	12.83%	18.42%	0.76%	1.06%	2.53%
Rice Paddy	3.58	3.31	3.37	3.96	-5.87%	19.46%	-0.38%	1.12%	1.43%
Barley	0.95	1.66	1.10	2.82	16.59%	69.88%	0.96%	3.37%	1.30%
Maize	3.49	2.86	3.13	3.59	-10.12%	25.52%	-0.66%	1.43%	2.79%
Millet	0.62		0.53		-13.84%		-0.93%		0.46%
Sorghum	0.62	0.60	0.63	0.76	0.93%	26.67%	0.06%	1.49%	0.31%
Tot cer	2.79		2.96		6.15%		0.37%		2.39%
Soybean	0.61		1.34		120.80%		5.08%		1.91%
Groundnut	0.61		0.77		25.70%		1.44%		-1.53%
Rapessed	0.81		1.11		36.35%		1.96%		1.77%
Sugarcane	48.62	50.85	55.98	59.05	15.14%	16.13%	0.88%	0.94%	0.74%
Pulses	0.66		0.63		-5.30%		-0.34%		0.62%
Seed cotton	2.04		2.81		37.86%		2.03%		2.20%
Cotton seed	1.33		1.74		30.77%		1.69%		
Cotton lint	0.68	0.71	0.89	0.84	30.65%	18.31%	1.69%	1.06%	

Source: Own calculation and FAPRI, Units: ton/ha, percentage.

For 2009, we can observe some differences in yields (mainly for barley, sugar cane and rice<sup>66</sup>). The estimations for 2025 are given in columns 3 and 4, and the percentage of evolution between 2025 and 2009 is indicated in columns 5 and 6. In columns 7, 8 and 9 the rate of mean exponential annual evolution are indicated between 2009 and 2025 according to our extrapolations (column 7) and to FAPRI outlook (column 8) for the crops available. In column 9 the rate of mean annual exponential evolution is indicated between the mean of years 1966 to 1970 and the mean of years 2004 to 2008. The utilization of average values on five years can moderate the influence of annually variations of yields due to climatic short term factors, but does not take in account, with a more important weight, the most recent evolutions. Generally it can be considered that the values calculated on period “1968”-“2006” overestimate the probable evolution for the next 16 years after 2009. From Table 72, we chose the most pertinent exogenous values for 2025 (in coherence with historical FAO data used), and we calculated the evolutions in percentage from 2009 to 2025 which are the parameters to be included in the partial equilibrium model. These values for the three counties are indicated on table 73.

**Table 73: Comparison of yield extrapolations for 2025 with FAPRI and historical data for India.**

	2009	2009	2025	2025	evolution	evolution	evolution/yea	evolution/yea	evolution/yea
	FAO	FAPRI	own extrapolation	FAPRI	own extrapolation	FAPRI	own extrapolation	FAPRI	r "1968" "2006" FAO
Wheat	2.91	2.89	3.56	3.16	22.48%	9.34%	1.28%	0.56%	2.53%
Rice Paddy	3.19	3.27	3.91	3.73	22.53%	14.22%	1.28%	0.83%	1.90%
Barley	2.17		2.72		25.55%		1.43%	0.00%	2.02%
Maize	2.00	2.09	2.58	2.53	29.07%	21.05%	1.61%	1.20%	1.80%
Millet	0.84		1.19		41.42%		2.19%		1.90%
Sorghum	0.96	1.00	0.95	1.08	-1.36%	8.00%	-0.09%	0.48%	1.34%
<b>Tot cer</b>	<b>2.57</b>		<b>3.28</b>		<b>27.50%</b>		<b>1.53%</b>		<b>2.38%</b>
Soybean	1.02	0.94	1.34	1.10	30.49%	17.02%	1.68%	0.99%	2.35%
Groundnut	1.01	0.92	1.24	1.19	22.82%	29.35%	1.29%	1.62%	1.24%
Rapessed	1.14	0.99	1.43	1.17	24.72%	18.18%	1.39%	1.05%	2.28%
Sugarcane	64.49	66.46	75.59	78.08	17.23%	17.48%	1.00%	1.01%	0.96%
Pulses	0.68		0.72		6.78%		0.41%		0.60%
Seed cotton	1.23		1.45		17.64%		1.02%		2.89%
Cotton seed	0.80		0.94		17.63%		1.02%		
Cotton lint	0.39	0.50	0.46	0.78	17.63%	56.14%	1.02%	2.82%	

Source: Own calculation and FAPRI; Units: ton/ha, percentage

<sup>66</sup> The yields given by FAPRI for rice are expressed in milled equivalent, so these values have been converted in equivalent paddy by dividing them by 0.667 which is the standard conversion coefficient used by FAO for the three countries.

For India (Table 73), FAPRI gives outlooks for a greater number of crops. The data for yields in 2009 are generally close to those of FAO and, like for Pakistan, a synthesis of our extrapolations and FAPRI outlooks has been made for 2025 (cf. Table 74)

**Table 74: Comparison of yield extrapolations for 2025 with FAPRI and historical data for Bangladesh.**

	2009	2009	2025	2025	evolution	evolution	evolution/year	evolution/year	evolution/year
	FAO	FAPRI	own extrapolation	FAPRI	own extrapolation	FAPRI	own extrapolation	FAPRI	FAO
Wheat	2.15		2.07		-3.59%		-0.23%		2.32%
Rice Paddy	4.20	3.88	5.05	4.54	20.17%	17.01%	1.15%	0.99%	2.21%
Barley	0.86		0.83		-3.85%		-0.24%		0.68%
Maize	5.68		8.47		48.96%		2.52%		4.82%
Millet	0.38		0.62		61.97%		3.06%		-0.72%
Sorghum	1.33		1.74		30.59%		1.68%		2.04%
Tot cer	4.14		4.91		18.47%		1.06%		2.18%
Soybean	1.47		2.18		48.74%		2.51%		0.00%
Groundnut	1.45		1.43		-1.45%		-0.09%		-0.38%
Rapessed	0.87		0.92		5.96%		0.36%		1.15%
Sugarcane	41.44		38.37		-7.41%		-0.48%		-0.53%
Pulses	0.87		0.92		5.98%		0.36%		0.33%
Seed cotton	2.77		3.70		33.61%		1.83%		4.14%
Cotton seed	1.85		2.46		32.99%		1.80%		
Cotton lint	0.92		1.23		33.20%		1.81%		

Source: Own calculation, FAPRI; Units: ton/ha, percentage.

For Bangladesh, the only data available from FAPRI for 2025 concerns rice. For all crops the outlooks for 2025 used in the model are indicated in Table 75.

**Table 75: Values of exogenous yields projections used in the model for the three countries.**

	Pakistan			India			Bangladesh		
	2009	2025	evolution	2009	2025	evolution	2009	2025	evolution
Wheat	2.66	3.15	18.6%	2.91	3.25	11.8%	2.15	2.30	6.9%
Rice Paddy	3.58	3.96	10.6%	3.19	3.80	19.1%	4.20	5.00	18.9%
Barley	0.95	1.20	26.6%	2.17	2.50	15.4%	0.86	0.90	4.7%
Maize	3.49	3.59	2.9%	2.00	2.58	29.1%	5.68	6.50	14.4%
Millet	0.62	0.70	13.7%	0.84	1.00	18.5%	0.38	0.45	18.0%
Sorghum	0.62	0.70	12.8%	0.96	1.05	9.1%	1.33	1.60	20.3%
Soybean	0.61	1.00	64.5%	1.02	1.25	22.0%	1.47	1.60	9.1%
Grounut	0.61	0.77	25.7%	1.01	1.20	19.1%	1.45	1.60	10.4%
Rapessed	0.81	1.11	36.4%	1.14	1.35	18.1%	0.87	0.92	6.0%
Sugarcane	48.62	56.00	15.2%	64.49	75.59	17.2%	41.44	38.37	-7.4%
Pulses	0.66	0.70	5.8%	0.68	0.72	6.8%	0.87	0.92	6.0%
Seed cotton	2.04	2.70	32.3%	1.23	1.80	45.9%	2.77	3.40	22.8%
Cotton seed	1.33	1.60	20.1%	0.80	1.20	49.7%	1.85	2.30	24.6%
Cotton lint	0.68	0.83	22.0%	0.39	0.60	52.0%	0.92	1.15	24.6%

Source: Own estimations ; Units: ton/ha, percentage.

The same work of comparison between our extrapolations for 2025 and FAPRI outlooks is to be done for animal products productions which are also exogenous parameters of the model.

Contrary to yields where evolutions are generally expressed in percent of change per year (r%) with the formula:  $r\% = (x_{t1}/x_{t0})^{1/(t1-t0)} - 1$ , for productions it is more pertinent to use mean annual variations v corresponding to the formula:  $v = (x_{t1}-x_{t0}) / (t1-t0)$  where  $x_{t1}$  and  $x_{t0}$  are final (year t1) and initial (year t0) values of variable x.

**Table 76: Extrapolation to 2025 of productions for each animal product and each country**

	Pakistan				India				Bangladesh			
	2025	2009	variation	evolution	2025	2009	variation	evolution	2025	2009	variation	evolution
Cow milk, whole, fresh	20662	11985	8677	72.4%	69214	52200	17014	32.6%	828	827	1	0.2%
Buffalo milk, whole, fresh	34109	21622	12487	57.8%	83821	59758	24063	40.3%	35	35	0	-0.7%
Sheep milk, whole, fresh	32	36	-4	-10.2%					37	35	3	8.0%
Goat milk, whole, fresh	865	719	146	20.3%	7972	4467	3505	78.5%	3930	2328	1602	68.8%
Milk, Total + (Total)	54845	34362	20483	59.6%	160710	116430	44280	38.0%	4007	3225	782	24.3%
Buffalo meat	1017	730	287	39.4%	1687	1463	225	15.4%	8	6	2	38.1%
Cattle meat	890	706	184	26.1%	1066	1056	10	1.0%	219	188	31	16.7%
Beef and Buffalo Meat + (Total)	1909	1436	473	32.9%	2728	2518	210	8.3%	227	194	33	17.0%
Sheep meat	180	154	26	16.7%	303	286	17	6.0%	6	4	2	66.7%
Goat meat	413	270	143	52.9%	651	568	84	14.7%	378	183	195	106.2%
Sheep and Goat Meat + (Total)	587	424	163	38.4%	953	853	100	11.7%	384	187	197	105.2%
Chicken meat	1360	650	710	109.1%	509	350	159	45.4%				
Poultry Meat + (Total)	1362	655	707	108.0%	4647	2125	2522	118.7%	224	157	67	42.8%
Meat nes	24	22	2	8.2%	4856	2087	2769	132.7%	282	198	84	42.6%
Meat, Total + (Total)	3509	2537	972	38.3%	191	169	22	12.8%	814	594	220	37.1%
Eggs Primary + (Total)	800	536	263	49.1%	5117	3323	1794	54.0%	433	220	213	97.1%

**Source: Own calculation from FAO data; Units: Thousand tons, percentage**

For the same reason that for yields, it is important to compare our extrapolations and annual evolutions first with FAPRI outlook and second to historical evolution from “1968” to “2006” so as to choose most pertinent hypotheses for the trend scenario of the model.

**Table 77: Comparison of animal production extrapolations for 2025 with historical evolution for Pakistan.**

	<b>2009</b>	<b>extrapolation 2025</b>	<b>annuelle variation</b>	<b>Variations 1968-2006</b>
<b>Cow milk, whole, fresh</b>	11985	20662	542	217
<b>Buffalo milk, whole, fresh</b>	21622	34109	780	397
<b>Sheep milk, whole, fresh</b>	36	32	0	0
<b>Goat milk, whole, fresh</b>	719	865	9	14
<b>Milk, Total + (Total)</b>	34362	54845	1280	629
<b>Buffalo meat</b>	730	1017	18	13
<b>Cattle meat</b>	706	890	12	11
<b>Beef and Buffalo Meat + (Total)</b>	1436	1909	30	24
<b>Sheep meat</b>	154	180	2	2
<b>Goat meat</b>	270	413	9	6
<b>Sheep and Goat Meat + (Total)</b>	424	587	10	8
<b>Chicken meat</b>	650	1360	44	12
<b>Poultry Meat + (Total)</b>	655	1362	44	13
<b>Meat nes</b>	22	24	0	0
<b>Meat, Total + (Total)</b>	2537	3509	61	45
<b>Eggs Primary + (Total)</b>	536	800	16	12

**Source: Own calculation from FAO data; Units: Thousand tons**

For Pakistan, FAPRI gives no outlook for all products. Final used data are given for the three countries in table 80.



**Table 78: Comparison of animal productions extrapolations for 2025 with FAPRI and historical data for India.**

	2009	2009	2025	2025	variation/year	variation/year	Variation
	FAO	FAPRI	extrapolation	FAPRI	extrapol 2025	FAPRI	1968-2006
Cow milk, whole, fresh	52200	45524	69214	77017	1063	1968	910
Buffalo milk, whole, fresh	59758	62876	83821	102202	1504	2458	1123
Sheep milk, whole, fresh							
Goat milk, whole, fresh	4467		7972		219		90
Milk, Total + (Total)	116430	108400	160710	179219	2768	4426	2123
Buffalo meat	1463		1687		14		20
Cattle meat	1056		1066		1		11
Beef and Buffalo Meat + (Total)	2518	2750	2728	3555	13	50	30
Sheep meat	286		303		1		3
Goat meat	568		651		5		7
Sheep and Goat Meat + (Total)	853		953		6		10
Pig meat	350		509		10		6
Chicken meat	2125	2550	4647	3241	158	43	39
Poultry Meat + (Total)	2087		4856		173		40
Meat nes	169		191		1		2
Meat, Total + (Total)	6016		7037		64		89
Eggs Primary + (Total)	3323		5117		112		66

Source: Own calculation from FAO data and FAPRI; Units: Thousand tons

**Table 79: Comparison of animal productions extrapolations for 2025 with historical data for Bangladesh.**

	2009	extrapolation 2025	variation extrapolation/ye ar annuelle	Variation 1968-2006
Cow milk. whole. fresh	827	828	0.1	4.2
Buffalo milk. whole. fresh	35	35	0	0.3
Sheep milk. whole. fresh	35	37	0.2	0.4
Goat milk. whole. fresh	2328	3930	100.2	41
Milk.Total + (Total)	3225	4007	48.9	46
Buffalo meat	6	8	0.1	0.1
Cattle meat	188	219	2	1.3
Beef and Buffalo Meat + (Total)	194	227	2.1	1.3
Sheep meat	4	6	0.2	0.1
Goat meat	183	378	12.2	3.5
Sheep and Goat Meat + (Total)	187	384	12.3	3.5
Chicken meat	157	224	4.2	2.6
Poultry Meat + (Total)	198	282	5.3	3.3
Meat nes	15	15	0	0.2
Meat. Total + (Total)	594	814	13.8	8.4
Eggs Primary + (Total)	220	433	13.3	5.3

Source: Own calculation from FAO data; Units: Thousand tons

**Table 80: Values of exogenous animal products projections used in the model for the three countries.**

	Pakistan			India			Bangladesh		
	2009	2025	variation/year	2009	2025	variation/year	2009	2025	variation/year
Cow milk, whole, fresh	11985	20662	542	52200	75000	1425	827	900	5
Buffalo milk, whole, fresh	21622	34109	780	59758	97000	2328	35	40	0
Sheep milk, whole, fresh	36	32	0				35	40	0
Goat milk, whole, fresh	719	865	9	4467	8000	221	2328	3930	100
Milk, Total + (Total)	34362	54845	1280	116430	180000	3973	3225	4910	105
Buffalo meat	730	1017	18	1463	1700	15	6	8	0
Cattle meat	706	890	12	1056	1500	28	188	219	2
Beef and Buffalo Meat + (Total)	1436	1909	30	2518	3200	43	194	227	2
Sheep meat	154	180	2	286	303	1	4	6	0
Goat meat	270	413	9	568	650	5	183	378	12
Sheep and Goat Meat + (Total)	424	587	10	853	953	6	187	384	12
Pig meat				350	450	6			
Chicken meat	650	1360	44	2125	4000	117	157	270	7
Poultry Meat + (Total)	655	1362	44	2087	4100	126	198	300	6
Meat nes	22	24	0	169	191	1	15	15	0
Meat, Total + (Total)	2537	3882	84	6016	8894	180	594	926	21
Eggs Primary + (Total)	536	800	16	3323	5000	105	220	433	13

Source: Own estimations ; Units: ton/ha, percentage.

### 6.5.2. Analysis of the main result for the different scenarios

As stated previously, the standard methodology for the construction of agricultural PEM which uses matrix of elasticities of supply and demand is only valid for small changes in different exogenous parameters (population, per capita income, etc.) and variables (especially price). The previous paragraph shows that for the period 2009-2025, these conditions are not fulfilled here and therefore the results obtained by the model are only qualitative indications of possible future situations and are not forecasts similar to those provided by econometric models.

It appears, however, interesting to calculate three different scenarios for 2025 to illustrate a trend situation (SC50) and two possible scenarios of “policy dialogue” between the three countries. The scenario SC51 corresponds to a policy of limiting the cumulated imports for the three countries from the rest of the world and scenario SC52 corresponds to a policy of coordination of price changes in the three countries. In all cases, compared to situation in 2009, it appears necessary, to obtain “possible solutions” from model, to greatly expand the possibilities of import

of each country. It is clear that these last two scenarios have foremost an objective of illustration of some possible more sophisticated uses of the model using simultaneously and with interdependence the three models constructed for the three countries. It can be demonstrated that in all other scenarios (SC1 to SC22, and SC50), even if the objective function optimized by the solver refers include a summation on the three countries, the results are identical to those which would be obtained by three independent optimizations. For scenarios SC51 and SC52 this is no more the case and, so, the evolutions of the different variables in a country (by example prices or food demand) are linked to the evolutions of all variables in the three countries.

The three scenarios 2025 are defined as follows (Table 81)

**Table 81: Specifications on trade deficit limitations in the three 2025 scenarios**

	SC50	SC51	SC52
Specification of scenario	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
Constraints on all products			
Pakistan (kt)	-2500;+2500	-2500;+2500	-INF;+INF
India (kt)	-7500;+7500	-7500;+7500	-INF;+INF
Bangladesh (kt)	-2500;+2500	-2500;+2500	-INF;+INF
Sum of the three countries		-5000;+5000	-INF;+INF

For **Pakistan**, the scenario SC50 that takes in account trend evolutions for exogenous parameters, but with some more trade flexibility “or potential liberalization) would result in relatively modest changes in the prices of major vegetal products except for wheat (+8.0%), rice (+2.9%) and pulses (+2.8%). Regarding animal products, the milk price would experience an increase of 50%, while those of various meats and eggs would be from 1 to 5%. The most important element is naturally increasing food demand due to demographic trends (+61 million people) and due to increase for income resulting in huge increased food expenditure per capita.

Overall food demand would increase by 8.8 Mt for cereals, 0.4 Mt for pulses, 1.2 for oils and 2.6 for sugar. Domestic consumption of animal products would increase sharply for various meats (+1.9 Mt for total), for eggs and especially for milk (+23.0 Mt). To meet this additional demand, due to reallocation of surfaces and changes in yields, grains production would increase only by 5.2 Mt and sugar by 0.8 Mt, creating important deficits. Regarding animal products, increases of egg production, all meat and even more milk would also be insufficient to meet human demand.

Concerning the feed ingredients, a total of 5.6 Mt of concentrates would be further needed, breaking down into bran by 1.8 Mt, oilseeds meal by 1.4, cereals grains by 1.2 (especially wheat and maize), oilseeds by 0.8 Mt (cottonseed ) and finally pulses by 0.4. Given these supply / demand imbalances, the external trade balance worsens in tonnage by 7.9 Mt for crops products<sup>67</sup>, more than 3 million tons for animal products and nearly 5 Mt for processed vegetal products (particularly sugar and oils).

These deficits are related to the low elasticity of the surfaces of main crops which globally rise slightly (+0.5 Mha in total) with a significant increase in level only for wheat (+0.2 Mha). The sharp rise in yields would not allow providing domestic supply sufficient to balance the demand.

Concerning nutritional level, per capita consumption would increase by 65.9 kg per capita including 53.6 for milk and therefore only 12.3 kg for all other foods (beef, chicken, vegetable oils and sugar). The total cereal consumption vary somewhat (+1.9 kg / capita / year with further growth of wheat). In terms of calories intake, there would be an increase of 9.5% (with +30.0% for animal products) and for protein intake, an increase by 13.1% (with +29.7% for animal protein). Food situation would improve substantially, but two negative elements should be taken into account: Firstly, the sharp deterioration of the trade balance (+157%) and secondly, the increase in food expenditure per capita in constant LCU, by 49.0%. Conversely, favorable element for the agricultural population, the total value of agricultural production would increase by 62%.

In **India**, despite trade liberalization, prices vary much more importantly, especially for rice (+133.8%), wheat (+104.5%) and milk (+96.4%). With a considerable increase in the population (+242 million people), food demands at the country level would increase especially by 83.6 Mt for cereals (+28.7 for rice and +43.7 for wheat), by 56.1 Mt for milk, by 12.8 Mt for sugar. Consumption of vegetal oils, pulses and all the meat and eggs would also increase sharply. Concerning the feed, the total demand of concentrates would increase by 23.8 Mt mainly in the form of oilseeds cakes (+15.0 Mt), bran (+7.5 Mt) and oilseeds (+4.9 Mt, mainly cotton). On the other side, uses of cereals and pulses, due to their very strong price increases, would decrease (-3.3 and -1.4 Mt respectively).

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<sup>67</sup> The current structure of the model allows import and export of sugar crops which in reality is very difficult to distance boundaries given the weight of these products, their high water content and low unit price. In reality, this trade would rather form of sugar and molasses.

Faced with this strong increase of human and animal demand, vegetal production would increase only slightly more (for example cereals +71.6 Mt, +9.7 Mt for oilseeds and +17.4 Mt for all processed agricultural products (oils, sugar, cakes)). Regarding animal products, it should be noted that, if for the eggs the deficit could widen significantly, it would almost balance for all meats and a significant surplus for milk that could, in the form of powder, contribute to supply Pakistan.

In this scenario, per capita consumption increase sharply between 2009 and 2025 mainly due to strong growth in income per capita and to high income elasticities in this country. In total, increase would be 72.2 kg / capita / year, of which 33.8 for grains (especially with an increase in wheat and, to a lesser extent, for rice), and 26.6 kg / capita / year for milk, leaving a balance of 11.8 kg / capita / year for all other foods (especially sugar, vegetal oil and eggs). At nutritional level, intake per capita increases significantly for both calories (+23.0%) and protein (+21.8%), animal products experiencing the highest increases (especially due to milk), +38.4% and +39.4% respectively.

As in Pakistan, this nutritional improvement would be accompanied by two strongly negative factors, on the one hand the considerable deterioration of trade balance (+123.9%) and the soaring cost of food per capita (+112.9%). The value of total agricultural production, vegetal and animal, would increase by 155.3%.

**Bangladesh**, would be, at level of price changes, in an intermediate situation between Pakistan and India, with significant increases for major cereals (especially +76.7% for rice, +63.3% for maize, +48.6% for sorghum), a slight increase for the pulses and for animal products, a sharp rise for milk (+36.3%) and moderate rises for all meat and eggs (from +13 to +20%).

The increase of the population (+29 million people) and per capita income, should lead first to a sharp increase in human demand (+16.2 Mt, of which only +10.5 for the rice). In addition to this overall increase in the consumption of cereals (+12.3 Mt), there also would be an increase in demand for milk (+1.6 Mt), sugar and vegetable oils. About the feeds, unlike in the other two countries, as milk production is not considered as a concentrates consumer (it is essentially obtained from traditional sheep flocks), there could be, given substitutions between ingredients, despite the progression of production of poultry meat and eggs, an overall decrease of 0.4 Mt of

total concentrates demand, which is characterized by a decline of 1.6 Mt of rice (due to its high price rise) to benefit of brans, oil cakes and molasses.

As in the other two countries, it would be a deterioration of the balance of trade in tonnage (-6.8 Mt) mainly due to rice (-2.5 Mt) and wheat (-1.7 Mt). Vegetal oils, sugar and brans would register as a sharp deterioration while the position "milk" would be roughly balanced. It could even have some excess eggs. Worth of external trade balance would deteriorate less than in Pakistan and India, but still by 63.8%.

In terms of per capita consumption, there would be a significant increase of all vegetal and animal foods (+50.6 kg / capita / year) including +30.4 kg / capita / year for rice alone, between 2009 and 2025. Wheat and sugar also make part of this increase, but in quantity, more modest. Regarding nutritional level, there is a strong improvement in per capita intake: +20.6% for calories and +17.2% for proteins. The food expenditures per capita would increase by 85.1%, while the value of agricultural production would grow by 105.1% and the external trade balance worsens by 63.8%.

The other two scenarios SC51 and SC52 should be considered as variants of the previous exploratory scenario. So it is in terms of changes in absolute and relative values compared to it and not to 2009 situation that results should be analysed.

In scenario SC51, the constraint limiting the cumulated deficit of the three countries has an impact on a large number of products (especially wheat, millet, sorghum, cottonseed, "other meal", brans). In tonnage, this cumulated deficit for the three countries (compared to SC50) decreases by 24.9 Mt (especially for wheat, rice, oilseeds, oil, meal, sugar and brans). It is mostly in India that we would observe changes of the balance of trade (+22.4 Mt), the changes being more limited in Pakistan (+2.3 Mt) and especially in Bangladesh (+0.2 Mt). Overall the prices are much affected in the three countries. In Pakistan, prices are significantly lower than those of SC50 scenario for rice, corn, sorghum, pulses and sugar, but are significantly higher for oilseeds and oilseed oils, sheep meat and bran. In India, prices rise for rice, sugar, soybean (seed, oil and a little meal) and all animal products except milk. In Bangladesh, the prices of wheat and all livestock products rise with a moderate rate.

It is in priority at level of human consumption that develops the impact of restrictions on foreign trade. This consumption decreases in total for the three countries by 12.7 Mt, having 13.3 Mt for

India and 0.3 for Bangladesh but Pakistan registers an increase of 0.9 Mt. For consumption per capita per year, there is an increase of 4 kg / capita / year in Pakistan (especially with wheat growth and decline for sugar). In India, consumption per capita fell by 9 kg / capita / year (mainly for wheat, but also for rice and sugar) and in Bangladesh, the decline is low (-2kg / capita / year) mainly for wheat and sugar.

It appears that limiting total imports favours domestic production. Given the price changes, the total area in the three countries increases by 9 Mha compared to SC50 (+22.5 Mt for production) including 7.7 for soybeans, rapeseed and 2.4 to 1.6 for sorghum. Surfaces for other cereals vary slightly while those for pulses regress by 1.9 Mha. This increase of total cultivated area occurs mainly in India (+8.5 Mha) then, in more moderate way, in Pakistan (+0.5 Mha), but they are practically unchanged in Bangladesh. Regarding uses of concentrates as animal feed, there is also a significant decrease in all three countries (-2.0 Mt) with a sharp decline of brans, wheat, all meal and inversely a strong growth of corn (+7.2 Mt). Regarding nutritional level, the situation would improve in Pakistan (+0.03% for calories and +4.6% for protein), but degrade slightly in Bangladesh (-0.5% and -0.2%) and especially in India (- 4.2% and -2.8%).

Regarding foreign trade, objective of this policy, the deficit would decrease by 80.3% in India, 6.7% in Pakistan, but increase by 3.2% in Bangladesh.

Overall, despite the highly simplified character of this scenario, therefore it appears that such a coordinated policy to focus on trade between countries of South Asia and to limit imports from the world market would have significant effects in terms of price variations for the three countries and that the majority of adjustments in price and tonnage would be done in India. Positive effects in terms of trade balance (especially for India and Pakistan) would have to be associated with a significant deterioration of nutritional intakes in India, even if they favour that in Pakistan and Bangladesh.

The theoretical scenario SC52, that focuses on the coordination of pricing policies in the three countries, is characterized by strong price increases compared to SC50 scenario in Pakistan, It would have many more contrasted affects in India and Bangladesh with, in particular, significant declines for rice and wheat prices. For animal products, in all cases, these countries would have extremely high increases of price (and unrealistic) except milk. Overall for total of the three countries, the balance of foreign trade in tonnage would improve by 4.0 Mt, the considerable



widening of the deficit by wheat (-38.2 Mt) being partly offset by an improvement for millet, sorghum and especially by a huge increase in the total exportable balance of milk mainly due to the collapse of human consumption in Pakistan and some rationing in Bangladesh. These decreases would more than offset the net increase of consumption in India.

Concerning concentrates used in animal feeding, there would be a small change in the total demand of the three countries (+0.9 Mt mainly due to the sharp decline of bran and cottonseed, more than offset by increases for wheat, rice and maize as well as cakes). Total rise of 0.9 Mt would decomposes in a decrease of 3.3 Mt in Pakistan, an increase by 4.4 in India and a slight decrease of 0.2 Mt in Bangladesh.

Concerning per capita consumption, in Pakistan, compared to SC50, there would be a decline of consumption by 207 kg / capita / year almost entirely due to the collapse of milk consumption, In terms of nutritional intake, there would be extremely strong declines of 11.3% for calories and of 30.8% for protein (mainly due to milk). Contrary, consumption per capita would increase by 32 kg / capita / year mainly in the form of milk and rice for India. Nutritional intake per capita would increase by 6.2% for calories and 8.2% for protein. Finally, for Bangladesh, the fall in consumption per capita per year, due to strong price increases, especially for rice and wheat would be 117 kg / capita / year, including -75 kg for rice, -17 for milk and -12 to wheat. This would lead to a sharp decline in daily intake of calories (-37.4%) and protein (-36.0%).

Both scenarios, by their global character, reveals totally unrealistic to the extent that they treat all products equally and lead to changes in balance of trade and of structure of human consumption not acceptable. Therefore, it should be necessary to have “credible” results, to define other scenarios of this type (political action on global balances and / or harmonization of price changes) more differentiated according to products.

It shows, however, at a qualitative level, that such coordinated policies would induce notable changes in agricultural situations for each respective country, some aspects for some products and some indicators being eventually favourable to a country and unfavourable to other two. This shows the necessity of a comprehensive analysis of the advantages and disadvantages of more realistic and detailed policies that could be evaluated with the model.

## 6.6. Conclusions

In this section, the structure and mode of implementation of the three PEM has been described in GAMS. Various illustrations of the possible uses of such models have been presented in the form of scenarios and the results were discussed. It should, however, in conclusion, to emphasize two points.

To perform these simulations, the reference year is the calendar year 2009, the last year for which data sheet and price is currently available in FAOSTAT, or is calculable from the trade figures. It would have been preferable to use an average of several years to limit the potential impact on the results of specific conditions that have characterized the year 2009 (including the level of yield, stocks changes, etc.). However, besides the very important work in terms of time that would have required the reconstitutions such a base for several years (e.g. 2007-2008-2009) to retain an average corresponding to a more "normal" situation, it appeared that the first two years that correspond to soar local and world prices, would have risked to lead more bias than improvements to the models.

In addition, as noted above, the fact that some variables (specially the production of animal products, the total cultivated area in each country, yields of various crops) are currently considered as exogenous, and therefore do not react to price changes, leads to high stiffness of the three models. It is clear that, from a mathematical point of view, there may be no price change on the basis of calculated demand elasticities and for a given change in income, which allows to absorb a given change, for example an increase of 20% of the milk production. It is therefore necessary to introduce flexibility in each model in term of a possible change in the balance of trade and price simultaneously. In this case (even if we fix arbitrarily limits for acceptable variations of trade) it can be no solution (and in this case we need to expand the range of variation allowed for a mathematical solution) or exist infinite solution (in this case, it must define in an economic model to optimize to make, in principle, only the computed solution).

The choice was made to retain the minimization of the sum of squares of price changes for all products and all three countries, which is a non-linear function (quadratic) and requires the use of an appropriate solver. This hypothesis is specific to three models in this thesis, is not generally adopted in other PEM consulted in the literature, but is a necessity in the current state of the three PEM, which could be removed by further improvements to the models as indicated by general

conclusion. The results of the scenarios must be considered as illustrations more than the final results fully validated as a view of the arbitrary (but as realistic as possible to some hypothesis).

# Chapter 7: Conclusion

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The most important countries of South Asia like Pakistan, India and Bangladesh are characterized by rising of income, rapid urbanization, high prices of food, growth of population and low availability of surface area for further cultivation which raised serious questions on future food security in these countries. Being the most populous countries of South Asia, these three countries together represents about forty percent of the world total undernourished population.

Thus, these three countries are of particular interest in food and feed economic analysis, from a regional point of view but probably also, for future of world economy.

Several contributions of this thesis in relation to the status of the previously existing information and estimates in the literature can be highlighted at descriptive, methodological and empirical levels.

The first contribution of this work is to collect, format and give consistency where possible, to a large number of statistical data on the entire agricultural sector of each country. If it is not an innovation, it was considered useful to present all these elements in detail, in the form of tables and graphs in a chapter essentially descriptive (chapter 2) with the evolution of their most important parameters: population, cultivated surface area, prices of crops and food products, protein and caloric intakes, etc.).

In chapters 3 and 4, the different historical elements (surfaces, yield, production, price and human demand) were also presented in detail before making econometric estimates, so on the one hand to show major trends, the major uncertainties and potential biases in all cases in the data. Though these were the most attenuated in the calculations retaining multi-year averages of prices and yield (supply function) and optionally of dummy variables for problematic period where quality of computed elasticities remains largely dependent on the validity of the data used.

An important contribution is the work done on the field of animal nutrition. This sector, even if it has become significant with more than 50 Mt of concentrate for all three countries, is usually totally neglected in quantitative economic analysis. The few existing studies (e.g. CGRT

Pakistan, 2003) are very old, concern only grains without by-products and use old methods of estimation (equation by equation). This failure to take into account in the analysis and models can be explained by the uncertainty in the data and also by the inability to use standard econometric methods.

Historical data, possibly biased of FAO were used to estimate functions of total demand for concentrates (relationship between total tonnages of concentrates used in each country as a function of livestock production) and, as such, the estimated coefficients may be biased. On the other hand, the original method of estimating demand elasticities proposed by Dr. Yves Dronne and inspired by a former work (Ludo Peterers, 1990) done on this subject, allows to be free from these series of data and requires that the establishment of a baseline (consumption and prices of various ingredients, quantities of various " equivalent compound feed " for poultry and dairy cattle in a given year) and nutritional data (composition of ingredients taken into account, nutritional constraints of different formulas). The values thus calculated may overestimate actual breeder's reactions in terms of adjusting their feed formulas to price changes, but constitute indicators that are not present in ancient literature.

On an empirical plan, the results for the various elasticities of supply and human demand is a contribution in relation to the literature where similar values are generally old or not documented. However, their validity remains, like all other authors, conditioned by the quality of the data used. In terms of methodology, this thesis provides an important innovation in the form of three models actually implanted under computer software. All of these programs in GAMS are presented in annex D to allow researchers and decision-makers to use these models for their own needs, either in its present form after some improvements. Such models do not currently exist for these countries, if yes then they are operational supplements to traditional econometric models that have been developed for a very limited number of products (mainly cereals and oilseeds) for some of these countries by organizations such as FAPRI. Where the structure and parameters of these models are not public (only the results of predictions made with them are published in detail), so they do not allow to perform specific simulations.

On the **supply side**, this thesis (Chapter 3) delineates a model to estimate the gross product per hectare response of different crops areas and empirically applies the model to estimate own and cross gross product per hectare elasticity of major and minor crops which cover more than 80 percent of the total cropped area in Pakistan, India and Bangladesh. The data used are collected from FAO data base and, in some cases, are corrected by data from economic survey of each respective country. After a general description of main evolutions of the supply side for these products (areas and yields) and prices received by farmers (these ones appear in some cases to be correlated with some international prices when the evolution of exchange rate between local currency of each country to dollar is taken in account), parameters are estimated by a translog share model.

After parameters estimation of a translog share model concerning 9, 10 and 6 crops for Pakistan, India and Bangladesh respectively, short run own and cross gross product elasticities are calculated. According to empirical estimations, it appears that in the three countries farmers are more or less responsive to gross product per hectare modifications, but contrary to the situation in many developed countries where the response is quick, in India, Pakistan and Bangladesh, farmers are influenced by the average product of several last year's yields and prices that they consider as anticipated gross product, thought in developed countries the data concerning the last crop (year  $t-1$ ) are much more important than those of previous years. The parameters of the different share equations have generally good significance when some dummies variables are introduced to take in account some apparent discontinuities in data (mainly prices).

Globally own gross product elasticities for main crops are lesser in Pakistan and Bangladesh than in India and are lower than those indicated in FAPRI database for these countries and for some other countries representing more modern and "free" agriculture. The generally low value of our calculated elasticities can be explained by the fact that in the three countries, and more especially in Pakistan and Bangladesh, a large part of the crop is not destined to market sale, but, independently of market prices, to satisfy farmer's families' food needs and in other cases feed for farmer's animals.

Short run cross gross product elasticities and partial Allen-Uzawa substitution elasticities have also been calculated, On this basis it is possible to distinguish influence of a crop on another in three possible ways: competitive, complementary and unrelated. The classification of crops is

compared for Pakistan India and Bangladesh but some unexplained differences can be observed. In fact it is important to stress on the fact that some data used in estimations could be biased, and, on a methodological point of view, due to lack of data, only output prices and yields are introduced here in estimations. But it is well known that the prices and availabilities of some input factors (water, irrigation, fertilizer, machine, labour, etc.) are also very important in farmer's decisions.

Low magnitude of direct elasticities for rice in Bangladesh and for wheat in Pakistan and India reflects more traditional agricultural practices due to the lack of improved production technology, credits, marketing system, farmer linkages, weak research and incentive for support price for minor crops other than rice and wheat. The analysis could be extended in different directions. Firstly, the cost of production and non-price factors could be included and data could be desegregated for different crop zones to obtain better values of elasticity, by a panel data approach, for each zone that may be different according to climatic, agronomic and social parameters. Secondly, it could be analysed if the anticipated gross product is the effective parameter taken into account by farmers or if the prices and yields (and eventually public subventions) have different roles and so, are to be introduced separately in the equations of translog system.

On the **demand side**, this study outlines a model to estimate the price demand elasticity of different food products and empirically applies the model to estimate own and cross price demand elasticity of major vegetal products and animal products, first, separately and then taken together. The products taken in account cover more than 95% of the total food consumption in Pakistan, India and Bangladesh. The data used were collected from FAO data base. Different relationship of substitution and complementary are calculated and compared for these countries. The results are also compared with results of other authors.

According to empirical estimations, it appears that in the three countries, consumers are more or less responsive to price modifications; the parameters of the different share equations have generally good significance, eventually with some dummies variables introduced to take in account some discontinuities in data (mainly prices). In these three countries, the results suggests that main food products like wheat, rice, eggs and milk are relatively less price elastic as compared to other food (sugar, vegetal oils, etc..). When expenditure rises, Pakistan and Indian

consumers diversify their consumption from cereals to other products (milk, eggs) more as compared to Bangladeshi.

In past years income growth has partly alleviated inadequate caloric and protein intake because, as income increases, individual may diversify their diet and substitute some more expensive sources of calories (and proteins) for less expensive ones.

The implications of our results for development policies in these countries that seek to improve caloric and protein intake are clear. First governments of these countries could target to improve income level of most vulnerable consumers (low income group). Second, as food prices have an indirect effect on caloric and protein intake, lower food prices should increase real income via income effect on demand. Food subsidy policies may have a positive role in improving caloric and protein intakes. Wheat subsidized policy may be more efficient to improve food security in Pakistan because people used to buy wheat flour even in case of flour crisis (cosmetic shortage) at higher price (Hussain et al. 2012). But government should also protect consumer against artificial shortage of wheat or sugar by protecting bands in between import and export parity prices, rather than pan-territorial pricing that crowded out private sector. In India and Bangladesh, rice subsidized policy may be more efficient. Edible oil in these countries, is an expensive food that also increased food expenditure because its major part is imported, so government should encourage the local production to reduce expenditure cost of household (Pan et al. 2008, Ali et al.2008). Globally, it appears that a combination of income and price policies, oriented toward specific populations, associated with some incentives to increase local production and control some imports, may be more effective in influencing consumption pattern and improving nutritional intake without implying excessive cost for Public budgets and significant impact on inflation for food products. Concerning the use of **concentrates in animal feed**, the relationship between the total amount demanded in each country and the evolution of major livestock (especially poultry meat, eggs and milk) is calculated. Then, using a method based on the econometric estimation of a translog approach using generated pseudo data by a model of compound feed formulation, it was possible to calculate matrixes of price elasticities of demand for each ingredient. Different relationships of substitution and complementary are also calculated, and according to the theory, nearly all direct price elasticities of demand are negative. It appears that in these countries, wheat and rice which are mainly used as human food are also consumed directly on farm level by animals. We can suppose that these cereals valorised at



lower prices in feed are products of lower quality not fit to human food. Rice and wheat brans (considered globally), and molasses which are important feed products are relatively high price elastic in Pakistan and India but relatively inelastic in Bangladesh. The main other ingredients used by feed industry are maize, cottonseed, rapeseed meal and soybean meal. Maize is highly price elastic and substitute of brans in three countries. For other products, national feed demands are less or high affected by their prices. It also appeared that in India, feed industry is more developed as compared to Pakistan and Bangladesh.

This thesis has built three agricultural partial equilibrium models for three main countries of South Asia (Pakistan, India and Bangladesh). It also estimate econometrically the various functions of supply, of human and animal demands, and thus calculated the various matrixes of direct and cross elasticities for price and expenditure, elasticity described above for human demand, which were used in the various simulations with the model. The partial equilibrium model for each of the three countries implemented in GAMS with nonlinear solver COUENNE has allowed the realization of various scenarios for 2009 and 2025. They show in particular the importance of relationships between the various demands of crops as food and feed and their supply taking into account net trade. These scenarios are initially focused on the analysis of the influence of variation in key exogenous parameters (population, per capita income, total cultivated area, animal production and yields of various crops) on domestic prices and quantities (area, production, consumption, trade) from the actual situation of 2009. Concerning influence on domestic prices, our results suggest that rising population led to significant price increase of food, and, in the opposite direction, increase of total cultivated area and amelioration of yields led to decrease price of food. An increase in animal production also implies a decrease in food cost even if a supplement in feed concentrates is necessary. Concerning influence on external trade, our results indicate that increase of population and of income per capita (implying an increase in food expenditure) led to degradation (deficit) for net value of external trade. On the contrary, the increase of total cultivated area and yield led to improvement for net value of external trade. Concerning influence on protein and calorie intake, our results indicate that increase of population, due to higher prices resulting from low response of supply in term of area and crop productions, led to decrease protein and calorie intake if not accompanied by improvement in animal production. On the contrary, the increase of income per capita, total cultivated area, yield and each animal product led to improvement of protein and calorie intake.

In the same context of this thesis, simplified public policies were also studied corresponding to i) various forms of subsidies, for one or all crops, paid to farmers, or ii) various forms of subsidy paid to consumers for one or all food products. Results of these scenarios were calculated and compared to the actual situation of 2009. The effectiveness of these different policies has been discussed in terms of impact on daily nutrient intakes (calories and protein), but also in terms of cost to the public authorities, impacts on the cost of food and feed and in terms of impact on the trade balance of each country. Our results indicate that policy to give subsidies to producers either for single crop like wheat or rice or total crops have no significant influence on domestic prices, trade balance, protein and calorie intakes but can only improve the income and conditions of producer which can further invest to increase yield. On the other hand, subsidies paid to consumer for one product (rice or wheat) or all products led to significant improvement of protein and caloric intakes as expected, but also to degradation of net value of external trade, increase of food expenditure and high cost for government if the whole population of each country is concerned as supposed in these simplified scenarios.

The developed model was also used to perform three exploratory scenarios relating to the year 2025, after estimation, based on various extrapolations and various works recently published, of predictable trend changes for the main exogenous parameters. Two of these scenarios for 2025 relate to hypothetical policies that could be implemented in the case of a political will of three countries to coordinate certain aspects of their agricultural policies: i) to limit the increase in the overall deficit of the South Asia region focusing on intra zone trade, or ii) desire to control and harmonize the evolution of agricultural prices in the three countries. For trend scenario of 2025 (which take in account a part of trade liberalization), our results indicate that in three countries, food and feed prices would be significantly increased due to high progression of demand resulting from increase of population and income per capita. Demand for feed products would also increase highly due to progression in animal production (particularly poultry meat and eggs, and milk). The value of net trade would be degraded, but compared to 2009, with this supposed rise of imports, protein and calorie intakes per capita would be increased.

For scenario relative to 2025 aiming to limit the increase in the overall deficit of the South Asia countries and focusing on intra zone trade, our results indicate that it would lead to significant price increase in India and Bangladesh but some price decrease in Pakistan except for seed oils that are imported. While it would lead to decrease of net deficit of external trade resulting from

rise of production and total surface area cultivated in three countries. Protein and calorie intake would be improved only in Pakistan resulting from increase in food consumption per capita but protein and calorie intake would be decreased in other two countries. This scenario would be more beneficial for Pakistan as compared to other two countries. For scenario in 2025 based on a control and harmonization of the evolution of agricultural prices in the three countries, our results suggest that it would lead to increase in prices and net trade. The protein and calorie intake would be increased in India but would decrease in other two countries. This scenario would be more beneficial to India as compared to other two countries.

It can be concluded that increase of population accompanied by increases of animal production, rising of income and improvement in yield can improve the situation of food security in these three countries at the condition that they have sufficient currencies to pay the rising agricultural imports and adapt their external trade policy to liberalize it and decrease the present tariffs and limitation on food products coming from foreign zones.

In this work, various difficulties were encountered and took a lot of work to ensure consistency. The data were mainly taken from FAOSTAT for surfaces and quantities (production, consumption, balance), but problem was especially with prices data. Due to missing or unreliable data particularly for consumer prices (other sources are also incomplete), we had to estimate these prices by indirect methods for certain products (in particular from unit values at import or export converted in local currency). A general problem was not having data for price on FAO databases after year 2007, last year for which estimates of functions of supply and demand have been estimated. Moreover for animal products there is no data for price before year 1991 in FAOSTAT, while for vegetal products, FAO divides prices of vegetal products into two separate bases (before 1991, this year being not included) and after 1991 with no recovery, so without possibility to test consistency of the two series. Finally we estimate demand functions using producer prices adjusted by fixed coefficients considered as "proxy" or "approach of consumer prices."

This work presents a number of limitations in estimates, a) some non-considered for reasons of data availability (eg fish), b) the simplified structure of the model: no representation of public policies in each country (price support, subsidies for some consumer taxes and quotas possible to import and / or export etc.) and their possible change over time. A fundamental assumption of

simplified working mode of the three models is that prices are totally determined within each country on the basis of supply: demand balances and foreign trade still allows, within certain quantitative limits, balancing markets for each product to reduce the local price changes (products traded with the outside being valued at the same price as domestic prices).

With a little more time, some aspects of the work could have been completed 1) especially for deeper comparison between the elasticities calculated in this thesis and those in the literature, 2) possibly calculating new econometric estimates with more years available now in FAO database. 3) for comparison of the results of the trend simulation for 2025 with some prospective studies or forecasts made by international or national agencies (in particular concerning outlooks for per capita food consumption and trade balances).

The work done in this thesis opens up some complements or possible methodological improvements, particularly at the level of the structure and the factors taken into account in the partial equilibrium model.

The first important improvement would be on the representation of relations between the three countries and the rest of the world whether on the base of prices or exchange. For this, it would be interesting to develop a fourth partial equilibrium model representing the "rest of the world" with the conventional assumption that domestic prices in each country are influenced (more or less strongly) with world price changes. Such a set of four partial equilibrium models "representing a closed system" would then retain the conventional assumption that prices are formed by balancing on the world market and thus changes of the balance of the three countries and in different countries influence world prices. A second major improvement would be on the representation of foreign trade policies introduced quota policies, custom duties and exchange rates, it would be interesting to analyse advantages and disadvantages of custom duties, changes of exchange rate and policy at level of external trade.

Currently, the production of animal products is exogenous and do not respond to price changes. A significant improvement would be to make these endogenous by calculating supply functions for the different livestock products in the three countries. These productions could be linked to prices of animals products, or better, could be based on production margins (the difference between value and cost for each livestock feed). Concerning on location (inside each country or outside) and activity level of the main processing industries (especially crushing and sugar), currently in

the model variations of transformations are assumed to be equal to changes in local production, which leads mechanically to the possibilities of oilseeds and sugar crops trade variations (which is not realistic for the second product). Moreover, we retained the assumption of constancy of processing margins and therefore a rigid relationship between the prices of oilseeds (sugar crops) and by-products: vegetal oils and meals (respectively sugar, and molasses). A more sophisticated model would introduce a better relation between the evolution of transformation inside each country and the evolution of the transformation margin. Such a formulation in form of explicit demand function for industries could give a better representation, for a same situation in term of crop productions, food and feed demand of final products (oils, meals, sugar, molasses), in term of part of external trade made in form of non-transformed crop products and transformed products.

Some other desirable improvements would be, as indicated previously to introduce more pertinent and actualized elasticity matrices (especially for food demand by finding in national data bases of each country historical series on effective market prices) for model calculations, then to get more precise information on specifications for feed formulations in Pakistan and Bangladesh (the present version of the model supposes that they are identical to that collected for India). At last but not least, to facilitate work of simulations using different set of modification of exogenous parameters, analysis and comparison of results of different scenarios, it would be useful to develop, at informatics level, more sophisticated interfaces for reading and writing inputs and outputs.

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## Annex A: Initial situation for each country

**Table 82: Detailed data for initial situation in 2009 for Pakistan:**

	Population	Price	Area	Yield	Production	Trade balance	Food	Feed	Seeds	Process	Variation of Stocks	Other uses
Population	170494											
Wheat		24.39	9046	2.66	24035	-2944	18781	481	1322	2	-5790	603
Rice		25.64	2883	2.39	6886	2735	2891		185		-933	142
Maize		17.82	935	3.49	3261	96	1375	697	87	15	-100	891
Millet		27.50	476	0.62	294	-11	137	147	6			15
Sorghum		27.50	248	0.62	154	-3	136	8	5			8
Other cereals		20.93	86	0.97	83	-4	35	42	6	1		3
Total pulses		21.57	1595	0.69	1103	-376	1166	217	69			27
Total sugcrops		1.06	1032	48.60	50138		6640		5505	42993	5000	
Soybean		32.06	0	0.61	0	0	0				0	
Sunflowerseed		33.00	320	1.31	420	-157			3	574		
Rapeseed		31.95	245	0.82	201	-455			1	900	300	55
Cottonseed		19.30	3106	1.33	4138	1		1035	121	2330		651
Otherseeds		35.10	176	3.06	537	-74	228		23	349	-1	10
Total sugar		47.92			4348	-77	4701			24	300	
Total molasses		4.57			1536	937		78		1522	1000	
Soybean oil		141.29			1	-73	27				-37	10
Sunflower oil		156.29			188	3	185					
Rapeseed oil		146.29			315		249					66
Cotton oil		131.29			416		356					60
Other oils		126.29			111	-1852	1281				-126	556
Soybean cake		20.21				-237		237				
Rapeseed cake		8.96			558	4		554				
Sunflower cake		3.67			258	5		254				
Cotton cake		7.22			1165	0		1165				
Othercakes		6.00			155	-14		169				
Total brans		3.91			3184	54		3091		39		
Bovine meat		76.81			1436	16	1420					
Ovine meat		125.18			424	8	416					
Pig meat												
Chicken meat		83.47			655	-1	656					
Other meats					22		22					
Total eggs		61.83			540		452		34			54
Total milk		14.90			34362	-52	29311	1686				3417
Total	170494	1484	20147		140925	-2472	70465	9861	7367	48749	-387	6568

**Source: Own calculation, Units: Population in thousands people, price in local currency unit per kilogram, area in thousand hectares, yield in tons per hectare and all others in thousands tons.**

**Table 83: Synthetic data for initial situation in 2009 for Pakistan:**

	Area	Yield	Production	Trade balance	Food	Feed	Seeds	Process	Variation of Stocks	Other uses
Total cereals	13674	2.54	34713	-131	23355	1375	1611	18	-6823	1662
Total oilseeds	3846	1.38	5296	-685	228	1035	148	4153	299	716
Total pulses	1595	0.69	1103	-376	1166	217	69	0	0	27
Total sugar crops	1032	48.60	50138	0	6640	0	5505	42993	5000	0
Total vegetal products	20147	4.53	91250	-1192	31389	2627	7333	47164	-1524	2405
Total meat			2537	23	2514	0	0	0	0	0
Total eggs			540	0	452	0	34	0	0	54
Total milk			34362	-52	29311	1686	0	0	0	3417
Total vegetal oils			1031	-1922	2098	0	0	0	-163	692
Total cakes			2137	-242	0	2379	0	0	0	0
Total sugar			4348	-77	4701	0	0	24	300	0
Total molasses			1536	937	0	78	0	1522	1000	0
Total brans			3184	54	0	3091	0	39	0	0
Total	20147		140925	-2472	70465	9861	7367	48749	-387	6568

**Source: Own calculation, Units: Area in thousand hectares, yield in tons per hectare and all others in thousands tons.**

**Table 84: Detailed data for initial situation in 2009 for India:**

	Population	Price	Area	Yield	Production	Trade balance	Food	Feed	Seeds	Process	Variation of Stocks	Other uses
Population	1207740											
Wheat		12.1	27750	2.91	80680	-34	69679	970	2852		-4880	2333
Rice		15.5	41920	2.13	89178	2140	82380	1784	1848	351	2000	2675
Maize		9.41	8330	2	16681	2649	6199	4100	790			2943
Millet		9.41	10400	0.85	8811	181	7713	141	345			431
Sorghum		9.63	7530	0.96	7250	81	6353	87	230			499
Other cereals		11.05	780	2.17	1691	26	1279	163	95	99		29
Total pulses		20.81	20930	0.68	14160	-3644	15104	1442	690			568
Total sugcrops		0.85	4420	64.49	285029		10802	5701	14251	250000		4275
Soybean		15.57	9730	1.03	10051	43	1223		553	6780	-1000	452
Sunflowerseed		24.41	1480	0.61	900	2			18	1041	161	
Rapeseed		20.5	6300	1.15	7221	35	528		39	6403		216
Cottonseed		8.84	10310	0.8	8265	1		3031	220	4600		413
Other seeds		18.5	11155	1.45	16218	648	6787	24	267	8641	582	433
Total sugar		29.39			26918	-2490	26041	185		5	-1457	1720
Total molasses		2.8			6540	-14		329		6225		
Soybean oil		62.42			1204	-1099	1571				-32	700
Sunflower oil		73.89			354	-521	826				-5	44
Rapeseed oil		68.56			2284	-42	2321				-5	
Cotton oil		53.56			820	-5	807				-18	
Other oils		48.56			3375	-6249	4923				-155	4546
Soybean cake		18.9			5424	3151		2273				
Rapeseed cake		7.14			3842	973		2869				
Sunflower cake		5.42			469	12		456				
Cotton cake		7.05			2300	2		2298				
Other cakes		6.62			7198	405		7187			409	16
Total brans		5.16			17731	68		11803		5860		
Bovine meat					2519	555	1964					
Ovine meat		125.67			853	52	801					
Pig meat					350	-1	351					
Chicken meat		86.86			2064	2	2062					
Other meats		36.46			169	1	160			8		
Total eggs		31.49			3324	79	2760		143		-10	332
Total milk		17.2			110947	490	87256	19125				4076
	1207740	864	161035	81	744819	-2504	339890	63969	22341	290013	-4410	26701

Source: Own calculation, Units: Population in thousands people, price in local currency unit per kilogram, area in thousand hectares, yield in tons per hectare and all others in thousands tons.

**Table 85: Synthetic data for initial situation in 2009 for Pakistan:**

	Area	Yield	Production	Trade balance	Food	Feed	Seeds	Process	variation of Stocks	Other uses
Total cereals	96710	2.11	204291	5043	173603	7245	6160	450	-2880	8910
Total oilseeds	38975	1.09	42655	729	8538	3055	1097	27465	-257	1514
Total pulses	20930	0.68	14160	-3644	15104	1442	690	0	0	568
Total sugar crops	4420	64.49	285029	0	10802	5701	14251	250000	0	4275
Total vegetal products	161035	3.39	546135	2128	208047	17443	22198	277915	-3137	15267
Total meat			5955	609	5338	0	0	8	0	0
Total eggs			3324	79	2760	0	143	0	-10	332
Total milk			110947	490	87256	19125	0	0	0	4076
Total vegetal oils			8037	-7916	10448	0	0	0	-215	5290
Total cakes			19232	4543	0	15083	0	0	409	16
Total sugar			26918	-2490	26041	185	0	5	-1457	1720
Total molasses			6540	-14	0	329	0	6225	0	0
Total brans			17731	68	0	11803	0	5860	0	0
Total	161035		744819	-2504	339890	63969	22341	290013	-4410	26701

Source: Own calculation, Units: Area in thousand hectares, yield in tons per hectare and all others in thousands tons.

**Table 86: Detailed data for initial situation in 2009 for Bangladesh:**

	Population	Price	Area	Yield	Production	Trade balance	Food	Feed	Seeds	Process	Variation of Stocks	Other uses
Population	147030											
Wheat		17.27	395	2.16	851	-2410	2351		38		-661	211
Rice		12.95	11354	2.8	31832	-33	25485	1593	757		-1041	2989
Maize		16.2	128	5.68	729	-609	1186	66	9			77
Millet		16	33	0.4	13		12		1			
Sorghum		16	0	1.33	0			0				
Other cereals		13	1	0.86	0			0				
Total pulses		32.51	235	0.87	205	-826	996	3	5			27
Total sugar crops		2.62	143	36.52	5233		300			4928		5
Soybean		28.73	40	1.47	59	-188	247					
Sunflowerseed		33										
Rapeseed		36.57	234	0.87	203	-172	20		4	340		11
Cottonseed		12.5	13	1.77	23					23		
Otherseeds		26.5	123	1.21	149	-87	9		4	219		4
Total sugar		51.37			757	-1433	1293			236	-659	2
Total molasses		6.63			87			87				
Soyoil		143.56			1	-393	253				9	150
Sunoil		158.56										
Rapeoil		148.56			101	-1	102					
Cotonoil		133.56			4		3					1
Otheroils		128.56			44	-915	413				-100	446
Soybean cake		19.6				-373		373				
Rapeseed cake		9.73			211			211				
Sunflower cake		4.5										
Cotton cake		9.3			12			12				
Other cakes		8.23			56	-50		106				
Total brans		2.6			3540	0		3524		17		
Bovine meat		208.2			194		194					
Ovine meat		252.11			187		187					
Pig meat												
Chicken meat		168.92			198		198					
Other meats		56.12			15		15					
Total eggs		79.89			219		176		21			22
Total milk		25.58			3224	-508	2966	488				278
	147030	1879	12698		48147	-7998	36406	6462	839	5763	-2452	4223

Source: Own calculation, Units: Population in thousands people, price in local currency unit per kilogram, area in thousand hectares, yield in tons per hectare and all others in thousands tons.



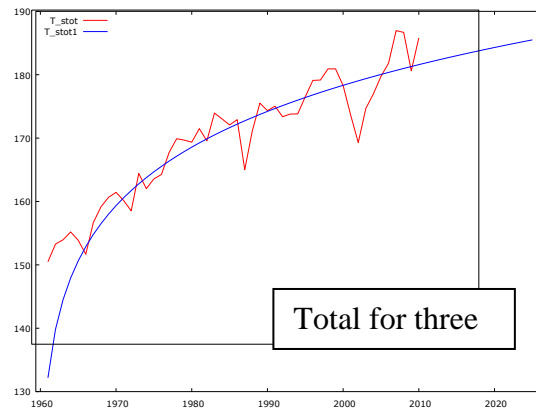
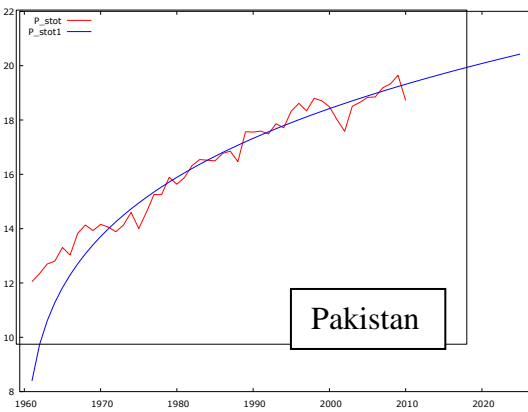
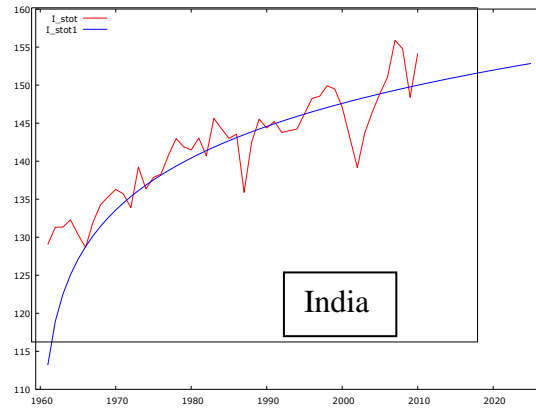
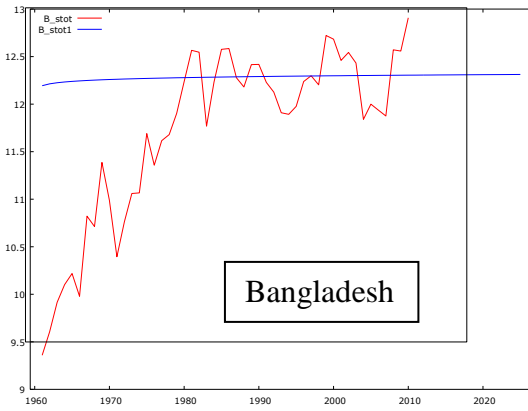
**Table 87: Synthetic data for initial situation in 2009 for Bangladesh:**

	Area	Yield	Production	Trade balance	Food	Feed	Seeds	Process	Variation of Stocks	Other uses
<b>Total cereals</b>	11910	2.81	33426	-3052	29034	1660	805	0	-1702	3277
<b>Total oilseeds</b>	410	1.06	434	-447	276	0	8	582	0	15
<b>Total pulses</b>	235	0.87	205	-826	996	3	5	0	0	27
<b>Total sugarcrops</b>	143	36.52	5233	0	300	0	0	4928	0	5
<b>Total vegetal products</b>	12698	3.09	39298	-4325	30606	1663	818	5510	-1702	3324
<b>Total meat</b>			594	0	594	0	0	0	0	0
<b>Total eggs</b>			219	0	176	0	21	0	0	22
<b>Total milk</b>			3224	-508	2966	488	0	0	0	278
<b>Total vegetal oils</b>			150	-1309	771	0	0	0	-91	597
<b>Total cakes</b>			278	-423	0	701	0	0	0	0
<b>Total sugar</b>			757	-1433	1293	0	0	236	-659	2
<b>Total molasses</b>			87	0	0	87	0	0	0	0
<b>Total brans</b>			3540	0	0	3524	0	17	0	0
<b>Total</b>	12698		48147	-7998	36406	6462	839	5763	-2452	4223

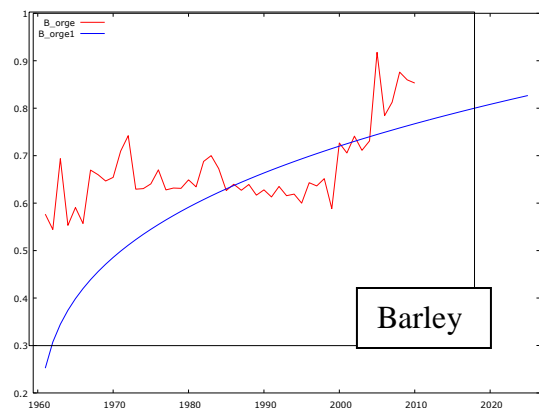
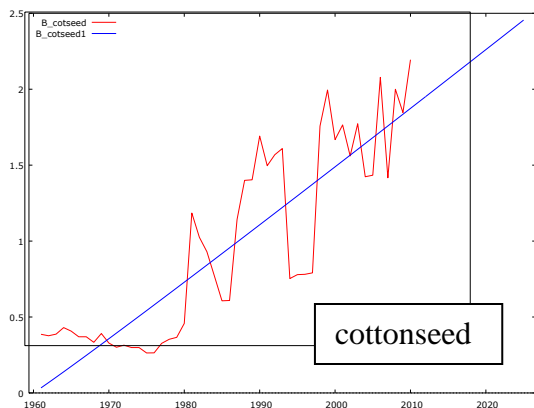
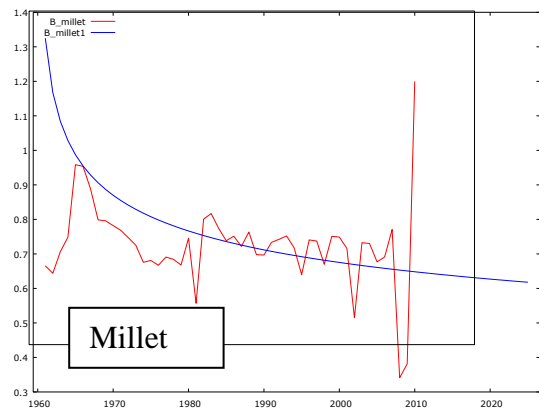
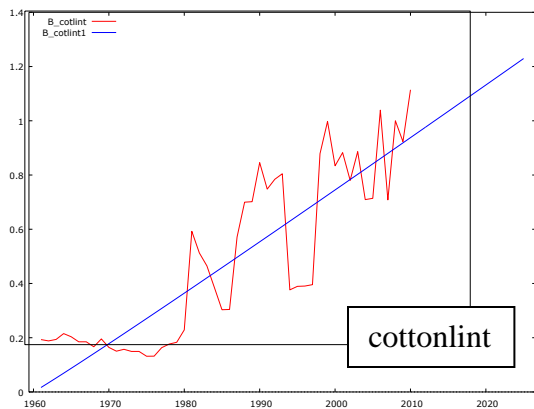
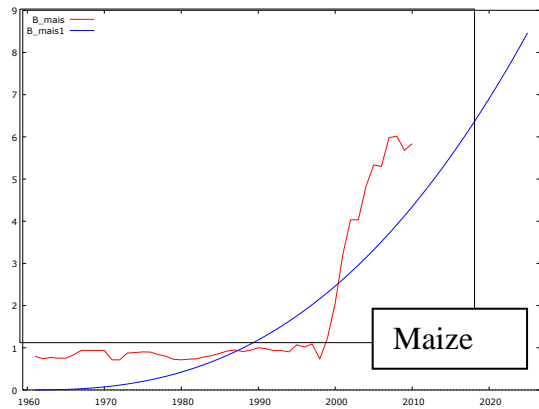
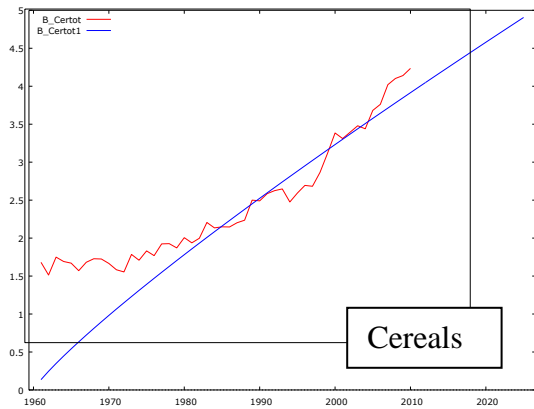
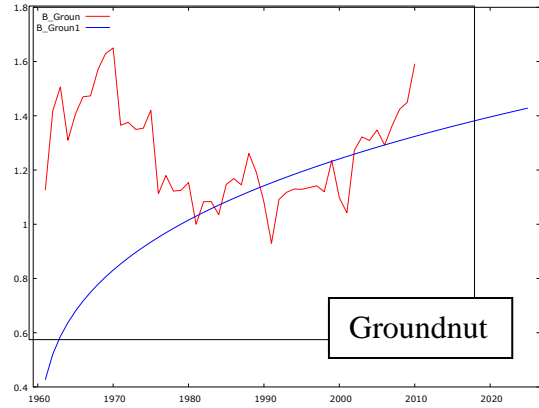
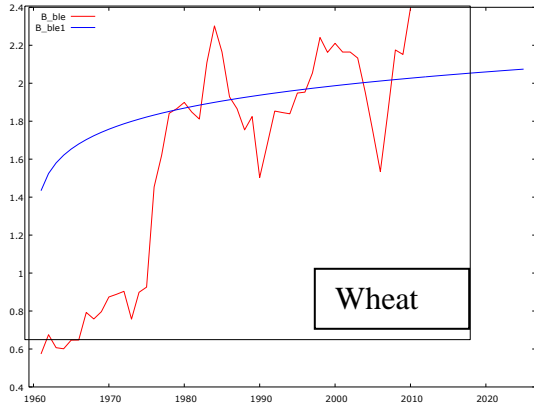
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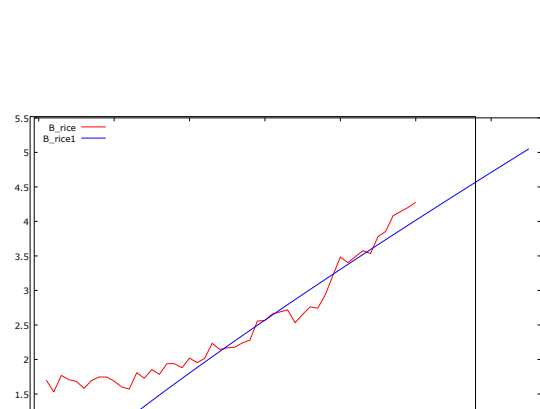
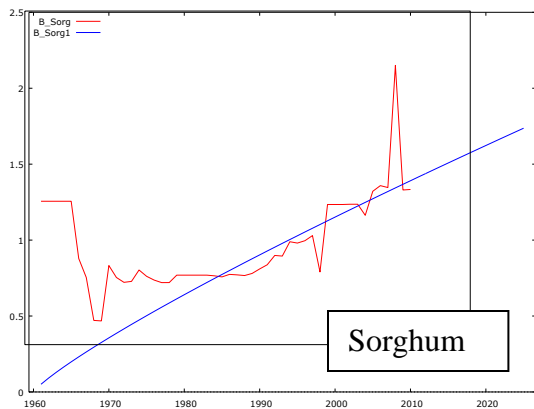
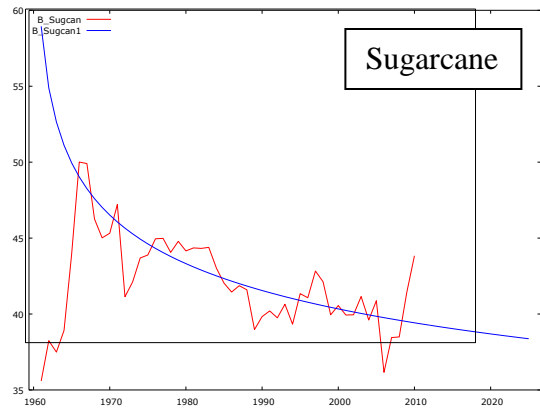
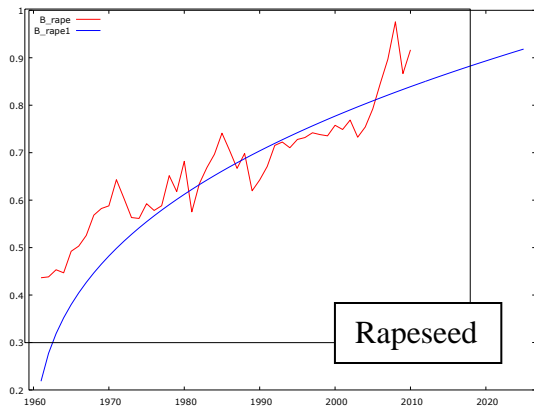
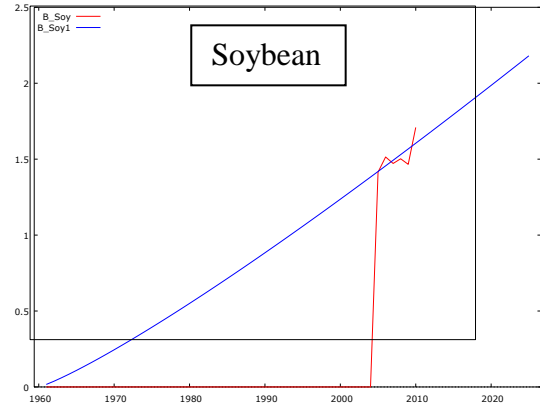
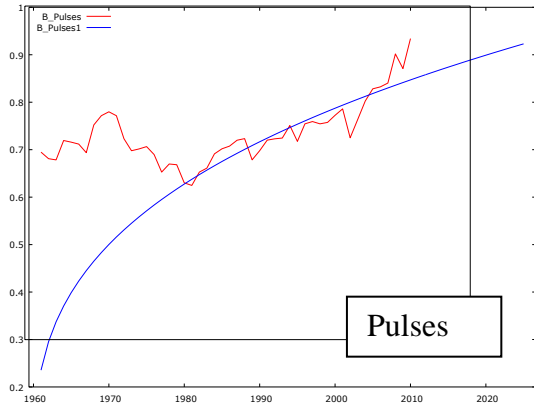
## Annex B: Graphs of surface, yield and animal production evolutions by country

### Total area by country

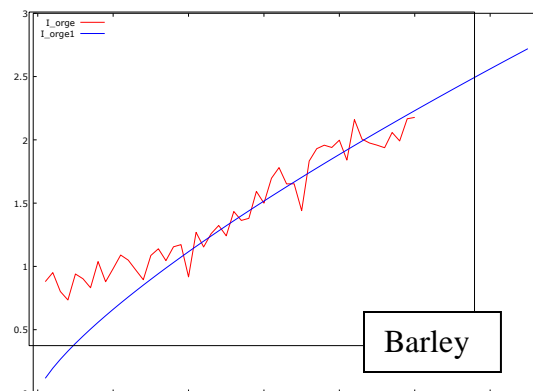
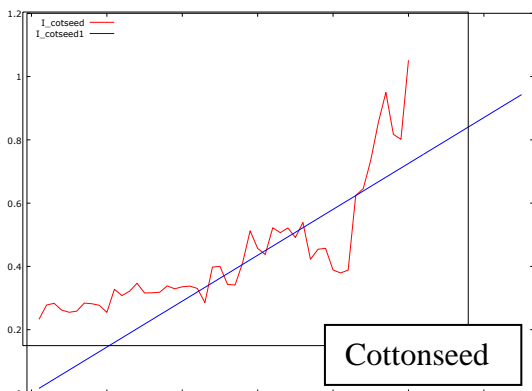
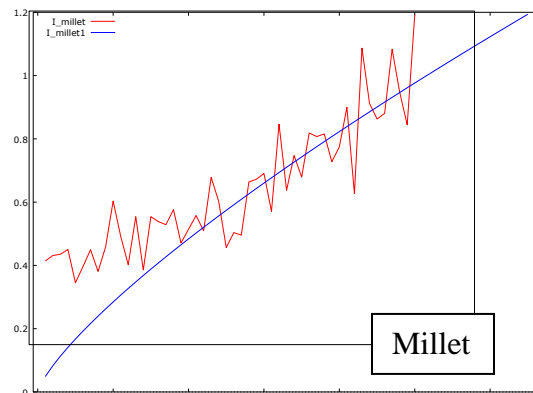
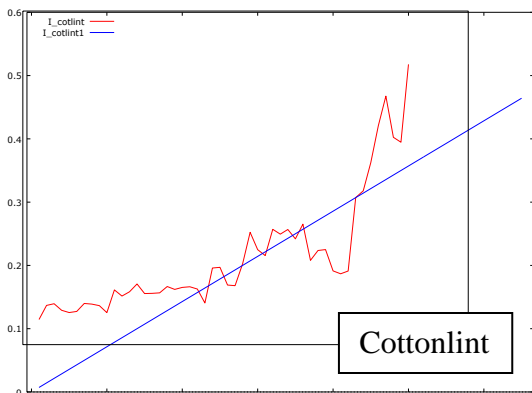
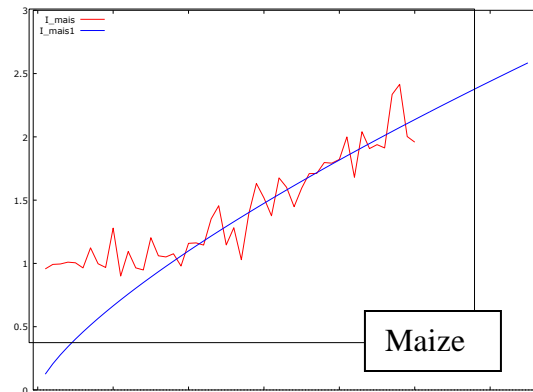
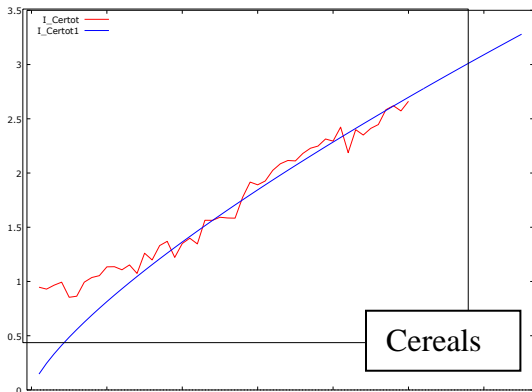
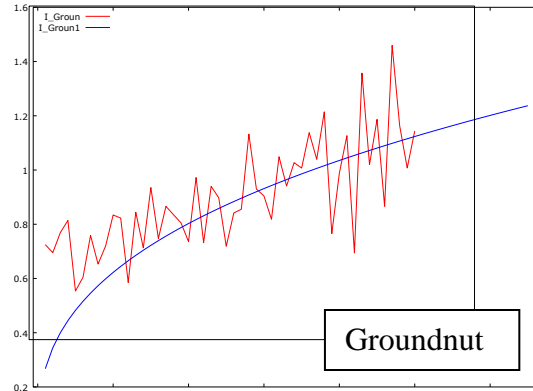
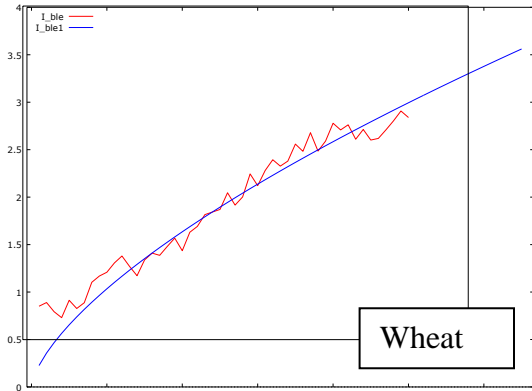


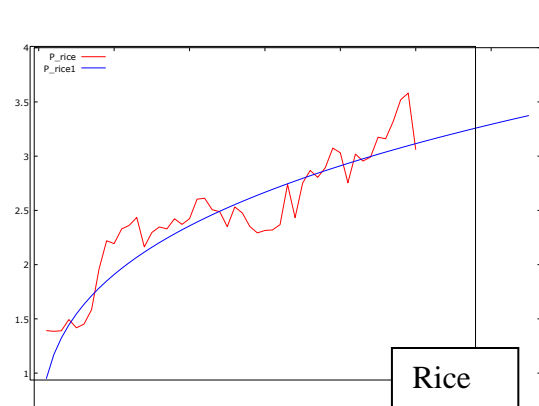
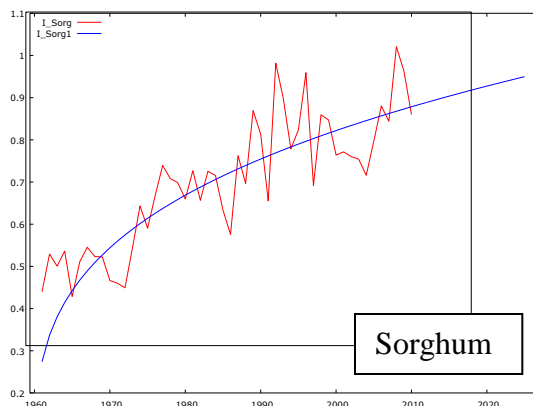
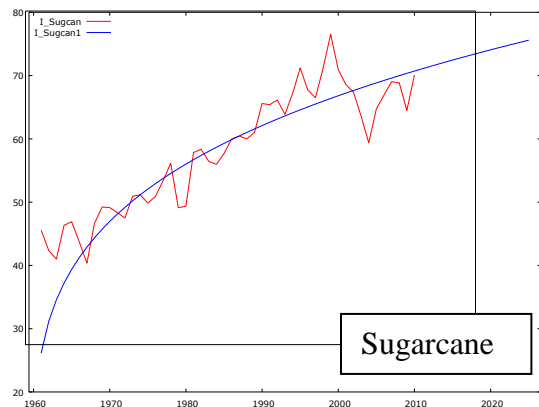
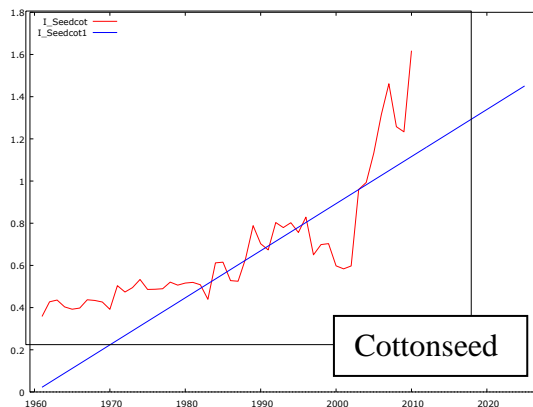
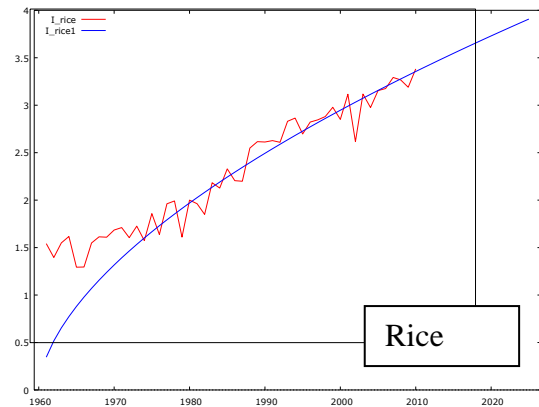
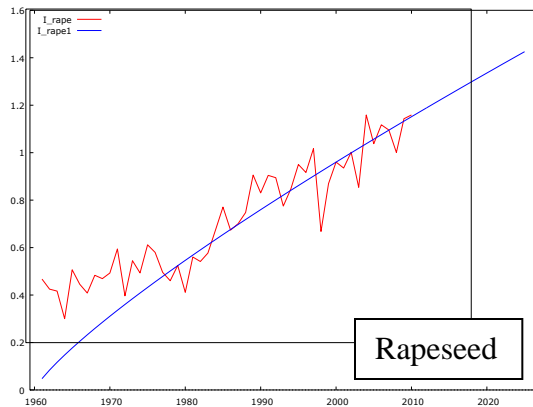
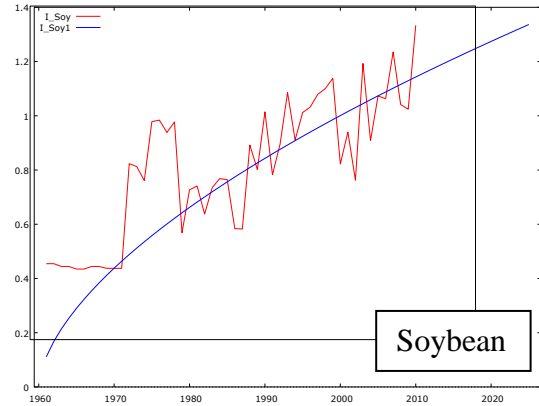
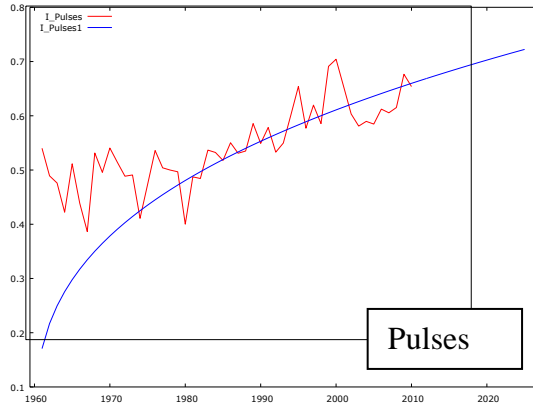
# Bangladesh: Evolution of yield



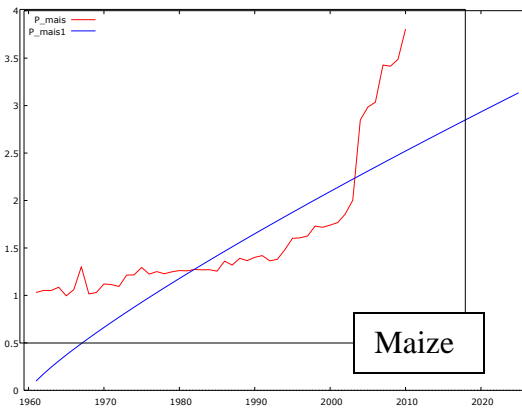
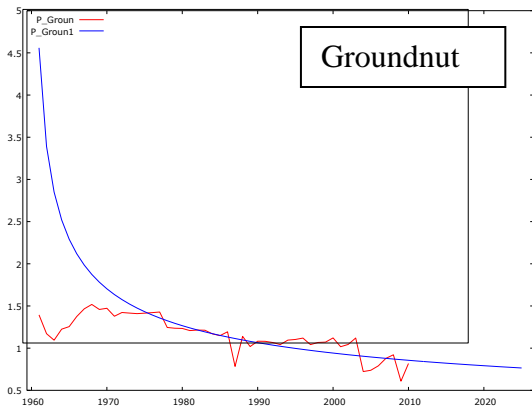
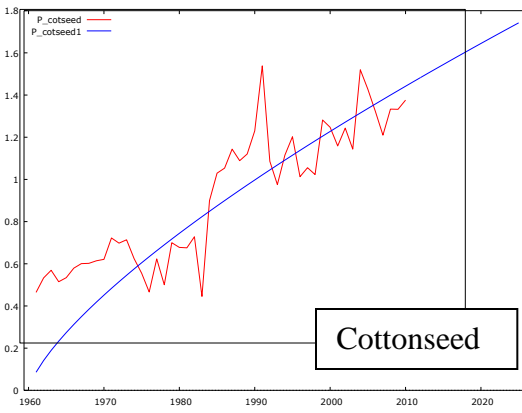
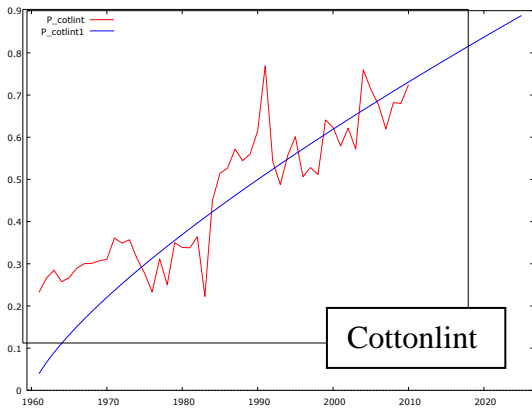
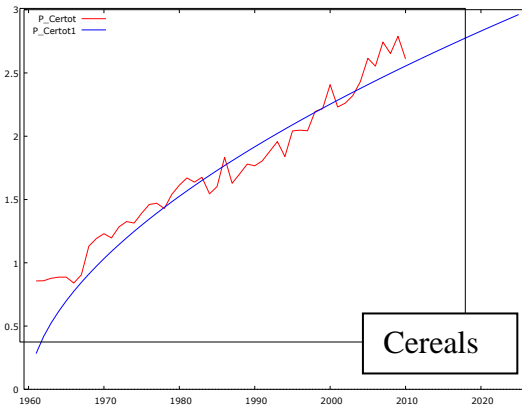
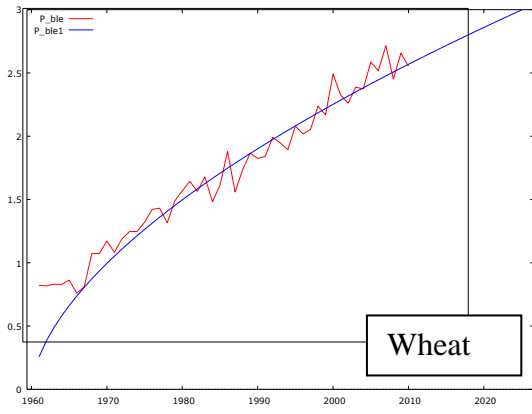


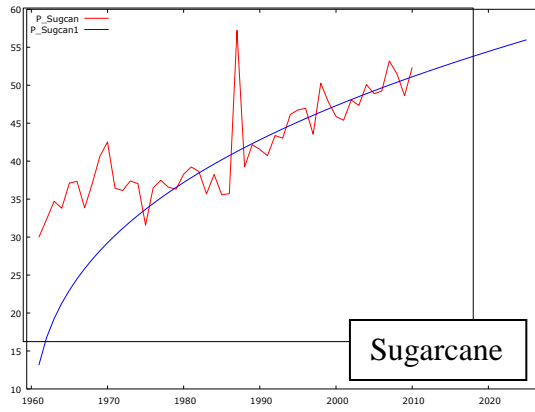
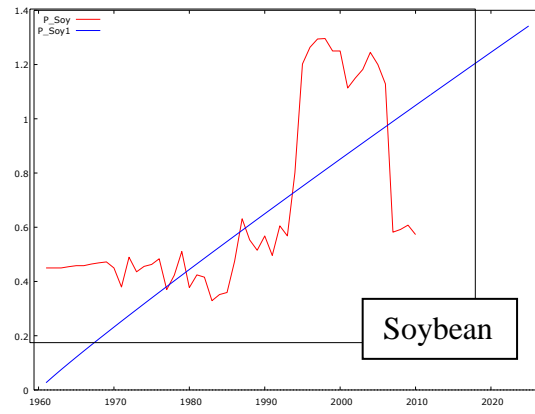
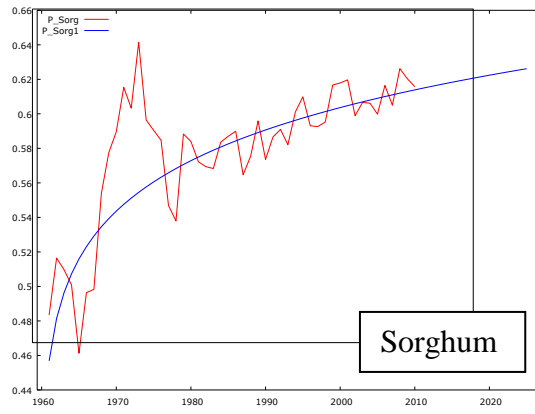
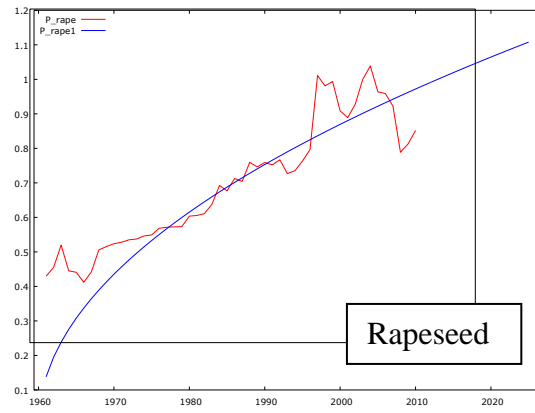
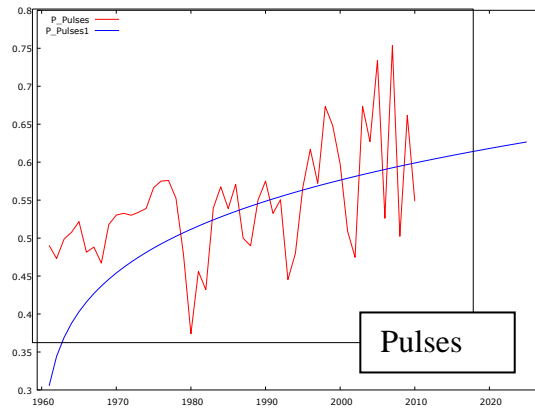
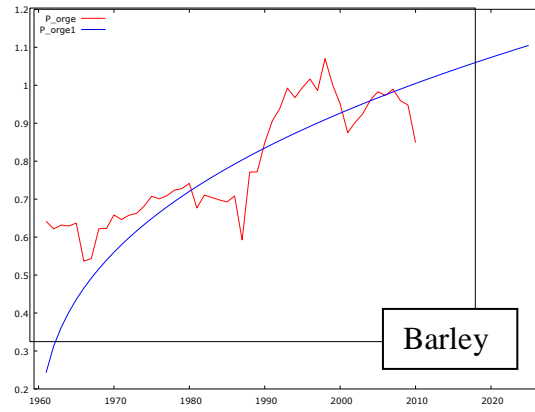
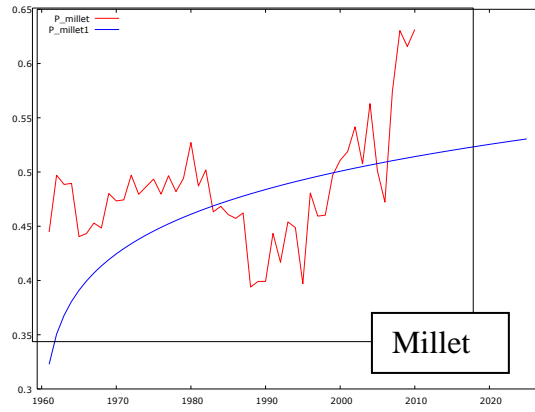
# India: Evolution of yield





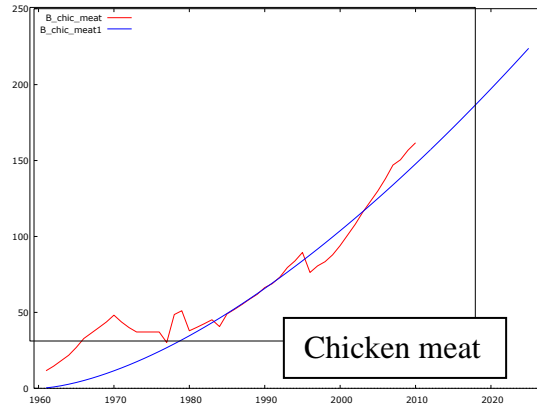
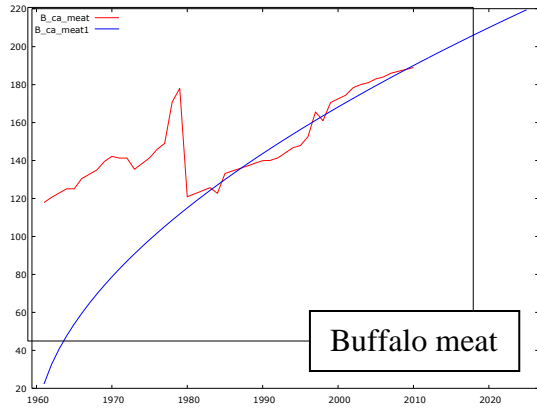
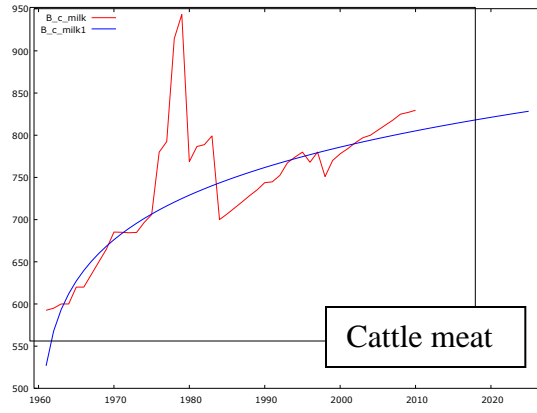
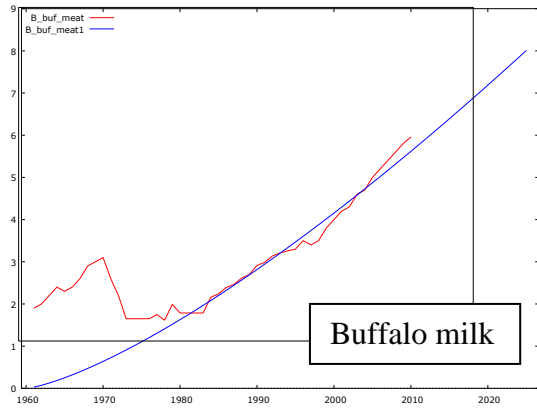
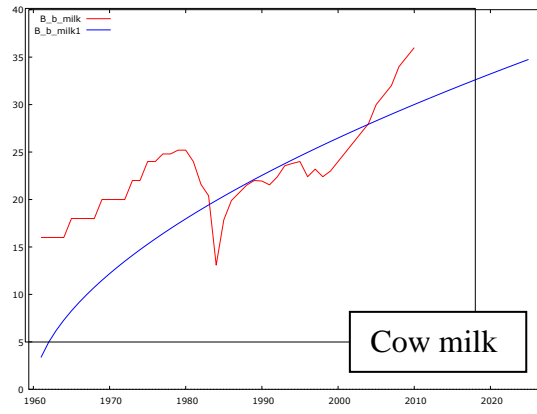
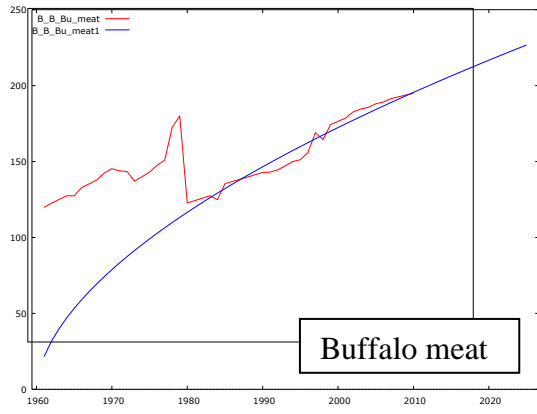
# Pakistan: Evolution of yields

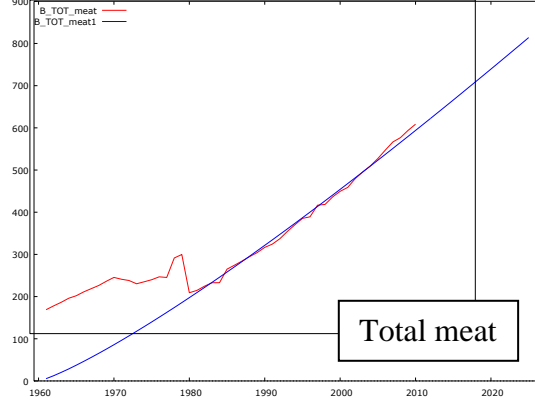
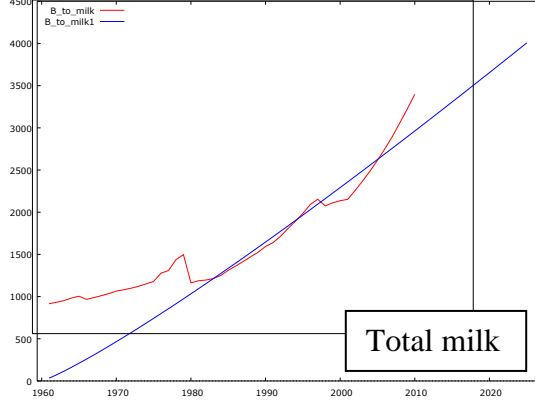
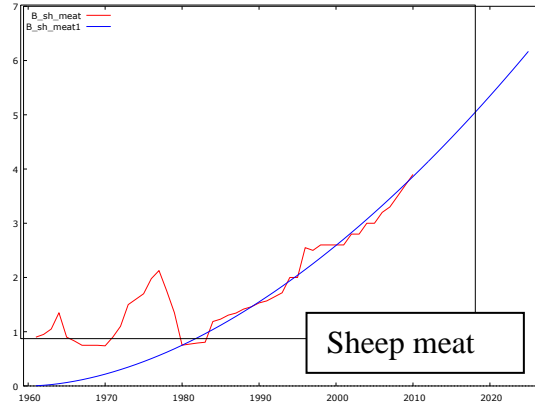
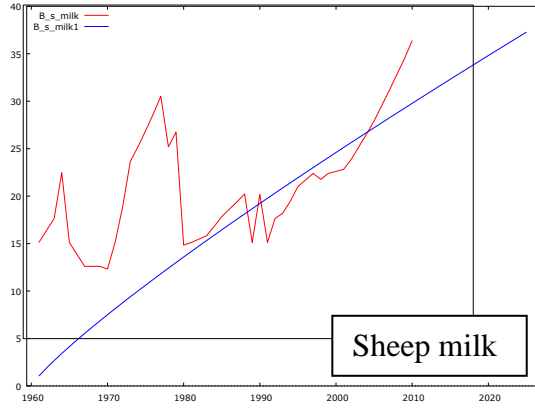
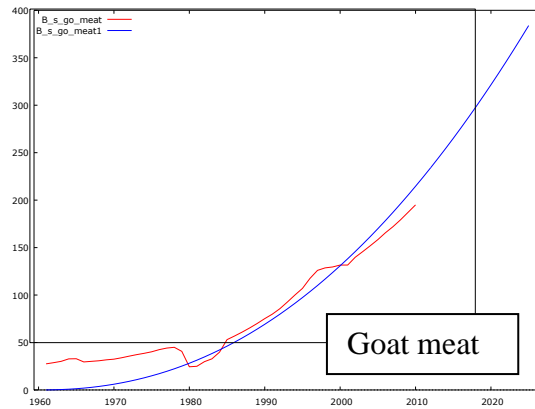
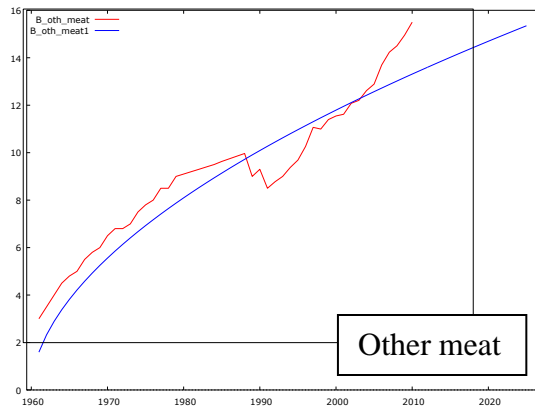
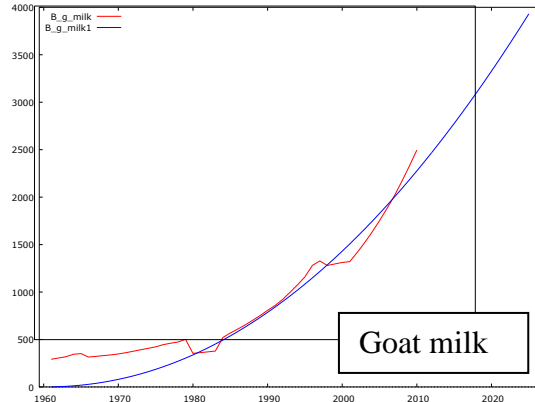
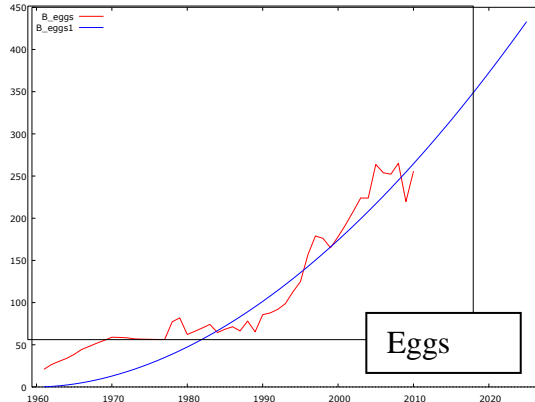




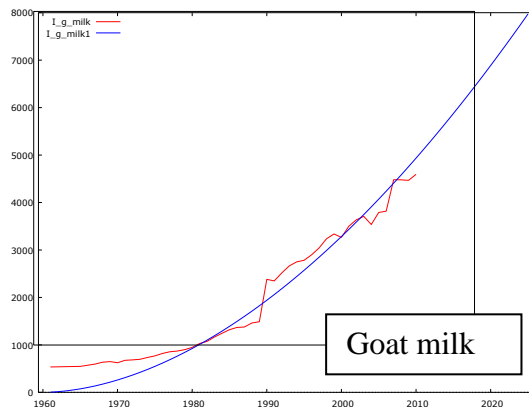
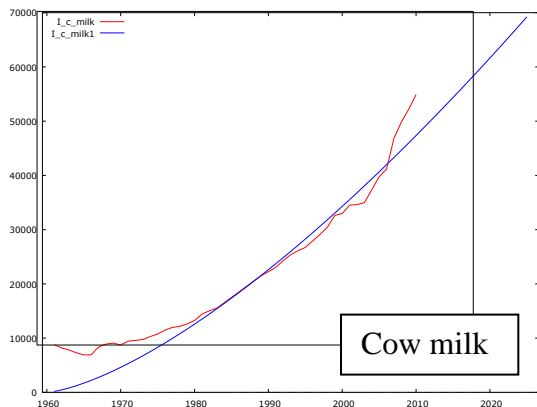
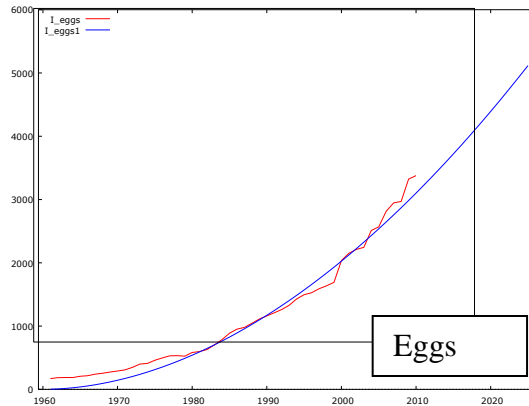
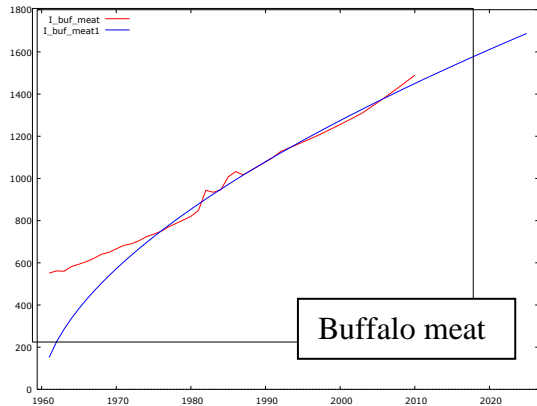
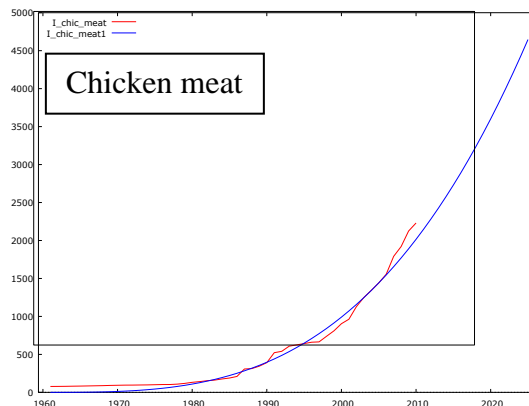
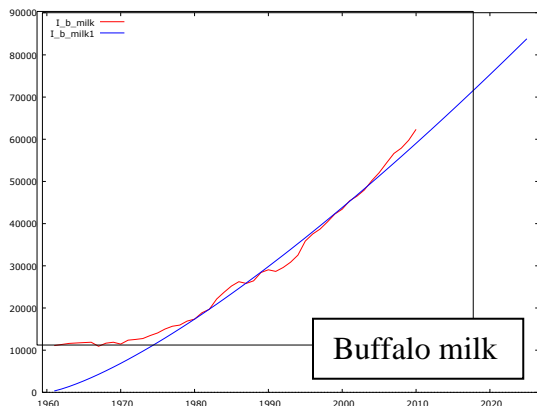
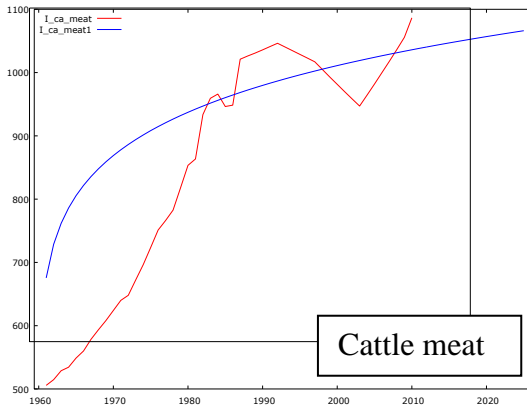
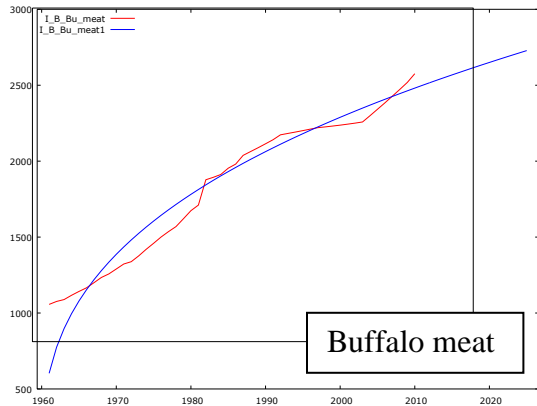


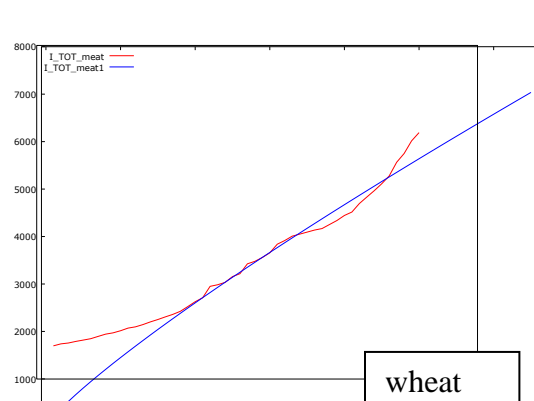
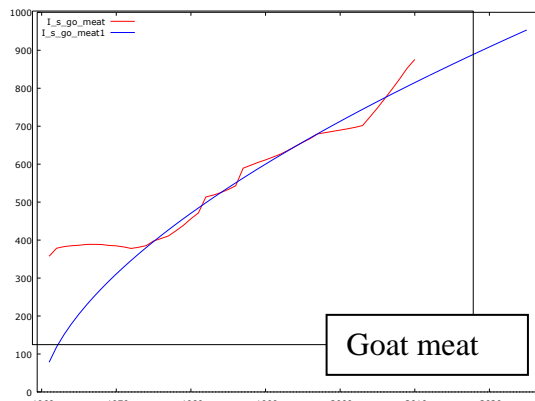
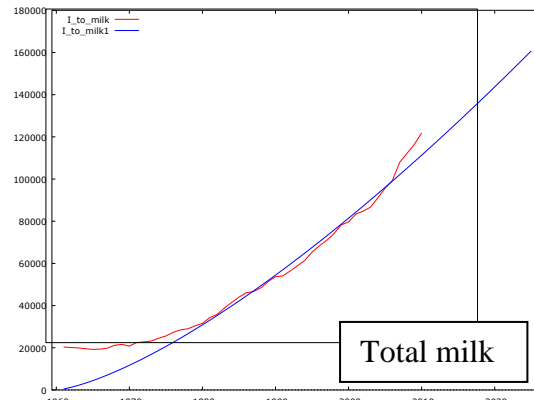
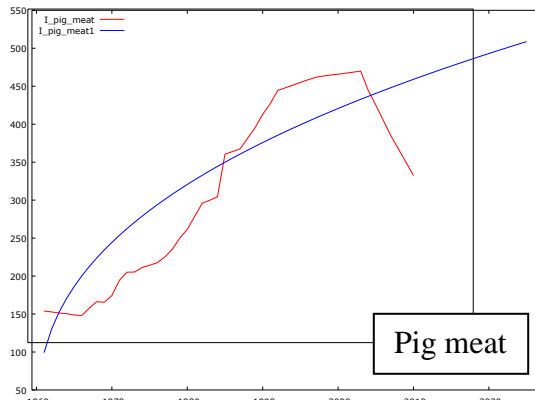
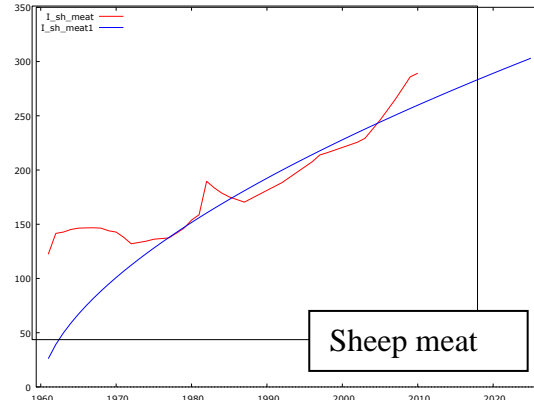
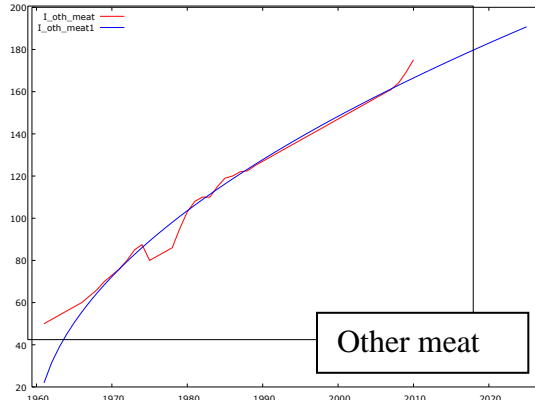
# Bangladesh: Evolution of animal productions



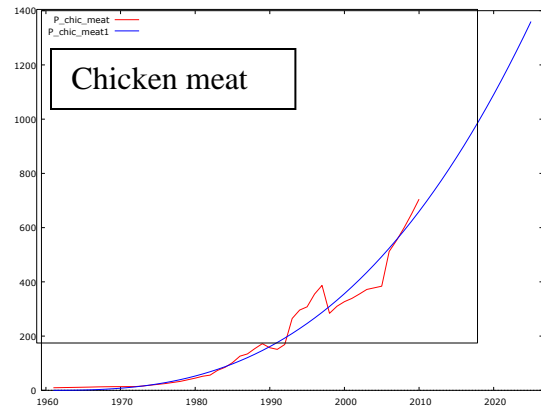
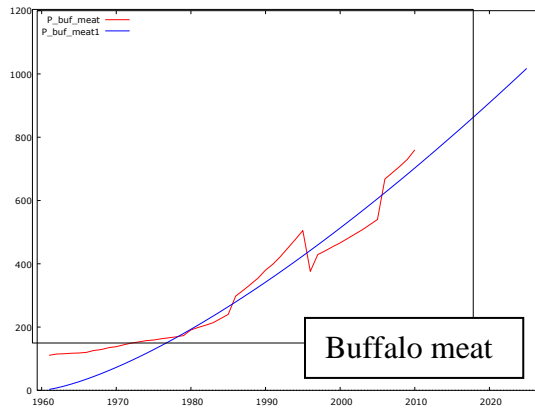
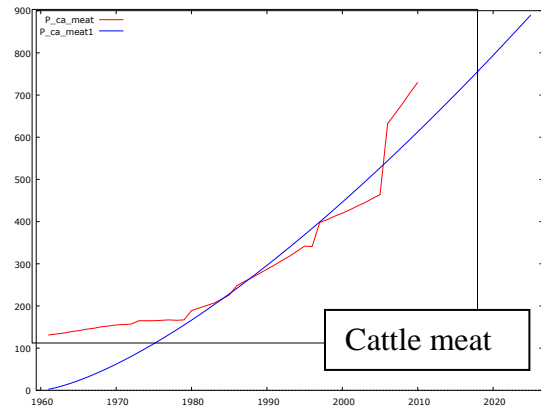
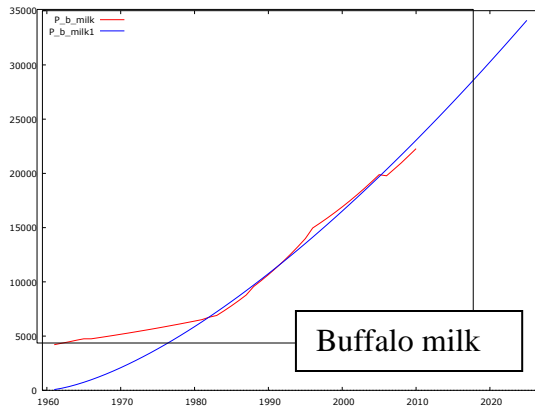
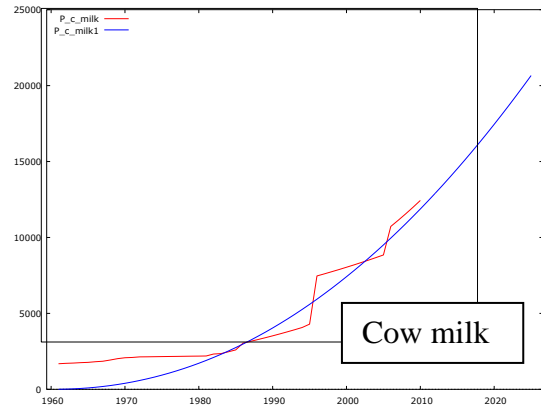
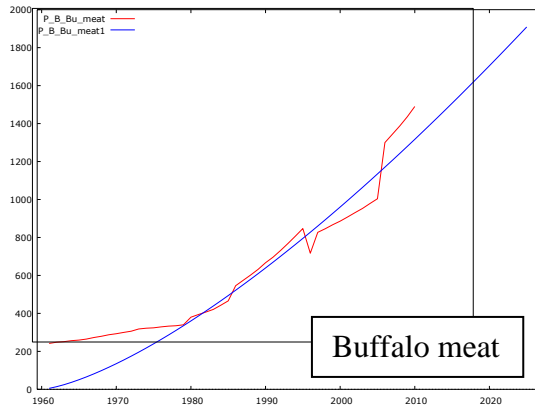


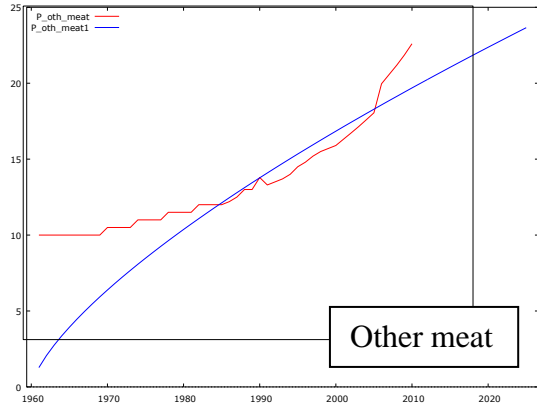
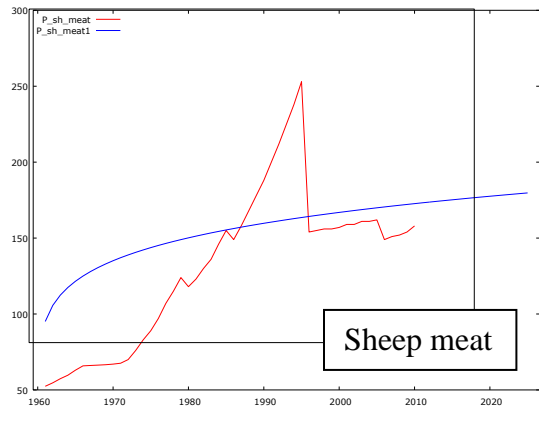
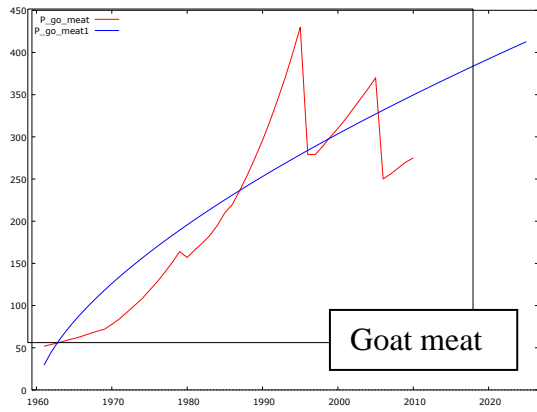
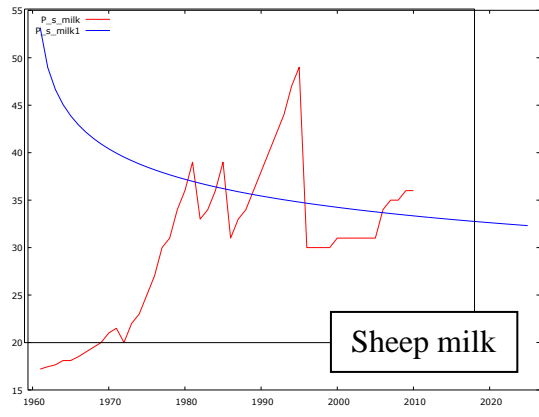
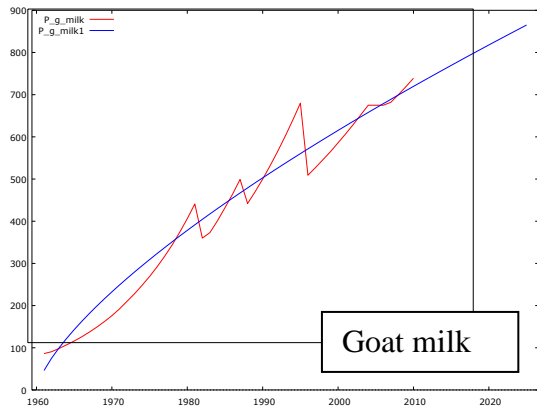
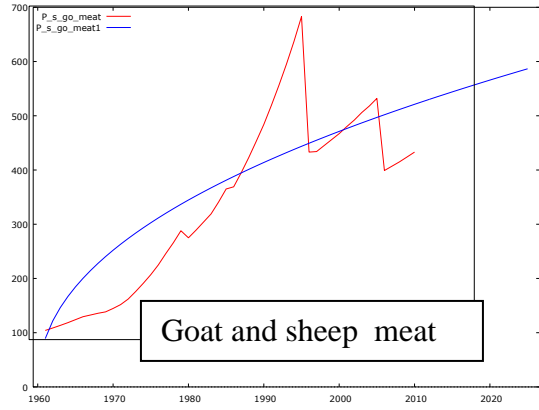
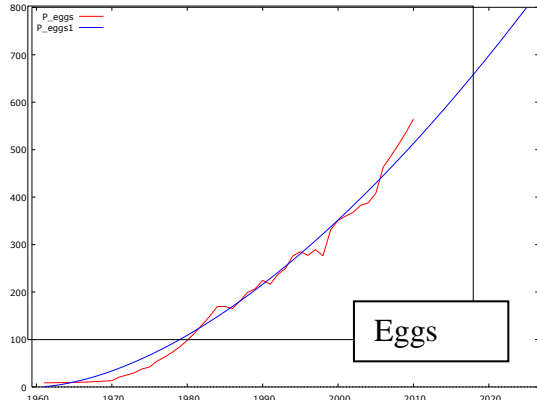
# India: Evolution of animal productions

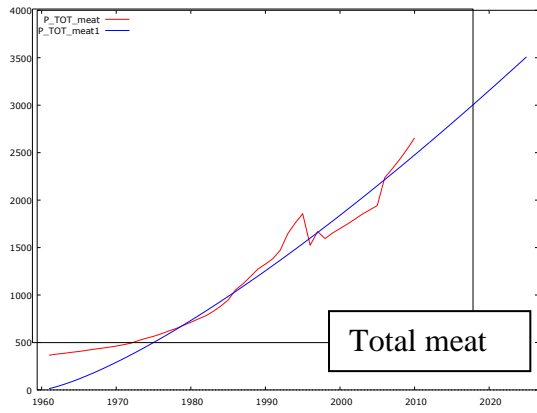
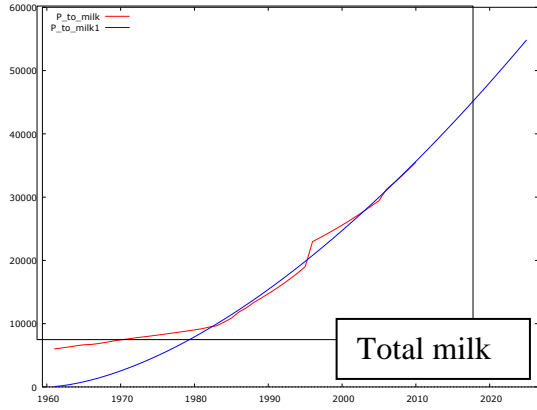




## Pakistan: Evolution of animal productions







## Annex C: Variations<sup>68</sup> of different exogenous variables in the different scenarios for each country and total.

**Table 88: Definitions and names of the various scenarios for 2009 and 2025**

	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
Specification of scenario	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
Constraints on specific products														
For all countries														
Variation of solde														
Total milk (kt)	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500			
Total Sugarcrops (kt)	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100	-100;+100			
Total brans (kt)	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000			
Constraints on other products														
Pakistan (kt)	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500			
India (kt)	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000	-1000;+1000			
Bangladesh (kt)	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500	-500;+500			
Constraints on all products														
Pakistan (kt)												-2500;+2500	-2500;+2500	-INF;+INF
India (kt)												-7500;+7500	-7500;+7500	-INF;+INF
Bangladesh (kt)												-2500;+2500	-2500;+2500	-INF;+INF
Sum of the three countries													-5000;+5000	-INF;+INF

<sup>68</sup> These « variations » are the differences, either in level or in percentage, between the calculated final value of the corresponding variable in the scenario and the observed initial value of this variable in 2009.



**Table 89: Variations of productions of all products in the different scenarios for Pakistan**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>PAKISTAN</b>														
Wheat	346	21	1398	1040	-11	2	7	159	43	1	29	5063	5315	5762
Rice	-117	2	220	340	-1	1	49	-2	4	0	1	878	526	948
Maize	62	7	142	125	-3	0	-12	56	14	0	7	196	317	69
Millet	72	3	51	-4	-1	0	-16	25	5	0	3	60	277	-7
Sorghum	30	0	36	8	0	0	-11	2	0	0	0	21	117	-15
Other cereals	0	0	4	4	0	0	0	0	0	0	0	2	2	2
Total pulses	0	0	55	55	0	0	0	0	0	0	0	86	86	86
Total sugar crops	-2113	-66	911	3059	34	0	130	-521	-133	-3	-96	8250	3870	7231
Soybean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower seed	0	0	21	21	0	0	0	0	0	0	0	176	176	176
Rapeseed	16	-1	38	14	0	0	-1	-6	-2	0	-1	73	108	73
Cottonseed	6	-1	223	212	1	-1	-3	-7	-2	0	-1	908	951	900
Otherseeds	0	0	27	27	0	0	0	0	0	0	0	226	226	226
Total sugar	-214	-7	92	309	3	0	13	-53	-13	0	-10	834	391	731
Total molasses	-75	-2	33	109	1	0	5	-19	-5	0	-3	295	138	258
Soybean oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower oil	0	0	7	7	0	0	0	0	0	0	0	58	58	58
Rapeseed oil	6	0	13	5	0	0	0	-2	-1	0	0	25	38	26
Cotton oil	1	0	40	38	0	0	-1	-1	0	0	0	162	170	161
Other oils	0	0	9	9	0	0	0	0	0	0	0	72	72	72
Soybean cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed cake	10	-1	24	8	0	0	-1	-4	-1	0	0	45	67	45
Sunflower cake	0	0	9	9	0	0	0	0	0	0	0	79	79	79
Cotton cake	3	-1	112	106	0	0	-2	-4	-1	0	-1	454	475	450
Other cakes	0	0	12	12	0	0	0	0	0	0	0	100	100	100
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bovine meat	0	0	0	0	72	0	0	0	0	0	0	473	473	473
Ovine meat	0	0	0	0	21	0	0	0	0	0	0	163	163	163
Pig meat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicken meat	0	0	0	0	33	0	0	0	0	0	0	707	707	707
Other meats	0	0	0	0	1	0	0	0	0	0	0	2	2	2
Total eggs	0	0	0	0	27	0	0	0	0	0	0	263	263	263
Total milk	0	0	0	0	1718	0	0	0	0	0	0	20483	20483	20483
Total	-1967	-46	3475	5514	1896	2	158	-378	-92	-2	-72	40156	35648	39524
Total cereals	393	33	1851	1513	-16	4	17	239	66	2	40	6220	6552	6760
Total oilseeds	22	-2	309	274	1	-1	-4	-13	-4	0	-2	1383	1461	1375
Total pulses	0	0	55	55	0	0	0	0	0	0	0	86	86	86
Total sugar crops	-2113	-66	911	3059	34	0	130	-521	-133	-3	-96	8250	3870	7231
Total vegetal products	-1697	-35	3126	4901	18	3	143	-295	-71	-2	-58	15939	11969	15452
Total meat	0	0	0	0	127	0	0	0	0	0	0	1345	1345	1345
Total eggs	0	0	0	0	27	0	0	0	0	0	0	263	263	263
Total milk	0	0	0	0	1718	0	0	0	0	0	0	20483	20483	20483
Total vegetal oils	7	0	69	58	0	0	-1	-3	-1	0	0	317	337	316
Total cakes	13	-1	157	136	1	0	-2	-7	-2	0	-1	679	722	675
Total sugar	-214	-7	92	309	3	0	13	-53	-13	0	-10	834	391	731
Total molasses	-75	-2	33	109	1	0	5	-19	-5	0	-3	295	138	258
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	-1967	-46	3475	5514	1896	2	158	-378	-92	-2	-72	40156	35648	39524

Source: Own calculation, Unit: Thousands tons

**Table 90: Variations of productions of all products in the different scenarios for India**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>INDIA</b>														
Wheat	-2140	601	2144	2528	2200	0	129	1336	1206	353	160	37105	36367	16201
Rice	453	253	2542	3054	157	-9	330	38	509	149	67	28725	28665	25213
Maize	821	33	1014	600	-319	0	168	-247	67	20	9	6139	7375	7166
Millet	78	-79	995	656	-86	1	-80	-63	-158	-46	-21	1364	878	2370
Sorghum	257	-18	238	533	-379	0	105	-248	-35	-10	-5	-1795	-383	1131
Other cereals	0	0	85	85	0	0	0	0	0	0	0	110	110	110
Total pulses	703	73	1318	767	-221	0	160	-96	146	43	19	2401	1113	3110
Total sugarcrops	-8802	-678	2000	12251	1405	-57	-1055	86	-1361	-398	-180	58629	65106	60655
Soybean	25	-124	550	263	527	0	-488	450	-250	-73	-33	2683	10586	1058
Sunflowerseed	0	0	45	45	0	0	0	0	0	0	0	221	221	221
Rapeseed	1312	0	393	-81	-354	0	119	-229	-1	0	0	-606	2115	1192
Cottonseed	-120	-51	776	713	-56	1	-57	-19	-103	-30	-14	3391	2660	4337
Other seeds	0	0	811	811	0	0	0	0	0	0	0	3973	3973	3973
Total sugar	-948	-73	215	1319	151	-6	-114	9	-147	-43	-19	6313	7010	6531
Total molasses	-230	-18	52	320	37	-1	-28	2	-36	-10	-5	1534	1703	1587
Soybean oil	4	-22	98	47	94	0	-87	80	-44	-13	-6	476	1880	188
Sunflower oil	0	0	15	15	0	0	0	0	0	0	0	75	75	75
Rapeseed oil	468	0	140	-29	-126	0	43	-82	0	0	0	-616	754	425
Cotton oil	-21	-9	138	127	-10	0	-10	-3	-18	-5	-2	604	474	773
Other oils	0	0	317	317	0	0	0	0	0	0	0	1552	1552	1552
Soybean cake	20	-100	440	210	421	0	-391	360	-200	-58	-26	2146	8469	847
Rapeseed cake	787	0	236	-49	-212	0	71	-137	0	0	0	-364	1269	715
Sunflower cake	0	0	20	20	0	0	0	0	0	0	0	99	99	99
Cotton cake	-60	-26	388	356	-28	0	-29	-10	-52	-15	-7	1695	1330	2168
Other cakes	0	0	675	675	0	0	0	0	0	0	0	3310	3310	3310
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bovine meat	0	0	0	0	126	0	0	0	0	0	0	682	682	682
Ovine meat	0	0	0	0	43	0	0	0	0	0	0	100	100	100
Pig meat	0	0	0	0	18	0	0	0	0	0	0	0	0	0
Chicken meat	0	0	0	0	103	0	0	0	0	0	0	2013	2013	2013
Other meats	0	0	0	0	8	0	0	0	0	0	0	22	22	22
Total eggs	0	0	0	0	166	0	0	0	0	0	0	1677	1677	1677
Total milk	0	0	0	0	5547	0	0	0	0	0	0	63570	63570	63570
Total	-7393	-238	15646	25555	9212	-71	-1212	1227	-478	-140	-63	227628	254773	213070
Total cereals	-530	791	7017	7456	1573	-8	652	815	1589	465	210	71647	73012	52191
Total oilseeds	1217	-176	2575	1750	117	1	-426	202	-354	-104	-47	9662	19554	10781
Total pulses	703	73	1318	767	-221	0	160	-96	146	43	19	2401	1113	3110
Total sugarcrops	-8802	-678	2000	12251	1405	-57	-1055	86	-1361	-398	-180	58629	65106	60655
Total vegetal products	-7413	10	12911	22224	2874	-64	-668	1007	19	6	3	142339	158785	126738
Total meat	0	0	0	0	298	0	0	0	0	0	0	2816	2816	2816
Total eggs	0	0	0	0	166	0	0	0	0	0	0	1677	1677	1677
Total milk	0	0	0	0	5547	0	0	0	0	0	0	63570	63570	63570
Total vegetal oils	451	-31	708	477	-43	0	-54	-5	-63	-18	-8	2492	4735	3013
Total cakes	747	-125	1760	1214	181	0	-348	213	-252	-74	-33	6887	14476	7139
Total sugar	-948	-73	215	1319	151	-6	-114	9	-147	-43	-19	6313	7010	6531
Total molasses	-230	-18	52	320	37	-1	-28	2	-36	-10	-5	1534	1703	1587
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	-7393	-238	15646	25555	9212	-71	-1212	1227	-478	-140	-63	227628	254773	213070

Source: Own calculation, Unit: Thousands tons

**Table 91: Variations of productions of all products in the different scenarios for Bangladesh**

Specification of scenario	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	BANGLADESH						Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
						Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat			
Wheat	-1	-1	43	43	1	0	-2	2	-2	-1	0	44	55	55
Rice	0	0	1592	1592	-2	0	0	-2	1	0	0	6374	6361	6362
Maize	20	21	19	19	-5	1	40	-26	43	18	0	421	281	293
Millet	0	0	1	1	0	0	0	0	0	0	0	2	2	2
Sorghum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cereals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total pulses	0	0	10	10	0	0	0	0	0	0	0	14	14	14
Total sugar crops	-2	-2	263	263	2	0	-3	-3	-4	-1	0	-380	-376	-371
Soybean	0	0	3	3	0	0	0	0	0	0	0	6	6	6
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	0	0	10	10	0	0	0	1	0	0	0	11	15	13
Cottonseed	0	0	1	1	0	0	0	0	0	0	0	5	6	5
Otherseeds	0	0	7	7	0	0	0	0	0	0	0	16	16	16
Total sugar	0	0	40	40	0	0	0	-1	-1	0	0	-58	-58	-57
Total molasses	0	0	5	5	0	0	0	0	0	0	0	-7	-7	-7
Soybean oil	0	0	1	1	0	0	0	0	0	0	0	1	1	1
Sunflower oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed oil	0	0	3	3	0	0	0	0	0	0	0	3	4	4
Cotton oil	0	0	0	0	0	0	0	0	0	0	0	1	1	1
Other oils	0	0	1	1	0	0	0	0	0	0	0	3	3	3
Soybean cake	0	0	2	2	0	0	0	0	0	0	0	5	5	5
Rapeseed cake	0	0	6	6	0	0	0	1	0	0	0	7	9	8
Sunflower cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton cake	0	0	1	1	0	0	0	0	0	0	0	3	3	3
Other cakes	0	0	2	2	0	0	0	0	0	0	0	4	4	4
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bovine meat	0	0	0	0	10	0	0	0	0	0	0	33	33	33
Ovine meat	0	0	0	0	9	0	0	0	0	0	0	197	197	197
Pig meat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicken meat	0	0	0	0	10	0	0	0	0	0	0	102	102	102
Othermeats	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Total eggs	0	0	0	0	11	0	0	0	0	0	0	213	213	213
Total milk	0	0	0	0	161	0	0	0	0	0	0	1686	1686	1686
Total	17	18	2011	2011	199	1	35	-29	36	15	0	8708	8577	8594
Total cereals	20	20	1655	1654	-5	1	39	-26	42	17	0	6842	6699	6712
Total oilseeds	0	0	22	22	0	0	0	1	0	0	0	39	43	41
Total pulses	0	0	10	10	0	0	0	0	0	0	0	14	14	14
Total sugarcrops	-2	-2	263	263	2	0	-3	-3	-4	-1	0	-380	-376	-371
Total vegetal products	18	18	1950	1949	-3	1	36	-29	37	16	0	6515	6380	6397
Total meat	0	0	0	0	30	0	0	0	0	0	0	332	332	332
Total eggs	0	0	0	0	11	0	0	0	0	0	0	213	213	213
Total milk	0	0	0	0	161	0	0	0	0	0	0	1686	1686	1686
Total vegetal oils	0	0	5	5	0	0	0	0	0	0	0	9	10	9
Total cakes	0	0	11	11	0	0	0	1	0	0	0	18	21	20
Total sugar	0	0	40	40	0	0	0	-1	-1	0	0	-58	-58	-57
Total molasses	0	0	5	5	0	0	0	0	0	0	0	-7	-7	-7
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	17	18	2011	2011	199	1	35	-29	36	15	0	8708	8577	8594

Source: Own calculation, Unit: Thousands tons

**Table 92: Variations of prices of all products in the different scenarios for Pakistan**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>PAKISTAN</b>														
Wheat	3.68%	1.47%	-9.82%	-7.59%	-0.73%	0.00%	1.29%	0.00%	2.96%	0.08%	1.45%	8.02%	5.71%	22.33%
Rice	-12.78%	0.42%	-9.90%	-1.59%	-0.26%	0.00%	-3.31%	0.00%	0.85%	0.02%	0.32%	2.89%	-54.29%	53.66%
Maize	-2.58%	0.10%	3.80%	0.93%	-0.01%	0.00%	2.72%	0.00%	0.19%	0.01%	-0.12%	0.65%	-29.30%	40.19%
Millet	2.90%	0.05%	3.37%	-0.65%	-0.03%	0.00%	-0.42%	0.00%	0.10%	0.00%	0.11%	0.50%	5.59%	39.21%
Sorghum	-2.40%	0.05%	3.12%	0.31%	-0.06%	0.00%	-3.00%	0.00%	0.10%	0.00%	-0.04%	0.83%	-23.45%	21.41%
Other cereals	-0.05%	0.00%	0.11%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	0.14%	23.35%
Total pulses	-8.78%	0.43%	0.99%	0.31%	-0.22%	0.00%	0.00%	0.00%	0.86%	0.02%	0.04%	2.84%	-34.61%	26.92%
Total sugar crops	-19.57%	0.10%	-21.63%	2.08%	-0.04%	0.00%	1.28%	0.00%	0.21%	0.01%	-0.29%	0.49%	-40.85%	0.00%
Soybean	2.33%	0.06%	0.67%	0.19%	-0.02%	0.00%	0.80%	0.00%	0.12%	0.00%	-0.01%	0.32%	9.30%	0.00%
Sunflowerseed	2.56%	0.06%	0.62%	0.18%	-0.03%	0.00%	0.00%	0.00%	0.13%	0.00%	-0.01%	0.41%	14.76%	0.00%
Rapeseed	5.47%	0.06%	4.91%	0.41%	-0.03%	0.00%	0.46%	0.00%	0.13%	0.00%	-0.05%	0.38%	20.97%	0.00%
Cottonseed	3.48%	0.07%	4.28%	0.72%	-0.04%	0.00%	-0.58%	0.00%	0.14%	0.00%	-0.09%	0.38%	28.27%	0.00%
Otherseeds	2.76%	0.07%	0.74%	0.21%	-0.04%	0.00%	0.00%	0.00%	0.14%	0.00%	-0.02%	0.43%	15.66%	0.00%
Total sugar	-4.19%	0.02%	-4.70%	0.45%	-0.01%	0.00%	0.28%	0.00%	0.05%	0.00%	-0.06%	0.11%	-8.46%	0.00%
Total molasses	-2.11%	-0.02%	-0.31%	-0.03%	0.01%	0.00%	0.01%	0.00%	-0.03%	0.00%	0.00%	-0.08%	-12.75%	0.00%
Soybean oil	3.75%	0.10%	1.00%	0.28%	-0.04%	0.00%	0.72%	0.00%	0.19%	0.01%	-0.02%	0.61%	24.45%	0.00%
Sunflower oil	1.59%	0.04%	0.55%	0.15%	-0.02%	0.00%	0.00%	0.00%	0.08%	0.00%	-0.01%	0.23%	8.88%	0.00%
Rapeseed oil	3.45%	0.04%	3.01%	0.25%	-0.02%	0.00%	0.29%	0.00%	0.08%	0.00%	-0.03%	0.22%	15.17%	0.00%
Cotton oil	2.92%	0.06%	3.48%	0.59%	-0.04%	0.00%	-0.46%	0.00%	0.12%	0.00%	-0.08%	0.32%	24.54%	0.00%
Other oils	2.42%	0.06%	0.67%	0.19%	-0.03%	0.00%	0.00%	0.00%	0.12%	0.00%	-0.01%	0.38%	13.86%	0.00%
Soybean cake	-1.21%	-0.03%	-0.24%	-0.07%	0.02%	0.00%	0.46%	0.00%	-0.06%	0.00%	0.00%	-0.31%	-19.59%	0.00%
Rapeseed cake	-0.36%	-0.01%	0.46%	0.06%	0.01%	0.00%	0.03%	0.00%	-0.02%	0.00%	-0.01%	0.10%	-19.30%	0.00%
Sunflower cake	1.88%	0.00%	-4.66%	-1.26%	0.00%	0.00%	0.00%	0.00%	-0.01%	0.00%	0.19%	1.14%	19.55%	0.00%
Cottoncake	-0.38%	-0.01%	0.25%	0.01%	0.01%	0.00%	-0.07%	0.00%	-0.03%	0.00%	0.00%	0.01%	-8.21%	0.00%
Othercakes	-0.11%	-0.01%	-0.29%	-0.08%	0.00%	0.00%	0.00%	0.00%	-0.01%	0.00%	0.01%	-0.09%	-2.69%	0.00%
Total brans	0.01%	0.00%	-0.02%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	20.80%	69.42%
Bovine meat	0.14%	0.78%	0.31%	0.17%	-0.40%	0.00%	0.00%	0.00%	1.58%	0.04%	0.14%	5.00%	3.83%	-100.00%
Ovine meat	5.96%	0.44%	-1.31%	-0.31%	-0.22%	0.00%	0.00%	0.00%	0.89%	0.02%	0.14%	2.86%	41.71%	241.28%
Pig meat	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Chicken meat	-0.17%	0.16%	0.11%	0.05%	-0.08%	0.00%	0.00%	0.00%	0.32%	0.01%	0.03%	1.01%	-0.55%	364.92%
Other meats	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total eggs	0.48%	0.20%	-0.03%	0.01%	-0.10%	0.00%	0.00%	0.00%	0.39%	0.01%	0.04%	1.25%	3.92%	410.03%
Total milk	3.54%	7.83%	2.55%	1.55%	-3.96%	0.00%	-0.01%	0.00%	15.77%	0.39%	1.45%	50.04%	53.00%	118.23%

Source: Own calculation, Unit: Percentage change from initial value of 2009

**Table 93: Variations of prices of all products in the different scenarios for India**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>INDIA</b>														
Wheat	-16.51%	3.33%	-6.99%	-1.56%	9.41%	0.00%	0.00%	-1.80%	6.69%	1.96%	0.89%	104.47%	77.86%	22.33%
Rice	21.11%	7.26%	-13.56%	-20.05%	-1.46%	0.00%	0.00%	-0.37%	14.57%	-4.26%	1.93%	133.79%	171.94%	53.66%
Maize	9.87%	0.39%	-4.24%	-8.10%	-2.15%	0.00%	0.00%	0.33%	0.78%	0.23%	0.10%	65.60%	64.51%	40.19%
Millet	-14.04%	0.56%	-2.97%	5.37%	-1.92%	0.00%	0.00%	0.01%	1.13%	0.33%	0.15%	-5.46%	-32.92%	39.21%
Sorghum	-13.94%	0.56%	3.92%	14.62%	-4.05%	0.00%	0.00%	0.46%	1.13%	0.33%	0.15%	-32.58%	-43.99%	21.41%
Other cereals	-2.32%	0.00%	-0.48%	0.79%	0.03%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	-3.40%	-18.79%	23.35%
Total pulses	-4.38%	0.00%	-1.34%	1.94%	0.80%	0.00%	0.00%	0.10%	0.00%	0.00%	0.00%	13.65%	-11.40%	26.92%
Total sugar crops	30.38%	0.63%	4.48%	-13.31%	-1.84%	0.00%	0.00%	0.09%	1.26%	0.37%	0.17%	6.84%	128.32%	0.00%
Soybean	-18.81%	0.11%	2.08%	12.31%	-0.59%	0.00%	0.00%	-0.10%	0.23%	0.07%	0.03%	0.55%	15.20%	0.00%
Sunflowerseed	1.02%	0.20%	-1.35%	-0.97%	-0.44%	0.00%	0.00%	0.05%	0.39%	0.11%	0.05%	3.42%	-1.64%	0.00%
Rapeseed	-2.90%	0.19%	-14.26%	-4.68%	-1.43%	0.00%	0.00%	0.32%	0.38%	0.11%	0.05%	-19.47%	-38.17%	0.00%
Cottonseed	2.74%	0.18%	25.45%	14.28%	-3.90%	0.00%	0.00%	0.29%	0.37%	0.11%	0.05%	-18.14%	-23.18%	0.00%
Otherseeds	1.99%	0.19%	-2.81%	-3.01%	0.35%	0.00%	0.00%	-0.01%	0.38%	0.11%	0.05%	20.87%	32.13%	0.00%
Total sugar	8.34%	0.17%	1.17%	-3.69%	-0.49%	0.00%	0.00%	0.02%	0.34%	0.10%	0.05%	2.49%	35.36%	0.00%
Total molasses	-7.80%	-0.05%	1.66%	4.91%	-0.05%	0.00%	0.00%	-0.01%	-0.11%	-0.03%	-0.01%	-28.27%	-38.35%	0.00%
Soybean oil	0.13%	0.31%	-7.76%	-3.89%	-0.23%	0.00%	0.00%	0.01%	0.63%	0.18%	0.08%	12.31%	30.65%	0.00%
Sunflower oil	0.85%	0.19%	-1.50%	-1.07%	-0.43%	0.00%	0.00%	0.05%	0.38%	0.11%	0.05%	-4.23%	-6.70%	0.00%
Rapeseed oil	-1.54%	0.17%	-10.96%	-3.53%	-1.26%	0.00%	0.00%	0.27%	0.33%	0.10%	0.04%	-19.99%	-30.25%	0.00%
Cotton oil	-1.40%	0.19%	20.46%	13.32%	-3.07%	0.00%	0.00%	0.24%	0.37%	0.11%	0.05%	-16.60%	-23.42%	0.00%
Other oils	-1.91%	0.19%	-2.42%	-0.82%	0.21%	0.00%	0.00%	0.01%	0.37%	0.11%	0.05%	0.49%	2.10%	0.00%
Soybean cake	-19.45%	-0.11%	7.83%	15.52%	-0.43%	0.00%	0.00%	-0.12%	-0.22%	-0.07%	-0.03%	-8.46%	-6.82%	0.00%
Rapeseed cake	-5.08%	-0.04%	-5.68%	-2.24%	0.33%	0.00%	0.00%	-0.01%	-0.08%	-0.02%	-0.01%	20.93%	-9.92%	0.00%
Sunflower cake	1.46%	-0.02%	1.99%	1.30%	-0.02%	0.00%	0.00%	0.00%	-0.04%	-0.01%	-0.01%	77.75%	52.53%	0.00%
Cotton cake	10.85%	-0.07%	5.85%	-1.95%	-1.07%	0.00%	0.00%	0.05%	-0.15%	-0.04%	-0.02%	1.55%	8.23%	0.00%
Other cakes	13.72%	-0.06%	-0.54%	-7.09%	0.40%	0.00%	0.00%	-0.07%	-0.11%	-0.03%	-0.01%	68.25%	100.14%	0.00%
Total brans	7.81%	0.00%	-5.16%	-7.15%	0.13%	0.00%	0.00%	0.03%	0.00%	0.00%	0.00%	-1.38%	1.92%	69.42%
Bovine meat	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ovine meat	21.39%	-0.31%	-8.52%	-19.47%	3.91%	0.00%	0.00%	-0.39%	-0.63%	-0.18%	-0.08%	29.38%	110.44%	241.28%
Pig meat	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Chicken meat	5.66%	0.51%	-1.10%	-3.83%	-0.15%	0.00%	0.00%	-0.03%	1.02%	0.30%	0.13%	15.73%	35.61%	364.92%
Other meats	2.39%	0.08%	-0.74%	-1.93%	0.21%	0.00%	0.00%	-0.03%	0.15%	0.04%	0.02%	4.79%	13.56%	254.61%
Total eggs	3.55%	0.25%	-0.82%	-2.55%	0.04%	0.00%	0.00%	-0.03%	0.51%	0.15%	0.07%	8.97%	21.59%	410.03%
Total milk	-3.06%	7.49%	15.75%	19.48%	-15.59%	0.00%	0.00%	0.93%	15.04%	4.40%	1.99%	96.39%	64.81%	118.23%

Source: Own calculation, Unit: Percentage change from initial value of 2009

**Table 94: Variations of prices of all products in the different scenarios for Bangladesh**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>BANGLADESH</b>														
Wheat	0.50%	0.51%	0.01%	0.04%	-1.45%	0.00%	0.00%	0.00%	1.71%	0.43%	0.00%	13.55%	53.86%	22.33%
Rice	5.40%	5.51%	-4.45%	-4.62%	-1.50%	0.00%	0.00%	0.00%	11.47%	4.71%	0.00%	76.75%	71.25%	53.66%
Maize	0.02%	0.02%	1.56%	1.73%	-5.01%	0.00%	0.00%	0.00%	2.51%	0.02%	0.00%	63.29%	56.31%	40.19%
Millet	0.01%	0.01%	0.00%	0.00%	-0.03%	0.00%	0.00%	0.00%	0.03%	0.01%	0.00%	0.18%	0.86%	39.21%
Sorghum	0.01%	0.01%	1.20%	1.33%	-3.83%	0.00%	0.00%	0.00%	1.90%	0.01%	0.00%	48.58%	44.60%	21.41%
Other cereals	0.00%	0.00%	0.10%	0.12%	-0.33%	0.00%	0.00%	0.00%	0.16%	0.00%	0.00%	4.22%	2.45%	23.35%
Total pulses	0.00%	0.00%	0.25%	0.28%	-0.80%	0.00%	0.00%	0.00%	0.39%	0.00%	0.00%	10.17%	9.18%	26.92%
Total sugar crops	0.11%	0.12%	0.06%	0.07%	-0.52%	0.00%	0.00%	0.00%	0.49%	0.10%	0.00%	1.26%	12.21%	0.00%
Soybean	0.02%	0.02%	0.01%	0.02%	-0.10%	0.00%	0.00%	0.00%	0.09%	0.02%	0.00%	0.78%	0.39%	0.00%
Sunflowerseed	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Rapeseed	0.02%	0.03%	0.00%	0.00%	-0.05%	0.00%	0.00%	0.00%	0.08%	0.02%	0.00%	0.02%	-0.35%	0.00%
Cottonseed	0.02%	0.02%	0.00%	0.00%	-0.06%	0.00%	0.00%	0.00%	0.07%	0.02%	0.00%	0.17%	0.06%	0.00%
Otherseeds	0.03%	0.03%	0.01%	0.01%	-0.10%	0.00%	0.00%	0.00%	0.10%	0.02%	0.00%	0.63%	0.40%	0.00%
Total sugar	0.04%	0.04%	0.02%	0.02%	-0.17%	0.00%	0.00%	0.00%	0.16%	0.03%	0.00%	0.38%	4.03%	0.00%
Total molasses	-0.01%	-0.01%	0.05%	0.06%	-0.15%	0.00%	0.00%	0.00%	0.06%	0.00%	0.00%	2.17%	1.60%	0.00%
Soybean oil	0.03%	0.03%	0.00%	0.00%	-0.09%	0.00%	0.00%	0.00%	0.11%	0.03%	0.00%	0.37%	0.24%	0.00%
Sunflower oil	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Rapeseed oil	0.02%	0.02%	0.02%	0.02%	-0.12%	0.00%	0.00%	0.00%	0.10%	0.02%	0.00%	0.97%	0.69%	0.00%
Cotton oil	0.01%	0.01%	0.01%	0.02%	-0.08%	0.00%	0.00%	0.00%	0.07%	0.01%	0.00%	0.70%	0.52%	0.00%
Other oils	0.03%	0.03%	0.00%	0.00%	-0.08%	0.00%	0.00%	0.00%	0.09%	0.02%	0.00%	0.46%	0.20%	0.00%
Soybean cake	-0.01%	-0.01%	0.02%	0.03%	-0.04%	0.00%	0.00%	0.00%	0.00%	-0.01%	0.00%	0.83%	0.33%	0.00%
Rapeseed cake	0.00%	0.00%	-0.17%	-0.19%	0.56%	0.00%	0.00%	0.00%	-0.28%	0.00%	0.00%	-6.98%	-7.17%	0.00%
Sunflower cake	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	-0.01%	0.00%	0.00%	-0.04%	-0.02%	0.00%
Cotton cake	-0.01%	-0.01%	-0.07%	-0.08%	0.25%	0.00%	0.00%	0.00%	-0.14%	-0.01%	0.00%	-3.06%	-2.44%	0.00%
Other cakes	0.00%	0.00%	0.06%	0.06%	-0.17%	0.00%	0.00%	0.00%	0.08%	0.00%	0.00%	2.26%	2.57%	0.00%
Total brans	0.00%	0.00%	-0.06%	-0.06%	0.18%	0.00%	0.00%	0.00%	-0.09%	0.00%	0.00%	-2.33%	-0.46%	69.42%
Bovine meat	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Ovine meat	0.91%	0.93%	0.30%	0.39%	-3.55%	0.00%	0.00%	0.00%	3.58%	0.80%	0.00%	15.53%	19.35%	241.28%
Pig meat	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Chicken meat	0.99%	1.01%	0.45%	0.55%	-4.22%	0.00%	0.00%	0.00%	4.07%	0.86%	0.00%	13.02%	16.23%	364.92%
Other meats	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total eggs	0.97%	0.99%	0.22%	0.30%	-3.46%	0.00%	0.00%	0.00%	3.64%	0.84%	0.00%	19.64%	24.48%	410.03%
Total milk	2.49%	2.55%	1.02%	1.28%	-10.32%	0.00%	0.00%	0.00%	10.09%	2.18%	0.00%	36.30%	45.24%	118.23%

Source: Own calculation, Unit: Percentage change from initial value of 2009

**Table 95: Variations of surface areas of all products in the different scenarios for Pakistan**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>PAKISTAN</b>														
Wheat	130	8	526	-61	-4	1	3	60	16	0	11	226	321	489
Rice	-49	1	92	-2	0	1	20	-1	2	0	0	63	-85	92
Maize	18	2	41	-11	-1	0	-3	16	4	0	2	29	63	-8
Millet	117	4	83	-30	-2	0	-26	40	9	0	5	31	383	-76
Sorghum	49	0	58	0	0	0	-18	3	-1	0	0	3	156	-56
Other cereals	0	0	4	0	0	0	0	0	0	0	0	2	2	2
Total pulses	0	0	80	0	0	0	0	0	0	0	0	32	32	32
Total sugar crops	-43	-1	19	11	1	0	3	-11	-3	0	-2	13	-77	-8
Soybean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflowerseed	0	0	16	0	0	0	0	0	0	0	0	6	6	6
Rapeseed	20	-1	46	4	1	0	-1	-7	-2	0	-1	0	42	0
Cottonseed	5	-1	168	4	0	-1	-2	-6	-2	0	-1	58	89	52
Otherseeds	0	0	9	0	0	0	0	0	0	0	0	4	4	4
Total cereals	264	15	804	-104	-7	1	-25	118	30	1	19	354	841	444
Total oilseeds	24	-2	239	9	1	-1	-4	-13	-4	0	-2	67	142	62
Total pulses	0	0	80	0	0	0	0	0	0	0	0	32	32	32
Total sugarcrops	-43	-1	19	11	1	0	3	-11	-3	0	-2	13	-77	-8
Total vegetal products	245	12	1141	-84	-6	1	-25	95	23	1	15	466	937	530

Source: Own calculation, Unit: Thousands hectares

**Table 96: Variations of surface areas of all products in the different scenarios for India**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>INDIA</b>														
Wheat	-736	207	738	-518	757	0	44	459	415	121	55	9492	9239	2302
Rice	213	119	1195	-661	74	-4	155	18	239	70	32	5477	5449	3827
Maize	410	17	506	-117	-160	0	84	-124	33	10	4	644	1261	1157
Millet	92	-93	1175	254	-101	1	-95	-75	-186	-54	-25	-309	-883	879
Sorghum	267	-18	247	177	-394	0	109	-257	-37	-11	-5	-2547	-1079	493
Othercer	0	0	39	0	0	0	0	0	0	0	0	51	51	51
Total pulses	1038	107	1948	87	-327	0	237	-141	215	63	29	2130	226	3178
Total sugar crops	-136	-11	31	-31	22	-1	-16	1	-21	-6	-3	148	248	179
Soybean	24	-120	533	-232	510	0	-473	436	-242	-71	-32	452	8103	-1121
Sunflowerseed	0	0	74	0	0	0	0	0	0	0	0	96	96	96
Rapeseed	1144	0	343	-386	-309	0	104	-200	-1	0	0	-1669	704	-101
Cottonseed	-149	-64	968	373	-70	1	-71	-24	-129	-38	-17	-893	-1806	286
Otherseeds	0	0	558	0	0	0	0	0	0	0	0	725	725	725
Total cereals	246	231	3899	-864	176	-3	298	22	465	136	61	12808	14037	8708
Total oilseeds	1019	-185	2475	-244	132	1	-440	212	-371	-109	-49	-1289	7822	-114
Total pulses	1038	107	1948	87	-327	0	237	-141	215	63	29	2130	226	3178
Total sugar crops	-136	-11	31	-31	22	-1	-16	1	-21	-6	-3	148	248	179
Total vegetal products	2168	143	8354	-1052	2	-3	78	94	288	84	38	13797	22334	11952

Source: Own calculation, Unit: Thousands hectares

**Table 97: Variations of surface areas of all products in the different scenarios for Bangladesh**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>BANGLADESH</b>														
Wheat	0	0	20	0	0	0	-1	1	-1	0	0	-7	-2	-2
Rice	0	0	568	0	-1	0	0	-1	0	0	0	122	117	118
Maize	4	4	3	-3	0	0	7	-5	8	3	0	56	31	33
Millet	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Sorghum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cereals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total pulses	0	0	12	0	0	0	0	0	0	0	0	2	2	2
Total sugar crops	0	0	7	0	0	0	0	0	0	0	0	0	0	0
Soybean	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	0	0	12	0	0	0	0	1	0	0	0	-1	3	1
Cottonseed	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Otherseeds	0	0	6	0	0	0	0	0	0	0	0	1	1	1
Total cereals	3	3	593	-3	-1	0	6	-4	7	3	0	171	147	150
Total oilseeds	0	0	21	0	0	0	0	1	0	0	0	0	5	3
Total pulses	0	0	12	0	0	0	0	0	0	0	0	2	2	2
Total sugar crops	0	0	7	0	0	0	0	0	0	0	0	0	0	0
Total vegetal products	3	3	632	-3	-1	0	6	-3	6	3	0	174	154	155

Source: Own calculation, Unit: Thousands hectares

**Table 98: Variations of surface areas of all products in the different scenarios for total of three countries**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>TOTAL of the three countries</b>														
Wheat	-606	214	1283	-579	753	1	46	520	430	121	66	9712	9558	2790
Rice	164	120	1855	-662	73	-4	176	16	241	70	32	5662	5482	4037
Maize	432	22	550	-131	-161	0	88	-112	45	13	6	728	1356	1183
Millet	209	-88	1259	224	-103	1	-121	-35	-177	-54	-19	-278	-500	803
Sorghum	316	-19	305	177	-394	0	91	-254	-37	-11	-5	-2544	-923	437
Other cereals	0	0	43	0	0	0	0	0	0	0	0	52	52	52
Total pulses	1038	107	2040	87	-327	0	237	-141	215	63	29	2164	261	3213
Total sugar crops	-180	-12	57	-20	23	-1	-14	-9	-24	-6	-5	161	171	172
Soybean	24	-120	535	-232	510	0	-473	436	-242	-71	-32	453	8103	-1120
Sunflowerseed	0	0	90	0	0	0	0	0	0	0	0	103	103	103
Rapeseed	1164	-1	401	-381	-308	0	102	-206	-3	0	-1	-1671	749	-100
Cottonseed	-145	-65	1136	378	-69	0	-74	-30	-131	-38	-18	-836	-1716	338
Otherseeds	0	0	573	0	0	0	0	0	0	0	0	730	730	730
Total cereals	514	250	5296	-970	168	-1	280	135	501	139	80	13333	15025	9302
Total oilseeds	1044	-187	2734	-236	133	0	-444	200	-375	-109	-51	-1222	7969	-50
Total pulses	1038	107	2040	87	-327	0	237	-141	215	63	29	2164	261	3213
Total sugar crops	-180	-12	57	-20	23	-1	-14	-9	-24	-6	-5	161	171	172
Total vegetal products	2416	158	10128	-1138	-4	-2	59	185	317	87	53	14436	23426	12637

Source: Own calculation, Unit: Thousands hectares



**Table 99: Variations of external trade of all products in the different scenarios for Pakistan**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>PAKISTAN</b>														
Wheat	-500	-23	500	500	-4	2	-5	150	-47	-160	-500	-2500	-2410	-1756
Rice	-222	11	136	265	-5	1	58	-2	21	-12	-77	-106	-603	229
Maize	-190	-21	340	252	-28	0	-49	55	-43	-31	87	-1063	-2156	-544
Millet	66	5	71	1	-11	0	-18	24	10	1	2	-89	92	-7
Sorghum	19	3	46	9	-2	0	-11	2	6	1	0	-9	17	31
Other cereals	-7	0	6	7	-2	0	1	0	0	0	0	-47	-92	-50
<b>Total pulses</b>	<b>59</b>	<b>-17</b>	<b>169</b>	<b>110</b>	<b>-3</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>-34</b>	<b>2</b>	<b>-6</b>	<b>-697</b>	<b>-537</b>	<b>-570</b>
<b>Total sugar crops</b>	<b>-100</b>	<b>7</b>	<b>-100</b>	<b>-61</b>	<b>-4</b>	<b>0</b>	<b>-14</b>	<b>57</b>	<b>15</b>	<b>0</b>	<b>11</b>	<b>-2460</b>	<b>-1979</b>	<b>-2348</b>
Soybean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottonseed	37	-2	38	17	-57	0	-11	0	-4	0	-3	-833	-116	-1154
Otherseeds	-11	0	-1	0	0	0	0	0	0	0	0	-83	-83	-83
<b>Total sugar</b>	<b>-500</b>	<b>-123</b>	<b>154</b>	<b>444</b>	<b>70</b>	<b>0</b>	<b>28</b>	<b>-53</b>	<b>-249</b>	<b>61</b>	<b>112</b>	<b>-1797</b>	<b>-1276</b>	<b>-3770</b>
<b>Total molasses</b>	<b>-165</b>	<b>-4</b>	<b>76</b>	<b>140</b>	<b>-2</b>	<b>0</b>	<b>-3</b>	<b>-19</b>	<b>-8</b>	<b>0</b>	<b>-8</b>	<b>223</b>	<b>-443</b>	<b>237</b>
Soybean oil	-1	-1	0	0	0	0	0	0	-1	0	0	-15	-8	-23
Sunflower oil	-9	-5	8	9	3	0	0	0	-9	1	2	-46	-17	-102
Rapeseed oil	-5	-7	18	8	4	0	0	-2	-13	1	3	-114	-54	-189
Cotton oil	-14	-9	47	43	5	0	-1	-1	-18	2	4	-38	59	-146
Other oils	-59	-32	18	24	18	0	1	0	-64	6	15	-646	-409	-1032
Soybean cake	-1	0	-2	0	-13	0	0	0	0	0	0	-188	-214	-238
Rapeseed cake	-24	-1	40	20	-31	0	-3	-4	-2	0	-2	-392	-618	-416
Sunflower cake	145	51	-322	-250	-41	0	69	0	104	3	50	333	333	333
Cotton cake	-30	3	115	105	-67	0	16	-4	5	0	0	-437	-593	-297
Othercakes	36	1	-16	-3	-10	0	-7	0	1	0	2	-27	270	-256
<b>Total brans</b>	<b>-13</b>	<b>5</b>	<b>-34</b>	<b>-20</b>	<b>-133</b>	<b>0</b>	<b>-56</b>	<b>0</b>	<b>10</b>	<b>0</b>	<b>4</b>	<b>-1755</b>	<b>596</b>	<b>2302</b>
Bovine meat	-101	-64	-14	-10	74	0	1	0	-128	-4	-13	-807	-1058	-1699
Ovine meat	-25	-2	-8	-3	54	0	-1	0	-5	1	1	223	434	579
Pig meat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicken meat	-34	-22	-2	-2	14	0	1	0	-44	-2	-5	67	-85	-2947
Other meats	-1	-1	0	0	1	0	0	0	-1	0	0	-15	-16	17
<b>Total eggs</b>	<b>-23</b>	<b>-9</b>	<b>-3</b>	<b>-2</b>	<b>26</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>-19</b>	<b>-1</b>	<b>-2</b>	<b>-19</b>	<b>-30</b>	<b>57</b>
<b>Total milk</b>	<b>-50</b>	<b>-50</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>0</b>	<b>38</b>	<b>0</b>	<b>-50</b>	<b>-50</b>	<b>-50</b>	<b>-2500</b>	<b>-2500</b>	<b>49794</b>
<b>Total</b>	<b>-1724</b>	<b>-308</b>	<b>1327</b>	<b>1653</b>	<b>-92</b>	<b>3</b>	<b>34</b>	<b>204</b>	<b>-569</b>	<b>-180</b>	<b>-375</b>	<b>-15836</b>	<b>-13496</b>	<b>35950</b>
<b>Total cereals</b>	<b>-835</b>	<b>-27</b>	<b>1098</b>	<b>1034</b>	<b>-52</b>	<b>4</b>	<b>-25</b>	<b>229</b>	<b>-54</b>	<b>-200</b>	<b>-488</b>	<b>-3815</b>	<b>-5151</b>	<b>-2098</b>
<b>Total oilseeds</b>	<b>26</b>	<b>-2</b>	<b>36</b>	<b>17</b>	<b>-57</b>	<b>0</b>	<b>-11</b>	<b>0</b>	<b>-4</b>	<b>0</b>	<b>-3</b>	<b>-915</b>	<b>-198</b>	<b>-1237</b>
<b>Total pulses</b>	<b>59</b>	<b>-17</b>	<b>169</b>	<b>110</b>	<b>-3</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>-34</b>	<b>2</b>	<b>-6</b>	<b>-697</b>	<b>-537</b>	<b>-570</b>
<b>Total sugercrops</b>	<b>-100</b>	<b>7</b>	<b>-100</b>	<b>-61</b>	<b>-4</b>	<b>0</b>	<b>-14</b>	<b>57</b>	<b>15</b>	<b>0</b>	<b>11</b>	<b>-2460</b>	<b>-1979</b>	<b>-2348</b>
<b>Total vegetal products</b>	<b>-850</b>	<b>-38</b>	<b>1204</b>	<b>1100</b>	<b>-116</b>	<b>4</b>	<b>-49</b>	<b>286</b>	<b>-77</b>	<b>-197</b>	<b>-486</b>	<b>-7887</b>	<b>-7866</b>	<b>-6253</b>
<b>Total meat</b>	<b>-161</b>	<b>-89</b>	<b>-24</b>	<b>-15</b>	<b>143</b>	<b>0</b>	<b>1</b>	<b>0</b>	<b>-178</b>	<b>-5</b>	<b>-17</b>	<b>-531</b>	<b>-725</b>	<b>-4050</b>
<b>Total eggs</b>	<b>-23</b>	<b>-9</b>	<b>-3</b>	<b>-2</b>	<b>26</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>-19</b>	<b>-1</b>	<b>-2</b>	<b>-19</b>	<b>-30</b>	<b>57</b>
<b>Total milk</b>	<b>-50</b>	<b>-50</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>0</b>	<b>38</b>	<b>0</b>	<b>-50</b>	<b>-50</b>	<b>-50</b>	<b>-2500</b>	<b>-2500</b>	<b>49794</b>
<b>Total vegetal oils</b>	<b>-88</b>	<b>-53</b>	<b>90</b>	<b>84</b>	<b>30</b>	<b>0</b>	<b>0</b>	<b>-3</b>	<b>-106</b>	<b>10</b>	<b>23</b>	<b>-860</b>	<b>-429</b>	<b>-1492</b>
<b>Total cakes</b>	<b>126</b>	<b>54</b>	<b>-186</b>	<b>-128</b>	<b>-161</b>	<b>0</b>	<b>74</b>	<b>-7</b>	<b>108</b>	<b>3</b>	<b>50</b>	<b>-711</b>	<b>-822</b>	<b>-874</b>
<b>Total sugar</b>	<b>-500</b>	<b>-123</b>	<b>154</b>	<b>444</b>	<b>70</b>	<b>0</b>	<b>28</b>	<b>-53</b>	<b>-249</b>	<b>61</b>	<b>112</b>	<b>-1797</b>	<b>-1276</b>	<b>-3770</b>
<b>Total molasses</b>	<b>-165</b>	<b>-4</b>	<b>76</b>	<b>140</b>	<b>-2</b>	<b>0</b>	<b>-3</b>	<b>-19</b>	<b>-8</b>	<b>0</b>	<b>-8</b>	<b>223</b>	<b>-443</b>	<b>237</b>
<b>Total brans</b>	<b>-13</b>	<b>5</b>	<b>-34</b>	<b>-20</b>	<b>-133</b>	<b>0</b>	<b>-56</b>	<b>0</b>	<b>10</b>	<b>0</b>	<b>4</b>	<b>-1755</b>	<b>596</b>	<b>2302</b>
<b>Total</b>	<b>-1724</b>	<b>-308</b>	<b>1327</b>	<b>1653</b>	<b>-92</b>	<b>3</b>	<b>34</b>	<b>204</b>	<b>-569</b>	<b>-180</b>	<b>-375</b>	<b>-15836</b>	<b>-13496</b>	<b>35950</b>

Source: Own calculation, Unit: Thousands tons

**Table 100: Variations of external trade of all products in the different scenarios for India**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Th)	Scenario 2025 with coordination of prices variations
<b>INDIA</b>														
Wheat	-585	440	-1000	-1000	-1000	0	125	1000	932	-322	-578	-7500	-1105	-48659
Rice	-1000	176	1000	1000	-1000	-9	323	-90	372	1	-281	1285	4299	-12580
Maize	241	-27	1000	828	-511	0	160	-229	-54	14	160	4895	532	2234
Millet	-1000	-158	1000	1000	-83	1	-77	-77	-317	54	-148	-3183	-5082	-475
Sorghum	-597	-94	363	912	-385	0	102	-247	-188	66	-112	-5370	-5016	-1536
Other cereals	99	-3	27	-39	-12	0	0	3	-5	-2	-1	11	11	11
<b>Total pulses</b>	<b>1000</b>	<b>462</b>	<b>-419</b>	<b>-1000</b>	<b>-999</b>	<b>0</b>	<b>152</b>	<b>-20</b>	<b>929</b>	<b>272</b>	<b>123</b>	<b>752</b>	<b>-473</b>	<b>1427</b>
<b>Total sugarcrops</b>	<b>-100</b>	<b>34</b>	<b>-100</b>	<b>100</b>	<b>-70</b>	<b>3</b>	<b>53</b>	<b>-4</b>	<b>68</b>	<b>20</b>	<b>9</b>	<b>-2637</b>	<b>-2961</b>	<b>-2738</b>
Soybean	-63	7	-30	13	-29	0	27	-25	14	4	2	-270	-705	-181
Sunflowerseed	0	0	-1	0	0	0	0	0	0	0	0	-1	-1	-1
Rapeseed	-33	0	-2	2	2	0	-1	1	0	0	0	-95	-110	-105
Cottonseed	180	-12	697	363	-337	0	2	16	-24	-7	-3	-4952	-4884	-3537
Otherseeds	-362	6	-23	0	8	0	0	-2	13	4	2	-1351	-1351	-1351
<b>Total sugar</b>	<b>-1000</b>	<b>-293</b>	<b>372</b>	<b>1000</b>	<b>-358</b>	<b>-6</b>	<b>-114</b>	<b>40</b>	<b>-583</b>	<b>-57</b>	<b>138</b>	<b>-6484</b>	<b>-2941</b>	<b>-4923</b>
<b>Total molasses</b>	<b>-82</b>	<b>-63</b>	<b>35</b>	<b>203</b>	<b>71</b>	<b>-1</b>	<b>-28</b>	<b>5</b>	<b>-127</b>	<b>-37</b>	<b>-17</b>	<b>386</b>	<b>126</b>	<b>824</b>
Soybean oil	46	-33	60	-7	28	0	-87	82	-65	-26	14	-484	1172	-761
Sunflower oil	23	-6	5	-8	-35	0	0	1	-11	-7	11	-460	-364	-424
Rapeseed oil	522	-16	71	-106	-228	0	43	-77	-32	-20	30	-1799	-600	-976
Cotton oil	-2	-15	161	125	-48	0	-10	-2	-29	-12	8	60	15	286
Other oils	111	-34	247	177	-202	0	0	7	-67	-42	63	-1584	-972	-1420
<b>Soybean cake</b>	<b>-720</b>	<b>-165</b>	<b>776</b>	<b>863</b>	<b>268</b>	<b>0</b>	<b>-391</b>	<b>363</b>	<b>-332</b>	<b>-97</b>	<b>-44</b>	<b>-2238</b>	<b>3432</b>	<b>-2285</b>
<b>Rapeseed cake</b>	<b>1000</b>	<b>40</b>	<b>-311</b>	<b>-674</b>	<b>-157</b>	<b>0</b>	<b>71</b>	<b>-160</b>	<b>80</b>	<b>24</b>	<b>11</b>	<b>1916</b>	<b>1870</b>	<b>-580</b>
<b>Sunflower cake</b>	<b>-60</b>	<b>-3</b>	<b>145</b>	<b>169</b>	<b>-61</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>-7</b>	<b>-2</b>	<b>-1</b>	<b>555</b>	<b>555</b>	<b>-382</b>
<b>Cotton cake</b>	<b>533</b>	<b>-71</b>	<b>573</b>	<b>177</b>	<b>-159</b>	<b>0</b>	<b>-29</b>	<b>-9</b>	<b>-142</b>	<b>-42</b>	<b>-19</b>	<b>-834</b>	<b>710</b>	<b>-392</b>
<b>Other cakes</b>	<b>-1000</b>	<b>384</b>	<b>1000</b>	<b>1000</b>	<b>439</b>	<b>0</b>	<b>0</b>	<b>-294</b>	<b>770</b>	<b>225</b>	<b>102</b>	<b>-7500</b>	<b>-5192</b>	<b>-13391</b>
<b>Total brans</b>	<b>875</b>	<b>61</b>	<b>-480</b>	<b>-482</b>	<b>-566</b>	<b>0</b>	<b>0</b>	<b>44</b>	<b>122</b>	<b>36</b>	<b>16</b>	<b>-7500</b>	<b>-4820</b>	<b>2832</b>
Bovine meat	-98	0	0	0	126	0	0	0	0	0	0	289	289	289
Ovine meat	40	-32	-91	-140	121	0	0	-5	-65	-19	-9	-427	24	806
Pig meat	-18	0	0	0	18	0	0	0	0	0	0	-70	-70	-70
Chicken meat	22	-22	-66	-105	84	0	0	-4	-43	-13	-6	873	1232	894
Other meats	15	-4	-12	-18	4	0	0	-1	-8	-2	-1	-150	-88	-27
<b>Total eggs</b>	<b>351</b>	<b>-73</b>	<b>-199</b>	<b>-302</b>	<b>-65</b>	<b>0</b>	<b>0</b>	<b>-14</b>	<b>-142</b>	<b>-44</b>	<b>-22</b>	<b>-2461</b>	<b>-1502</b>	<b>-1659</b>
<b>Total milk</b>	<b>50</b>	<b>-50</b>	<b>-50</b>	<b>-50</b>	<b>50</b>	<b>0</b>	<b>0</b>	<b>-50</b>	<b>-50</b>	<b>-50</b>	<b>-50</b>	<b>7500</b>	<b>7500</b>	<b>-18481</b>
<b>Total</b>	<b>-1610</b>	<b>436</b>	<b>4750</b>	<b>4001</b>	<b>-5088</b>	<b>-12</b>	<b>322</b>	<b>254</b>	<b>1008</b>	<b>-83</b>	<b>-603</b>	<b>-38829</b>	<b>-16471</b>	<b>-107332</b>
<b>Total cereals</b>	<b>-2841</b>	<b>334</b>	<b>2390</b>	<b>2701</b>	<b>-2991</b>	<b>-8</b>	<b>633</b>	<b>361</b>	<b>739</b>	<b>-189</b>	<b>-960</b>	<b>-9862</b>	<b>-6362</b>	<b>-61004</b>
<b>Total oilseeds</b>	<b>-278</b>	<b>1</b>	<b>641</b>	<b>378</b>	<b>-356</b>	<b>0</b>	<b>28</b>	<b>-9</b>	<b>3</b>	<b>1</b>	<b>0</b>	<b>-6669</b>	<b>-7051</b>	<b>-5175</b>
<b>Total pulses</b>	<b>1000</b>	<b>462</b>	<b>-419</b>	<b>-1000</b>	<b>-999</b>	<b>0</b>	<b>152</b>	<b>-20</b>	<b>929</b>	<b>272</b>	<b>123</b>	<b>752</b>	<b>-473</b>	<b>1427</b>
<b>Total sugar crops</b>	<b>-100</b>	<b>34</b>	<b>-100</b>	<b>100</b>	<b>-70</b>	<b>3</b>	<b>53</b>	<b>-4</b>	<b>68</b>	<b>20</b>	<b>9</b>	<b>-2637</b>	<b>-2961</b>	<b>-2738</b>
<b>Total vegetal products</b>	<b>-2219</b>	<b>832</b>	<b>2512</b>	<b>2179</b>	<b>-4417</b>	<b>-5</b>	<b>866</b>	<b>327</b>	<b>1739</b>	<b>103</b>	<b>-828</b>	<b>-18416</b>	<b>-16847</b>	<b>-67491</b>
<b>Total meat</b>	<b>-39</b>	<b>-58</b>	<b>-169</b>	<b>-263</b>	<b>352</b>	<b>0</b>	<b>0</b>	<b>-10</b>	<b>-116</b>	<b>-34</b>	<b>-16</b>	<b>514</b>	<b>1386</b>	<b>1891</b>
<b>Total eggs</b>	<b>351</b>	<b>-73</b>	<b>-199</b>	<b>-302</b>	<b>-65</b>	<b>0</b>	<b>0</b>	<b>-14</b>	<b>-142</b>	<b>-44</b>	<b>-22</b>	<b>-2461</b>	<b>-1502</b>	<b>-1659</b>
<b>Total milk</b>	<b>50</b>	<b>-50</b>	<b>-50</b>	<b>-50</b>	<b>50</b>	<b>0</b>	<b>0</b>	<b>-50</b>	<b>-50</b>	<b>-50</b>	<b>-50</b>	<b>7500</b>	<b>7500</b>	<b>-18481</b>
<b>Total vegetal oils</b>	<b>700</b>	<b>-104</b>	<b>545</b>	<b>181</b>	<b>-486</b>	<b>0</b>	<b>-54</b>	<b>11</b>	<b>-204</b>	<b>-108</b>	<b>126</b>	<b>-4266</b>	<b>-749</b>	<b>-3295</b>
<b>Total cakes</b>	<b>-247</b>	<b>184</b>	<b>2183</b>	<b>1535</b>	<b>330</b>	<b>0</b>	<b>-348</b>	<b>-98</b>	<b>370</b>	<b>108</b>	<b>49</b>	<b>-8101</b>	<b>1376</b>	<b>-17029</b>
<b>Total sugar</b>	<b>-1000</b>	<b>-293</b>	<b>372</b>	<b>1000</b>	<b>-358</b>	<b>-6</b>	<b>-114</b>	<b>40</b>	<b>-583</b>	<b>-57</b>	<b>138</b>	<b>-6484</b>	<b>-2941</b>	<b>-4923</b>
<b>Total molasses</b>	<b>-82</b>	<b>-63</b>	<b>35</b>	<b>203</b>	<b>71</b>	<b>-1</b>	<b>-28</b>	<b>5</b>	<b>-127</b>	<b>-37</b>	<b>-17</b>	<b>386</b>	<b>126</b>	<b>824</b>
<b>Total brans</b>	<b>875</b>	<b>61</b>	<b>-480</b>	<b>-482</b>	<b>-566</b>	<b>0</b>	<b>0</b>	<b>44</b>	<b>122</b>	<b>36</b>	<b>16</b>	<b>-7500</b>	<b>-4820</b>	<b>2832</b>
<b>Total</b>	<b>-1610</b>	<b>436</b>	<b>4750</b>	<b>4001</b>	<b>-5088</b>	<b>-12</b>	<b>322</b>	<b>254</b>	<b>1008</b>	<b>-83</b>	<b>-603</b>	<b>-38829</b>	<b>-16471</b>	<b>-107332</b>

Source: Own calculation, Unit: Thousands tons

**Table 101: Variations of external trade of all products in the different scenarios for Bangladesh**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>BANGLADESH</b>														
Wheat	-8	-64	-26	-25	-91	0	-2	2	-89	-71	-48	-1715	-1485	415
Rice	91	170	500	500	-500	0	0	-2	500	-364	-107	-2500	-2500	10786
Maize	-61	-24	58	61	-67	1	40	-26	-16	26	25	302	-32	231
Millet	-1	0	1	1	1	0	0	0	0	0	2	-2	-11	-2
Sorghum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cereals	0	0	0	0	0	0	0	0	0	0	0	-1	-1	0
Total pulses	-50	0	10	10	0	0	0	0	0	0	0	-191	-190	-185
Total sugar crops	-15	0	0	0	0	0	0	0	0	0	0	-60	-60	-60
Soybean	-12	0	0	0	0	0	0	0	0	0	0	-49	-49	-49
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	-1	0	0	0	0	0	0	0	0	0	0	-4	-4	-4
Cottonseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other seeds	0	0	0	0	0	0	0	0	0	0	0	-2	-2	-2
Total sugar	-49	-37	35	35	-27	0	0	-1	-61	-3	-34	-967	-783	-204
Total molasses	-2	-2	5	5	2	0	0	0	-6	-2	0	-132	-123	-94
Soybean oil	-2	-8	-5	-6	-9	0	0	0	-13	-6	0	-215	-219	12
Sunflower oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed oil	-1	-3	1	1	-4	0	0	0	-5	-3	0	-84	-84	9
Cotton oil	0	0	0	0	0	0	0	0	0	0	0	-2	-2	1
Other oils	-4	-14	-8	-8	-15	0	0	0	-21	-10	0	-350	-356	22
Soybean cake	0	0	3	3	-10	0	0	0	0	0	0	-99	-102	-150
Rapeseed cake	1	1	5	5	-3	0	0	1	1	1	0	-82	-82	-69
Sunflower cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton cake	0	0	1	1	0	0	0	0	0	0	0	1	1	0
Other cakes	-1	-1	2	2	0	0	0	0	-3	-1	0	-86	-78	-81
Total brans	4	4	-3	-3	-59	0	0	0	9	3	0	-786	-776	-573
Bovine meat	-10	0	0	0	10	0	0	0	0	0	0	-6	-6	-6
Ovine meat	-1	-4	-4	-4	1	0	0	0	-5	-4	-1	73	79	302
Pig meat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicken meat	-2	-4	-4	-4	1	0	0	0	-4	-4	-1	-22	-16	300
Other meats	-1	0	0	0	1	0	0	0	0	0	0	-3	-3	-3
Total eggs	-4	-3	-3	-3	6	0	0	0	-3	-3	-1	126	130	279
Total milk	-50	-50	-50	-50	50	0	0	0	-50	-50	-12	75	149	3047
Total	-180	-40	516	520	-712	1	38	-26	233	-491	-176	-6780	-6605	13921
Total cereals	21	82	533	536	-657	1	39	-26	395	-408	-128	-3916	-4029	11429
Total oilseeds	-14	0	0	0	0	0	0	0	0	0	0	-55	-55	-55
Total pulses	-50	0	10	10	0	0	0	0	0	0	0	-191	-190	-185
Total sugar crops	-15	0	0	0	0	0	0	0	0	0	0	-60	-60	-60
Total vegetal products	-58	82	543	547	-657	1	39	-26	394	-409	-128	-4222	-4334	11129
Total meat	-14	-8	-8	-8	12	0	0	0	-9	-8	-2	43	54	593
Total eggs	-4	-3	-3	-3	6	0	0	0	-3	-3	-1	126	130	279
Total milk	-50	-50	-50	-50	50	0	0	0	-50	-50	-12	75	149	3047
Total vegetal oils	-8	-26	-13	-13	-27	0	0	0	-39	-20	1	-651	-661	44
Total cakes	0	0	10	10	-12	0	0	1	-2	0	0	-267	-261	-300
Total sugar	-49	-37	35	35	-27	0	0	-1	-61	-3	-34	-967	-783	-204
Total molasses	-2	-2	5	5	2	0	0	0	-6	-2	0	-132	-123	-94
Total brans	4	4	-3	-3	-59	0	0	0	9	3	0	-786	-776	-573
Total	-180	-40	516	520	-712	1	38	-26	233	-491	-176	-6780	-6605	13921

Source: Own calculation, Unit: Thousands tons

**Table 102: Variations of external trade of all products in the different scenarios for total of three countries**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>TOTAL of the three countries</b>														
Wheat	-1093	353	-526	-525	-1095	2	118	1152	796	-553	-1126	-11715	-5000	-50000
Rice	-1132	356	1636	1765	-1505	-7	381	-94	893	-375	-465	-1321	1196	-1565
Maize	-10	-73	1398	1141	-606	1	151	-200	-113	10	272	4134	-1656	1921
Millet	-935	-154	1072	1001	-93	1	-95	-53	-307	55	-144	-3274	-5000	-484
Sorghum	-577	-91	409	921	-387	0	90	-245	-183	67	-113	-5380	-5000	-1505
Other cereals	92	-3	32	-32	-15	0	1	3	-6	-2	-1	-36	-81	-40
Total pulses	1009	445	-240	-879	-1002	0	153	-20	894	274	117	-136	-1201	672
Total sugar crops	-215	41	-200	39	-74	3	38	53	83	20	20	-5157	-5000	-5146
Soybean	-75	7	-30	13	-29	0	27	-25	14	4	2	-320	-755	-230
Sunflowerseed	0	0	-1	0	0	0	0	0	0	0	0	-1	-1	-1
Rapeseed	-35	0	-3	2	2	0	-1	1	0	0	0	-99	-114	-109
Cottonseed	217	-14	735	379	-395	0	-10	16	-27	-7	-6	-5784	-5000	-4692
Other seeds	-374	6	-24	0	8	0	0	-2	13	4	2	-1435	-1435	-1435
Total sugar	-1549	-453	561	1479	-315	-6	-86	-13	-893	1	216	-9248	-5000	-8898
Total molasses	-248	-69	116	348	71	-2	-30	-14	-141	-39	-25	477	-440	967
Soybean oil	42	-42	55	-12	19	0	-87	82	-79	-33	15	-714	945	-771
Sunflower oil	14	-10	13	1	-32	0	0	1	-21	-6	13	-506	-382	-525
Rapeseed oil	516	-26	90	-98	-228	0	43	-79	-50	-22	33	-1997	-738	-1157
Cotton oil	-17	-24	208	168	-43	0	-11	-3	-48	-11	12	21	73	141
Other oils	48	-80	257	193	-199	0	1	7	-152	-47	79	-2581	-1738	-2431
Soybean cake	-721	-166	777	865	245	0	-391	363	-332	-97	-44	-2525	3116	-2673
Rapeseed cake	976	40	-266	-649	-190	0	68	-163	79	24	8	1442	1171	-1064
Sunflower cake	85	48	-177	-81	-102	0	69	3	97	1	49	889	889	-49
Cotton cake	503	-68	688	282	-226	0	-13	-13	-137	-42	-18	-1271	118	-690
Other cakes	-964	383	986	999	429	0	-7	-294	769	225	104	-7613	-5000	-13728
Total brans	866	70	-517	-505	-758	0	-56	44	141	39	20	-10041	-5000	4561
Bovine meat	-209	-64	-14	-10	210	0	1	0	-128	-4	-13	-524	-775	-1416
Ovine meat	14	-38	-103	-147	176	0	-1	-5	-75	-23	-9	-131	536	1686
Pig meat	-18	0	0	0	18	0	0	0	0	0	0	-70	-70	-70
Chicken meat	-14	-48	-72	-111	99	0	1	-4	-91	-19	-12	919	1130	-1753
Other meats	13	-5	-12	-18	6	0	0	-1	-9	-2	-1	-168	-107	-12
Total eggs	324	-85	-204	-306	-32	0	0	-14	-164	-47	-24	-2353	-1403	-1323
Total milk	-50	-150	-50	-50	150	0	37	-50	-150	-150	-112	5075	5149	34359
Total	-3514	89	6593	6173	-5893	-8	394	432	672	-754	-1153	-61444	-36572	-57461
Tot cereals	-3655	389	4021	4271	-3700	-3	647	563	1080	-797	-1576	-17592	-15541	-51674
Total oilseeds	-266	-1	677	395	-414	0	17	-9	-1	1	-3	-7640	-7305	-6467
Total pulses	1009	445	-240	-879	-1002	0	153	-20	894	274	117	-136	-1201	672
Total sugercrops	-215	41	-200	39	-74	3	38	53	83	20	20	-5157	-5000	-5146
Total vegetal products	-3127	875	4258	3826	-5191	-1	855	587	2056	-502	-1442	-30526	-29047	-62616
Total meat	-213	-155	-201	-287	508	0	1	-10	-302	-48	-35	26	715	-1565
Total eggs	324	-85	-204	-306	-32	0	0	-14	-164	-47	-24	-2353	-1403	-1323
Total milk	-50	-150	-50	-50	150	0	37	-50	-150	-150	-112	5075	5149	34359
Total vegetal oils	604	-182	622	251	-482	0	-54	8	-350	-118	151	-5777	-1839	-4744
Total cakes	-121	237	2007	1417	157	0	-274	-105	476	111	99	-9078	293	-18203
Total sugar	-1549	-453	561	1479	-315	-6	-86	-13	-893	1	216	-9248	-5000	-8898
Total molasses	-248	-69	116	348	71	-2	-30	-14	-141	-39	-25	477	-440	967
Total brans	866	70	-517	-505	-758	0	-56	44	141	39	20	-10041	-5000	4561
Total	-3514	89	6593	6173	-5893	-8	394	432	672	-754	-1153	-61444	-36572	-57461

Source: Own calculation, Unit: Thousands ton

**Table 103: Variations of food consumption for all products in the different scenarios for Pakistan**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>PAKISTAN</b>														
Wheat	870	41	739	536	-31	0	11	0	83	161	528	7148	8158	6475
Rice	109	-9	77	75	4	0	-10	0	-17	12	78	980	1134	714
Maize	190	21	-109	-79	-11	0	9	0	43	31	-89	653	1251	242
Millet	5	-3	-8	0	2	0	0	0	-6	-1	0	23	50	-50
Sorghum	8	-3	-8	0	2	0	1	0	-6	-1	0	23	71	-36
Other cereals	2	0	0	0	0	0	0	0	0	0	0	13	13	13
<b>Total pulses</b>	<b>95</b>	<b>-2</b>	<b>-23</b>	<b>-5</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>-5</b>	<b>-3</b>	<b>-6</b>	<b>397</b>	<b>662</b>	<b>213</b>
<b>Total sugarcrops</b>	<b>332</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2390</b>	<b>2390</b>	<b>2390</b>
Soybean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflowersseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottonseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Otherseeds	11	0	0	0	0	0	0	0	0	0	0	82	82	82
<b>Total sugar</b>	<b>286</b>	<b>117</b>	<b>-62</b>	<b>-134</b>	<b>-67</b>	<b>0</b>	<b>-15</b>	<b>0</b>	<b>235</b>	<b>-61</b>	<b>-121</b>	<b>2631</b>	<b>1668</b>	<b>4502</b>
<b>Total molasses</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
Soybean oil	1	1	0	0	0	0	0	0	1	0	0	15	8	23
Sunflower oil	9	5	-1	-2	-3	0	0	0	9	-1	-2	104	75	159
Rapeseed oil	10	6	-4	-3	-4	0	0	0	13	-1	-3	140	92	215
Cotton oil	15	9	-7	-5	-5	0	0	0	18	-2	-4	200	111	307
Other oils	59	32	-9	-15	-18	0	-1	0	64	-6	-15	718	481	1104
Soyban cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total brans</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
Bovine meat	101	64	14	10	-2	0	-1	0	128	4	13	1279	1530	2172
Ovine meat	25	2	8	3	-33	0	1	0	5	-1	-1	-61	-271	-416
Pig meat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicken meat	34	22	2	2	19	0	-1	0	44	2	5	640	793	3654
Other meats	1	1	0	0	0	0	0	0	1	0	0	17	18	-16
<b>Total eggs</b>	<b>23</b>	<b>9</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>19</b>	<b>1</b>	<b>2</b>	<b>282</b>	<b>293</b>	<b>206</b>
<b>Total milk</b>	<b>50</b>	<b>50</b>	<b>-50</b>	<b>-50</b>	<b>1668</b>	<b>0</b>	<b>-38</b>	<b>0</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>22983</b>	<b>22983</b>	<b>-29311</b>
<b>Total</b>	<b>2238</b>	<b>362</b>	<b>562</b>	<b>334</b>	<b>1521</b>	<b>0</b>	<b>-44</b>	<b>0</b>	<b>678</b>	<b>182</b>	<b>436</b>	<b>40657</b>	<b>41591</b>	<b>-7358</b>
<b>Total cereals</b>	<b>1184</b>	<b>47</b>	<b>692</b>	<b>532</b>	<b>-35</b>	<b>0</b>	<b>11</b>	<b>0</b>	<b>96</b>	<b>201</b>	<b>518</b>	<b>8839</b>	<b>10675</b>	<b>7358</b>
<b>Total oilseeds</b>	<b>11</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>82</b>	<b>82</b>	<b>82</b>
<b>Total pulses</b>	<b>95</b>	<b>-2</b>	<b>-23</b>	<b>-5</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>-5</b>	<b>-3</b>	<b>-6</b>	<b>397</b>	<b>662</b>	<b>213</b>
<b>Total sugar crops</b>	<b>332</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2390</b>	<b>2390</b>	<b>2390</b>
<b>Total vegetal products</b>	<b>1622</b>	<b>45</b>	<b>669</b>	<b>527</b>	<b>-34</b>	<b>0</b>	<b>11</b>	<b>0</b>	<b>91</b>	<b>198</b>	<b>512</b>	<b>11709</b>	<b>13810</b>	<b>10043</b>
<b>Total meat</b>	<b>161</b>	<b>89</b>	<b>24</b>	<b>15</b>	<b>-17</b>	<b>0</b>	<b>-1</b>	<b>0</b>	<b>178</b>	<b>5</b>	<b>17</b>	<b>1875</b>	<b>2070</b>	<b>5394</b>
<b>Total eggs</b>	<b>23</b>	<b>9</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>19</b>	<b>1</b>	<b>2</b>	<b>282</b>	<b>293</b>	<b>206</b>
<b>Total milk</b>	<b>50</b>	<b>50</b>	<b>-50</b>	<b>-50</b>	<b>1668</b>	<b>0</b>	<b>-38</b>	<b>0</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>22983</b>	<b>22983</b>	<b>-29311</b>
<b>Total vegetal oils</b>	<b>95</b>	<b>52</b>	<b>-22</b>	<b>-26</b>	<b>-30</b>	<b>0</b>	<b>-1</b>	<b>0</b>	<b>105</b>	<b>-10</b>	<b>-24</b>	<b>1177</b>	<b>766</b>	<b>1808</b>
<b>Total cakes</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Total sugar</b>	<b>286</b>	<b>117</b>	<b>-62</b>	<b>-134</b>	<b>-67</b>	<b>0</b>	<b>-15</b>	<b>0</b>	<b>235</b>	<b>-61</b>	<b>-121</b>	<b>2631</b>	<b>1668</b>	<b>4502</b>
<b>Total molasses</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Total brans</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
<b>Total</b>	<b>2238</b>	<b>362</b>	<b>562</b>	<b>334</b>	<b>1521</b>	<b>0</b>	<b>-44</b>	<b>0</b>	<b>678</b>	<b>182</b>	<b>436</b>	<b>40657</b>	<b>41591</b>	<b>-7358</b>

Source: Own calculation, Unit: Thousands tons

**Table 104: Variations of food consumption for all products in the different scenarios for India**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>INDIA</b>														
Wheat	-1169	111	3006	3374	3036	0	0	297	176	646	725	43702	37472	62826
Rice	2029	131	1112	1497	1082	0	0	125	244	179	362	28652	25910	37664
Maize	-190	83	-120	67	211	0	0	-32	166	18	-145	3799	2770	2337
Millet	1042	82	-40	-322	-25	0	0	17	164	-99	128	3767	5335	2860
Sorghum	857	68	-110	-369	4	0	0	9	135	-81	105	3467	4543	2595
Other cereals	64	0	0	0	0	0	0	0	0	0	0	256	256	256
Total pulses	755	0	0	0	0	0	0	0	0	0	0	3021	3021	3021
Total sugar crops	540	0	0	0	0	0	0	0	0	0	0	2160	2160	2160
Soybean	61	0	0	0	0	0	0	0	0	0	0	245	245	245
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	26	0	0	0	0	0	0	0	0	0	0	106	106	106
Cottonseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other seeds	339	0	0	0	0	0	0	0	0	0	0	1357	1357	1357
Total sugar	52	220	-157	319	510	0	0	-31	437	14	-157	12797	9951	11454
Total molasses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean oil	-42	11	37	53	66	0	0	-2	21	13	-20	960	707	949
Sunflower oil	-23	6	10	24	35	0	0	-1	11	7	-11	535	439	499
Rapeseed oil	-54	16	69	77	102	0	0	-4	32	20	-30	1583	1354	1401
Cotton oil	-19	6	-22	2	38	0	0	-2	11	7	-10	544	459	487
Other oils	-111	34	69	140	202	0	0	-7	67	42	-63	3136	2524	2972
Soybean cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bovine meat	98	0	0	0	0	0	0	0	0	0	0	393	393	393
Ovine meat	-40	32	91	140	-78	0	0	5	65	19	9	527	76	-706
Pig meat	18	0	0	0	0	0	0	0	0	0	0	70	70	70
Chicken meat	-22	22	66	105	19	0	0	4	43	13	6	1140	781	1119
Other meats	-15	4	12	18	5	0	0	1	8	2	1	172	110	49
Total eggs	-351	73	199	302	231	0	0	14	142	44	22	4138	3179	3336
Total milk	-50	50	50	50	5497	0	0	50	50	50	50	56070	56070	82051
Total	3797	947	4271	5477	10934	0	0	443	1771	896	971	172598	159288	219501
Total cereals	2633	475	3847	4247	4308	0	0	416	885	664	1175	83644	76285	108538
Total oilseeds	427	0	0	0	0	0	0	0	0	0	0	1708	1708	1708
Total pulses	755	0	0	0	0	0	0	0	0	0	0	3021	3021	3021
Total sugar crops	540	0	0	0	0	0	0	0	0	0	0	2160	2160	2160
Total vegetal products	4355	475	3847	4247	4308	0	0	416	885	664	1175	90533	83174	115426
Total meat	39	58	169	263	-54	0	0	10	116	34	16	2302	1430	925
Total eggs	-351	73	199	302	231	0	0	14	142	44	22	4138	3179	3336
Total milk	-50	50	50	50	5497	0	0	50	50	50	50	56070	56070	82051
Total vegetal oils	-249	72	164	296	443	0	0	-17	141	89	-135	6758	5484	6308
Total cakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugar	52	220	-157	319	510	0	0	-31	437	14	-157	12797	9951	11454
Total molasses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3797	947	4271	5477	10934	0	0	443	1771	896	971	172598	159288	219501

Source: Own calculation, Unit: Thousands tons

**Table 105: Variations of food consumption for all products in the different scenarios for Bangladesh**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>BANGLADESH</b>														
Wheat	7	63	67	68	92	0	0	0	86	70	48	1760	1540	-360
Rice	299	228	634	649	672	0	0	0	175	704	107	10459	10446	-2838
Maize	74	37	-29	-32	53	0	0	0	47	-15	-25	121	306	52
Millet	1	0	0	0	-1	0	0	0	0	0	-2	5	13	4
Sorghum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cereals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total pulses</b>	<b>50</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>199</b>	<b>199</b>	<b>199</b>
<b>Total sugcrops</b>	<b>15</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>60</b>	<b>60</b>	<b>60</b>
Soybean	12	0	0	0	0	0	0	0	0	0	0	49	49	49
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	1	0	0	0	0	0	0	0	0	0	0	4	4	4
Cottonseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Otherseeds	0	0	0	0	0	0	0	0	0	0	0	2	2	2
<b>Total sugar</b>	<b>48</b>	<b>36</b>	<b>5</b>	<b>5</b>	<b>27</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>60</b>	<b>3</b>	<b>34</b>	<b>909</b>	<b>725</b>	<b>147</b>
<b>Total molasses</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
Soybean oil	2	8	6	6	9	0	0	0	13	6	0	216	220	-11
Sunflower oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed oil	1	3	2	2	4	0	0	0	5	3	0	87	89	-5
Cotton oil	0	0	0	0	0	0	0	0	0	0	0	3	3	0
Other oils	4	14	10	10	15	0	0	0	21	10	0	353	360	-19
Soybean cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total brans</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>
Bovine meat	10	0	0	0	0	0	0	0	0	0	0	39	39	39
Ovine meat	1	4	4	4	8	0	0	0	5	4	1	124	118	-105
Pig meat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicken meat	2	4	4	4	9	0	0	0	4	4	1	124	118	-198
Other meats	1	0	0	0	0	0	0	0	0	0	0	3	3	3
<b>Total eggs</b>	<b>4</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>3</b>	<b>1</b>	<b>87</b>	<b>83</b>	<b>-66</b>
<b>Total milk</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>111</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>50</b>	<b>50</b>	<b>12</b>	<b>1610</b>	<b>1537</b>	<b>-1361</b>
<b>Total</b>	<b>583</b>	<b>451</b>	<b>756</b>	<b>769</b>	<b>1004</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>470</b>	<b>842</b>	<b>176</b>	<b>16213</b>	<b>15914</b>	<b>-4403</b>
Tot cereals	381	328	671	685	816	0	0	0	309	759	128	12344	12305	-3142
Total oilseeds	14	0	0	0	0	0	0	0	0	0	0	55	55	55
Total pulses	50	0	0	0	0	0	0	0	0	0	0	199	199	199
Total sugcrops	15	0	0	0	0	0	0	0	0	0	0	60	60	60
<b>Total vegetal products</b>	<b>459</b>	<b>328</b>	<b>671</b>	<b>685</b>	<b>816</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>309</b>	<b>759</b>	<b>128</b>	<b>12658</b>	<b>12620</b>	<b>-2828</b>
<b>Total meat</b>	<b>14</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>18</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>9</b>	<b>8</b>	<b>2</b>	<b>290</b>	<b>278</b>	<b>-261</b>
<b>Total eggs</b>	<b>4</b>	<b>3</b>	<b>3</b>	<b>3</b>	<b>5</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3</b>	<b>3</b>	<b>1</b>	<b>87</b>	<b>83</b>	<b>-66</b>
<b>Total milk</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>111</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>50</b>	<b>50</b>	<b>12</b>	<b>1610</b>	<b>1537</b>	<b>-1361</b>
Total vegetal oils	8	26	18	19	27	0	0	0	39	20	-1	659	671	-35
Total cakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugar	48	36	5	5	27	0	0	0	60	3	34	909	725	147
Total molasses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total</b>	<b>583</b>	<b>451</b>	<b>756</b>	<b>769</b>	<b>1004</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>470</b>	<b>842</b>	<b>176</b>	<b>16213</b>	<b>15914</b>	<b>-4403</b>

Source: Own calculation, Unit: Thousands tons

**Table 106: Variations of food consumption for all products in the different scenarios for total of three countries**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>TOTAL of the three countries</b>														
Wheat	-292	215	3812	3978	3096	0	11	297	345	877	1301	52610	47170	68942
Rice	2437	351	1823	2221	1758	0	-10	125	402	896	547	40091	37489	35539
Maize	74	141	-258	-44	253	0	9	-32	256	33	-259	4573	4327	2630
Millet	1048	79	-48	-322	-23	0	0	17	158	-100	126	3794	5397	2815
Sorghum	865	64	-118	-369	6	0	1	9	129	-82	105	3490	4613	2559
Other cereals	66	0	0	0	0	0	0	0	0	0	0	268	268	268
Total pulses	900	-2	-23	-5	1	0	0	0	-5	-3	-6	3617	3882	3433
Total sugarcrops	887	0	0	0	0	0	0	0	0	0	0	4611	4611	4611
Soybean	74	0	0	0	0	0	0	0	0	0	0	294	294	294
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	27	0	0	0	0	0	0	0	0	0	0	110	110	110
Cottonseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other seeds	351	0	0	0	0	0	0	0	0	0	0	1441	1441	1441
Total sugar	387	373	-213	190	470	0	-15	-31	732	-44	-245	16337	12344	16103
Total molasses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean oil	-38	20	43	59	74	0	0	-2	35	20	-21	1192	936	960
Sunflower oil	-14	10	9	22	32	0	0	-1	21	6	-13	639	514	658
Rapeseed oil	-43	26	67	77	102	0	0	-4	49	21	-33	1809	1534	1611
Cotton oil	-3	15	-29	-3	33	0	0	-2	29	5	-14	747	572	794
Other oils	-48	80	70	134	199	0	-1	-7	152	47	-79	4208	3365	4058
Soybean cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bovine meat	209	64	14	10	-2	0	-1	0	128	4	13	1711	1962	2603
Ovine meat	-14	38	103	147	-103	0	1	5	75	23	9	590	-77	-1227
Pig meat	18	0	0	0	0	0	0	0	0	0	0	70	70	70
Chicken meat	14	48	72	111	47	0	-1	4	91	19	12	1904	1692	4576
Other meats	-13	5	12	18	5	0	0	1	9	2	1	191	131	36
Total eggs	-324	85	204	306	236	0	0	14	164	47	24	4507	3556	3476
Total milk	50	150	50	50	7277	0	-37	50	150	150	112	80663	80590	51380
Total	6617	1760	5589	6581	13460	0	-44	443	2919	1921	1582	229468	216793	207740
Total cereals	4198	851	5211	5464	5089	0	11	416	1289	1624	1821	104827	99266	112753
Total oilseeds	452	0	0	0	0	0	0	0	0	0	0	1845	1845	1845
Total pulses	900	-2	-23	-5	1	0	0	0	-5	-3	-6	3617	3882	3433
Total sugar crops	887	0	0	0	0	0	0	0	0	0	0	4611	4611	4611
Total vegetal products	6437	848	5188	5459	5090	0	11	416	1285	1620	1815	114900	109604	122641
Total meat	213	155	201	287	-53	0	-1	10	302	48	35	4467	3778	6058
Total eggs	-324	85	204	306	236	0	0	14	164	47	24	4507	3556	3476
Total milk	50	150	50	50	7277	0	-37	50	150	150	112	80663	80590	51380
Total vegetal oils	-146	150	160	289	440	0	-1	-17	286	99	-159	8594	6921	8082
Total cakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugar	387	373	-213	190	470	0	-15	-31	732	-44	-245	16337	12344	16103
Total molasses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	6617	1760	5589	6581	13460	0	-44	443	2919	1921	1582	229468	216793	207740

Source: Own calculation, Unit: Thousands tons



**Table 107: Variations of feed consumption for all concentrates in the different scenarios for Pakistan**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>PAKISTAN</b>														
Wheat	-43	2	81	13	26	0	0	0	5	0	-1	382	-481	971
Rice	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maize	61	7	-93	-47	36	0	29	0	14	0	9	603	1216	372
Millet	0	1	-12	-5	8	0	2	0	2	0	1	126	130	51
Sorghum	2	0	-3	-1	0	0	0	0	0	0	0	8	27	-8
Other cereals	5	0	-2	-3	2	0	-1	0	0	0	0	36	81	39
Total pulses	-154	19	-95	-50	2	0	-2	0	39	1	12	384	-41	442
Total sugar crops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottonseed	-38	2	-44	-17	57	0	11	0	4	0	3	830	112	1152
Others seeds	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totsugar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total molasses	89	2	-43	-31	4	0	7	0	4	0	5	72	582	22
Soybean cake	1	0	2	0	13	0	0	0	0	0	0	188	214	238
Rapeseed cake	35	0	-16	-12	31	0	2	0	1	0	2	437	684	461
Sunflower cake	-145	-51	332	260	41	0	-69	0	-104	-3	-50	-254	-254	-254
Cotton cake	33	-3	-3	2	67	0	-17	0	-6	0	-1	891	1069	748
Other cakes	-36	-1	28	15	10	0	7	0	-1	0	-2	127	-169	356
Total brans	13	-5	34	20	133	0	56	0	-10	0	-4	1755	-596	-2302
	-178	-26	166	144	429	0	27	0	-53	-1	-27	5586	2573	2289
Total cereals	24	11	-29	-43	72	0	30	0	21	1	9	1155	973	1426
Total oilseeds	-38	2	-44	-17	57	0	11	0	4	0	3	830	112	1152
Total pulses	-154	19	-95	-50	2	0	-2	0	39	1	12	384	-41	442
Total sugar crops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total vegetal products	-167	32	-168	-110	131	0	40	0	64	2	23	2370	1044	3020
Total vegetal oils	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total cakes	-113	-55	343	265	162	0	-76	0	-110	-3	-51	1390	1544	1549
Total sugar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total molasses	89	2	-43	-31	4	0	7	0	4	0	5	72	582	22
Total brans	13	-5	34	20	133	0	56	0	-10	0	-4	1755	-596	-2302
Total	-178	-26	166	144	429	0	27	0	-53	-1	-27	5586	2573	2289

Source: Own calculation, Unit: Thousands tons

**Table 108: Variations of feed consumption for all concentrates in the different scenarios for India**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>INDIA</b>														
Wheat	-311	28	62	207	86	0	0	-8	56	16	7	-73	-949	1797
Rice	-586	-59	377	586	72	0	0	2	-118	-35	-16	-1454	-1784	-39
Maize	731	-24	87	-283	-5	0	0	25	-48	-14	-6	-2617	3953	2486
Millet	33	1	-4	-30	25	0	0	-1	2	0	0	790	654	-44
Sorghum	-11	10	-23	-15	14	0	0	-2	19	6	3	185	124	56
Other cereals	-163	3	53	123	12	0	0	-3	5	2	1	-163	-163	-163
Total pulses	-1087	-393	1673	1764	789	0	0	-70	-790	-231	-105	-1442	-1442	-1442
Total sugar crops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottonseed	0	13	-718	-370	339	0	0	-16	27	8	4	4971	4923	3531
Other seeds	23	-6	10	0	-8	0	0	2	-13	-4	-2	-24	-24	-24
Total molasses	-148	46	17	118	-34	0	0	-3	91	27	12	1148	1577	763
Soybean cake	740	66	-336	-653	153	0	0	-3	132	39	17	4384	5037	3131
Rapeseed cake	-213	-40	547	625	-55	0	0	23	-81	-24	-11	-2280	-601	1295
Sunflower cake	60	3	-125	-149	61	0	0	-3	7	2	1	-456	-456	482
Cotton cake	-593	45	-185	179	131	0	0	0	91	27	12	2530	620	2561
Other cakes	1000	-384	-325	-325	-439	0	0	294	-770	-225	-102	10810	8501	16700
Total brans	-875	-61	480	482	566	0	0	-44	-122	-36	-16	7500	4820	-2832
Total	-1401	-753	1591	2259	1708	0	0	193	-1512	-442	-200	23810	24790	28257
Total cereals	-306	-42	553	588	205	0	0	12	-85	-25	-11	-3331	1835	4093
Total oilseeds	23	7	-708	-370	331	0	0	-14	14	4	2	4947	4899	3507
Total pulses	-1087	-393	1673	1764	789	0	0	-70	-790	-231	-105	-1442	-1442	-1442
Total suger crops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total vegetal products	-1371	-429	1517	1981	1325	0	0	-72	-860	-252	-114	173	5292	6158
Total vegetal oils	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total cakes	994	-310	-423	-321	-149	0	0	311	-622	-182	-82	14988	13100	24168
Total sugar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total molasses	-148	46	17	118	-34	0	0	-3	91	27	12	1148	1577	763
Total brans	-875	-61	480	482	566	0	0	-44	-122	-36	-16	7500	4820	-2832
Total	-1401	-753	1591	2259	1708	0	0	193	-1512	-442	-200	23810	24790	28257

Source: Own calculation, Unit: Thousands tons

**Table 109: Variations of feed consumption for all concentrates in the different scenarios for Bangladesh**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>BANGLADESH</b>														
Wheat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rice	-390	-398	420	443	-174	0	0	0	-674	-340	0	-1593	-1593	-1593
Maize	8	8	-10	-10	10	0	0	0	11	7	0	-5	5	8
Millet	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sorghum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cereals	0	0	0	0	0	0	0	0	0	0	0	1	1	0
Total pulses	0	0	0	0	0	0	0	0	0	0	0	6	5	0
Total sugar crops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean bean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton seed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other seeds	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total molasses	2	2	0	0	-2	0	0	0	6	2	0	125	116	87
Soybean cake	0	0	-1	-1	10	0	0	0	0	0	0	104	107	155
Rapeseed cake	-1	-1	1	1	3	0	0	0	-1	-1	0	89	91	77
Sunflower cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton cake	0	0	0	0	0	0	0	0	0	0	0	2	2	3
Other cakes	1	1	0	0	0	0	0	0	3	1	0	90	82	86
Total brans	-4	-4	3	3	59	0	0	0	-9	-3	0	786	776	573
Total	-384	-392	414	437	-95	0	0	0	-663	-335	0	-396	-408	-604
Total cereals	-382	-390	411	433	-164	0	0	0	-663	-333	0	-1598	-1587	-1584
Total oilseeds	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total pulses	0	0	0	0	0	0	0	0	0	0	0	6	5	0
Total sugarcrops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total vegetal products	-382	-390	411	433	-164	0	0	0	-662	-333	0	-1592	-1582	-1584
Total vegetal oils	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total cakes	0	0	1	1	12	0	0	0	2	0	0	285	282	320
Total sugar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total molasses	2	2	0	0	-2	0	0	0	6	2	0	125	116	87
Total brans	-4	-4	3	3	59	0	0	0	-9	-3	0	786	776	573
Total	-384	-392	414	437	-95	0	0	0	-663	-335	0	-396	-408	-604

Source: Own calculation, Unit: Thousands tons

**Table 110: Variations of feed consumption for all concentrates in the different scenarios for total of three countries**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>TOTAL of the three countries</b>														
Wheat	-354	30	144	220	112	0	0	-8	61	16	6	310	-1430	2768
Rice	-976	-457	798	1029	-102	0	0	2	-792	-375	-16	-3047	-3377	-1632
Maize	799	-10	-16	-340	41	0	29	25	-24	-7	2	-2019	5174	2866
Millet	33	2	-16	-35	33	0	2	-1	4	1	1	915	784	7
Sorghum	-10	10	-26	-17	14	0	0	-2	20	6	3	194	151	49
Other cereals	-158	3	52	121	15	0	-1	-3	6	2	1	-127	-82	-123
Total pulses	-1240	-374	1578	1714	790	0	-2	-70	-750	-230	-93	-1052	-1477	-1000
Total sugarcrops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottonseed	0	15	-762	-387	396	0	11	-16	30	8	6	5801	5035	4684
Otherseeds	23	-6	10	0	-8	0	0	2	-13	-4	-2	-24	-24	-24
Total sugar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total molasses	-57	49	-26	86	-33	0	7	-3	101	28	17	1345	2275	872
Soybean oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other oils	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean cake	741	66	-334	-653	176	0	0	-3	132	39	17	4676	5357	3524
Rapeseed cake	-179	-41	532	615	-22	0	2	23	-81	-24	-9	-1754	174	1833
Sunflower cake	-85	-48	207	111	102	0	-69	-3	-97	-1	-49	-710	-710	228
Cotton cake	-560	42	-188	181	198	0	-17	0	84	26	11	3423	1690	3311
Othercakes	964	-383	-297	-310	-429	0	7	294	-769	-225	-104	11027	8414	17142
Total brans	-866	-70	517	505	758	0	56	-44	-141	-39	-20	10041	5000	-4561
Total	-1925	-1171	2171	2840	2042	0	27	193	-2228	-779	-227	29000	26955	29942
Total cereals	-664	-422	934	978	113	0	30	12	-726	-358	-2	-3774	1221	3934
Total oilseeds	23	9	-753	-387	388	0	11	-14	18	4	5	5777	5011	4660
Total pulses	-1240	-374	1578	1714	790	0	-2	-70	-750	-230	-93	-1052	-1477	-1000
Total sugarcrops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total vegetal products	-1882	-787	1760	2305	1292	0	40	-72	-1458	-583	-91	952	4754	7593
Total meat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total eggs	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total milk	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total vegetal oils	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total cakes	881	-364	-80	-56	25	0	-76	311	-730	-185	-133	16663	14926	26038
Total sugar	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total molasses	-57	49	-26	86	-33	0	7	-3	101	28	17	1345	2275	872
Total brans	-866	-70	517	505	758	0	56	-44	-141	-39	-20	10041	5000	-4561
Total		-1171	2171	2840	2042	0	27	193	-2228	-779	-227	29000	26955	29942

Source: Own calculation, Unit: Thousands tons

**Table 111: Variations of food consumption per capita for all food products in the different scenarios for Pakistan**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>PAKISTAN</b>														
Wheat	-0.384	0.241	4.337	3.145	-0.185	0	0.066	0	0.487	0.943	3.1	1.668	6.025	-1.232
Rice	-0.2	-0.05	0.454	0.44	0.022	0	-0.06	0	-0.101	0.071	0.459	-0.261	0.401	-1.411
Maize	0.678	0.125	-0.637	-0.464	-0.067	0	0.051	0	0.252	0.179	-0.521	0.681	3.258	-1.09
Millet	-0.009	-0.019	-0.047	0.002	0.011	0	-0.002	0	-0.038	-0.007	-0.001	-0.114	0.001	-0.427
Sorghum	0.008	-0.019	-0.046	-0.001	0.011	0	0.007	0	-0.038	-0.007	0	-0.114	0.093	-0.367
Other cereals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total pulses	0.204	-0.014	-0.134	-0.031	0.008	0	0.002	0	-0.029	-0.02	-0.033	-0.097	1.046	-0.894
Total sugar crops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottonseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Otherseds	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugar	0.286	0.685	-0.363	-0.788	-0.39	0	-0.089	0	1.381	-0.36	-0.712	4.048	-0.106	12.116
Total molasses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean oil	-0.002	0.004	-0.001	-0.002	-0.002	0	-0.001	0	0.008	-0.001	-0.002	0.023	-0.006	0.058
Sunflower oil	0	0.027	-0.007	-0.013	-0.016	0	-0.001	0	0.055	-0.005	-0.012	0.161	0.036	0.4
Rapeseed oil	-0.013	0.036	-0.026	-0.018	-0.021	0	-0.003	0	0.073	-0.007	-0.017	0.216	0.008	0.539
Cotton oil	-0.013	0.052	-0.041	-0.029	-0.03	0	0.003	0	0.105	-0.01	-0.023	0.309	-0.076	0.771
Other oils	-0.03	0.187	-0.053	-0.089	-0.108	0	-0.005	0	0.377	-0.035	-0.086	1.108	0.085	2.773
Soybean cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bovine meat	0.168	0.375	0.08	0.059	-0.014	0	-0.004	0	0.75	0.024	0.075	3.313	4.396	7.161
Ovine meat	0.021	0.011	0.045	0.018	-0.193	0	0.004	0	0.027	-0.005	-0.004	-0.908	-1.814	-2.44
Pig meat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicken meat	0.009	0.13	0.013	0.013	0.109	0	-0.004	0	0.257	0.011	0.029	1.741	2.4	14.741
Othermeats	0.001	0.004	0.001	0.001	0	0	0	0	0.009	0	0.001	0.038	0.042	-0.101
Total eggs	0.003	0.055	0.015	0.009	0.004	0	-0.001	0	0.109	0.004	0.011	0.514	0.564	0.187
Total milk	-7.907	0.293	-0.293	-0.293	9.784	0	-0.22	0	0.293	0.293	0.293	53.612	53.612	-171.918
Total	-7.181	2.122	3.297	1.961	8.924	0	-0.256	0	3.976	1.07	2.558	65.94	69.966	-141.135
Total cereals	0.092	0.278	4.06	3.123	-0.207	0	0.062	0	0.562	1.179	3.037	1.861	9.779	-4.528
Total oilseeds	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total pulses	0.204	-0.014	-0.134	-0.031	0.008	0	0.002	0	-0.029	-0.02	-0.033	-0.097	1.046	-0.894
Total sugrcrops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total vegetal products	0.296	0.264	3.927	3.092	-0.199	0	0.064	0	0.533	1.159	3.004	1.764	10.826	-5.422
Total meat	0.197	0.52	0.139	0.091	-0.098	0	-0.004	0	1.042	0.031	0.101	4.185	5.023	19.361
Total eggs	0.003	0.055	0.015	0.009	0.004	0	-0.001	0	0.109	0.004	0.011	0.514	0.564	0.187
Total milk	-7.907	0.293	-0.293	-0.293	9.784	0	-0.22	0	0.293	0.293	0.293	53.612	53.612	-171.918
Total vegetal oils	-0.057	0.306	-0.128	-0.151	-0.177	0	-0.007	0	0.617	-0.057	-0.14	1.818	0.048	4.541
Total cakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugar	0.286	0.685	-0.363	-0.788	-0.39	0	-0.089	0	1.381	-0.36	-0.712	4.048	-0.106	12.116
Total molasses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	-7.181	2.122	3.297	1.961	8.924	0	-0.256	0	3.976	1.07	2.558	65.94	69.966	-141.135

Source: Own calculation, Unit: Kilogram per capita per year

**Table 112: Variations of food consumption per capita for all food products in the different scenarios for India**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>INDIA</b>														
Wheat	-3.669	0.092	2.489	2.794	2.514	0	0	0.246	0.145	0.535	0.6	20.539	16.24	33.734
Rice	-1.648	0.109	0.92	1.24	0.896	0	0	0.103	0.202	0.149	0.3	8.401	6.509	14.619
Maize	-0.394	0.069	-0.1	0.055	0.175	0	0	-0.026	0.137	0.015	-0.12	1.766	1.056	0.757
Millet	0.517	0.068	-0.033	-0.267	-0.02	0	0	0.014	0.136	-0.082	0.106	1.535	2.616	0.909
Sorghum	0.425	0.056	-0.091	-0.305	0.003	0	0	0.008	0.112	-0.067	0.087	1.516	2.258	0.914
Other cereals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total pulses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugarcrops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottonseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Otherseeds	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugar	-0.986	0.182	-0.13	0.264	0.422	0	0	-0.026	0.361	0.012	-0.13	5.236	3.272	4.309
Total molasses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean oil	-0.095	0.009	0.031	0.044	0.055	0	0	-0.002	0.017	0.011	-0.017	0.446	0.271	0.438
Sunflower oil	-0.051	0.005	0.008	0.02	0.029	0	0	-0.001	0.009	0.006	-0.009	0.255	0.189	0.23
Rapeseed oil	-0.134	0.013	0.057	0.064	0.084	0	0	-0.004	0.026	0.017	-0.025	0.772	0.614	0.647
Cotton oil	-0.047	0.005	-0.018	0.002	0.031	0	0	-0.001	0.009	0.006	-0.009	0.264	0.205	0.225
Other oils	-0.282	0.028	0.057	0.116	0.168	0	0	-0.006	0.055	0.035	-0.053	1.485	1.062	1.372
Soybean cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bovine meat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ovine meat	-0.063	0.027	0.076	0.116	-0.065	0	0	0.004	0.054	0.016	0.007	0.253	-0.058	-0.598
Pig meat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicken meat	-0.099	0.018	0.055	0.087	0.016	0	0	0.003	0.036	0.011	0.005	0.502	0.254	0.488
Other meats	-0.018	0.003	0.01	0.015	0.004	0	0	0.001	0.006	0.002	0.001	0.096	0.054	0.012
Total eggs	-0.386	0.06	0.165	0.25	0.191	0	0	0.012	0.118	0.037	0.018	2.474	1.813	1.921
Total milk	-3.48	0.041	0.041	0.041	4.552	0	0	0.041	0.041	0.041	0.041	26.647	26.647	44.574
	-10.407	0.784	3.537	4.535	9.053	0	0	0.367	1.466	0.742	0.804	72.187	63.004	104.55
	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total cereals	-4.769	0.393	3.185	3.516	3.567	0	0	0.345	0.733	0.55	0.973	33.757	28.679	50.933
Total oilseeds	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total pulses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugarcrops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total vegetal products	-4.769	0.393	3.185	3.516	3.567	0	0	0.345	0.733	0.55	0.973	33.757	28.679	50.933
Total meat	-0.18	0.048	0.14	0.218	-0.045	0	0	0.008	0.096	0.028	0.013	0.852	0.25	-0.099
Total eggs	-0.386	0.06	0.165	0.25	0.191	0	0	0.012	0.118	0.037	0.018	2.474	1.813	1.921
Total milk	-3.48	0.041	0.041	0.041	4.552	0	0	0.041	0.041	0.041	0.041	26.647	26.647	44.574
Total vegetal oils	-0.608	0.06	0.136	0.245	0.367	0	0	-0.014	0.117	0.074	-0.111	3.221	2.342	2.911
Total cakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugar	-0.986	0.182	-0.13	0.264	0.422	0	0	-0.026	0.361	0.012	-0.13	5.236	3.272	4.309
Total molasses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	-10.407	0.784	3.537	4.535	9.053	0	0	0.367	1.466	0.742	0.804	72.187	63.004	104.55

Source: Own calculation, Unit: Kilogram per capita per year

**Table 113: Variations of food consumption per capita for all food products in the different scenarios for Bangladesh**

Specification of scenario	SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
	Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>BANGLADESH</b>														
Wheat	-0.717	0.429	0.455	0.463	0.625	0	0	0	0.588	0.477	0.328	7.31	6.065	-4.705
Rice	-6.317	1.551	4.311	4.412	4.573	0	0	0	1.188	4.79	0.726	30.389	30.316	-44.976
Maize	0.094	0.252	-0.199	-0.215	0.359	0	0	0	0.323	-0.105	-0.17	-0.661	0.391	-1.052
Millet	0.003	0	-0.001	-0.001	-0.005	0	0	0	0.001	-0.001	-0.013	0.012	0.06	0.011
Sorghum	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other cereals	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total pulses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugar crops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflowerseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cottonseed	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Otherseeds	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugar	-0.105	0.248	0.037	0.035	0.184	0	0	0	0.41	0.021	0.23	3.686	2.644	-0.632
Total molasses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Soybean oil	-0.066	0.057	0.041	0.041	0.061	0	0	0	0.087	0.044	-0.002	0.94	0.961	-0.351
Sunflower oil	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed oil	-0.027	0.023	0.016	0.017	0.025	0	0	0	0.035	0.018	-0.001	0.377	0.386	-0.142
Cotton oil	-0.001	0.001	0	0	0.001	0	0	0	0.001	0.001	0	0.011	0.011	-0.004
Other oils	-0.108	0.093	0.067	0.068	0.099	0	0	0	0.143	0.071	-0.003	1.534	1.57	-0.574
Soybean cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rapeseed cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sunflower cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cotton cake	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Othercakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bovine meat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ovine meat	-0.052	0.03	0.03	0.03	0.056	0	0	0	0.036	0.03	0.007	0.491	0.457	-0.805
Pig meat	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chicken meat	-0.051	0.027	0.026	0.026	0.064	0	0	0	0.025	0.027	0.007	0.476	0.447	-1.347
Othermeats	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total eggs	-0.031	0.018	0.017	0.017	0.033	0	0	0	0.021	0.018	0.004	0.293	0.274	-0.572
Total milk	-0.637	0.34	0.34	0.34	0.756	0	0	0	0.34	0.34	0.083	5.766	5.348	-11.074
Total	-8.013	3.069	5.14	5.233	6.831	0	0	0	3.198	5.73	1.195	50.626	48.929	-66.222
Total cereals	-6.937	2.232	4.565	4.658	5.552	0	0	0	2.1	5.161	0.871	37.051	36.831	-50.721
Total oilseeds	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total pulses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugarcrops	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total vegetal products	-6.937	2.232	4.565	4.658	5.552	0	0	0	2.1	5.161	0.871	37.051	36.831	-50.721
Total meat	-0.104	0.057	0.056	0.056	0.12	0	0	0	0.06	0.057	0.014	0.968	0.904	-2.152
Total eggs	-0.031	0.018	0.017	0.017	0.033	0	0	0	0.021	0.018	0.004	0.293	0.274	-0.572
Total milk	-0.637	0.34	0.34	0.34	0.756	0	0	0	0.34	0.34	0.083	5.766	5.348	-11.074
Total vegetal oils	-0.201	0.174	0.124	0.126	0.186	0	0	0	0.267	0.133	-0.006	2.862	2.928	-1.071
Total cakes	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total sugar	-0.105	0.248	0.037	0.035	0.184	0	0	0	0.41	0.021	0.23	3.686	2.644	-0.632
Total molasses	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total brans	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	-8.013	3.069	5.14	5.233	6.831	0	0	0	3.198	5.73	1.195	50.626	48.929	-66.222

Source: Own calculation, Unit: Kilogram per capita per year

**Table 114: Variations of food expenditure for all food products in the different scenarios for three countries**

		SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52	
		Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations	
		<b>National level</b>														
Initial	Pakistan	2889588	2889588	2889588	2889588	2889588	2889588	2889588	2889588	2889588	2889588	2889588	2889588	2889588	2889588	
Initial	India	8471381	8471381	8471381	8471381	8471381	8471381	8471381	8471381	8471381	8471381	8471381	8471381	8471381	8471381	
Initial	Bangladesh	1469102	1469102	1469102	1469102	1469102	1469102	1469102	1469102	1469102	1469102	1469102	1469102	1469102	1469102	
Final	Pakistan	3027961	3025435	2869109	2877988	2887304	2889590	2890996	2889588	3161490	2898323	2924075	5855097	5762280	4755664	
Final	India	8681228	8834626	8576240	8651016	8445617	8471381	8471381	8475901	9198002	8691876	8568708	21647104	20538503	23735603	
Final	Bangladesh	1543943	1542698	1463086	1462666	1474770	1469102	1469102	1469102	1612755	1548273	1476451	3263098	3255362	1900889	
Variation	Pakistan	138372	135847	-20479	-11600	-2285	2	1408	0	271901	8734	34486	2965509	2872692	1866076	
Variation	India	209847	363245	104859	179635	-25763	0	0	4520	726622	220495	97327	13175723	12067123	15264222	
Variation	Bangladesh	74841	73597	-6016	-6436	5668	0	0	0	143653	79171	7349	1793997	1786260	431788	
Evolution (%)	Pakistan	4.79%	4.70%	-0.71%	-0.40%	-0.08%	0.00%	0.05%	0.00%	9.41%	0.30%	1.19%	102.63%	99.42%	64.58%	
Evolution (%)	India	2.48%	4.29%	1.24%	2.12%	-0.30%	0.00%	0.00%	0.05%	8.58%	2.60%	1.15%	155.53%	142.45%	180.19%	
Evolution (%)	Bangladesh	5.09%	5.01%	-0.41%	-0.44%	0.39%	0.00%	0.00%	0.00%	9.78%	5.39%	0.50%	122.12%	121.59%	29.39%	
		<b>Per Head</b>														
Initial	Pakistan	16948	16948	16948	16948	16948	16948	16948	16948	16948	16948	16948	16948	16948	16948	
Initial	India	7014	7014	7014	7014	7014	7014	7014	7014	7014	7014	7014	7014	7014	7014	
Initial	Bangladesh	9992	9992	9992	9992	9992	9992	9992	9992	9992	9992	9992	9992	9992	9992	
Final	Pakistan	16914	17745	16828	16880	16935	16948	16957	16948	18543	17000	17151	25251	24851	20510	
Final	India	6846	7315	7101	7163	6993	7014	7014	7018	7616	7197	7095	14936	14171	16377	
Final	Bangladesh	10001	10492	9951	9948	10030	9992	9992	9992	10969	10530	10042	18495	18451	10774	
Variation	Pakistan	-34	797	-120	-68	-13	0	8	0	1595	51	202	8303	7903	3562	
Variation	India	-169	301	87	149	-21	0	0	4	602	183	81	7922	7157	9363	
Variation	Bangladesh	9	501	-41	-44	39	0	0	0	977	538	50	8503	8459	782	
Evolution (%)	Pakistan	-0.20%	4.70%	-0.71%	-0.40%	-0.08%	0.00%	0.05%	0.00%	9.41%	0.30%	1.19%	48.99%	46.63%	21.01%	
Evolution (%)	India	-2.40%	4.29%	1.24%	2.12%	-0.30%	0.00%	0.00%	0.05%	8.58%	2.60%	1.15%	112.94%	102.04%	133.49%	
Evolution (%)	Bangladesh	0.09%	5.01%	-0.41%	-0.44%	0.39%	0.00%	0.00%	0.00%	9.78%	5.39%	0.50%	85.10%	84.66%	7.83%	

Source: Own calculation, Unit: Thousands local currency unit (LCU) at national level and LCU per capita per year

**Table 115: Variations of gross margin\* for total animal production in the different scenarios for three countries**

		SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52	
		Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations	
		<b>National level</b>														
Initial	Pakistan	690655	690655	690655	690655	690655	690655	690655	690655	690655	690655	690655	690655	690655	690655	
Initial	India	2544423	2544423	2544423	2544423	2544423	2544423	2544423	2544423	2544423	2544423	2544423	2544423	2544423	2544423	
Initial	Bangladesh	125616	125616	125616	125616	125616	125616	125616	125616	125616	125616	125616	125616	125616	125616	
Final	Pakistan	721413	739883	712105	707476	711688	698804	698028	698805	781582	700868	706326	1505280	1583773	2694376	
Final	India	2402673	2611587	2774789	2844198	2189652	2435287	2435287	2454495	2789330	2538836	2482124	7317793	6323456	10634272	
Final	Bangladesh	162258	162320	160711	161019	155145	159400	159400	159400	171179	161894	159400	353576	371543	980308	
Variation	Pakistan	30757	49228	21449	16821	21052	8149	7373	8150	90926	10213	15671	814624	893117	2003720	
Variation	India	-141750	67164	230366	299775	-354771	-109136	-109136	-89927	244907	-5587	-62299	4773370	3779033	8089849	
Variation	Bangladesh	36642	36703	35095	35402	29529	33783	33783	33783	45563	36278	33783	227960	245927	854692	
Evolution (%)	Pakistan	4.45%	7.13%	3.11%	2.44%	3.05%	1.18%	1.07%	1.18%	13.17%	1.48%	2.27%	117.95%	129.31%	290.12%	
Evolution (%)	India	-5.57%	2.64%	9.05%	11.78%	-13.94%	-4.29%	-4.29%	-3.53%	9.63%	-0.22%	-2.45%	187.60%	148.52%	317.94%	
Evolution (%)	Bangladesh	29.17%	29.22%	27.94%	28.18%	23.51%	26.89%	26.89%	26.89%	36.27%	28.88%	26.89%	181.47%	195.78%	680.40%	

Source: Own calculation, Unit: Thousands local currency unit (LCU) \* Gross margin is defined as the difference between total value of animal production less cost of feed products



**Table 116: Variations of Public cost of subsidy for all food products in the different scenarios for three countries**

		SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
		Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
		National level													
Initial	Pakistan	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Initial	India	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Initial	Bangladesh	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final	Pakistan	0	0	0	0	0	179407	17782	59011	294720	10709	47578	0	0	0
Final	India	0	0	0	0	0	747411	166485	119047	854353	159505	114561	0	0	0
Final	Bangladesh	0	0	0	0	0	65329	41226	1474	149236	87682	7639	0	0	0
Variation	Pakistan	0	0	0	0	0	179407	17782	59011	294720	10709	47578	0	0	0
Variation	India	0	0	0	0	0	747411	166485	119047	854353	159505	114561	0	0	0
Variation	Bangladesh	0	0	0	0	0	65329	41226	1474	149236	87682	7639	0	0	0
		Per Head													
Initial	Pakistan	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Initial	India	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Initial	Bangladesh	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final	Pakistan	0	0	0	0	0	1.052	0.104	0.346	1.729	0.063	0.279	0	0	0
Final	India	0	0	0	0	0	0.619	0.138	0.099	0.707	0.132	0.095	0	0	0
Final	Bangladesh	0	0	0	0	0	0.444	0.28	0.01	1.015	0.596	0.052	0	0	0
Variation	Pakistan	0	0	0	0	0	1.052	0.104	0.346	1.729	0.063	0.279	0	0	0
Variation	India	0	0	0	0	0	0.619	0.138	0.099	0.707	0.132	0.095	0	0	0
Variation	Bangladesh	0	0	0	0	0	0.444	0.28	0.01	1.015	0.596	0.052	0	0	0

Source: Own calculation

**Table 117: Variations of external trade for all food products in the different scenarios for three countries**

		SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
		Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
		National level													
Initial	Pakistan	-277227	-277227	-277227	-277227	-277227	-277227	-277227	-277227	-277227	-277227	-277227	-277227	-277227	-277227
Initial	India	-506894	-506894	-506894	-506894	-506894	-506894	-506894	-506894	-506894	-506894	-506894	-506894	-506894	-506894
Initial	Bangladesh	-361285	-361285	-361285	-361285	-361285	-361285	-361285	-361285	-361285	-361285	-361285	-361285	-361285	-361285
Final	Pakistan	-363666	-300258	-233138	-215415	-257480	-277165	-279123	-275016	-322999	-278858	-284527	-713481	-665479	10578
Final	India	-490691	-514837	-413015	-456603	-604239	-507253	-508877	-498063	-519202	-518623	-508143	-1134969	-223867	-2519428
Final	Bangladesh	-370062	-370156	-357812	-357884	-369409	-361270	-360702	-361679	-372141	-374024	-365464	-591803	-610997	573366
Variation	Pakistan	-86438	-23031	44090	61812	19747	62	-1896	2211	-45772	-1631	-7299	-436253	-388252	287805
Variation	India	16204	-7942	93880	50292	-97344	-358	-1982	8832	-12308	-11728	-1248	-628075	283027	-2012533
Variation	Bangladesh	-8778	-8871	3473	3401	-8124	15	583	-395	-10857	-12739	-4179	-230518	-249712	934651
Evolution (%)	Pakistan	31.18%	8.31%	-15.90%	-22.30%	-7.12%	-0.02%	0.68%	-0.80%	16.51%	0.59%	2.63%	157.36%	140.05%	-103.82%
Evolution (%)	India	-3.20%	1.57%	-18.52%	-9.92%	19.20%	0.07%	0.39%	-1.74%	2.43%	2.31%	0.25%	123.91%	-55.84%	397.03%
Evolution (%)	Bangladesh	2.43%	2.46%	-0.96%	-0.94%	2.25%	0.00%	-0.16%	0.11%	3.01%	3.53%	1.16%	63.81%	69.12%	-258.70%

Source: Own calculation, Unit: Thousands local currency unit (LCU)

**Table 118: Variations of kcal intake from all food products in the different scenarios for three countries**

		Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>National level</b>															
Initial	Pakistan	134527115	134527115	134527115	134527115	134527115	134527115	134527115	134527115	134527115	134527115	134527115	134527115	134527115	134527115
Initial	India	909409307	909409307	909409307	909409307	909409307	909409307	909409307	909409307	909409307	909409307	909409307	909409307	909409307	909409307
Initial	Bangladesh	124165923	124165923	124165923	124165923	124165923	124165923	124165923	124165923	124165923	124165923	124165923	124165923	124165923	124165923
Final	Pakistan	140693140	135673945	136091277	135398992	134971373	134527022	134465565	134527115	136807382	134858370	135481527	200347285	200410584	177731486
Final	India	921666686	912590182	922702866	927008858	931898283	909409307	909409363	910552194	915496483	912303286	911654976	1342108336	1296665320	1424834768
Final	Bangladesh	126064414	125697294	126843610	126896181	127524846	124165923	124165918	124165923	125792722	127162591	124743238	179647843	178950466	112531311
Variation	Pakistan	6166025	1146830	1564162	872777	444258	-93	-61550	0	2280267	331255	954412	65820170	65883469	43204370
Variation	India	12257378	3180875	13293559	17599550	22488975	0	55	1142886	6087176	2893979	2245669	432699028	387256013	515425460
Variation	Bangladesh	1898491	1531371	2677686	2730258	3358923	0	-5	0	1626799	2996668	577314	55481920	54784543	-11634613
Evolution (%)	Pakistan	4.58%	0.85%	1.16%	0.65%	0.33%	0.00%	-0.05%	0.00%	1.70%	0.25%	0.71%	48.93%	48.97%	32.12%
Evolution (%)	India	1.35%	0.35%	1.46%	1.94%	2.47%	0.00%	0.00%	0.13%	0.67%	0.32%	0.25%	47.58%	42.58%	56.68%
Evolution (%)	Bangladesh	1.53%	1.23%	2.16%	2.20%	2.71%	0.00%	0.00%	0.00%	1.31%	2.41%	0.46%	44.68%	44.12%	-9.37%
<b>Per Head</b>															
Initial	Pakistan	2162	2162	2162	2162	2162	2162	2162	2162	2162	2162	2162	2162	2162	2162
Initial	India	2063	2063	2063	2063	2063	2063	2063	2063	2063	2063	2063	2063	2063	2063
Initial	Bangladesh	2314	2314	2314	2314	2314	2314	2314	2314	2314	2314	2314	2314	2314	2314
Final	Pakistan	2153	2180	2187	2176	2169	2162	2161	2162	2198	2167	2177	2367	2368	2100
Final	India	1991	2070	2093	2103	2114	2063	2063	2066	2077	2070	2068	2537	2451	2693
Final	Bangladesh	2237	2342	2364	2365	2376	2314	2314	2314	2344	2370	2324	2790	2779	1747
Variation	Pakistan	-8.6	18.4	25.1	14	7.1	0	-1	0	36.6	5.3	15.3	205.5	206.2	-61.7
Variation	India	-71.8	7.2	30.2	39.9	51	0	0	2.6	13.8	6.6	5.1	474.1	388.2	630.5
Variation	Bangladesh	-76.5	28.5	49.9	50.9	62.6	0	0	0	30.3	55.8	10.8	475.9	465.1	-566.3
Evolution (%)	Pakistan	-0.40%	0.85%	1.16%	0.65%	0.33%	0.00%	-0.05%	0.00%	1.70%	0.25%	0.71%	9.51%	9.54%	-2.86%
Evolution (%)	India	-3.48%	0.35%	1.46%	1.94%	2.47%	0.00%	0.00%	0.13%	0.67%	0.32%	0.25%	22.98%	18.82%	30.56%
Evolution (%)	Bangladesh	-3.31%	1.23%	2.16%	2.20%	2.71%	0.00%	0.00%	0.00%	1.31%	2.41%	0.46%	20.57%	20.10%	-24.48%

Source: Own calculation, Unit: Thousand kilocalories per year at national level and kilocalories per capita per day

**Table 119: Variations of protein intake from all food products in the different scenarios for three countries**

		SC1	SC2	SC3	SC4	SC5	SC10	SC11	SC12	SC20	SC21	SC22	SC50	SC51	SC52
		Population of each country increased by 5%	Total food expenditure per head increased by 5%	Total cultivated area increased by 5%	Yield of each crop increased by 5%	Production for each animal product increased by 5%	Subvention of 10% of initial producer price given to producers for all crops	Subvention of 10% of initial producer price given to producers for only rice	Subvention of 10% of initial producer price given to producers for only wheat	Subvention of 10% of initial consumer price given to consumers for all food products	Subvention of 10% of initial consumer price given to consumers for only rice	Subvention of 10% of initial consumer price given to consumers for only wheat	Scenario 2025	Scenario 2025 with limitations of regional deficit (4500 Tht)	Scenario 2025 with coordination of prices variations
<b>National level</b>															
Initial	Pakistan	3556610	3556610	3556610	3556610	3556610	3556610	3556610	3556610	3556610	3556610	3556610	3556610	3556610	3556610
Initial	India	22119584	22119584	22119584	22119584	22119584	22119584	22119584	22119584	22119584	22119584	22119584	22119584	22119584	22119584
Initial	Bangladesh	2599193	2599193	2599193	2599193	2599193	2599193	2599193	2599193	2599193	2599193	2599193	2599193	2599193	2599193
Final	Pakistan	3695793	3574184	3603921	3594883	3614660	3556610	3556122	3556610	3590018	3573899	3597553	5470779	5693516	3742822
Final	India	22535634	22176854	22451104	22498733	22667773	22119584	22119585	22155561	22226987	22178305	22215588	32329898	31578534	34790765
Final	Bangladesh	2646520	2626641	2649958	2650903	2665407	2599193	2599193	2599193	2625660	2656393	2608887	3654470	3648880	2341937
Variation	Pakistan	139183	17574	47310	38273	58050	-1	-489	0	33407	17289	40942	1914169	2136906	186211
Variation	India	416050	57271	331520	379149	548189	0	1	35978	107403	58721	96004	10210314	9458950	12671181
Variation	Bangladesh	47327	27447	50764	51710	66214	0	0	0	26467	57200	9693	1055277	1049686	-257256
Evolution (%)	Pakistan	3.91%	0.49%	1.33%	1.08%	1.63%	0.00%	-0.01%	0.00%	0.94%	0.49%	1.15%	53.82%	60.08%	5.24%
Evolution (%)	India	1.88%	0.26%	1.50%	1.71%	2.48%	0.00%	0.00%	0.16%	0.49%	0.27%	0.43%	46.16%	42.76%	57.28%
Evolution (%)	Bangladesh	1.82%	1.06%	1.95%	1.99%	2.55%	0.00%	0.00%	0.00%	1.02%	2.20%	0.37%	40.60%	40.39%	-9.90%
<b>Per Head</b>															
Initial	Pakistan	57.2	57.2	57.2	57.2	57.2	57.2	57.2	57.2	57.2	57.2	57.2	57.2	57.2	57.2
Initial	India	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2	50.2
Initial	Bangladesh	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4	48.4
Final	Pakistan	56.6	57.4	57.9	57.8	58.1	57.2	57.1	57.2	57.7	57.4	57.8	64.6	67.3	44.2
Final	India	48.7	50.3	50.9	51	51.4	50.2	50.2	50.3	50.4	50.4	50.4	61.1	59.7	65.8
Final	Bangladesh	47	48.9	49.4	49.4	49.7	48.4	48.4	48.4	48.9	49.5	48.6	56.7	56.7	36.4
Variation	Pakistan	-0.6	0.3	0.8	0.6	0.9	0	0	0	0.5	0.3	0.7	7.5	10.1	-12.9
Variation	India	-1.5	0.1	0.8	0.9	1.2	0	0	0.1	0.2	0.1	0.2	10.9	9.5	15.6
Variation	Bangladesh	-1.5	0.5	0.9	1	1.2	0	0	0	0.5	1.1	0.2	8.3	8.2	-12.1
Evolution (%)	Pakistan	-1.03%	0.49%	1.33%	1.08%	1.63%	0.00%	-0.01%	0.00%	0.94%	0.49%	1.15%	13.10%	17.71%	-22.62%
Evolution (%)	India	-2.97%	0.26%	1.50%	1.71%	2.48%	0.00%	0.00%	0.16%	0.49%	0.27%	0.43%	21.80%	18.97%	31.07%
Evolution (%)	Bangladesh	-3.03%	1.06%	1.95%	1.99%	2.55%	0.00%	0.00%	0.00%	1.02%	2.20%	0.37%	17.17%	16.99%	-24.91%

Source: Own calculation, Unit: kilogram per year at national level and grams per capita per day

## Annex D: Programs implemented in GAMS

```

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

*   Main program South_Asia.gms
*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

$if exist OUTPUT.xls $call 'del OUTPUT.xls'
$if exist \MODELES_OUTPUT\NEW_MODEL_OUTPUT.xls $call 'copy \MODELES_OUTPUT\NEW_MODEL_OUTPUT.xls
OUTPUT.xls '

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
$OFFSYMXREF
$OFFSYMLIST
$OFFFUELLIST
$OFFFUELXREF
$OFFFLISTING
OPTION LIMROW = 0;
OPTION LIMCOL = 0;
OPTION ITERLIM = 1E7;
OPTION RESLIM = 8E4;
OPTION SOLPRINT=ON ;

$include \FICH_inc\RY_SETS.inc
$include \FICH_inc\RY_DECLARE.inc
$include \FICH_inc\RY_LECTURE.inc

PARAMETER SCENARIO;
* Scen =1 simulations  2025
* Scen =2 simulations  2009
SCENARIO = 2;

* AJUSTEMENTS EVENTUEL SUR ELASTICITES
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
ELAS_OFR_PRICE(COUNTRY,PRODUCT,PRODUCT1) =ELAS_OFR_PRICE(COUNTRY,PRODUCT,PRODUCT1) *1;
ELAS_DE_H_REV(COUNTRY,PRODUCT)           =ELAS_DE_H_REV(COUNTRY,PRODUCT)           *1;
ELAS_DE_H_PRICE(COUNTRY,PRODUCT,PRODUCT1) =ELAS_DE_H_PRICE(COUNTRY,PRODUCT,PRODUCT1) *1;
ELAS_DE_A_PRICE(COUNTRY,PRODUCT,PRODUCT1) =ELAS_DE_A_PRICE(COUNTRY,PRODUCT,PRODUCT1) *1;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX Hypotheses sur PRODUCTS animaux
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
*
*   SCENARIO 2025
* PAKISTAN XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
if( (SCENARIO eq 1),
DPOP_EXO("PAK")           =0.36 ;
DREV_UNIT_EXO("PAK")      =0.45 ;

DSURFTOT_EXO("PAK")       =0.02 ;
DREND_EXO("PAK",PRODUCT) =DREND_EXO1(PRODUCT,"PAK") ;

VAR_PROD_ANI("PAK",ANI)   =VAR_PROD_ANII(ANI,"PAK") ;

VAR_SOLDE_MIN_EXO("PAK",PRODUCT)=-1000.;
VAR_SOLDE_MAX_EXO("PAK",PRODUCT)=+1000.;

SUBPROD("PAK", PRODUCT)   = 0.0;
SUBCONS("PAK", PRODUCT)   = 0.0;

*IND XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
DPOP_EXO("IND")           =0.20 ;
DREV_UNIT_EXO("IND")      =1.08 ;

DSURFTOT_EXO("IND")       =0.065;
DREND_EXO("IND",PRODUCT) =DREND_EXO1(PRODUCT,"IND") ;

VAR_PROD_ANI("IND",ANI)   =VAR_PROD_ANII(ANI,"IND") ;

VAR_SOLDE_MIN_EXO("IND",PRODUCT)=-5000.;

```

```

VAR_SOLDE_MAX_EXO("IND",PRODUCT)=+5000.;

SUBPROD("IND",PRODUCT) = 0.00;
SUBCONS("IND",PRODUCT) = 0.00;

*BAN XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
DPOP_EXO("BAN") =0.20 ;
DREV_UNIT_EXO("BAN") =-0.760;

DSURFTOT_EXO("BAN") =0.010;
DREND_EXO("BAN",PRODUCT) =DREND_EXO1(PRODUCT,"BAN") ;
VAR_PROD_ANI("BAN",ANI) =VAR_PROD_ANI1(ANI,"BAN") ;

VAR_SOLDE_MIN_EXO("BAN",PRODUCT)=-1000.;
VAR_SOLDE_MAX_EXO("BAN",PRODUCT)=+1000.;

SUBPROD("BAN",PRODUCT) = 0.00;
SUBCONS("BAN",PRODUCT) = 0.00;
);

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXX Hypotheses sur autres parametres XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
if( (SCENARIO eq 2),

VAR_SOLDE_MIN_EXO(COUNTRY,PRODUCT)=-500;
VAR_SOLDE_MAX_EXO(COUNTRY,PRODUCT)= 500;

VAR_SOLDE_MIN_EXO("IND",PRODUCT)=-1000;
VAR_SOLDE_MAX_EXO("IND",PRODUCT)= 1000;

SUBPROD(COUNTRY,"Rice") = 0.10 ;
SUBCONS(COUNTRY,PRODUCT) = 0.00 ;

DPOP_EXO(COUNTRY) = 0.0 ;
DREV_UNIT_EXO(COUNTRY) = 0.0 ;

DSURFTOT_EXO(COUNTRY) = 0.0 ;
DREND_EXO(COUNTRY,PRODUCT) = 0.0 ;
VAR_PROD_ANI(COUNTRY,ANI) = PROD_INIT(COUNTRY,ANI)*0.0 ;
);

VAR_SOLDE_MIN_EXO(COUNTRY,"Totmilk")=-50.;
VAR_SOLDE_MAX_EXO(COUNTRY,"Totmilk")=+50.;
VAR_SOLDE_MIN_EXO(COUNTRY,"Totsugercrops")=-100.;
VAR_SOLDE_MAX_EXO(COUNTRY,"Totsugercrops")=+100.;
VAR_SOLDE_MIN_EXO(COUNTRY,"Totbrans")=-1000.;
VAR_SOLDE_MAX_EXO(COUNTRY,"Totbrans")=+1000.;

*cccccccccccccccccccccccccccccc
PROD_ANI_FINAL(COUNTRY,ANI) =PROD_INIT(COUNTRY,ANI)+VAR_PROD_ANI(COUNTRY,ANI);

*XXXXXXXXXXXXXXXXXXXX PAKISTAN
FEED_FINAL_TOT("PAK") = (5.3936-0.0491*(2009-
1966))*(PROD_ANI_FINAL("PAK","Toteggs")+PROD_ANI_FINAL("PAK","Poulmeat"))
+0.1272*PROD_ANI_FINAL("PAK","Totmilk")
+ 786.4;
FEED_FINAL_VOL("PAK") = (5.3936-0.0491*(2009-
1966))*(PROD_ANI_FINAL("PAK","Toteggs")+PROD_ANI_FINAL("PAK","Poulmeat"));
FEED_FINAL_MILK("PAK")= 0.1272*PROD_ANI_FINAL("PAK","Totmilk");
FEED_FINAL_AUT("PAK") = 786.4 ;

*XXXXXXXXXXXXXXXXXXXX INDIA
FEED_FINAL_TOT("IND") = 3.5*(PROD_ANI_FINAL("IND","Toteggs")+PROD_ANI_FINAL("IND","Poulmeat"))
+0.1698*PROD_ANI_FINAL("IND","Totmilk")
+8645.850;
FEED_FINAL_VOL("IND") = 3.5*(PROD_ANI_FINAL("IND","Toteggs")+PROD_ANI_FINAL("IND","Poulmeat"));
FEED_FINAL_MILK("IND")= 0.1698*PROD_ANI_FINAL("IND","Totmilk");
FEED_FINAL_AUT("IND") = 8645.850;

*XXXXXXXXXXXXXXXXXXXX BANGLADESH
FEED_FINAL_TOT("BAN") = 5.3321*(PROD_ANI_FINAL("BAN","Toteggs")+PROD_ANI_FINAL("BAN","Poulmeat"))

```



\*XXX  
\* READING of PARAMETRES and Initial situation  
\* File RY\_READING.inc  
\*XXX

SET ANNEE  
/1966\*2011/;

SET COUNTRY  
/  
PAK  
IND  
BAN  
/;

SET PRODUCT  
/  
Totpop

\* rice en milled  
Totcer  
Wheat  
Rice  
Barley  
Rye  
Oats  
Maize  
Millet  
Sorghum  
Othercer

Ricepaddy

Totsugcrops  
SugarCane  
Sugarbeet

Totoilseeds  
Soybean  
Sunflowerseed  
Rapeseed  
Cottonseed  
Groundnuts  
Coconuts  
Sesameseed  
Palmkernels  
Olives  
Otherseeds

Totsugar

Totpulses

Totvegoils  
Soyoil  
Rapeoil  
Cotonoil  
Palmoil  
Groundoil  
Sunoil  
Pkernoil  
Cocoil  
Sesamoil  
Oliveoil  
Ricebranoil  
Maizegermoil  
Otheroils

Totmeat  
Bovmeat  
Pigmeat

Ovinemeat  
Poulmeat  
Othermeats

Toteggs

Totmilk

Totbrans

Totmolasses

Totcakes  
Rapecake  
Soycake  
Suncake  
Copcake  
Cottoncake  
Groundcake  
Pkerncake  
Sesamcake  
Othercakes

Castorseed  
Linseed  
Saffloseed  
Totseeds

Totcer1

Totoilmeals

Forages

Seedcotton

Cottonlint

MillSorg

;/  
ALIAS(PRODUCT,PRODUCT1);

SET PROD\_FEED(PRODUCT)

/  
Wheat  
Rice  
Maize  
Millet  
Sorghum  
Othercer

Soybean  
Sunflowerseed  
Rapeseed  
Cottonseed  
Otherseeds

Rapecake  
Soycake  
Suncake  
Cottoncake  
Othercakes

Totpulses

Totbrans

Totmolasses

```
;/
ALIAS(PROD_FEED,PROD_FEED1);
```

```
SET PROD_NON_FEED(PRODUCT)
```

```
/
Totsugar
Totvegoils
Soyoil
Rapeoil
Cotonoil
Palmoil
Groundoil
Sunoil
Pkernoil
Cocoil
Sesamoil
Oliveoil
Ricebranoil
Maizegermoil
Otheroils
```

```
Totmeat
Bovmeat
Pigmeat
Ovinemeat
Poulmeat
Othermeats
```

```
Toteggs
```

```
Totmilk
```

```
;/
```

```
SET CER_TOT(PRODUCT)
```

```
/
Wheat
Rice
Barley
Rye
Oats
Maize
Millet
Sorghum
Othercer
;/
```

```
SET CER_SHORT(CER_TOT)
```

```
/
Wheat
Rice
Maize
Millet
Sorghum
Othercer
/
```

```
SET CER_DIV(CER_TOT)
```

```
/
Barley
Rye
Oats
;/
```

```
SET OILSEED_SUC_TOT(PRODUCT)
```

```
/
Soybean
Sunflowerseed
Rapeseed
Cottonseed
```



Groundnuts  
Coconuts  
Sesameseed  
Palmkernels  
Olives  
Castorseed  
Linseed  
Saffloseed

Otherseeds  
Totoilseeds  
Totseeds

Totsugcrops  
/;

SET OILSEED\_TOT(OILSEED\_SUC\_TOT)

/  
Soybean  
Sunflowerseed  
Rapeseed  
Cottonseed

Groundnuts  
Coconuts  
Sesameseed  
Palmkernels  
Olives  
Castorseed  
Linseed  
Saffloseed

Otherseeds  
Totoilseeds  
Totseeds  
/;

SET OILSEED\_SHORT(OILSEED\_TOT)

/  
Soybean  
Sunflowerseed  
Rapeseed  
Cottonseed  
Otherseeds  
/;

SET OILSEED\_DIV(OILSEED\_TOT)

/  
Groundnuts  
Coconuts  
Sesameseed  
Palmkernels  
Olives  
Castorseed  
Linseed  
Saffloseed  
/;

SET VEG(PRODUCT)

/  
Wheat  
Rice  
Maize  
Millet  
Sorghum  
Othercer  
Totcer

Totsugcrops

Soybean  
Sunflowerseed  
Rapeseed  
Cottonseed  
Otherseeds  
Totoilseeds

Totpulses

Seedcotton  
/;  
ALIAS(VEG,VEG1);

SET ANI(PRODUCT)

/  
Bovmeat  
Pigmeat  
Ovinemeat  
Poulmeat  
Othermeats

Toteggs

Totmilk  
/;  
ALIAS(ANI,ANI1);

SET PRODTRANSF\_TOT(PRODUCT)

/  
Totsugar

Totvegoils  
Soyoil  
Rapeoil  
Cotonoil  
Palmoil  
Groundoil  
Sunoil  
Pkernoil  
Cocoil  
Sesamoil  
Oliveoil  
Ricebranoil  
Maizegermoil  
Otheroils

Totbrans

Totmolasses

Totcakes  
Rapecake  
Soycake  
Suncake  
Copcake  
Cottoncake  
Groundcake  
Pkerncake  
Sesamcake  
Othercakes  
/;  
ALIAS(PRODTRANSF\_TOT,PRODTRANSF\_TOT1);

SET TOURTEAU\_TOT(PRODTRANSF\_TOT)

/  
Rapecake  
Soycake

Cottoncake  
Suncake

Copcake  
Groundcake  
Pkerncake  
Sesamcake

Othercakes  
Totcakes  
/;

SET TOURTEAU\_SHORT(TOURTEAU\_TOT)

/  
Rapecake  
Soycake  
Cottoncake  
Suncake  
Othercakes  
/;

SET TOURTEAU\_DIV(TOURTEAU\_TOT)

/  
Copcake  
Groundcake  
Pkerncake  
Sesamcake  
/;

SET HUILE\_TOT(PRODTRANSF\_TOT)

/  
Soyoil  
Rapeoil  
Cotonoil  
Sunoil

Palmoil  
Groundoil  
Pkernoil  
Cocoil  
Sesamoil  
Oliveoil  
Ricebranoil  
Maizegermoil

Otheroils  
Totvegoils  
/;

SET HUILE\_SHORT(HUILE\_TOT)

/  
Soyoil  
Rapeoil  
Cotonoil  
Sunoil  
Otheroils  
/;

ALIAS(HUILE\_SHORT,HUILE\_SHORT1);

SET HUILE\_DIV(HUILE\_TOT)

/  
Palmoil  
Groundoil  
Pkernoil  
Cocoil  
Sesamoil  
Oliveoil  
Ricebranoil  
Maizegermoil  
/;



Rapecake  
Soycake  
Cottoncake  
Suncake  
Othercakes

Bovmeat  
Pigmeat  
Ovinemeat  
Poulmeat  
Othermeats

Toteggs

Totmilk

Totbrans

Totmolasses

Totsugar

/;  
ALIAS(PRODUCT\_SHORT\_SANS\_HUIL,PRODUCT\_SHORT\_SANS\_HUIL1);

SET MIL\_SORG(PRODUCT\_SHORT)

/  
Millet  
Sorghum  
/;  
ALIAS(MIL\_SORG,MIL\_SORG1);

SET PRODUCT\_SHORT\_SANS\_MS(PRODUCT\_SHORT)

/  
Wheat  
Rice  
Maize  
Othercer

Totsugcrops

Soybean  
Sunflowerseed  
Rapeseed  
Cottonseed  
Otherseeds

Totpulses

Rapecake  
Soycake  
Cottoncake  
Suncake  
Othercakes

Bovmeat  
Pigmeat  
Ovinemeat  
Poulmeat  
Othermeats

Toteggs

Totmilk

Totbrans

Totmolasses

```
Totsugar  
/;  
ALIAS(PRODUCT_SHORT_SANS_MS,PRODUCT_SHORT_SANS_MS1);
```

```
SET VEG_SHORT(PRODUCT_SHORT)  
/  
Wheat  
Rice  
Maize  
Millet  
Sorghum  
Othercer
```

Totsucrops

```
Soybean  
Sunflowerseed  
Rapeseed  
Cottonseed  
Otherseeds
```

Totpulses

```
/;  
ALIAS(VEG_SHORT,VEG_SHORT1);
```

```
SET YES_VAR_PROCESS(PRODUCT_SHORT)  
/  
Totsucrops
```

```
Soybean  
Sunflowerseed  
Rapeseed  
Cottonseed  
Otherseeds  
/;
```

```
SET NO_VAR_PROCESS(PRODUCT_SHORT)  
/  
Wheat  
Rice  
Maize  
Millet  
Sorghum  
Othercer
```

Totpulses

```
Soyoil  
Rapeoil  
Cotonoil  
Sunoil  
Otheroils
```

```
Rapecake  
Soycake  
Cottoncake  
Suncake  
Othercakes
```

```
Bovmeat  
Pigmeat  
Ovinemeat  
Poulmeat  
Othermeats
```

Toteggs

Totmilk

Totbrans

Totmolasses

Totsugar

/;

SET OIL\_SUC\_SHORT(PRODUCT\_SHORT)

/

Soybean

Sunflowerseed

Rapeseed

Cottonseed

Otherseeds

Totsugcrops

/;

ALIAS(OIL\_SUC\_SHORT,OIL\_SUC\_SHORT1);

SET PROD\_FEED\_SHORT(PRODUCT\_SHORT)

/

Wheat

Rice

Maize

Millet

Sorghum

Othercer

Soybean

Sunflowerseed

Rapeseed

Cottonseed

Otherseeds

Rapecake

Soycake

Suncake

Cottoncake

Othercakes

\*Totsugar

Totpulses

Totbrans

Totmolasses

\*Totsugcrops

/;

ALIAS(PROD\_FEED\_SHORT,PROD\_FEED\_SHORT1);

SET PROD\_NON\_FEED\_SHORT(PRODUCT\_SHORT)

/

Totsugar

Totsugcrops

Soyoil

Rapeoil

Cotonoil

Sunoil

Otheroils

Bovmeat

Pigmeat

Ovinemeat

Poulmeat

Othermeats

Toteggs

Totmilk

/;

SET PROD\_DIVERS\_FEED(PRODUCT\_SHORT)

/

Rapecake

Soycake

Suncake

Cottoncake

Othercakes

Totbrans

Totmolasses

/;

SET PROD\_DIVERS\_CONS(PRODUCT\_SHORT)

/

Totsugar

Soyoil

Rapeoil

Cotonoil

Sunoil

Otheroils

/;

SET ANI\_SHORT(PRODUCT\_SHORT)

/

Bovmeat

Pigmeat

Ovinemeat

Poulmeat

Othermeats

Toteggs

Totmilk

/;

\*XX

SET COPROD

/

TOURTEAU

HUILE

BRANRIZ

BRANBLE

SUGAR

MOLASSE

/;

set corres(PRODUCT,COPROD,PRODUCT1)

/

Soybean.HUILE.Soyoil

Soybean.TOURTEAU.Soycake

Sunflowerseed.HUILE.Sunoil

Sunflowerseed.TOURTEAU.Suncake

Rapeseed.HUILE.Rapeoil

Rapeseed.TOURTEAU.Rapecake

Cottonseed.HUILE.Cotonoil

Cottonseed.TOURTEAU.Cottoncake

Otherseeds.HUILE.Otheroils

Otherseeds.TOURTEAU.Othercakes

Totsugcrops.SUGAR.Totsugar

Totsugcrops.MOLASSE.Totmolasses

/;

SET POSTE



```
/
pop
prix
prod
impt
varstock
expt
domsupply
feed
seed
process
otheruse
food
area
yield
prod1
solde
inc_feed
inc_food
cons_tete
/;
```

```
SET POSTE_CONS(POSTE)
```

```
/
varstock
food
feed
solde
seed
process
otheruse
/;
```

```

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
*
* File RY_DECLARATION.inc
*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
PARAMETER
QBIL1(COUNTRY,PRODUCT,POSTE)
QBIL2(COUNTRY,PRODUCT,POSTE)
QBIL3(COUNTRY,PRODUCT,POSTE)
QBIL(COUNTRY,PRODUCT,POSTE)
QSRP1(COUNTRY,PRODUCT,POSTE)
QSRP2(COUNTRY,PRODUCT,POSTE)
QSRP3(COUNTRY,PRODUCT,POSTE)
QSRP(COUNTRY,PRODUCT,POSTE)

CAL_QBIL(COUNTRY,PRODUCT,POSTE)
VRAI_QBIL(COUNTRY,PRODUCT,POSTE)

ELAS_DE_H_REV(COUNTRY,PRODUCT)
ELAS_DE_H_PRICE(COUNTRY,PRODUCT,PRODUCT1)
ELAS_DE_A_PRICE(COUNTRY,PRODUCT,PRODUCT1)
ELAS_OFR_PRICE(COUNTRY,PRODUCT,PRODUCT1)

PROD_INIT(COUNTRY,PRODUCT)

PRICE_INIT(PRODUCT,COUNTRY)
PRICE_FEED_INIT(PRODUCT,COUNTRY)
PRICE_PROD_INIT(PRODUCT,COUNTRY)
PRICE_CONS_INIT(PRODUCT,COUNTRY)
DIF_PRICE_PROD_CONS(PRODUCT,COUNTRY)
DIF_PRICE_PROD_FEED(PRODUCT,COUNTRY)
SUBCONS(COUNTRY,PRODUCT)
SUBPROD(COUNTRY,PRODUCT)

POP_INIT(COUNTRY)
SURF_INIT(COUNTRY,PRODUCT)
REND_INIT(COUNTRY,PRODUCT)
SOLDE_INIT(COUNTRY,PRODUCT)
FOOD_INIT(COUNTRY,PRODUCT)
FEED_INIT(COUNTRY,PRODUCT)
SEED_INIT(COUNTRY,PRODUCT)
VARSTOCK_INIT(COUNTRY,PRODUCT)
PROCESS_INIT(COUNTRY,PRODUCT)
OTHERUSE_INIT(COUNTRY,PRODUCT)

MARGE_TRIT(COUNTRY,PRODUCT)
VAR_MARGE_TRIT(COUNTRY,PRODUCT)

VERIF_BIL_TOT_CER(COUNTRY,POSTE)
VERIF_BIL_TOT_SEED(COUNTRY,POSTE)
VERIF_BIL_TOT_TOUR(COUNTRY,POSTE)
VERIF_BIL_TOT_HUIL(COUNTRY,POSTE)
VERIF_EQUILIBRE(COUNTRY,PRODUCT)

VERIF_PROD_BIL_QSRP(COUNTRY,VEG)
RENDTECH_COTON(COUNTRY)
RENDTECH_ARACH(COUNTRY)

GLOBAL_INIT(COUNTRY,PRODUCT,POSTE)
VAR_GLOBAL(COUNTRY,PRODUCT,POSTE)
GLOBAL_FINAL(COUNTRY,PRODUCT,POSTE)
EVOL_GLOBAL(COUNTRY,PRODUCT,POSTE)

COEF_CONV(COUNTRY,PRODUCT,COPROD)

PROD_FINAL(COUNTRY,PRODUCT)
SURF_FINAL(COUNTRY,PRODUCT)
REND_FINAL(COUNTRY,PRODUCT)
SOLDE_FINAL(COUNTRY,PRODUCT)
SEED_FINAL(COUNTRY,PRODUCT)
VARSTOCK_FINAL(COUNTRY,PRODUCT)

```

PROCESS\_FINAL(COUNTRY,PRODUCT)  
OTHERUSE\_FINAL(COUNTRY,PRODUCT)

FEED\_INIT\_TOT1(COUNTRY)  
FEED\_INIT\_TOT(COUNTRY)  
FEED\_INIT\_VOL(COUNTRY)  
FEED\_INIT\_MILK(COUNTRY)  
FEED\_INIT\_AUT(COUNTRY)

FEED\_FINAL\_TOT1(COUNTRY)  
FEED\_FINAL\_TOT(COUNTRY)  
FEED\_FINAL\_VOL(COUNTRY)  
FEED\_FINAL\_MILK(COUNTRY)  
FEED\_FINAL\_AUT(COUNTRY)  
BESOIN\_FINAL\_TOT(COUNTRY)

VAR\_FEED\_TOT(COUNTRY)  
VAR\_FEED\_VOL(COUNTRY)  
VAR\_FEED\_MILK(COUNTRY)  
VAR\_FEED\_AUT(COUNTRY)

INC\_FEED\_INIT(COUNTRY,PRODUCT)  
FEED\_UNIT\_INIT(COUNTRY,PRODUCT)

FOOD\_INIT\_TOT1(COUNTRY)  
FOOD\_UNIT\_INIT(COUNTRY,PRODUCT)  
INC\_FOOD\_INIT(COUNTRY,PRODUCT)  
BESOIN\_FOOD\_FINAL(COUNTRY)

BESOIN\_FEED\_FINAL(COUNTRY)  
VAR\_PROD\_ANI(COUNTRY,PRODUCT)  
PROD\_ANI\_FINAL(COUNTRY,PRODUCT)

DPOP\_EXO(COUNTRY)  
DREV\_UNIT\_EXO(COUNTRY)  
DREND\_EXO(COUNTRY,PRODUCT)  
DSURFTOT\_EXO(COUNTRY)  
DPROD\_EXO(COUNTRY,PRODUCT)  
DGDP\_UNIT\_EXO(COUNTRY)  
VAR\_VARSTOCK\_EXO(COUNTRY,PRODUCT)  
VAR\_SOLDE\_MIN\_EXO(COUNTRY,PRODUCT)  
VAR\_SOLDE\_MAX\_EXO(COUNTRY,PRODUCT)  
VAR\_OTHERUSE\_EXO(COUNTRY,PRODUCT)

;

```

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
*
* File RY_READING.inc
*XXXXXXXXXXXXXXXXXXXXXXXXXXXX LECTURE DES ELASTICITES XXXXXXXXXXXXXXXXXXXXXXX

$libinclude xlexport ELAS_DE_H_REV .\FICH_DON_FIXE\YD_ELASTICITES.xls EDH_Revenu!b27:o30;
$libinclude xlexport ELAS_DE_H_PRICE .\FICH_DON_FIXE\YD_ELASTICITES.xls EDH_prix!b3:p47;
$libinclude xlexport ELAS_DE_A_PRICE .\FICH_DON_FIXE\YD_ELASTICITES.xls EDA_prix!c5:t53;
$libinclude xlexport ELAS_OFR_PRICE .\FICH_DON_FIXE\YD_ELASTICITES.xls ES_prix!b3:p47;
$libinclude xldump ELAS_DE_H_prix verif.xls

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
ELAS_DE_H_REV(COUNTRY,"Millet") =ELAS_DE_H_REV(COUNTRY,"MillSorg");
ELAS_DE_H_REV(COUNTRY,"Sorghum") =ELAS_DE_H_REV(COUNTRY,"MillSorg");
ELAS_DE_H_REV(COUNTRY,"Soyoil") =ELAS_DE_H_REV(COUNTRY,"Totvegoils");
ELAS_DE_H_REV(COUNTRY,"Sunoil") =ELAS_DE_H_REV(COUNTRY,"Totvegoils");
ELAS_DE_H_REV(COUNTRY,"Rapeoil") =ELAS_DE_H_REV(COUNTRY,"Totvegoils");
ELAS_DE_H_REV(COUNTRY,"Cotonoil") =ELAS_DE_H_REV(COUNTRY,"Totvegoils");
ELAS_DE_H_REV(COUNTRY,"Otheroils") =ELAS_DE_H_REV(COUNTRY,"Totvegoils");

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
ELAS_DE_H_PRICE(COUNTRY,PRODUCT_SHORT,MIL_SORG1)
=ELAS_DE_H_PRICE(COUNTRY,PRODUCT_SHORT,"MillSorg")/2;
ELAS_DE_H_PRICE(COUNTRY,PRODUCT_SHORT,HUILE_SHORT1)
=ELAS_DE_H_PRICE(COUNTRY,PRODUCT_SHORT,"Totvegoils")/5;

ELAS_DE_H_PRICE(COUNTRY,MIL_SORG,PRODUCT_SHORT1)
=ELAS_DE_H_PRICE(COUNTRY,"MillSorg",PRODUCT_SHORT1);
ELAS_DE_H_PRICE(COUNTRY,MIL_SORG,MIL_SORG1) =0;
ELAS_DE_H_PRICE(COUNTRY,MIL_SORG,MIL_SORG) =ELAS_DE_H_PRICE(COUNTRY,"MillSorg","MillSorg");

ELAS_DE_H_PRICE(COUNTRY,HUILE_SHORT,PRODUCT_SHORT1)
=ELAS_DE_H_PRICE(COUNTRY,"Totvegoils",PRODUCT_SHORT1);
ELAS_DE_H_PRICE(COUNTRY,HUILE_SHORT,HUILE_SHORT1) =0;
ELAS_DE_H_PRICE(COUNTRY,HUILE_SHORT,HUILE_SHORT) =ELAS_DE_H_PRICE(COUNTRY,"Totvegoils","Totvegoils");

ELAS_DE_H_PRICE(COUNTRY,MIL_SORG,HUILE_SHORT1) =ELAS_DE_H_PRICE(COUNTRY,"MillSorg","Totvegoils")/5;
ELAS_DE_H_PRICE(COUNTRY,HUILE_SHORT,MIL_SORG1) =ELAS_DE_H_PRICE(COUNTRY,"Totvegoils","MillSorg")/2;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX LECTURE DES NUTRIMENTS
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
SET SET_nut /kcal,prot;
PARAMETER NUTRI(PRODUCT,SET_nut);
$libinclude xlexport NUTRI .\FICH_DON_FIXE\YD_Bilans_3P_court.xlsx NUTRI!c4:e50;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX LESTURE DES BILANS XXXXXXXXXXXXXXXXXXXXXXX
$libinclude xlexport QBIL1 .\FICH_DON_FIXE\YD_Bilans_3P_court.xlsx bilan!c3:o68;
$libinclude xlexport QBIL2 .\FICH_DON_FIXE\YD_Bilans_3P_court.xlsx bilan!u3:ag68;
$libinclude xlexport QBIL3 .\FICH_DON_FIXE\YD_Bilans_3P_court.xlsx bilan!am3:ay68;

QBIL(COUNTRY,PRODUCT,POSTE)=
QBIL1(COUNTRY,PRODUCT,POSTE)+QBIL2(COUNTRY,PRODUCT,POSTE)+QBIL3(COUNTRY,PRODUCT,POSTE);
QBIL(COUNTRY,"Othercer",POSTE)=QBIL(COUNTRY,"Othercer",POSTE)+SUM(CER_DIV,QBIL(COUNTRY,CER_DIV,POSTE));
VERIF_BIL_TOT_CER(COUNTRY,POSTE) =QBIL(COUNTRY,"Totcer",POSTE)-
SUM(CER_SHORT,QBIL(COUNTRY,CER_SHORT,POSTE));
display VERIF_BIL_TOT_CER;
QBIL(COUNTRY,"Totcer",POSTE) = QBIL(COUNTRY,"Totcer",POSTE)-VERIF_BIL_TOT_CER(COUNTRY,POSTE);
VERIF_BIL_TOT_CER(COUNTRY,POSTE) =QBIL(COUNTRY,"Totcer",POSTE)-
SUM(CER_SHORT,QBIL(COUNTRY,CER_SHORT,POSTE));
display VERIF_BIL_TOT_CER;

QBIL(COUNTRY,"Otherseeds",POSTE)=QBIL(COUNTRY,"Otherseeds",POSTE)+SUM(OILSEED_DIV,QBIL(COUNTRY,OILSEED_DIV,P
OSTE));
VERIF_BIL_TOT_SEED(COUNTRY,POSTE) = QBIL(COUNTRY,"Totoilseeds",POSTE)-
SUM(OILSEED_SHORT,QBIL(COUNTRY,OILSEED_SHORT,POSTE));
display VERIF_BIL_TOT_SEED;
QBIL(COUNTRY,"Totoilseeds",POSTE)=QBIL(COUNTRY,"Totoilseeds",POSTE)-VERIF_BIL_TOT_SEED(COUNTRY,POSTE);
VERIF_BIL_TOT_SEED(COUNTRY,POSTE) = QBIL(COUNTRY,"Totoilseeds",POSTE)-
SUM(OILSEED_SHORT,QBIL(COUNTRY,OILSEED_SHORT,POSTE));
display VERIF_BIL_TOT_SEED;

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QBIL(COUNTRY,"Othercakes",POSTE)=QBIL(COUNTRY,"Othercakes",POSTE)+SUM(TOURTEAU_DIV,QBIL(COUNTRY,TOURTEAU_
DIV,POSTE));
VERIF_BIL_TOT_TOUR(COUNTRY,POSTE) = QBIL(COUNTRY,"Totcakes",POSTE)-
SUM(TOURTEAU_SHORT,QBIL(COUNTRY,TOURTEAU_SHORT,POSTE));
display VERIF_BIL_TOT_TOUR;
QBIL(COUNTRY,"Totcakes",POSTE)=QBIL(COUNTRY,"Totcakes",POSTE)-VERIF_BIL_TOT_TOUR(COUNTRY,POSTE);
VERIF_BIL_TOT_TOUR(COUNTRY,POSTE) = QBIL(COUNTRY,"Totcakes",POSTE)-
SUM(TOURTEAU_SHORT,QBIL(COUNTRY,TOURTEAU_SHORT,POSTE));
display VERIF_BIL_TOT_TOUR;

QBIL(COUNTRY,"Otheroils",POSTE)=QBIL(COUNTRY,"Otheroils",POSTE)+SUM(HUILE_DIV,QBIL(COUNTRY,HUILE_DIV,POSTE));
VERIF_BIL_TOT_HUIL(COUNTRY,POSTE) = QBIL(COUNTRY,"Totvegoils",POSTE)-
SUM(HUILE_SHORT,QBIL(COUNTRY,HUILE_SHORT,POSTE));
display VERIF_BIL_TOT_HUIL;
QBIL(COUNTRY,"Totvegoils",POSTE) =QBIL(COUNTRY,"Totvegoils",POSTE)- VERIF_BIL_TOT_HUIL(COUNTRY,POSTE);
VERIF_BIL_TOT_HUIL(COUNTRY,POSTE) = QBIL(COUNTRY,"Totvegoils",POSTE)-
SUM(HUILE_SHORT,QBIL(COUNTRY,HUILE_SHORT,POSTE));
display VERIF_BIL_TOT_HUIL;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX verifications dse cumul
VERIF_EQUILIBRE(COUNTRY,PRODUCT)=
QBIL(COUNTRY,PRODUCT,"prod")+QBIL(COUNTRY,PRODUCT,"impt")+QBIL(COUNTRY,PRODUCT,"varstock")
-
(QBIL(COUNTRY,PRODUCT,"expt")+QBIL(COUNTRY,PRODUCT,"food")+QBIL(COUNTRY,PRODUCT,"feed")+QBIL(COUNTRY,PRO
DUCT,"seed")
+QBIL(COUNTRY,PRODUCT,"process")+QBIL(COUNTRY,PRODUCT,"otheruse"));
display VERIF_EQUILIBRE;
QBIL(COUNTRY,PRODUCT,"prod")=QBIL(COUNTRY,PRODUCT,"prod")-VERIF_EQUILIBRE(COUNTRY,PRODUCT);
VERIF_EQUILIBRE(COUNTRY,PRODUCT)=
QBIL(COUNTRY,PRODUCT,"prod")+QBIL(COUNTRY,PRODUCT,"impt")+QBIL(COUNTRY,PRODUCT,"varstock")
-
(QBIL(COUNTRY,PRODUCT,"expt")+QBIL(COUNTRY,PRODUCT,"food")+QBIL(COUNTRY,PRODUCT,"feed")+QBIL(COUNTRY,PRO
DUCT,"seed")
+QBIL(COUNTRY,PRODUCT,"process")+QBIL(COUNTRY,PRODUCT,"otheruse"));
display VERIF_EQUILIBRE;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX LESTURE DES PRICE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
$libinclude xliimport PRICE_FEED_INIT .\FICH_DON_FIXE\YD_Bilans_3P_court.xlsx PRICE!c4:f50;
$libinclude xliimport PRICE_PROD_INIT .\FICH_DON_FIXE\YD_Bilans_3P_court.xlsx PRICE!h4:k50;
$libinclude xliimport PRICE_CONS_INIT .\FICH_DON_FIXE\YD_Bilans_3P_court.xlsx PRICE!q4:t50;

PRICE_FEED_INIT(PRODUCT,"IND") = PRICE_FEED_INIT(PRODUCT,"IND")*1.20 ;
PRICE_PROD_INIT(PRODUCT,"IND") = PRICE_PROD_INIT(PRODUCT,"IND")*1.20 ;
PRICE_CONS_INIT(PRODUCT,"IND") = PRICE_CONS_INIT(PRODUCT,"IND")*1.20 ;

DIF_PRICE_PROD_CONS(PRODUCT,COUNTRY) =
(PRICE_PROD_INIT(PRODUCT,COUNTRY)-PRICE_CONS_INIT(PRODUCT,COUNTRY))
$(PRICE_PROD_INIT(PRODUCT,COUNTRY)*PRICE_CONS_INIT(PRODUCT,COUNTRY));
DIF_PRICE_PROD_FEED(PRODUCT,COUNTRY) =
(PRICE_PROD_INIT(PRODUCT,COUNTRY)-PRICE_FEED_INIT(PRODUCT,COUNTRY))
$(PRICE_PROD_INIT(PRODUCT,COUNTRY)*PRICE_FEED_INIT(PRODUCT,COUNTRY));
display DIF_PRICE_PROD_CONS,DIF_PRICE_PROD_FEED ;

PRICE_CONS_INIT("Soyoil","BAN")=PRICE_CONS_INIT("Rapeoil","BAN")-5;
PRICE_CONS_INIT("Sunoil","BAN")=PRICE_CONS_INIT("Rapeoil","BAN")+10;

PRICE_CONS_INIT("Soyoil","PAK")=PRICE_CONS_INIT("Rapeoil","PAK")-5;
PRICE_CONS_INIT("Sunoil","PAK")=PRICE_CONS_INIT("Rapeoil","PAK")+10;

PRICE_CONS_INIT("Otheroils",COUNTRY)=PRICE_CONS_INIT("Rapeoil",COUNTRY)-20;
PRICE_CONS_INIT("Cotonoil",COUNTRY) =PRICE_CONS_INIT("Rapeoil",COUNTRY)-15;

PRICE_CONS_INIT("Bovmeat","BAN") = 0;
PRICE_CONS_INIT("Othermeats","BAN") = 0;
PRICE_PROD_INIT("Bovmeat","BAN") = 0;
PRICE_PROD_INIT("Othermeats","BAN") = 0;

PRICE_INIT(PRODUCT_SHORT,COUNTRY) = PRICE_PROD_INIT(PRODUCT_SHORT,COUNTRY);
PRICE_INIT(PROD_DIVERS_FEED,COUNTRY) = PRICE_FEED_INIT(PROD_DIVERS_FEED,COUNTRY);

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PRICE_INIT(PROD_DIVERS_CONS,COUNTRY) = PRICE_CONS_INIT(PROD_DIVERS_CONS,COUNTRY);
display PRICE_INIT;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
$libinclude xlexport QSRP1 \FICH_DON_FIXE\YD_Bilans_3P_court.xlsx SRP!c265:g304;
$libinclude xlexport QSRP2 \FICH_DON_FIXE\YD_Bilans_3P_court.xlsx SRP!i265:m304;
$libinclude xlexport QSRP3 \FICH_DON_FIXE\YD_Bilans_3P_court.xlsx SRP!o265:s304;

QSRP(COUNTRY,PRODUCT,POSTE)= (
QSRP1(COUNTRY,PRODUCT,POSTE)+QSRP2(COUNTRY,PRODUCT,POSTE)+QSRP3(COUNTRY,PRODUCT,POSTE))/1000;
RENDTECH_COTON(COUNTRY) = QBIL(COUNTRY,"Cottonseed","prod")/QSRP(COUNTRY,"Seedcotton","prod");
display RENDTECH_COTON;
QSRP(COUNTRY,"Rice","prod")=QSRP(COUNTRY,"Ricepaddy","prod")*2/3;
QSRP(COUNTRY,"Rice","area")=QSRP(COUNTRY,"Ricepaddy","area");
QSRP(COUNTRY,"Othercer","prod")= QSRP(COUNTRY,"Othercer","prod")+SUM(CER_DIV,QSRP(COUNTRY,CER_DIV,"prod"));
QSRP(COUNTRY,"Othercer","area")= QSRP(COUNTRY,"Othercer","area")+SUM(CER_DIV,QSRP(COUNTRY,CER_DIV,"area"));

RENDTECH_ARACH(COUNTRY) = QBIL(COUNTRY,"Groundnuts","prod")/QSRP(COUNTRY,"Groundnuts","prod");
display RENDTECH_ARACH;
QSRP(COUNTRY,"Groundnuts","prod")=QSRP(COUNTRY,"Groundnuts","prod")*0.70 ;

QSRP(COUNTRY,"Otherseeds","prod")=
QSRP(COUNTRY,"Otherseeds","prod")+SUM(OILSEED_DIV,QSRP(COUNTRY,OILSEED_DIV,"prod"));
QSRP(COUNTRY,"Otherseeds","area")=
QSRP(COUNTRY,"Otherseeds","area")+SUM(OILSEED_DIV,QSRP(COUNTRY,OILSEED_DIV,"area"));

QSRP(COUNTRY,"Totsugcrops","prod")=QBIL(COUNTRY,"Totsugcrops","prod");
VERIF_PROD_BIL_QSRP(COUNTRY,VEG)= QBIL(COUNTRY,VEG,"prod")-QSRP(COUNTRY,VEG,"prod");
display VERIF_PROD_BIL_QSRP;

QSRP(COUNTRY,VEG,"prod")=QBIL(COUNTRY,VEG,"prod") ;
QSRP(COUNTRY,"Cottonseed","area")=QSRP(COUNTRY,"Seedcotton","area") ;
QSRP(COUNTRY,"Totoilseeds","area")=QSRP(COUNTRY,"Cottonseed","area")+QSRP(COUNTRY,"Soybean","area")
+QSRP(COUNTRY,"Sunflowerseed","area")+QSRP(COUNTRY,"Rapeseed","area")+QSRP(COUNTRY,"Otherseeds","area");

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
* productions avec liste courte de PRODUCTS
POP_INIT(COUNTRY) = QBIL(COUNTRY,"Totpop","pop");
PROD_INIT(COUNTRY,PRODUCT) = QBIL(COUNTRY,PRODUCT,"prod");
SURF_INIT(COUNTRY,VEG) = QSRP(COUNTRY,VEG,"area");
REND_INIT(COUNTRY,VEG)$SURF_INIT(COUNTRY,VEG) =PROD_INIT(COUNTRY,VEG)/SURF_INIT(COUNTRY,VEG);
SOLDE_INIT(COUNTRY,PRODUCT) = QBIL(COUNTRY,PRODUCT,"expt")-QBIL(COUNTRY,PRODUCT,"impt");
FOOD_INIT(COUNTRY,PRODUCT) = QBIL(COUNTRY,PRODUCT,"food");
FEED_INIT(COUNTRY,PRODUCT) = QBIL(COUNTRY,PRODUCT,"feed");
SEED_INIT(COUNTRY,PRODUCT) = QBIL(COUNTRY,PRODUCT,"seed");
VARSTOCK_INIT(COUNTRY,PRODUCT) = QBIL(COUNTRY,PRODUCT,"varstock");
PROCESS_INIT(COUNTRY,PRODUCT) = QBIL(COUNTRY,PRODUCT,"process");
OTHERUSE_INIT(COUNTRY,PRODUCT) = QBIL(COUNTRY,PRODUCT,"otheruse");
display FEED_INIT,SURF_INIT,REND_INIT,PROD_INIT;

GLOBAL_INIT(COUNTRY,"Totpop","pop") =POP_INIT(COUNTRY) ;
GLOBAL_INIT(COUNTRY,PRODUCT,"prod") =PROD_INIT(COUNTRY,PRODUCT) ;
GLOBAL_INIT(COUNTRY,PRODUCT,"prix") =PRICE_INIT(PRODUCT,COUNTRY) ;
GLOBAL_INIT(COUNTRY,VEG,"area") =SURF_INIT(COUNTRY,VEG) ;
GLOBAL_INIT(COUNTRY,VEG,"yield") =REND_INIT(COUNTRY,VEG) ;
GLOBAL_INIT(COUNTRY,PRODUCT,"solde")=SOLDE_INIT(COUNTRY,PRODUCT) ;
GLOBAL_INIT(COUNTRY,PRODUCT,"food") =FOOD_INIT(COUNTRY,PRODUCT) ;
GLOBAL_INIT(COUNTRY,PRODUCT,"feed") =FEED_INIT(COUNTRY,PRODUCT) ;
GLOBAL_INIT(COUNTRY,PRODUCT,"seed") =SEED_INIT(COUNTRY,PRODUCT) ;
GLOBAL_INIT(COUNTRY,PRODUCT,"varstock") =VARSTOCK_INIT(COUNTRY,PRODUCT);
GLOBAL_INIT(COUNTRY,PRODUCT,"process") =PROCESS_INIT(COUNTRY,PRODUCT);
GLOBAL_INIT(COUNTRY,PRODUCT,"otheruse") =OTHERUSE_INIT(COUNTRY,PRODUCT);

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
* total des conso de MP en feed
PARAMETER FEED_AJUST_cons_fixe(COUNTRY,PROD_FEED);
FEED_AJUST_cons_fixe("PAK","Totbrans") = 789 ;
FEED_AJUST_cons_fixe("IND","Totbrans") = 8646 ;
FEED_AJUST_cons_fixe("BAN","Totbrans") = 930 ;
FEED_INIT(COUNTRY,PROD_FEED) = FEED_INIT(COUNTRY,PROD_FEED)-FEED_AJUST_cons_fixe(COUNTRY,PROD_FEED);

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*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
*      File RY_DEF_MODEL.inc
*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

VAR_SOLDE_MIN_EXO(COUNTRY,"Totpop")= 0;
VAR_SOLDE_MAX_EXO(COUNTRY,"Totpop")= 0;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
POSITIVE VARIABLES
FOOD_FINAL(COUNTRY,PRODUCT_SHORT)
FEED_FINAL(COUNTRY,PRODUCT_SHORT)
FOOD_UNIT_FINAL(COUNTRY,PRODUCT_SHORT)
FEED_UNIT_FINAL(COUNTRY,PRODUCT_SHORT)
;

VARIABLES
DPRICE_PROD(COUNTRY,PRODUCT_SHORT)
DPRICE_CONS(COUNTRY,PRODUCT_SHORT)
DPRICE_FEED(COUNTRY,PRODUCT_SHORT)

DSURF(COUNTRY,PRODUCT_SHORT)
DREND(COUNTRY,PRODUCT_SHORT)

VAR_PROD(COUNTRY,PRODUCT_SHORT)
VAR_REND(COUNTRY,PRODUCT_SHORT)
VAR_SOLDE(COUNTRY,PRODUCT_SHORT)
VAR_FOOD(COUNTRY,PRODUCT_SHORT)
VAR_FEED(COUNTRY,PRODUCT_SHORT)
VAR_SEED(COUNTRY,PRODUCT_SHORT)
VAR_VARSTOCK(COUNTRY,PRODUCT_SHORT)
VAR_PROCESS(COUNTRY,PRODUCT_SHORT)
VAR_OTHERUSE(COUNTRY,PRODUCT_SHORT)
EVOL_FOOD_UNIT(COUNTRY,PRODUCT_SHORT)
EVOL_FEED_UNIT(COUNTRY,PRODUCT_SHORT)

FONC_ECO
;

DPRICE_PROD.lo(COUNTRY,PRODUCT_SHORT)=-1;

DSURF.lo(COUNTRY,PRODUCT_SHORT)=-1;
DREND.lo(COUNTRY,PRODUCT_SHORT)=-1;

EVOL_FOOD_UNIT.lo(COUNTRY,PRODUCT_SHORT)=-1;
EVOL_FEED_UNIT.lo(COUNTRY,PRODUCT_SHORT)=-1;

VAR_PROD.lo(COUNTRY,PRODUCT_SHORT)  =-PROD_INIT(COUNTRY,PRODUCT_SHORT);

VAR_PROCESS.lo(COUNTRY,OIL_SUC_SHORT) =-PROCESS_INIT(COUNTRY,OIL_SUC_SHORT);
VAR_OTHERUSE.lo(COUNTRY,OIL_SUC_SHORT)=-OTHERUSE_INIT(COUNTRY,OIL_SUC_SHORT) ;
VAR_PROCESS.fx(COUNTRY,No_VAR_PROCESS)= 0;

DPRICE_PROD.l(COUNTRY,PRODUCT_SHORT)=0;
DPRICE_CONS.l(COUNTRY,PRODUCT_SHORT)=0;
DPRICE_FEED.l(COUNTRY,PRODUCT_SHORT)=0;
VAR_SOLDE.l(COUNTRY,PRODUCT_SHORT) =0;

VAR_VARSTOCK_EXO(COUNTRY,PRODUCT) =0.00;
VAR_OTHERUSE_EXO(COUNTRY,PRODUCT) =0.00;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXX
EQUATION objectif_QCP :
objectif_QCP .. FONC_ECO =E=SUM((COUNTRY,PRODUCT_SHORT),POWER(DPRICE_PROD(COUNTRY,PRODUCT_SHORT),2));

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXX
EQUATION equilibre(COUNTRY,PRODUCT_SHORT);
equilibre(COUNTRY,PRODUCT_SHORT).. VAR_PROD(COUNTRY,PRODUCT_SHORT) -

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(VAR_FOOD(COUNTRY,PRODUCT_SHORT)+VAR_FEED(COUNTRY,PRODUCT_SHORT)+VAR_SEED(COUNTRY,PRODUCT_SHOR
T)+VAR_PROCESS(COUNTRY,PRODUCT_SHORT)

+VAR_OTHERUSE(COUNTRY,PRODUCT_SHORT)+VAR_SOLDE(COUNTRY,PRODUCT_SHORT)+VAR_VARSTOCK(COUNTRY,PR
ODUCT_SHORT))=E=0 ;

*XXXXXXXXXXXXXXXXXXXXX EQUATIONS DE PROD
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
EQUATION E_evol_surf_veg(COUNTRY,PRODUCT_SHORT);
E_evol_surf_veg(COUNTRY,PRODUCT_SHORT).. DSURF(COUNTRY,PRODUCT_SHORT) =E=
(DSURFTOT_EXO(COUNTRY)+SUM(PRODUCT_SHORT1,
ELAS_OFR_PRICE(COUNTRY,PRODUCT_SHORT,PRODUCT_SHORT1)*
(DPRICE_PROD(COUNTRY,PRODUCT_SHORT1)+
SUBPROD(COUNTRY,PRODUCT_SHORT1)))$(SURF_INIT(COUNTRY,PRODUCT_SHORT) gt 0);

EQUATION E_var_seed(COUNTRY,PRODUCT_SHORT);
E_var_seed(COUNTRY,PRODUCT_SHORT).. VAR_SEED(COUNTRY,PRODUCT_SHORT) =E=

SEED_INIT(COUNTRY,PRODUCT_SHORT)*DSURF(COUNTRY,PRODUCT_SHORT)$(SURF_INIT(COUNTRY,PRODUCT_SHORT) gt
0);

EQUATION evol_rend_veg(COUNTRY,PRODUCT_SHORT);
evol_rend_veg(COUNTRY,PRODUCT_SHORT).. DREND(COUNTRY,PRODUCT_SHORT) =E=
DREND_EXO(COUNTRY,PRODUCT_SHORT);

EQUATION E_var_rend_veg(COUNTRY,PRODUCT_SHORT);
E_var_rend_veg(COUNTRY,PRODUCT_SHORT).. VAR_REND(COUNTRY,PRODUCT_SHORT) =E=
DREND(COUNTRY,PRODUCT_SHORT)*REND_INIT(COUNTRY,PRODUCT_SHORT);

EQUATION E_var_prod(COUNTRY,PRODUCT_SHORT);
E_var_prod(COUNTRY,PRODUCT_SHORT).. VAR_PROD(COUNTRY,PRODUCT_SHORT) =E=

PROD_INIT(COUNTRY,PRODUCT_SHORT)*(DREND(COUNTRY,PRODUCT_SHORT)+DSURF(COUNTRY,PRODUCT_SHORT))$(SU
RF_INIT(COUNTRY,PRODUCT_SHORT) ne 0)
+VAR_PROD_ANI(COUNTRY,PRODUCT_SHORT)$(VAR_PROD_ANI(COUNTRY,PRODUCT_SHORT) ne 0)

+SUM((PRODUCT_SHORT1,COPROD),VAR_PROCESS(COUNTRY,PRODUCT_SHORT1)*COEF_CONV(COUNTRY,PRODUCT_SHOR
T1,COPROD)
*corres(PRODUCT_SHORT1,COPROD,PRODUCT_SHORT));

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX COPROD
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
EQUATION var_prod_transf_G(COUNTRY,OIL_SUC_SHORT);
var_prod_transf_G(COUNTRY,OIL_SUC_SHORT).. VAR_PROCESS(COUNTRY,OIL_SUC_SHORT) =E=
VAR_PROD(COUNTRY,OIL_SUC_SHORT) ;

EQUATION var_prod_brans(COUNTRY);
var_prod_brans(COUNTRY).. VAR_PROD(COUNTRY,"Totbrans") =E=
VAR_FOOD(COUNTRY,"Rice")*COEF_CONV(COUNTRY,"Rice","BRANRIZ")*corres("Rice","BRANRIZ","Totbrans")
+VAR_FOOD(COUNTRY,"Wheat")*COEF_CONV(COUNTRY,"Wheat","BRANBLE")*corres("Wheat","BRANBLE","Totbrans");

*XXXXXXXXXXXXXXXXXXXXX EQUATIONS DE DEMANDE HUMAINE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
EQUATION E_evol_food_unit(COUNTRY,PRODUCT_SHORT);
E_evol_food_unit(COUNTRY,PRODUCT_SHORT).. EVOL_FOOD_UNIT(COUNTRY,PRODUCT_SHORT) =E=

(SUM(PRODUCT_SHORT1,ELAS_DE_H_PRICE(COUNTRY,PRODUCT_SHORT,PRODUCT_SHORT1)*(DPRICE_CONS(COUNTRY,PR
ODUCT_SHORT1)-SUBCONS(COUNTRY,PRODUCT_SHORT1)))
+ELAS_DE_H_REV(COUNTRY,PRODUCT_SHORT)*DREV_UNIT_EXO(COUNTRY) )
$FOOD_INIT(COUNTRY,PRODUCT_SHORT);

EQUATION E_final_food_unit(COUNTRY,PRODUCT_SHORT);
E_final_food_unit(COUNTRY,PRODUCT_SHORT).. FOOD_UNIT_FINAL(COUNTRY,PRODUCT_SHORT)=E=
FOOD_UNIT_INIT(COUNTRY,PRODUCT_SHORT)*(1+EVOL_FOOD_UNIT(COUNTRY,PRODUCT_SHORT));

EQUATION E_final_cons_food(COUNTRY,PRODUCT_SHORT);
E_final_cons_food(COUNTRY,PRODUCT_SHORT).. FOOD_FINAL(COUNTRY,PRODUCT_SHORT)=E=
POP_INIT(COUNTRY)*(1+DPOP_EXO(COUNTRY))*FOOD_UNIT_FINAL(COUNTRY,PRODUCT_SHORT);

EQUATION E_var_food(COUNTRY,PRODUCT_SHORT);

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E_var_food(COUNTRY,PRODUCT_SHORT).. VAR_FOOD(COUNTRY,PRODUCT_SHORT) =E=
    FOOD_FINAL(COUNTRY,PRODUCT_SHORT)-FOOD_INIT(COUNTRY,PRODUCT_SHORT);

*XXXXXXXXXXXXXXXXXXXXX EQUATIONS DE DEMANDE ANIMALE XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
EQUATION E_evol_feed_unit(COUNTRY,PROD_FEED_SHORT);
E_evol_feed_unit(COUNTRY,PROD_FEED_SHORT).. EVOL_FEED_UNIT(COUNTRY,PROD_FEED_SHORT) =E=
    SUM(PROD_FEED_SHORT1,ELAS_DE_A_PRICE(COUNTRY,PROD_FEED_SHORT,PROD_FEED_SHORT1)*
        DPRICE_FEED(COUNTRY,PROD_FEED_SHORT1))$FEED_UNIT_INIT(COUNTRY,PROD_FEED_SHORT);

EQUATION E_evol_non_feed_unit(COUNTRY,PROD_NON_FEED_SHORT);
E_evol_non_feed_unit(COUNTRY,PROD_NON_FEED_SHORT).. EVOL_FEED_UNIT(COUNTRY,PROD_NON_FEED_SHORT) =E=0;

EQUATION E_final_feed_unit(COUNTRY,PROD_FEED_SHORT);
E_final_feed_unit(COUNTRY,PROD_FEED_SHORT).. FEED_UNIT_FINAL(COUNTRY,PROD_FEED_SHORT)=E=
    FEED_UNIT_INIT(COUNTRY,PROD_FEED_SHORT)*(1+EVOL_FEED_UNIT(COUNTRY,PROD_FEED_SHORT));

EQUATION E_final_cons_feed(COUNTRY,PROD_FEED_SHORT);
E_final_cons_feed(COUNTRY,PROD_FEED_SHORT).. FEED_FINAL(COUNTRY,PROD_FEED_SHORT)=E=
    BESOIN_FEED_FINAL(COUNTRY)*FEED_UNIT_FINAL(COUNTRY,PROD_FEED_SHORT);

EQUATION E_final_cons_non_feed(COUNTRY,PROD_NON_FEED_SHORT);
E_final_cons_non_feed(COUNTRY,PROD_NON_FEED_SHORT).. FEED_FINAL(COUNTRY,PROD_NON_FEED_SHORT)=E=
    FEED_INIT(COUNTRY,PROD_NON_FEED_SHORT);

EQUATION E_var_feed(COUNTRY,PRODUCT_SHORT);
E_var_feed(COUNTRY,PRODUCT_SHORT).. VAR_FEED(COUNTRY,PRODUCT_SHORT) =E=
    FEED_FINAL(COUNTRY,PRODUCT_SHORT)-FEED_INIT(COUNTRY,PRODUCT_SHORT);

*XXXXXXXXXXXXXXXXXXXXX EQUATIONS POUR LES AUTRES DEMANDES
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
EQUATION E_var_varstock(COUNTRY,PRODUCT_SHORT);
E_var_varstock(COUNTRY,PRODUCT_SHORT)..
VAR_VARSTOCK(COUNTRY,PRODUCT_SHORT)=E=VAR_VARSTOCK_EXO(COUNTRY,PRODUCT_SHORT);

EQUATION E_var_otheruses(COUNTRY,PRODUCT_SHORT);
E_var_otheruses(COUNTRY,PRODUCT_SHORT)..
VAR_OTHERUSE(COUNTRY,PRODUCT_SHORT)=E=VAR_OTHERUSE_EXO(COUNTRY,PRODUCT_SHORT);

EQUATION E_var_min_solde(COUNTRY,PRODUCT_SHORT);
E_var_min_solde(COUNTRY,PRODUCT_SHORT)..
VAR_SOLDE(COUNTRY,PRODUCT_SHORT)=G=VAR_SOLDE_MIN_EXO(COUNTRY,PRODUCT_SHORT);

EQUATION E_var_max_solde(COUNTRY,PRODUCT_SHORT);
E_var_max_solde(COUNTRY,PRODUCT_SHORT)..
VAR_SOLDE(COUNTRY,PRODUCT_SHORT)=L=VAR_SOLDE_MAX_EXO(COUNTRY,PRODUCT_SHORT);

*XXXXXXXXXXXXXXXXXXXXX RELATIONS ENTRE PRICE
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
EQUATION E_DPRICE_PROD_CONS(COUNTRY,PRODUCT_SHORT);
E_DPRICE_PROD_CONS(COUNTRY,PRODUCT_SHORT)..
DPRICE_PROD(COUNTRY,PRODUCT_SHORT)=E=DPRICE_CONS(COUNTRY,PRODUCT_SHORT);

EQUATION E_DPRICE_PROD_FEED(COUNTRY,PRODUCT_SHORT);
E_DPRICE_PROD_FEED(COUNTRY,PRODUCT_SHORT)..
DPRICE_PROD(COUNTRY,PRODUCT_SHORT)=E=DPRICE_FEED(COUNTRY,PRODUCT_SHORT);

EQUATION E_DPRICE_TRIT(COUNTRY,OIL_SUC_SHORT);
E_DPRICE_TRIT(COUNTRY,OIL_SUC_SHORT)..
DPRICE_PROD(COUNTRY,OIL_SUC_SHORT)*PRICE_INIT(OIL_SUC_SHORT,COUNTRY)
=E=SUM((PRODUCT_SHORT1,COPROD)$corres(OIL_SUC_SHORT,COPROD,PRODUCT_SHORT1),COEF_CONV(COUNTRY,OIL_SUC_SHORT,COPROD)
    *DPRICE_PROD(COUNTRY,PRODUCT_SHORT1)*PRICE_INIT(PRODUCT_SHORT1,COUNTRY));

EQUATION E_VAR_SOLDE_TOT(PRODUCT_SHORT);
E_VAR_SOLDE_TOT(PRODUCT_SHORT).. SUM(COUNTRY,VAR_SOLDE(COUNTRY,PRODUCT_SHORT)) =G= -4500;

*XXXXXXXXXXXXXXXXXXXXX FIN XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

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MODEL MOD_ASIE_SUD /ALL/;
*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
*      FILE RY_OUTPUT.inc
*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

PARAMETER FEED_INIT_TOT2 ;
FEED_INIT_TOT2(COUNTRY) = SUM(PROD_FEED_SHORT,FEED_INIT(COUNTRY,PROD_FEED_SHORT));
FEED_FINAL_TOT1(COUNTRY) = SUM(PROD_FEED_SHORT,FEED_FINAL.I(COUNTRY,PROD_FEED_SHORT));
display FEED_INIT_TOT1,FEED_INIT_TOT2,FEED_FINAL_TOT1;

* variation des taux d incorporation
PARAMETERS SUM_var_inc_feed(COUNTRY),SUM_var_quant_feed(COUNTRY), SUM_feed_unit_final(COUNTRY) ;
SUM_var_inc_feed(COUNTRY) = SUM(PROD_FEED_SHORT,EVOL_FEED_UNIT.I(COUNTRY,PROD_FEED_SHORT));
SUM_var_quant_feed(COUNTRY) =
SUM(PROD_FEED_SHORT,EVOL_FEED_UNIT.I(COUNTRY,PROD_FEED_SHORT)*FEED_INIT(COUNTRY,PROD_FEED_SHORT));
SUM_feed_unit_final(COUNTRY)= SUM(PROD_FEED_SHORT,FEED_UNIT_FINAL.I(COUNTRY,PROD_FEED_SHORT));
display SUM_var_inc_feed,SUM_var_quant_feed,SUM_feed_unit_final;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
VAR_GLOBAL(COUNTRY,"Totpop","pop")      =DPOP_EXO(COUNTRY)*POP_INIT(COUNTRY);
EVOL_GLOBAL(COUNTRY,"Totpop","pop")      =VAR_GLOBAL(COUNTRY,"Totpop","pop")
/GLOBAL_INIT(COUNTRY,"Totpop","pop");
GLOBAL_FINAL(COUNTRY,"Totpop","pop")=GLOBAL_INIT(COUNTRY,"Totpop","pop")+VAR_GLOBAL(COUNTRY,"Totpop","pop");

VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"area")
=DSURF.I(COUNTRY,PRODUCT_SHORT)*SURF_INIT(COUNTRY,PRODUCT_SHORT);
VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"yield") =VAR_REND.I(COUNTRY,PRODUCT_SHORT);
VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"prix")
=DPRICE_prod.I(COUNTRY,PRODUCT_SHORT)*PRICE_INIT(PRODUCT_SHORT,COUNTRY);

VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"prod") =VAR_PROD.I(COUNTRY,PRODUCT_SHORT);
VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"solde") =VAR_SOLDE.I(COUNTRY,PRODUCT_SHORT);
VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"food") =VAR_FOOD.I(COUNTRY,PRODUCT_SHORT);
VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"feed") =VAR_FEED.I(COUNTRY,PRODUCT_SHORT);
VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"seed") =VAR_SEED.I(COUNTRY,PRODUCT_SHORT);
VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"varstock")=VAR_VARSTOCK.I(COUNTRY,PRODUCT_SHORT);
VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"process") =VAR_PROCESS.I(COUNTRY,PRODUCT_SHORT);
VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"otheruse")=VAR_OTHERUSE.I(COUNTRY,PRODUCT_SHORT);

* VERIFICATIONS EQUILIBRES XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
PARAMETER V_EQUI(COUNTRY,PRODUCT_SHORT),V_EQUI_BIL(COUNTRY,PRODUCT_SHORT);
V_EQUI(COUNTRY,PRODUCT_SHORT)= VAR_PROD.I(COUNTRY,PRODUCT_SHORT)-
(VAR_SOLDE.I(COUNTRY,PRODUCT_SHORT)+VAR_FOOD.I(COUNTRY,PRODUCT_SHORT)
+VAR_FEED.I(COUNTRY,PRODUCT_SHORT)+VAR_SEED.I(COUNTRY,PRODUCT_SHORT)
+VAR_VARSTOCK.I(COUNTRY,PRODUCT_SHORT)+VAR_PROCESS.I(COUNTRY,PRODUCT_SHORT)
+VAR_OTHERUSE.I(COUNTRY,PRODUCT_SHORT));
display V_EQUI;

V_EQUI_BIL(COUNTRY,PRODUCT_SHORT)=VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"prod") -
SUM(POSTE_CONS,VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,POSTE_CONS));
display V_EQUI_BIL;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,POSTE)=GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,POSTE)+VAR_GLOBAL(CO
UNTRY,PRODUCT_SHORT,POSTE);
EVOL_GLOBAL(COUNTRY,PRODUCT_SHORT,POSTE) $GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,POSTE)
=VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,POSTE)/GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,POSTE);

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
PARAMETERS VAR_GLOBAL_incfood(COUNTRY,PRODUCT_SHORT),VAR_GLOBAL_infeed(COUNTRY,PRODUCT_SHORT);
PARAMETERS VAR_GLOBAL_incfood1(COUNTRY,PRODUCT_SHORT),VAR_GLOBAL_infeed1(COUNTRY,PRODUCT_SHORT);

GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,"cons_tete")
=GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,"food")/(POP_INIT(COUNTRY)*(1+DPOP_EXO(COUNTRY)))*1000;
VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"cons_tete") =GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,"cons_tete")-
GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"cons_tete");
EVOL_GLOBAL(COUNTRY,PRODUCT_SHORT,"cons_tete") $GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"cons_tete")
= VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"cons_tete")/GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"cons_tete");

VAR_GLOBAL_incfood(COUNTRY,PRODUCT_SHORT)=EVOL_FOOD_UNIT.I(COUNTRY,PRODUCT_SHORT);

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GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,"inc_food")
$$SUM(PRODUCT_SHORT1,GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT1,"food"))

=GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,"food")/SUM(PRODUCT_SHORT1,GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT
1,"food"));
VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"inc_food") = GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,"inc_food") -
GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"inc_food");
EVOL_GLOBAL(COUNTRY,PRODUCT_SHORT,"inc_food") $GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"inc_food")
= VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"inc_food")/GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"inc_food");

VAR_GLOBAL_infeed(COUNTRY,PRODUCT_SHORT) = EVOL_FEED_UNIT.I(COUNTRY,PRODUCT_SHORT);
GLOBAL_FINAL(COUNTRY,PROD_FEED_SHORT,"inc_feed")
$$SUM(PROD_FEED_SHORT1,GLOBAL_FINAL(COUNTRY,PROD_FEED_SHORT1,"feed"))

=GLOBAL_FINAL(COUNTRY,PROD_FEED_SHORT,"feed")/SUM(PROD_FEED_SHORT1,GLOBAL_FINAL(COUNTRY,PROD_FEED_S
HORT1,"feed"));
VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"inc_feed") = GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,"inc_feed") -
GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"inc_feed");
EVOL_GLOBAL(COUNTRY,PRODUCT_SHORT,"inc_feed") $GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"inc_feed")
= VAR_GLOBAL(COUNTRY,PRODUCT_SHORT,"inc_feed")/GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"inc_feed");

VAR_GLOBAL_incfood1(COUNTRY,PRODUCT_SHORT)=EVOL_GLOBAL(COUNTRY,PRODUCT_SHORT,"inc_food");
VAR_GLOBAL_infeed1(COUNTRY,PRODUCT_SHORT)=EVOL_GLOBAL(COUNTRY,PRODUCT_SHORT,"inc_feed");
display VAR_GLOBAL_infeed,VAR_GLOBAL_infeed1,VAR_GLOBAL_incfood,VAR_GLOBAL_incfood1;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
VAR_MARGE_TRIT(COUNTRY,OIL_SUC_SHORT)=
SUM((PRODUCT_SHORT1,COPROD),COEF_CONV(COUNTRY,OIL_SUC_SHORT,COPROD))

*corres(OIL_SUC_SHORT,COPROD,PRODUCT_SHORT1)*DPRICE_PROD.I(COUNTRY,PRODUCT_SHORT1)*PRICE_INIT(PRODUCT_
SHORT1,COUNTRY)
-DPRICE_PROD.I(COUNTRY,OIL_SUC_SHORT)*PRICE_INIT(OIL_SUC_SHORT,COUNTRY);
display MARGE_TRIT,VAR_MARGE_TRIT;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
$libinclude xlexport GLOBAL_INIT OUTPUT.xls init!b3:s50;
$libinclude xlexport GLOBAL_INIT OUTPUT.xls init!x3:ao50;
$libinclude xlexport GLOBAL_INIT OUTPUT.xls init!at3:bk50;

$libinclude xlexport VAR_GLOBAL OUTPUT.xls var!b3:s50;
$libinclude xlexport VAR_GLOBAL OUTPUT.xls var!x3:ao50;
$libinclude xlexport VAR_GLOBAL OUTPUT.xls var!at3:bk50;

$libinclude xlexport GLOBAL_FINAL OUTPUT.xls final!b3:s50;
$libinclude xlexport GLOBAL_FINAL OUTPUT.xls final!x3:ao50;
$libinclude xlexport GLOBAL_FINAL OUTPUT.xls final!at3:bk50;

$libinclude xlexport EVOL_GLOBAL OUTPUT.xls evol!b3:s50;
$libinclude xlexport EVOL_GLOBAL OUTPUT.xls evol!x3:ao50;
$libinclude xlexport EVOL_GLOBAL OUTPUT.xls evol!at3:bk50;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

$libinclude xlexport ELAS_OFR_PRICE OUTPUT.xls ELAST!b3:au137;
$libinclude xlexport ELAS_DE_H_PRICE OUTPUT.xls ELAST!b141:au276;
$libinclude xlexport ELAS_DE_A_PRICE OUTPUT.xls ELAST!b280:au415;
$libinclude xlexport ELAS_DE_H_REV OUTPUT.xls ELAST!c421:au424;

SET SSET /revenu/;
PARAMETER ELAS_DE_H_REV1(COUNTRY,PRODUCT,SSET);
ELAS_DE_H_REV1(COUNTRY,PRODUCT,"revenu") =ELAS_DE_H_REV(COUNTRY,PRODUCT);

$libinclude xlexport ELAS_DE_H_REV1 OUTPUT.xls ELAST!az141:bb276;

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
*XXXXXXXXXXXXXXXXXXXXXXXXXXXX PRICE
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
* multiplicateur prix_prod prix_cons saul huile et sucre
PARAMETER COEF1(PRODUCT);
COEF1(PRODUCT) = 1.3;

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COEF1(PROD_DIVERS_CONS) = 1.0;

SET POST_PRICE /prix_init,prix_f_deb,prix_p_deb,prix_c_deb,prix_fin,prix_f_fin,prix_p_fin,prix_c_fin/;
PARAMETER GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,POST_PRICE);

GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_init") = PRICE_INIT(PRODUCT_SHORT,COUNTRY) ;
GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_fin") =
PRICE_INIT(PRODUCT_SHORT,COUNTRY)*(1+DPRICE_PROD.I(COUNTRY,PRODUCT_SHORT)) ;
GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_f_deb") = PRICE_FEED_INIT(PRODUCT_SHORT,COUNTRY) ;
GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_p_deb") = PRICE_PROD_INIT(PRODUCT_SHORT,COUNTRY) ;
GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_c_deb") = PRICE_CONS_INIT(PRODUCT_SHORT,COUNTRY) ;
GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_c_deb")$(PRICE_CONS_INIT(PRODUCT_SHORT,COUNTRY) eq 0) =
PRICE_PROD_INIT(PRODUCT_SHORT,COUNTRY)*COEF1(PRODUCT_SHORT) ;
GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_f_fin") =
GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_f_deb")*(1+DPRICE_FEED.I(COUNTRY,PRODUCT_SHORT));
GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_p_fin") =
GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_p_deb")*(1+DPRICE_PROD.I(COUNTRY,PRODUCT_SHORT));
GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_c_fin") =
GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_c_deb")*(1+DPRICE_CONS.I(COUNTRY,PRODUCT_SHORT));

$!binclude xlexport GLOBAL_PRICE OUTPUT.xls PRICE!b3:k140;

*XXXXXXXXXXXXXXXXXXXXXXXXX
SET L_IND
/pop,VPVEG,VPANI,DEPVEG,DEPANI,COUTFEED,SUBPVEG,SUBCVEG,SUBPANI,SUBCANI,SOLDVEG,SOLDANI,kcalani,kcalveg,pro
tani,protveg/;
SET D_IND /debut, fin/;
PARAMETERS INDICATOR(D_IND,COUNTRY,L_IND);

* valeurs debut
INDICATOR("debut",COUNTRY,"pop") = GLOBAL_INIT(COUNTRY,"Totpop","pop") ;

INDICATOR("debut",COUNTRY,"VPVEG")=SUM(VEG_SHORT,GLOBAL_INIT(COUNTRY,VEG_SHORT,"prod")*GLOBAL_PRICE(CO
UNTRY,VEG_SHORT,"prix_p_deb"));
INDICATOR("debut",COUNTRY,"VPANI")=SUM(ANI_SHORT,GLOBAL_INIT(COUNTRY,ANI_SHORT,"prod")*GLOBAL_PRICE(CO
UNTRY,ANI_SHORT,"prix_p_deb"));

INDICATOR("debut",COUNTRY,"DEPANI")=SUM(ANI_SHORT,GLOBAL_INIT(COUNTRY,ANI_SHORT,"food")*GLOBAL_PRICE(CO
UNTRY,ANI_SHORT,"prix_c_deb"));
INDICATOR("debut",COUNTRY,"DEPVEG")=SUM(PRODUCT_SHORT,GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"food")*GLOBA
L_PRICE(COUNTRY,PRODUCT_SHORT,"prix_c_deb"))
-INDICATOR("debut",COUNTRY,"DEPANI") ;

INDICATOR("debut",COUNTRY,"COUTFEED")=SUM(PROD_FEED_SHORT,GLOBAL_INIT(COUNTRY,PROD_FEED_SHORT,"feed")*
GLOBAL_PRICE(COUNTRY,PROD_FEED_SHORT,"prix_c_deb"));

INDICATOR("debut",COUNTRY,"SOLDANI")=SUM(ANI_SHORT,GLOBAL_INIT(COUNTRY,ANI_SHORT,"solde")*GLOBAL_PRICE(C
OUNTRY,ANI_SHORT,"prix_init"));
INDICATOR("debut",COUNTRY,"SOLDVEG")=SUM(PRODUCT_SHORT,GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"solde")*GLO
BAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_init"))
-INDICATOR("debut",COUNTRY,"SOLDANI");

INDICATOR("debut",COUNTRY,"SUBPANI") = 0;
INDICATOR("debut",COUNTRY,"SUBPVEG") = 0;
INDICATOR("debut",COUNTRY,"SUBCANI") = 0;
INDICATOR("debut",COUNTRY,"SUBCVEG") = 0;

INDICATOR("debut",COUNTRY,"kcalani")=SUM(ANI,GLOBAL_INIT(COUNTRY,ANI,"food")*NUTRI(ANI,"kcal"));
INDICATOR("debut",COUNTRY,"kcalveg")=SUM(PRODUCT_SHORT,GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"food")*NUTRI(P
RODUCT_SHORT,"kcal"))
-INDICATOR("debut",COUNTRY,"kcalani");
INDICATOR("debut",COUNTRY,"protani")=SUM(ANI,GLOBAL_INIT(COUNTRY,ANI,"food")*NUTRI(ANI,"prot"));
INDICATOR("debut",COUNTRY,"protveg")=SUM(PRODUCT_SHORT,GLOBAL_INIT(COUNTRY,PRODUCT_SHORT,"food")*NUTRI(P
RODUCT_SHORT,"prot"))
-INDICATOR("debut",COUNTRY,"protani");

* valeurs fin
INDICATOR("fin",COUNTRY,"pop") = GLOBAL_FINAL(COUNTRY,"Totpop","pop") ;

```

```
INDICATOR("fin",COUNTRY,"VPVEG")=SUM(VEG_SHORT,GLOBAL_FINAL(COUNTRY,VEG_SHORT,"prod")*GLOBAL_PRICE(CO
UNTRY,VEG_SHORT,"prix_fin"));
INDICATOR("fin",COUNTRY,"VPANI")=SUM(ANI_SHORT,GLOBAL_FINAL(COUNTRY,ANI_SHORT,"prod")*GLOBAL_PRICE(COU
NTRY,ANI_SHORT,"prix_fin"));
```

```
INDICATOR("fin",COUNTRY,"DEPANI")=SUM(ANI_SHORT,GLOBAL_FINAL(COUNTRY,ANI_SHORT,"food")*GLOBAL_PRICE(CO
UNTRY,ANI_SHORT,"prix_c_fin"));
INDICATOR("fin",COUNTRY,"DEPVEG")=SUM(PRODUCT_SHORT,GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,"food")*GLOBA
L_PRICE(COUNTRY,PRODUCT_SHORT,"prix_c_fin"))
-INDICATOR("fin",COUNTRY,"DEPANI");
```

```
INDICATOR("fin",COUNTRY,"COUTFEED")=SUM(PROD_FEED_SHORT,GLOBAL_FINAL(COUNTRY,PROD_FEED_SHORT,"feed")*
GLOBAL_PRICE(COUNTRY,PROD_FEED_SHORT,"prix_f_fin"));
```

```
INDICATOR("fin",COUNTRY,"SOLDANI")=SUM(ANI_SHORT,GLOBAL_INIT(COUNTRY,ANI_SHORT,"solde")*GLOBAL_PRICE(CO
UNTRY,ANI_SHORT,"prix_fin"));
INDICATOR("fin",COUNTRY,"SOLDVEG")=SUM(PRODUCT_SHORT,GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,"solde")*GLOB
AL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_fin"))
-INDICATOR("debut",COUNTRY,"SOLDANI");
```

```
INDICATOR("fin",COUNTRY,"SUBPANI") =
SUM(ANI_SHORT,SUBPROD(COUNTRY,ANI_SHORT)*GLOBAL_PRICE(COUNTRY,ANI_SHORT,"prix_p_deb")*GLOBAL_FINAL(CO
UNTRY,ANI_SHORT,"prod"));
INDICATOR("fin",COUNTRY,"SUBPVEG") =
SUM(VEG_SHORT,SUBPROD(COUNTRY,VEG_SHORT)*GLOBAL_PRICE(COUNTRY,VEG_SHORT,"prix_p_deb")*GLOBAL_FINAL(C
OUNTRY,VEG_SHORT,"prod"));
```

```
INDICATOR("fin",COUNTRY,"SUBCANI") =
SUM(ANI_SHORT,SUBCONS(COUNTRY,ANI_SHORT)*GLOBAL_PRICE(COUNTRY,ANI_SHORT,"prix_c_deb")*GLOBAL_FINAL(CO
UNTRY,ANI_SHORT,"food"));
INDICATOR("fin",COUNTRY,"SUBCVEG") =
SUM(PRODUCT_SHORT,SUBCONS(COUNTRY,PRODUCT_SHORT)*GLOBAL_PRICE(COUNTRY,PRODUCT_SHORT,"prix_c_deb")*
GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,"food"))
-INDICATOR("fin",COUNTRY,"SUBCANI");
```

```
INDICATOR("fin",COUNTRY,"kcalani")=SUM(ANI,GLOBAL_FINAL(COUNTRY,ANI,"food")*NUTRI(ANI,"kcal"));
INDICATOR("fin",COUNTRY,"kcalveg")=SUM(PRODUCT_SHORT,GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,"food")*NUTRI(P
RODUCT_SHORT,"kcal"))
-INDICATOR("fin",COUNTRY,"kcalani");
INDICATOR("fin",COUNTRY,"protani")=SUM(ANI,GLOBAL_FINAL(COUNTRY,ANI,"food")*NUTRI(ANI,"prot"));
INDICATOR("fin",COUNTRY,"protveg")=SUM(PRODUCT_SHORT,GLOBAL_FINAL(COUNTRY,PRODUCT_SHORT,"food")*NUTRI(PR
ODUCT_SHORT,"prot"))
-INDICATOR("fin",COUNTRY,"protani");
```

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$libinclude xlexport INDICATOR OUTPUT.xls INDICATOR!b3:y10;
```

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*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
SET SET_INDIC /effet_prix_surf, effet_sub_surf, effet_prix_dem_H, effet_sub_dem_H, effet_rev_dem_H, effet_prix_dem_A/;
PARAMETER INDIC(COUNTRY, PRODUCT_SHORT,SET_INDIC);
```

```
* Effet prix sur surfaces
INDIC(COUNTRY, PRODUCT_SHORT,"effet_prix_surf") = SUM(PRODUCT_SHORT1,
ELAS_OFR_PRICE(COUNTRY,PRODUCT_SHORT,PRODUCT_SHORT1)*DPRICE_PROD.I(COUNTRY,PRODUCT_SHORT1));
```

```
* Effet subventionsur surfaces
INDIC(COUNTRY, PRODUCT_SHORT,"effet_sub_surf") = SUM(PRODUCT_SHORT1,
ELAS_OFR_PRICE(COUNTRY,PRODUCT_SHORT,PRODUCT_SHORT1)*SUBPROD(COUNTRY,PRODUCT_SHORT1));
```

```
* Effet prix sur demande hum
INDIC(COUNTRY, PRODUCT_SHORT,"effet_prix_dem_H") =
SUM(PRODUCT_SHORT1,ELAS_DE_H_PRICE(COUNTRY,PRODUCT_SHORT,PRODUCT_SHORT1)*DPRICE_CONS.I(COUNTRY,PR
ODUCT_SHORT1));
```

```
* Effet subvention cons sur demande hum
INDIC(COUNTRY, PRODUCT_SHORT,"effet_sub_dem_H") = -
SUM(PRODUCT_SHORT1,ELAS_DE_H_PRICE(COUNTRY,PRODUCT_SHORT,PRODUCT_SHORT1)*SUBCONS(COUNTRY,PRODUC
T_SHORT1));
```

```
* Effet revenu sur demande hum
```

```

INDIC(COUNTRY, PRODUCT_SHORT,"effet_rev_dem_H") =
ELAS_DE_H_REV(COUNTRY,PRODUCT_SHORT)*DREV_UNIT_EXO(COUNTRY);

* Effet prix sur substit en feed
INDIC(COUNTRY, PROD_FEED_SHORT,"effet_prix_dem_A") =
SUM(PROD_FEED_SHORT1,ELAS_DE_A_PRICE(COUNTRY,PROD_FEED_SHORT,PROD_FEED_SHORT1)*
DPRICE_FEED.I(COUNTRY,PROD_FEED_SHORT1)) $FEED_UNIT_INIT(COUNTRY,PROD_FEED_SHORT);

$libinclude xlexport INDIC OUTPUT.xls EFFETS!b3:i100

*XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
* OUTPUT_FEED *XXXXXXXXXXXXXXXXXXXXXXXXXXXX

SET SET_FEED / bes_tot_init,bes_tot_final,var_bes_tot, evol_bes_tot,cons_tot_init,cons_tot_init_ajust/;
SET SET_FEED1 /cons_init, cons_init_ajust,inc_feed_init,evol_feed_unit,feed_unit_final,cons_final,dprix_feed/;

PARAMETER GLOBAL_FEED(SET_FEED,COUNTRY),GLOBAL_FEED1(PROD_FEED_SHORT,SET_FEED1,COUNTRY);
GLOBAL_FEED("bes_tot_init",COUNTRY) = FEED_INIT_TOT(COUNTRY);
GLOBAL_FEED("bes_tot_final",COUNTRY) = FEED_FINAL_TOT(COUNTRY);
GLOBAL_FEED("var_bes_tot",COUNTRY) = VAR_FEED_TOT(COUNTRY);
GLOBAL_FEED("evol_bes_tot",COUNTRY) = HAUSSE_pct_DEM_FEED(COUNTRY);

GLOBAL_FEED("cons_tot_init",COUNTRY) =
SUM(PROD_FEED_SHORT,GLOBAL_INIT(COUNTRY,PROD_FEED_SHORT,"feed"));
GLOBAL_FEED("cons_tot_init_ajust",COUNTRY) = FEED_INIT_TOT1(COUNTRY);

$libinclude xlexport GLOBAL_FEED OUTPUT.xls FEED!c2:f10;

GLOBAL_FEED1(PROD_FEED_SHORT,"cons_init",COUNTRY) = GLOBAL_INIT(COUNTRY,PROD_FEED_SHORT,"feed");
GLOBAL_FEED1(PROD_FEED_SHORT,"cons_init_ajust",COUNTRY) = FEED_INIT(COUNTRY,PROD_FEED_SHORT);
GLOBAL_FEED1(PROD_FEED_SHORT,"inc_feed_init",COUNTRY) = INC_FEED_INIT(COUNTRY,PROD_FEED_SHORT);
GLOBAL_FEED1(PROD_FEED_SHORT,"evol_feed_unit",COUNTRY) = EVOL_FEED_UNIT.I(COUNTRY,PROD_FEED_SHORT);
GLOBAL_FEED1(PROD_FEED_SHORT,"feed_unit_final",COUNTRY) = FEED_UNIT_FINAL.I(COUNTRY,PROD_FEED_SHORT);
GLOBAL_FEED1(PROD_FEED_SHORT,"cons_final",COUNTRY) = FEED_FINAL.I(COUNTRY,PROD_FEED_SHORT);
GLOBAL_FEED1(PROD_FEED_SHORT,"dprix_feed",COUNTRY) = DPRICE_FEED.I(COUNTRY,PROD_FEED_SHORT);

$libinclude xlexport GLOBAL_FEED1 OUTPUT.xls FEED!b16:f250;

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# Annex E: Published articles

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## ESTIMATING THE SUPPLY RESPONSE OF MAIN CROPS IN DEVELOPING COUNTRIES: THE CASE OF PAKISTAN AND INDIA

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### ABSTRACT

The production of main crops in developing countries is an important factor concerning farmers, population revenues and economic development. To contribute to better knowledge on the synthetic parameters describing supply response, this article exploits annual data set following Pakistan and India over 42 years (1966 - 2008) to develop two classic translog models estimating the responses of areas for wheat, cotton, rice, maize, sugarcane, dry beans, rapeseed, soybeans, sorghum and millet to changes in their gross product per hectare. The coefficients of each crop's equation in the system are estimated with the Full Information Maximum Likelihood. The own and cross gross product elasticities for each crop are calculated and compared to the data existing in literature, showing two results: firstly, the major crops areas are found to be weakly gross product-responsive as compared to minor crops, as well as to developed countries and secondly, Pakistani producers have responded weakly to gross product as compared to Indian producers. Policy reforms could help producers respond more easily to price changes, as well as to raise average productivity levels.

**Keywords:** crops, supply response, Pakistan, India, area allocation, FIML, gross product, elasticity, translog.

### INTRODUCTION

Pakistan and India are very important developing countries of South-Asia in terms of agricultural area, population, production and consumption of raw agricultural products. These two countries have a common border. In spite of structural shift towards industrialization, agriculture sector is still a large sector of economy in these two countries. For India, agriculture contributes to Gross Domestic Product (GDP) at 17.8 percent (FAOSTAT) whether 52 percent of total employed force depends on agriculture for livelihood. Total surface area of India is 329 million hectares (Mha) in which arable land is 158 Mha. On the other hand for Pakistan, agriculture contributes to GDP at 21.8 percent (economic survey of Pakistan, 2008-2009) whether 44.7 percent of total employed force depends on agriculture for livelihood. Total surface area of Pakistan is 80 Mha in which arable land is 20 Mha.

Major crops such as wheat, rice, cotton and sugarcane on average contribute 29.8 percent to value added in overall agriculture and 6.5 percent to GDP of Pakistan. The minor crops contribute 12 percent of values added in overall agriculture. In Pakistan, farmers usually do subsistence farming. They keep a certain part of their own production for family consumption and put remaining for market sale.

In this article we will focus on analysis of the ten most important crops of these two countries: wheat, rice, cotton, sugarcane, maize, dry beans, soybean, rapeseed, sorghum and millet which account 138 Mha in India (87% of total arable land) and 18 Mha in Pakistan (89% of arable land).

Main reasons for selecting these two countries are same cultural and climatic conditions.

Pakistan and India should have higher production per hectare and more cultivated land to meet the need of growing population like other developing countries. Even if an important part of crop is consumed by farmer's families, producers are also increasingly responding to market prices and, eventually, policy decisions such as specific aids and support prices in their land allocation among crops. This article is composed of two parts: Firstly, the methodology is presented that has been used to estimate the combined influence of prices and yields (gross product per hectare) on allocation of land among crops and to calculate matrixes of own and cross elasticities. This is an important challenge for econometric simulations as in present economical literature either there is no standard data available or they are old or even not documented. These matrixes are necessary to calculate new market equilibrium, in association with food and feed demand elasticities, to some exogenous modifications such as national policy interventions, international prices modifications, human and animal population increases. The third part presents the obtained results and its comparison with the sparse data available in the literature. Lastly, the results obtained of the two countries are compared with each other and recommendations are given to improve production sector.

### METHODOLOGY USED FOR ESTIMATIONS

From the farmer's point of view, within limits set by his own goals and by institution, infrastructure, technology and market structure, a given set of input and output prices makes some courses of actions more desirable than others. Thus, the incentive content of price has effect on the choice of production alternatives with available resources and their impact on resource accumulation.



On the price side, according to most researchers farmers anticipate prices from their knowledge of current and past price (Nerlove, 1985). Most time-series studies are for particular crops and use acreage as a proxy for output because acreage is thought to be more subject to the farmer's control than output because output is affected by other factors which have an impact on yields like climate, soil, water availability and technology etc.

Individual crops respond more or less strongly and quickly to price factors, but growth in one crop usually takes resources away from other crops. The price elasticity of agriculture overall is very low in short run because the main factors of production (land, capital, and labor) are fixed.

Price elasticities of supply enter into a number of policy calculations, including support price and buffer stock operation (Gotsch *et al.*, 1975; Pinckney, 1989). A study of the price response incorporating the interdependence of different crops can improve the knowledge and therefore the reliability of supply parameters used in calculations. Once the direction and magnitude of interactions among crops and the factors influencing the supply are determined, planners will be generally helped in assessing the effect of a price policy on the output of different crops as well as the welfare of the farmers.

Krishna (1963) estimated short run and long run elasticities of supply (acreage) of agricultural commodities derived from time series data for Punjab region of Indo-Pakistan sub-continent.

Most research in economic literature on farmers' land allocation decisions focuses on determinants such as portfolio selection, safety-first behavior or learning, and uses market prices to value production (Feder, 1980; Just *et al.*, 1983; Bellon *et al.*, 1993; Brush *et al.*, 1992; Smale *et al.*, 1994). If, however, market prices fail to reflect the value of farmers' product, economic models may lead to wrong expectations and "surprising" farmer response to price signals. The inelastic supply response of maize farmers in rural Mexico in spite of decreasing maize prices after NAFTA is an example (Nadal, 2000).

We consider this question with reference to the problem of farmers' choice of land allocation. Farmers' land allocation decisions have long been a subject of economics. Especially those related to high yielding crop varieties that have been studied in detail by the technology adoption literature following the Green Revolution (Feder, 1980; Just *et al.*, 1983; Bellon *et al.*, 1993; Brush *et al.*, 1992; Smale *et al.*, 1994).

Smale *et al.*, (1994) show that farmers' land allocation to high yielding and traditional crop varieties have multiple explanations such as input fixity, safety first behavior, learning and portfolio selection. They also value farmers' maize output at market prices in their empirical analysis of maize cultivation in Malawi

In this paper, statistical approach to determine influence of variation of gross product per hectare of different main crops on allocation of cultivated surface area in India and Pakistan is applied. In first part of this

paper, direct and cross gross product elasticities to acreage of different crops are calculated while second part covers comparison between farmer reactions to gross product per hectare of one country with other.

In the field of microeconomics, the choice of allocating system of production when we know the price received by farmers ( $P_i$ ), the yield ( $Y_i$ ) and the direct cost of production per hectare ( $C_i$ ) i.e., when we know the value of gross product  $V_i = Y_i * P_i$  and the gross margin  $M_i = Y_i * P_i - C_i$ , is conventionally written as a linear program:

$$\text{Max } \sum_i (S_i * M_i) \quad (1)$$

Under general constraints:

$$\sum_i S_i = S_{\text{total}} \quad (2)$$

And different other constraints expressing agricultural parameters, availabilities in production factors (labor, machines, etc.) are taken into account.

As illustrated by linear programming problem, the key characteristic of the dual relationship is that all of the information about the solution to the primal can be obtained from the corresponding dual, and all of the information with respect to the solution of dual can be obtained from the corresponding primal. Either the maximization or the minimization problem may be solved as the primal, and all information regarding the solution to the dual is obtained without resolving the problem. Production (vs. demand) function has corresponding dual cost (revenue) function. The term dual used in this context means that all of the information needed to obtain the corresponding cost (revenue) function is contained in the production (demand) function and conversely the cost (revenue) function contains all the information needed to derive the production (demand) function.

In the classical theory of production for each of the  $i$  crops ( $i = 1$  to  $N$ ), the total revenue ( $R$ ) and production function can be written as

$$R = \sum_i x_i * p_i \quad (3)$$

And

$$x_i * = f(p_i) \quad (4)$$

The optimal  $x_i$  (noted  $x_i^*$ ) is given by the Shepard lemma:

$$x_i^* = dR/dp_i \quad (5)$$

Here we are more focused on relation of revenue per hectare of specific agricultural products with allocation of surface area to different agricultural commodities. We know that total revenue is a function of price, surface and yield.

$$R = f(P_i, S_i, Y_i) \quad (6)$$

Where

$R$  = total revenue of the  $i$  crops planted by the farmer

$P_i$  = price of crop  $i$

$S_i$  = area of crop  $i$

$Y_i$  = yield of crop  $i$



To limit the number of parameters to estimate, we consider that the farmer is taking his decision of allocation, not on the basis of anticipated prices and of anticipated yields, but on the basis of the anticipated gross product per hectare of each product ( $V^a$ )<sup>3</sup> that is defined by:

$$V_i^a = P_i^a * Y_i^a \quad (7)$$

In the particular case of cotton we have to consider that the total revenue is composed together by the sale of the cotton lint with parameters  $Y_{\text{lint}}$  and  $P_{\text{lint}}$  and for the cottonseed with parameters  $Y_{\text{cseed}}$  and  $P_{\text{cseed}}$ . So for this crop,  $V_{\text{cot}}$  is written:

$$V_{\text{cot}}^a = Y_{\text{lint}}^a * P_{\text{lint}}^a + Y_{\text{cseed}}^a * P_{\text{cseed}}^a \quad (8)$$

With introduction of anticipated gross product the total revenue of the farmer can be written:

$$R^a = g(S_i, V_i^a) = \sum_i (S_i * V_i^a) \quad (9)$$

The translog production function was introduced in 1971 by Christensen, Jorgenson and Lau, and was logical choice given the difficulties posed by other functional forms. It is simply a second order Taylor's series expansion of  $\ln(R)$  in  $\ln(x_i)$  whereas the Cobb-Douglas is a first order expansion. The revenue function as a Taylor's series can be written as

$$\ln(R^a) = \beta_0 + \sum_i \beta_i \ln(V_i^a) + 1/2 \sum_{ij} \beta_{ij} \ln(V_i^a) * \ln(V_j^a) \quad (10)$$

$j$  ( $j = 1$  to  $N$ ) represents numbers of crops. Some mathematical relations are to be satisfied by the coefficients  $\beta_i$  and  $\beta_{ij}$  to express

- the equality of the two partial deviates of  $\ln(R)$  in function of  $\ln(V_i)$  and  $\ln(V_j)$  which implies:

$$\beta_{ij} = \beta_{ji} \quad (11)$$

- the constant return of total revenue  $g(S_i, k * V_i) = k * g(S_i, V_i)$  implies:

$$\sum_i \beta_i = 1 \quad (12)$$

$$\sum_i \beta_{ij} = \sum_j \beta_{ij} = 0 \quad (13)$$

For anticipated prices and yield we consider that the farmer uses a moving average of the preceding year's data.

For yield the equation is:

$$Y_i^a(t) = 1/N1 * \sum_d Y_i(t-d) \text{ for } d = 1 \text{ to } N1 \quad (14)$$

For price:

$$P_i^a(t) = 1/(N2+1) * \sum_d P_i(t-d) \text{ for } d = 0 \text{ to } N2 \quad (15)$$

The difference between the two equations is due to the fact that price concerns calendar year's average, farmers have information about the price concerning the year of plantation and harvest. But for yields, they have to refer only on preceding years. One empirical advantage of using "smoothed" data for prices and yields is to limit the impact of equations estimated parameters of the uncertainty on the "true" values. The values of  $N1$  and  $N2$

(the same for all products) have been chosen for each country in a manner to get the best estimations on the basis of the  $R2_{\text{adjusted}}$  and the sign of own gross product elasticities. The counterpart is that the estimated coefficients of equations (and the elasticities) are smaller (in absolute value) than those which would have been calculated with "true" annual values.

The transposition of Shepard lemma gives

$$S_i^* = dR^a/dV_i^a \quad (16)$$

We can write

$$S_i^* = R^a * (dR^a/R^a) / (V_i^a * (dV_i^a/V_i^a)) = (R^a/V_i^a) * (dR^a/R^a) / (dV_i^a/V_i^a) \quad (17)$$

That is equivalent to:

$$S_i^* * V_i^a/R^a = (dR^a/R^a) / (dV_i^a/V_i^a) = d\ln(R^a)/d\ln(V_i^a) \quad (18)$$

Where

$S_i^* * V_i^a/R^a = r_i$  is the anticipated share of the crop  $i$  in the total anticipated revenue.

In the particular case where we utilize a translog function for total revenue.

$$\ln(R) = \beta_0 + \sum_i \beta_i \ln(V_i) + \sum_{ij} \beta_{ij} \ln(V_i) * \ln(V_j) \quad (19)$$

We have:

$$r_i = d\ln(R)/d\ln(V_i) = \beta_i + \sum_{ij} \beta_{ij} \ln(V_j) \quad (20)$$

For estimation purpose when we have chosen a functional form for the revenue function. We can use  $i$  equations of the revenue shares to estimate the coefficients of the revenue function and the value of the different gross product surface elasticities for each crop. By definition  $\sum_i r_i = 1$ , we have to estimate only  $i-1$  equations, the coefficients of the last one (in occurrence that concerning wheat) being calculated from those of the other equations. The system has been estimated with the free software GRETLL and the method FIML (Full Information Maximum Likelihood) which is equivalent to the SUR method (Seemingly Unrelated Regression) iterative and gives results which are independent of the equation not included in the system.

In the case of translog, it can be demonstrated that the expressions of surface gross product elasticities can be calculated from the parameters of the system of equations ( $\beta_{ij}$ ) and the part of each crop in the total revenue ( $r_i$ ) and are obtained by formulas:

$$E_{ii} = d\ln(S_i)/d\ln(V_i) = (\beta_{ii} + r_i r_i - r_i) / r_i \quad (21)$$

$$E_{ij} = d\ln(S_i)/d\ln(V_j) = (\beta_{ij} + r_j r_i) / r_i \quad (22)$$

Where  $E_{ii}$  is own gross product elasticity of crop  $i$  surface to its gross product and  $E_{ij}$  is cross elasticity of crop  $i$  surface to gross revenue per hectare of crop  $j$ . To be consistent with economic theory, all the own elasticities must be positive, i.e., if all other revenues are constant, the area of a crop increases when its gross product increases.



### ANALYSIS OF EQUATIONS PARAMETERS AND ELASTICITIES FOR PAKISTAN AND INDIA

The Table-1(a, b, c) shows the eight and nine equations of the translog system for Pakistan and India, respectively. The  $R^2$  values are nearly always high, more than 0.85. For the same crop they are higher in India as compared to Pakistan. The  $R^2$  adjusted values are also generally high (more than 0.80) but slightly lower for Pakistan as compared to India. Although for some crops these values are lower, that indicates less good estimations when different relations between parameters of the different equations are taken into account. It is mainly the case concerning  $R^2$  adjusted for some crops in Pakistan; soybean: 0.433, millet: 0.575.

The significance of different parameters at the probability levels of 1%, 5% and 10% are indicated on Table-1(a, b, c) by one star (\*), two stars (\*\*), and three stars (\*\*\*) respectively. For the coefficients of own gross product value in the equation of each crop (in fact of each  $r_i$  that is the part of global revenue of  $i$  crop), the sign is always positive (in accordance with theory) and the value is generally significant at 5% probability. Many coefficients corresponding to cross effects are also significant.

The Durbin-Watson coefficients (DW) often indicate some autocorrelation between the residuals of each equation. This fact has not been corrected, as according to our opinion, the data are too much uncertain to justify this correction (for example by introducing the lagged value of  $r_i$ ). This variable is calculated by a formula taking in account the lagged values of prices and yields.

The elasticities indicated in Table-2 express the variation of surface of each crop due to 1% change of the gross product per hectare of this crop or other. Confirming to what was expected, the signs of own elasticities are always positive for India and Pakistan for nine crops (Wheat, corn, cotton, sugar cane, rice, sorghum, millet, rapeseed, soybean), and for dry bean in India, but for Pakistan, it was necessary to exclude dry bean from the translog system so we made a specific estimation for dry bean for Pakistan with parameters independent of the equations of the other products based on the formula:

$$\ln(S_{db}) = a_0 + a_1 * \ln(S_{db}(-1)) + a_2 * \ln(P_{db}(-1)) + a_3 * \ln(P_r(-1)) \quad (23)$$

The coefficients are:

$$\begin{aligned} 1\_Sdb &= 2, 07637 + 0, 567427 * 1\_Sdb_{-1} + 0, \\ 120239 * 1\_Pdb_{-1} + 0, 028171 * 1\_Pr_{-1} & \quad (24) \\ (3.810) (4.964) (1.918) (0.4821) \\ R^2 &= 0.9355, R^2 \text{ adjusted} = 0.9304, () = t \text{ values} \end{aligned}$$

These results show that for dry bean in Pakistan, the surface at time  $t$  is linked to the value at time  $t-1$  and  $a_2$ , which can be considered as the own and cross elasticities for dry bean. That is near to 0.12 but it is significant only at 10% probability. The price of rice (Pr) that is supposed to be the most linked product to dry bean (these two products are essentially festinated to farmer family food) is not significant.

The elasticities indicated in Table-2 have not been calculated for specific years but as mean values for the period 1966-2008. The values of  $r_i$  and  $r_j$  appearing in equations (21) and (22) have been replaced by their mean of the period.

Concerning the own revenue elasticities of crops areas in India, the value is high for sorghum (0.503) and rapeseed (0.273), 0.2 for millet, wheat and cotton, but lower than 0.1 for rice, dry bean, corn, soybean and sugar cane. For Pakistan, we have high values for soybean (0.944), rapeseed (0.612) and sorghum (0.399), 0.1 for rice, wheat, sugar cane and millet but low for cotton and corn (0.008). Globally, in the two countries sorghum and rapeseed areas appear to respond significantly to commercial revenue. This can be explained by the fact that these two crops are used in industry of animal feeding. For soybean, the elasticity is also relatively high for India as compared to Pakistan (but the elasticity is much important as area is very small compared to India). For all other crops, the own elasticities are generally low (compared to that in developed countries) and lower in Pakistan as compared to India. This indicates that the farmers are weakly influenced by prices as either 1) an important part of their crop (rice, wheat, dry bean, etc.) is necessary for family needs independently of prices and revenue per hectare or 2) the crop is sold to manufacturers (cotton by example) but in the areas where this crop is cultivated, there is no real alternatives to it.

Wheat and rice occupy a central position in the agricultural farming system in Pakistan and India. Own elasticity for rice is low in Pakistan and India (0.089 and 0.037, respectively). For wheat, elasticity in Pakistan is 0.066 but in India, it is 0.214. This can be explained by the fact that in Pakistan, wheat is the first cereal consumed as food so it is necessary for farmer to maintain a significant area of this crop even if gross product is less competitive compared to some other crops, but in India where food is more based on rice, the wheat's area is more influenced by gross product.

It is also interesting to analyze the positions of crops as substitutes and complements on the basis of the signs of the cross elasticities. When the sign is positive, this indicates that an increase in the gross revenue of a crop simultaneously increases the area of the other crops, they are said "complementary crops". When the effect is opposite (cross elasticity is negative) the two crops are said to be substitutes. The values of gross products elasticities are much influenced by the importance of each crop area (a "small" crop having tendency to have a higher revenue elasticity compared to a "major" crop) and the matrix of these own and cross elasticities is not symmetric. So it is interesting to introduce the Allen-Uzawa partial elasticities of substitution (Christev A. 2007) that, in the case of a translog function are defined by  $\sigma_{ij} = E_{ij}/r_j$  where  $E_{ij}$  is the gross product elasticity and  $r_j$  is the share of crop  $j$  in the total revenue. The Allen-Uzawa elasticities have the same sign than the gross product elasticities and form a symmetric matrix. Even if there has been a lot of discussion after the seminal work of Uzawa (1962), their



statistical information is widely reported in empirical studies of production and can be considered as indication on the “ease to change” (or substitution) between two factors in a multiproduct technology. The matrix is not presented here but Table-3 summarizes our results for Pakistan and India. In this table all figures smaller than 0.5 in absolute value have been deleted as they are considered to be too small to draw valid conclusions on the two crops relationship.

For wheat that is a major crop in the two countries, it appears that this crop is a significant substitute for rapeseed and a complementary crop to soybean in the both countries. But relationships are different for corn, millet and sorghum for each country: wheat is a substitute for corn and millet in India but a complement in Pakistan. On contrary, wheat is a complement for sorghum in India but a substitute in Pakistan. At last, wheat is a substitute for dry bean in India and a substitute for sugarcane in Pakistan.

For rice that is also a very important crop in India and Pakistan, this crop is a substitute for millet and soybean in both countries, but relations are opposite for corn and sorghum. In both countries, there appeared no significant relation between wheat and rice.

Globally, there are only ten relationships between crops which are the same in the two countries : cotton-millet (C), cotton-soybean (S), millet-rapeseed (S), millet-rice (S), millet-soybean (S), rapeseed-sorghum (C), rapeseed-wheat (S), rice-millet (S), rice-soybean (S), sugarcane-soybean (C), wheat-soybean (C). Where “C” represents compliments and “S” represents substitute.

In fact three types of crops are taken in analysis: food crops, cash crops and feed crops. In Pakistan and India, wheat and rice are used as staple food so they are less competitive to each other and are generally considered as complementary crops, but in our results there is no significant relationship. Cash crops (cotton, sugarcane) are more responsive to own gross product, they are substitutes in India, but have no significant relationship in Pakistan. Feed crops like millet, sorghum, maize are generally considered as substitutes of each other at demand level, but this relationship does not appear at supply level. In India feed industry is more developed than in Pakistan, so traditional feed like millet, sorghum, maize are generally sold to feed manufactures in India while they are directly used by farmers as feed in Pakistan.

It is difficult to explain, the different results of gross products elasticities, Allen-Uzawa partial

substitution elasticities for the different crops. However it seems possible to draw some conclusions from our results, even if, as it was said previously, the Figures presented are highly dependent on the quality of data used in the estimations (mainly concerning prices received by farmers indicated by FAO, but also in some cases concerning areas evolutions which have been corrected with national data when possible).

#### COMPARISON OF PAKISTAN AND INDIA ELASTICITIES WITH LITERATURE DATA

As elasticities are important parameters widely used in empirical works with agricultural models, it is important to compare our results with the values calculated by other authors. In fact, in general literature, there is only information on the own elasticities. We have used the data available in the elasticity database of FAPRI and Table-4 summarizes the results. In general, there are important differences between our results and cited by FAPRI, but we have no information on the sources and methodologies concerning FAPRI data. Concerning wheat we observe that for India, our elasticity is near that of FAPRI for India (0.214 versus 0.290), but for Pakistan it is much smaller (0.066 versus 0.230) and is also smaller than that calculated by Khan (0.31). The data of FAPRI and Khan for a “subsistence” crop in Pakistan seems high as they are near those of developed countries where farmers are very responsible to market prices such as Australia and even European Union, even if, in this zone, the impact of direct and indirect aids can be important. Concerning rice, our Figures are lower than those of FAPRI for India and Pakistan. Concerning corn, we have the same conclusion, but we can observe that FAPRI Figures are higher for India and Pakistan than for Australia.

For Pakistan, it is possible to compare our results with those published by Khan (2003). There could be two reasons for this difference: First, it can be due to data used and period taken in account for the econometric estimations. Second, it can be due to differences in the methodology used.

In Khan’s approach, as prices used are expressed in current value, the rate of inflation is implicitly supposed to have important role on absolute area growth rate of each crop. In Pakistan the average inflation rate on the period taken was 8.2% and it was 7.8% in India. In our methodology, due to relationship imposed on parameters:  $\sum \beta_{ij} = 0$ , inflation has no impact on allocation of crops.



Table-1(a). Value and significance of equations coefficients.

	Rapeseed		Rice		Cotton	
	Pakistan	India	Pakistan	India	Pakistan	India
Const.	3.91%***	1.78%**	15.74%***	47.10%***	13.24%***	-4.16%**
l_Vc	1.65%***	3.53%***	-0.10%	-0.52%	-0.59%***	-0.53%
l_Vr	-0.10%	-0.52%	11.51%***	23.99%***	-5.47%***	-11.32%***
l-Vdb		-0.21%		-0.44%**		-0.16%
l_Vco	-0.59%***	-0.53%	-5.47%***	-11.32%***	25.77%***	23.76%***
l_Vm	0.07%	-0.32%*	-0.52%***	-0.67%***	-1.29%***	-0.67%***
l_Vsoja	0.00%	-0.42%**	-0.01%*	-0.93%***	-0.01%	-0.86%***
l_Vsc	-0.54%***	0.36%	-1.46%*	-2.90%***	-7.03%***	-3.25%***
l_Vso	0.15%***	0.12%	-0.50%***	-0.62%*	-0.18%	-1.42%***
l_Vmi	-0.10%	-0.41%*	-0.70%***	-1.25%***	-0.01%	-0.22%
l_Vb	-0.54%	-1.58%***	-2.75%***	-5.33%***	-11.19%***	-5.34%***
dum_66_79		0.14%		0.72%		0.25%
dum_91_92	-0.16%		-1.10%*		3.98%***	
dum_91_01		0.71%***		-0.60%		1.65%**
dum_93_01	-0.93%***		0.30%		3.11%***	
dum_99_01		-0.36%		-0.36%		1.57%*
dum_02_08	-0.94%***	0.22%	0.59%	-2.63%***	1.88%	3.31%***
Trend		0.04%**		0.03%		-0.20%***
R <sup>2</sup>	0.887	0.887	0.788	0.957	0.797	0.926
R <sup>2</sup> ajust	0.842	0.825	0.703	0.934	0.715	0.884

Source = results from analysis

Table-1(b). Value and significance of equations coefficients.

	Corn		Soybean		Sugar cane	
	Pakistan	India	Pakistan	India	Pakistan	India
Const.	5.87%***	5.60%***	0.02%	0.75%	0.24%	2.96%***
l_Vc	0.07%	-0.32%*	0.00%	-0.42%**	-0.54%***	0.36%
l_Vr	-0.52%***	-0.67%***	-0.01%*	-0.93%***	-1.46%*	-2.90%***
l-Vdb		-0.02%		-0.43%***		-0.30%***
l_Vco	-1.29%***	-0.67%***	-0.01%	-0.86%***	-7.03%***	-3.25%***
l_Vm	2.43%***	2.81%***	0.01%**	-0.03%	-0.41%***	-0.20%***
l_Vsoja	0.01%**	-0.03%	0.01%***	1.21%***	0.00%	0.79%***
l_Vsc	-0.41%***	-0.20%***	0.00%	0.79%***	15.26%***	7.11%***
l_Vso	0.01%	-0.19%	-0.01%*	0.28%**	-0.24%**	-0.18%
l_Vmi	-0.16%***	0.21%**	0.00%	-0.04%	-0.60%**	-0.24%*
l_Vb	-0.14%	-0.91%***	0.00%	0.42%	-4.98%***	-1.16%***
dum_66_79		-0.05%		-0.31%*		0.22%



dum_91_92	-0.16%**		0.00%		-0.33%	
dum_91_01		0.07%		0.54%***		0.22%
dum_93_01	-0.13%		0.00%		1.96%**	
dum_99_01		0.06%		0.31%*		-0.09%
dum_02_08	-0.15%	0.50%***	-0.02%***	1.02%***	3.86%***	0.67%
Trend		-0.01%*		0.05%***		0.06%**
R <sup>2</sup>	0.976	0.972	0.595	0.966	0.838	0.927
R <sup>2</sup> ajust	0.967	0.956	0.433	0.947	0.773	0.887

Source = results from analysis

Table-1(c). Value and significance of equations coefficients.

	Millet	Millet	Dry bean	Dry bean	Wheat	Wheat
	Pakistan	India	Pakistan	India	Pakistan	India
Constant.	3.54%***	9.59%***		4.65%***	54.82%	19.30%
l_Vc	-0.10%	-0.41%*		-0.21%	-0.54%	-1.58%
l_Vr	-0.70%***	-1.25%***		-0.44%**	-2.75%	-5.33%
l_Vdb		-0.05%		2.02%***	0.00%	-0.47%
l_Vco	-0.01%	-0.22%		-0.16%	-11.19%	-5.34%
l_Vm	-0.16%***	0.21%**		-0.02%	-0.14%	-0.91%
l_Vsoja	0.00%	-0.04%		-0.43%***	0.00%	0.42%
l_Vsc	-0.60%**	-0.24%*		-0.30%***	-4.98%	-1.16%
l_Vso	0.11%***	-0.76%***		0.07%	-0.05%	-1.82%
l_Vmi	0.94%***	3.47%***		-0.05%	0.52%	-0.70%
l_Vb	0.52%**	-0.70%***		-0.47%**	19.13%	16.89%
dum_66_79		-0.37%***		-0.01%		-0.03%
dum_91_92	-0.45%***				-1.56%	
dum_91_01		-0.05%		-0.35%***		-1.90%
dum_93_01	-0.97%***				-2.79%	
dum_99_01		0.08%		-0.74%***		-1.02%
dum_02_08	-0.95%***	0.16%		-0.62%***	-3.75%	-3.75%
Trend		-0.08%***		0.01%		0.20%
R <sup>2</sup>	0.697	0.984		0.936		
R <sup>2</sup> ajust	0.575	0.975		0.9		

Source = results from analysis

**Table-2.** Matrix of calculated gross products elasticities for India and Pakistan.

Crop	Country	Corn	Cotton	Dry bean	Millet	Rapeseed	Rice	Sorghum	Soybean	Sugar cane	Wheat
Corn	India	5.7%	2.7%	1%	10%	-9%	10%	-3.9%	0.2%	0.1%	-1.7%
Corn	Pakistan	0.8%	-6.9%		-5%	3%	-9%	1%	0.4%	-1.5%	17.2%
Cotton	India	0.3%	14.7%	1.3%	2.0%	0.9%	-6.9%	-2.2%	-2%	-4.4%	-3.6%
Cotton	Pakistan	-4%	2.1%		0.8%	-0.3%	-0.2%	0.1%	0.0%	-0.5%	-1.8%
Dry bean	Pakistan										
Dry bean	India	1.8%	18.7%	8.8%	0.1%	-8.6%	11.3%	6.8%	-21%	-8.4%	-8.8%
Millet	India	10%	19.4%	0%	24.9%	-12%	-9%	-24%	-0.3%	-1%	-8.5%
Millet	Pakistan	-16%	44%		12%	-10%	-70%	13%	-0.2%	-56%	84%
Rapeseed	India	-9%	8.3%	-5.7%	-12%	27%	16%	7%	-14%	20%	-39%
Rapeseed	Pakistan	9%	-11%		-8.8%	61.2%	2.3%	15.0%	0.2%	-37%	-29%
Rice	India	0.8%	-5.4%	0.6%	-0.7%	1.3%	3.7%	1.3%	-1.6%	-0.8%	0.7%
Rice	Pakistan	-2%	-0.6%		-5.0%	0.2%	8.9%	-3.7%	-0.1%	2.7%	-0.3%
Sorghum	India	-3%	-19.0%	4.2%	-22%	6.6%	14.5%	50.3%	10.4%	1.6%	-43%
Sorghum	Pakistan	5%	9.9%		23%	30.5%	-88%	39.9%	-2.0%	-32%	13.7%
Soybean	India	0.5%	-50%	-37%	-0.9%	-34.6%	-48%	28.6%	9.6%	78.1%	53.6%
Soybean	Pakistan	149.7 %	-53%		-23.4%	35.4%	-182%	-165%	94.4%	73.7%	71.0%
Sugar cane	India	0.0%	-1.6%	-2.1%	-0.4%	7.5%	-3.7%	0.6%	11.5%	1.8%	0.6%
Sugar cane	Pakistan	-0.2%	-1.5%		-3.2%	-2.6%	2.1%	-1.1%	0.0%	16.9%	-10%
Wheat	India	-3.0%	-6.2%	-1.0%	-1.5%	-7.0%	1.6%	-8.3%	3.7%	0.3%	21.4%
Wheat	Pakistan	1.9%	-3.5%		3.1%	-1.3%	-0.2%	0.3%	0.0%	-6.8%	6.6%

Source = results from analysis

Interpretation of coefficients: by example for Pakistan, when gross product of corn increases by 10% (all other gross products being unchanged) area of corn increases by  $10\% \times 0.8\% = 0.08\%$  and when gross product of rice increases by 10% area of corn decreases by  $10\% \times 9\% = 0.9\%$

**Table-3.** Substitute and complementary crops in Pakistan and India.

Crop	Country	Corn	Cotton	Dry bean	Millet	Rapeseed	Rice	Sorghum	Soybean	Sugar cane	Wheat
Corn	India			C	C	S	C	S			S
Corn	Pakistan			NA	S	C	S	C	C		C
Cotton	India			C	C	C		S	S	S	
Cotton	Pakistan			NA	C	S			S		
Dry bean	India	C	C			S	C	C	S	S	S
Dry bean	Pakistan	NA	NA		NA	NA	NA	NA	NA	NA	NA
Millet	India	C	C			S	S	S	S		S
Millet	Pakistan	S	C	NA		S	S	C	S	S	C
Rapeseed	India	S	C	S	S		C	C	S	C	S
Rapeseed	Pakistan	C	S	NA	S			C	C	S	S
Rice	India	C			S	C		C	S		





Rice	Pakistan	S		NA	S			S	S		
Sorghum	India	S	S	C	S	C	C		C		S
Sorghum	Pakistan	C		NA	C	C	S		S	S	C
Soybean	India		S	S	S	S	S	C		C	C
Soybean	Pakistan	C	S	NA	S	C	S	S		C	C
Sugar cane	India		S	S		C			C		
Sugar cane	Pakistan			NA	S	S		S	C		S
Wheat	India	S		S	S	S		C	C		
Wheat	Pakistan	C		NA	C	S		S	C	S	

C = complement. S = substitute. NA = not available

Green = same relationship in India and Pakistan. Orange = diagonal term no signification

Source = results from analysis

**Table-4.** Comparison of own elasticities of Pakistan and India with elasticities cited by FAPRI Khan (2003) and developed countries.

	India	India	Pakistan	Pakistan	Pakistan	Australia	UE 15
	Present study	FAPRI	Present study	FAPRI	Khan (2003)	FAPRI	FAPRI
Corn	0.057	0.210	0.008	0.280	0.11	0.23	0.08
Cotton	0.147		0.021				
Dry bean	0.088						
Millet	0.249		0.123		1.71		
Rapeseed	0.273	0.340	0.612			0.26	0.28
Rice	0.037	0.110	0.089	0.290		0.17	
Sorghum	0.503	0.300	0.399	0.200	0.11	0.35	
Soybean	0.096	0.360	0.944				0.19
Sugar cane	0.018	0.210	0.169	0.070		0.14	0.31
Wheat	0.214	0.290	0.066	0.230	0.31	0.33	0.12

## CONCLUSIONS

The study delineates a model to estimate the gross product per hectare elasticities of different crops and empirically applies the model to estimate own and cross gross product per hectare elasticity of major and minor crops which cover more than 80 percent of the total cropped area in Pakistan and India. The data used in this study are collected from FAO database and, in some cases, are corrected by data from economic survey of Pakistan 2010. After a general description of main evolutions of the supply side for these products (areas and yields), prices received by farmers which appeared in some cases to be correlated with some international prices when the evolution of conversion rate between Indian and Pakistan rupees to dollar are taken in account.

After parameters estimation of a translog share model concerning 9 crops in Pakistan and 10 crops in India, we calculated short run own and cross gross product elasticities for these products. According to our empirical estimations, it appears that in the two countries farmers are

more or less responsive to gross product per hectare modifications, but contrary to the situation in many developed countries where the response is quick, in India and Pakistan farmers are influenced by the average product of last years' yields and prices (or consider as anticipated gross product), though in developed countries the data concerning the last crop (year t-1) are much more important than those of proceeding years. The parameters of the different share equations have generally good significance when some dummy variables are introduced to take into account some apparent discontinuities in data (mainly prices).

Globally own gross product elasticities for main crops are weaker in Pakistan as compared to India and are lower than those indicated in FAPRI database for these countries and some other representing more modern and "free" agriculture (developed countries). It means that farmers in developed countries like Australia and European Union are more responsive to gross product as compared to developing countries like Pakistan and India.



In our analysis, Pakistan is lowest developed country so it has also lowest values of gross product elasticities.

Short run cross revenue elasticities and partial Allen-Uzawa substitution elasticities have also been calculated, the latter parameters indicate the "ease of change" between two products areas. On this basis it is possible to distinguish the influence of a crop on another in three possible ways: competitive, complementary and unrelated. The classification of crops is compared for Pakistan and India, but some unexplained differences can be observed. In fact it is important to stress on the fact that some data used in estimations could be biased, and, on a methodological point of view, due to lack of data we only introduce the output prices and yields in our estimation. But it is well known that the prices and availabilities of some input factors (water, irrigation, fertilizer, machine, labor, etc.) are also very important in farmer's decisions.

Therefore a careful analysis of gross product per hectare (and when possible of gross profit) change for any crop is necessary because this can not only affect the production (acreage) of that particular crop but also change composition of other crops. This indicates that there is a need to develop a systematic and comprehensive approach on which agro-policy reflecting government priorities for certain crops should be based. In Pakistan, low magnitude of elasticity reflects more traditional agricultural practices compared to India due to the lack of improved production technology, credits, marketing system, farmer linkages, weak research and incentive for support price for feed crops excluding wheat. The analysis could be extended in different directions. Firstly, the cost of production and non price factors should be included and data should be desegregated for different crop zones to obtain better values of elasticity, by a panel data approach, for each zone that may be different according to climatic, agronomic and social parameters. Secondly, it should be analyzed if the anticipated gross product is the effective parameter taken into account by farmers or if the prices and yields (and eventually public subventions) have different roles. Finally, our objective is to use these matrixes of supply prices elasticities simultaneously with matrixes of food and feed demand to analyze economic impact on producers, consumers and public finance of some possible public policies (subvention, taxations, etc.) or some modifications in international prices.

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## Estimates of Supply Response of Major Crops in Bangladesh

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The production of crops is an important economic activity for farmers, crop income, nutrition and economic transformation in developing countries. To facilitate better understanding of the synthetic parameters influencing supply response, this study uses annual data of Bangladesh covering 42 years to estimate a classic translog model providing area responses of rice, wheat, cotton, maize, sugarcane and rapeseed to changes in their gross product per hectare. The coefficients of each crop's equation in the system are estimated with the Full Information Maximum Likelihood method. The own and cross gross product elasticities for each crop are calculated showing important results. The crop area of the major crop (rice) is weakly gross product responsive as compared with the minor crops. Appropriate policy reforms could help the producers to respond more to price changes as well as to raise levels of average productivity.

### I. INTRODUCTION

Bangladesh is primarily an agrarian economy. Agriculture is the single largest producing sector of economy since it comprises about 20 per cent of the country's GDP and employs around 50 per cent of the total labour force. The performance of this sector has an overwhelming impact on employment generation, poverty alleviation, and food security. According to most researchers farmers anticipate prices from their knowledge of current and past prices (Nerlove 1958). Most time-series studies are for particular crops and use acreage as a proxy for output because acreage is thought to be more subject to farmer's control than output because output is affected by other factors which have an impact on yields like climate, soil, water availability and technology, etc. Price elasticities of supply enter into a number of policy calculations, including support price and buffer stock operation (Gotsch and Falcon 1975, Pinckney 1989). A

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study of the price response incorporating the interdependence of different crops can improve the knowledge and therefore the reliability of supply parameters used in calculations. Krishna (1963) estimated short run and long run elasticities of supply (acreage) of agricultural commodities derived from time series data for Punjab region of Indo-Pakistan sub-continent.

Most research in economic literature on farmers land allocation decisions focuses on determinants such as portfolio selection, safety-first behaviour or learning, and uses market prices to value production (Feder 1980, Just and Zilberman 1983, Bellon and Taylor 1993, Brush, Just and Leathers 1992, Smale, Just and Leathers 1994). If, however, market prices fail to reflect the value of farmers' product, economic models may lead to wrong predictions and "surprising" farmers response to price signals. The inelastic supply response of maize farmers in rural Mexico despite of decreasing maize prices after NAFTA is an example (Nadal 2000). We consider this question with reference to the problem of farmers' choice of land allocation. Farmers' land allocation decisions have long been a subject of economic research, especially those related to high yielding crop varieties that have been studied in detail by the technology adoption literature following the Green Revolution (Feder 1980, Just and Zilberman 1983, Bellon and Taylor 1993, Brush *et al.* 1992, Smale, Just and Leathers 1994).

Bangladesh should have higher production per hectare and more cultivated land to meet the needs of its growing population. Even if a significant proportion of crop is consumed by farmer's families, producers are also increasingly responding to market prices and, eventually, policy decisions such as support prices in their land allocation among crops. This paper is composed of two parts: Firstly, the methodology has been used to estimate the combined influence of prices and yields (gross product per hectare) on allocation of land among crops and to calculate matrices of own and cross price elasticities. This is an important challenge for econometric simulations as in present literature either there is no standard data available or not documented. These matrices are necessary to calculate new market equilibrium, in association with food and feed demand elasticities, to some exogenous factors such as national policy interventions, global price scenario, and population growth. Secondly, we present the own and cross gross product elasticities of each crop estimated from the coefficients of the translog functions.

## II. METHODOLOGY

The choice of allocating system of production when we know the price received by farmers ( $P_i$ ), the yield ( $Y_i$ ) and the direct cost of production per

hectare ( $C_i$ ) i.e. when we know the value of gross product  $V_i = Y_i * P_i$  and the gross margin  $M_i = Y_i * P_i - C_i$ , is conventionally written as a linear program:

$$\text{Max } \sum_i (S_i * M_i) \quad (1)$$

subject to:

$$\sum_i S_i = S_{total} \quad (2)$$

Different other constraints expressing agricultural parameters, availabilities in production factors (labour, machines, etc.) are also taken into account.

In the classical theory of production for each of the  $i$  crops ( $i= 1$  to  $N^1$ ), the total revenue ( $R$ ) and production function can be written as:

$$R = \sum_i x_i * p_i \quad (3)$$

and

$$x_i = f(p_i) \quad (4)$$

The optimal  $x_i$  (noted  $x_i^*$ ) is given by the Shepard lemma:

$$x_i^* = dR/dp_i \quad (5)$$

Here we are more focused on relation of revenue per hectare of specific agricultural products with allocation of area to different agricultural commodities. We know that total revenue is a function of price, area and yield.

$$R = f(P_i, S_i, Y_i) \quad (6)$$

where

$R$  is the total revenue of the  $N$  crops planted by the farmer

$P_i$  is the price of crop  $i$

$S_i$  is the area of crop  $i$

$Y_i$  is the yield of crop  $i$

To limit the number of parameters to estimate, we assume that the farmer is taking his allocation decision not on the basis of anticipated prices and of anticipated yields, but on the basis of the anticipated gross product per hectare of each product ( $V^a$ )<sup>2</sup> that is defined by:

$$V_i^a = P_i^a * Y_i^a \quad (7)$$

<sup>1</sup>N=6.

<sup>2</sup> In fact, the farmer allocation is also dependent on the input prices (fertilizer, seeds, irrigation water, cost of labour etc.), but we have no information on the evolution of these cost by crop for Bangladesh. So we consider only output prices in estimation, even if in a complementary study we introduce price of urea in Bangladesh in the translog model.

With introduction of anticipated gross product the total revenue of the farmer can be written as:

$$R^a = g(S_i, V^a_i) = \sum_i (S_i * V^a_i) \quad (8)$$

The translog production function was introduced by Christensen, Jorgenson and Lau (1971), and was a logical choice given the difficulties posed by other functional forms. It is simply a second order Taylor's series expansion of  $\ln(R)$  in  $\ln(x_i)$ , whereas the Cobb-Douglas is a first order expansion. The revenue function as a Taylor's series can be written as:

$$\ln(R^a) = \beta_0 + \sum_i \beta_i \ln(V^a_i) + \sum_{ij} \beta_{ij} \ln(V^a_i) * \ln(V^a_j) \quad (9)$$

$j$  ( $j = 1$  to  $N$ ) represents numbers of crops. Some mathematical relations are to be satisfied by the coefficients  $\beta_i$  and  $\beta_{ij}$  to express:

(a) the equality of the two partial derivatives of  $\ln(R)$  in function of  $\ln(V_i)$  and  $\ln(V_j)$  which implies:

$$\beta_{ij} = \beta_{ji} \quad (10)$$

(b) the constant return of total revenue  $g(S_i, k * V_i) = k * g(S_i, V_i)$  implies:

$$\sum \beta_i = 1 \quad (11)$$

$$\sum_i \beta_{ij} = \sum_j \beta_{ij} = 0 \quad (12)$$

For anticipated prices and yield, we consider that the farmer uses a moving average of the preceding year's data.

For yield, the equation is:

$$Y^a_i(t) = 1/N1 * \sum_d Y_{i(t-d)} \text{ for } d=1 \text{ to } N1 \quad (13)$$

For price, the equation is:

$$P^a_i(t) = 1/(N2+1) * \sum_d P_{i(t-d)} \text{ for } d=0 \text{ to } N2 \quad (14)$$

The difference between the two equations is due to the fact that price concerns calendar year's average since the farmers have information about the price concerning the year of plantation and harvest. But for yields, they have to rely only on preceding years. One empirical advantage of using "smoothed" data for prices and yields is to limit the impact on estimated parameters of the uncertainty on the "true" values. The values of  $N1$  and  $N2$  (the same for all products) have been chosen for each country in a manner to get the best estimations on the basis of the adjusted  $R^2$  and the sign of own gross product elasticities.<sup>3</sup> The counterpart is that the estimated coefficients of equations (and the elasticities) are smaller (in absolute value) than those which would have been calculated with "true" annual values.

<sup>3</sup> For Bangladesh  $N1=2$  and  $N2=1$ .

The transposition of Sheppard lemma gives:

$$S_i^* = dR^a/dV_i^a \quad (15)$$

We can write

$$S_i^* = R^a * (dR^a/R^a) / (V_i^a * (dV_i^a/V_i^a)) = (R^a/V_i^a) * (dR^a/R^a) / (dV_i^a/V_i^a) \quad (16)$$

That is equivalent to:

$$S_i^* V_i^a / R^a = (dR^a/R^a) / (dV_i^a/V_i^a) = d\ln(R^a)/d\ln(V_i^a) \quad (17)$$

where

$S_i^* V_i^a / R^a = r_i$  is the anticipated share of the crop  $i$  in the total anticipated revenue.

In the particular case where we utilize a translog function for total revenue.

$$\ln(R) = \beta_0 + \sum \beta_i \ln(V_i) + \sum \beta_{ij} \ln(V_i) * \ln(V_j) \quad (18)$$

We have:

$$r_i = d\ln(R)/d\ln(V_i) = \beta_i + \sum \beta_{ij} \ln(V_j) \quad (19)$$

for estimation purpose when we have chosen a functional form for the revenue function. We can use equations of the revenue shares to estimate the coefficients of the revenue function and the value of the different gross product area elasticities for each crop. Since by definition  $\sum r_i = 1$ , we have to estimate only  $N-1$  equations, the coefficients of the last one being calculated from those of the other equations. The system has been estimated with the free software GRETJ and the method FIML (Full Information Maximum Likelihood) which is equivalent to the iterative SUR method (Seemingly Unrelated Regression) and gives results which are independent of the equations not included in the system.

In the case of translog, it can be demonstrated that the expressions of surface gross product elasticities can be calculated from the parameters of the system of equations ( $\beta_{ij}$ ) and the part of each crop in the total revenue ( $r_i$ ) and are obtained by:

$$E_{ii} = d\ln(S_i)/d\ln(V_i) = (\beta_{ii} + r_i r_i - r_i) / r_i \quad (20)$$

$$E_{ij} = d\ln(S_i)/d\ln(V_j) = (\beta_{ij} + r_j r_i) / r_i \quad (21)$$

where  $E_{ii}$  is own gross product elasticity of crop  $i$  surface to its gross product and  $E_{ij}$  is cross elasticity of crop  $i$  surface to gross revenue per hectare of crop  $j$ . To be consistent with economic theory, all the own elasticities must be positive, i.e. if all other revenues are constant, the area of a crop increases when its gross product increases.

### III. INTERPRETATION OF REGRESSION RESULTS

Table I shows the estimated equations of the translog system for Bangladesh. The  $R^2$  values are mostly high, more than 0.75 except maize (0.50). The

explanatory power becomes lower when different relations between parameters of different equations are taken into account. The significance of different parameters for different crops at the probability levels of 1%, 5% and 10% are also indicated in Table I. For the coefficients of own gross product value in the equation of each crop, the sign is always positive (in accordance with theory) and the value is generally significant at 5% probability level. Many coefficients corresponding to cross effects are also significant.

The Durbin-Watson statistics often indicate some autocorrelation between the residuals of each equation. This fact has not been addressed here, as according to our opinion, the data are not that reliable to justify this correction (for example, by introducing the lagged value of  $r_i$ ).

The elasticities indicated in Table II express the variation of surface area of each crop due to change in the gross product per hectare. Conforming to what was expected, the signs of own elasticities are always positive for Bangladesh for six crops (wheat, maize, cotton, sugarcane, rice and rapeseed), considered in the exercise.

The elasticities indicated in Table II have not been calculated for specific years but as mean values for the period, 1966-2008. The values of  $r_i$  and  $r_j$  appearing in equations (21) and (22) have been replaced by their mean value of the period. Concerning the own revenue elasticities of crop areas, the values are higher for maize (7.62), wheat (2.66) and sugarcane (2.40) while these are lower for cotton (1.36), rapeseed (0.40) and especially for rice (0.012).

TABLE I  
ESTIMATED REGRESSION RESULTS FOR SELECTED  
CROPS IN BANGLADESH

	Wheat (A)	Rice (A)	Rapeseed (A)	Cotton (A)	Maize (A)	Sugarcane (A)
constant	3.2%***	95.3%***	2.6%***	0.2%***	-0.18%	3.0%***
V(wheat)	3.9%***	-3.6%***	0.6%***	0.09%**	-0.7%***	0.36%
V(rice)	-3.6%***	8.3%***	-1.7%***	-0.3%***	0.9%***	-2.9%***
V(rapeseed)	0.7%***	-1.7%	1.7%***	-0.032%	-0.32***	-0.3%***
V(cotton)	.091%**	-0.3%***	-0.03%	0.2%***	0.01%	-3.3%***
V(maize)	-0.7%***	0.9%***	-0.3%***	-0.01%	0.3%***	-0.2%***
V(sugarcane)	0.40%**	-3.7%	-0.31%**	0.00%	-0.22%**	0.8%***
dum_71_74	0.30%	0.11%	-0.16	-0.03%	-0.16	0.22%
Trend	.07%***	-0.1%***	0.00	0.00%	0.02***	0.06%**
R <sup>2</sup>	0.85	0.82	0.75	0.87	0.50	0.93
R <sup>2</sup> adj	0.81	0.77	0.69	0.84	0.37	0.89

Source: Authors' calculations.

Note: (A) = surface area and V = gross product per hectare



Rice being the staple food occupies a central position in the agricultural farming system in Bangladesh. Own gross product elasticity for rice has the lowest value (0.012). It means that 10% increase in gross product per hectare of rice can increase its area by 0.12%. The elasticity coefficient, though small, however, does underline the role of gross product per hectare in influencing the area planted to rice crop. One of the main reasons for having low value of elasticity coefficient may be attributed to the fact that a very large area is already devoted to rice cultivation and its dominance in the cropping pattern, not leaving much scope for further expansion of rice area.

Wheat is the second largest crop in terms of surface area among six crops considered here. The elasticity of wheat is 2.66 which is much higher compared to rice. It means that there is ample scope of its area expansion. The elasticity of maize is the highest (7.62), representing the largest influence of gross product per hectare on its area. One of the main reasons is the high price of maize or development of good market structure for it. Elasticity of cotton (1.36) and sugarcane (2.40) also indicates that areas cultivated for these two crops have been increasing due to increase in gross product per hectare.

TABLE II  
MATRIX OF ESTIMATED GROSS PRODUCT ELASTICITIES OF  
SELECTED FOR BANGLADESH

	Wheat (A)	Rice (A)	Rapeseed (A)	Cotton (A)	Maize (A)	Sugarcane (A)
Wheat (V)	2.66	-2.12	2.2	0.30	-2.24	-0.78
Rice (V)	-0.075	0.012	-0.02	-0.01	0.12	-0.02
Rapeseed (V)	4.20	-1.10	0.40	-0.18	-1.87	-1.46
Cotton (V)	5.80	-6.52	-1.77	1.36	0.72	0.45
Maize (V)	-36.0	55.5	-16.0	0.62	7.62	-10.7
Sugarcane(V)	-0.66	-0.58	-0.64	0.02	-0.55	2.4

Source: Authors' calculations.

Note: (A) = surface area and (V) = gross product per hectare.

It is also interesting to analyse the crops in terms of substitutes and complements on the basis of the signs of the estimated cross elasticities. When the sign is positive, this indicates that an increase in the gross revenue of a crop simultaneously increases the area of the other crops (they are said to be "complementary crops"). When cross elasticity is negative, the two crops are said to be substitutes. The values of gross product elasticities are much influenced by the importance of each crop area (a "minor" crop having tendency to have higher revenue elasticity compared to a "major" crop) and the matrix of these own and cross elasticities is not symmetric. Table III shows that for rice which is a major crop, it appears that this crop is a significant complement for maize and substitute for wheat, rapeseed, cotton and sugarcane. The main reason behind this may be its

importance as a staple food covering large cultivated area and land suitability. Wheat, which is also an important crop, is a substitute for maize and sugar cane.

Globally, there are different relationships between crops which are generally taken into account : cotton-wheat (C), cotton-rice (S), cotton-rapeseed (S), cotton-maize (C), cotton-sugarcane (C), rapeseed-rice (S), rapeseed-wheat (C), rapeseed-cotton (S), rapeseed-maize (S), rapeseed-sugarcane (C), maize-wheat (S), maize-rice (C), maize-rapeseed (S), maize-cotton (C), maize-sugarcane (S), sugarcane-wheat (S), sugarcane-rice (S), sugarcane-rapeseed (S), sugarcane-maize (S), where (C) represents compliments and (S) represents substitutes.

In fact, three types of crops have been analysed: food crops, cash crops and feed crops. In Bangladesh, rice and wheat are used as staple food so they are less competitive to each other but in our results there is a negative relationship between gross product per hectare of wheat and surface area of rice while there is no relationship between gross product revenue of rice and surface area of wheat. It may be due to dominance of rice in terms of area; also rice receives price support by the government. Cash crops (such as cotton and sugarcane) are more responsive to gross product per hectare. Feed crops like maize is generally considered as the most responsive crop to gross product per hectare and this may be due to boom in animal, especially poultry production. As mentioned earlier, the figures presented are highly dependent on the quality of data used in the estimations (mainly concerning prices received by farmers indicated by FAO, but also in some cases concerning areas which have been adjusted with national data whenever possible<sup>4</sup>).

TABLE III  
SUBSTITUTE AND COMPLEMENTARY CROPS IN BANGLADESH

	Wheat	Rice	Rapeseed	Cotton	Maize	Sugarcane
Wheat	-	S	C	C	S	S
Rice	I	-	I	I	C	I
Rapeseed	C	S	-	S	S	S
Cotton	C	S	S	-	C	C
Maize	S	C	S	C	-	S
Sugarcane	S	S	S	I	S	-

Source: Authors' Calculations from Table II.

Notes: C= complement, S=substitute, I = independent.

#### IV. CONCLUDING REMARKS

The paper develops a model to estimate the gross product per hectare elasticities of different crops and empirically applies the model to estimate own

<sup>4</sup>In cases when these adjustments were not possible, we had to introduce dummy variables in the translog system of equations.

and cross gross product per hectare elasticity of major and minor crops which cover more than 80 per cent of the total cropped area in Bangladesh. The data used in this study are collected from FAO database.

Based on parameter estimation of a translog model for six crops in Bangladesh, short run own and cross elasticities for these crops were calculated. According to our empirical exercise, it appears that farmers are more or less responsive to gross product per hectare, but contrary to the situation in many developed countries where the response is quick, in Bangladesh farmers are influenced by the average product of last years' yields and prices (considered as anticipated gross product). The parameters of the different share equations have statistical significance when some dummy variables are introduced to take into account some apparent discontinuities in data (mainly prices).

Globally, own gross product elasticity for major crop (rice) is weaker as compared to other crops. On this basis it is possible to distinguish the influence of a crop on another in three possible ways: competitive, complementary and unrelated. The classification of crops is compared for Bangladesh, but some unexplained differences can be observed. In fact it is important to emphasise that some data used in estimations could be biased, and, from a methodological point of view, due to lack of data we could only incorporate output prices and yields in our estimation. But it is well known that the prices and availabilities of some inputs (irrigation, fertilizer, machine, labour, etc.) are also important in farmer's allocation decisions.

Therefore, a careful analysis of gross product per hectare (and when possible of gross profit) change for any crop is necessary because this not only affects the production (acreage) of that particular crop but also changes the composition of other crops. This indicates that there is a need to develop a systematic and comprehensive approach on which agro-policy reflecting government priorities for certain crops should be based. In Bangladesh, low magnitude of elasticity for rice reflects lack of improved production technology, access to credit, marketing system, weak research-extension linkages, and support price for feed crops excluding wheat. The analysis could be extended in different directions. Firstly, the cost of production and non-price factors should be included and data should be disaggregated for different crop zones to obtain better values of elasticity, by a panel data approach; for each zone that may be different according to climatic, agronomic and social parameters. Secondly, it should be analysed whether the anticipated gross product is the effective parameter taken into account by farmers or if the prices and yields have different roles. Finally, these matrices of gross product supply elasticities can be used along with matrices of food and feed price elasticities of demand to analyse their implications for producers and consumers welfare and also for appropriate formulation of public policies.

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