Economic and Social Commission for Asia and the Pacific

CGPRT Centre Monograph No. 42

The CGPRT Feed Crops Supply/Demand and Potential/Constraints for their Expansion in South Asia

Proceedings of a Workshop Held in Bogor, Indonesia September 3-4, 2002

United Nations

The CGPRT Centre

The Regional Co-ordination Centre for Research and Development of Coarse Grains, Pulses, Roots and Tuber Crops in the Humid Tropics of Asia and the Pacific (CGPRT Centre) was established in 1981 as a subsidiary body of UN/ESCAP.

Objectives

In co-operation with ESCAP member countries, the Centre will initiate and promote research, training and dissemination of information on socio-economic and related aspects of CGPRT crops in Asia and the Pacific. In its activities, the Centre aims to serve the needs of institutions concerned with planning, research, extension and development in relation to CGPRT crop production, marketing and use.

Programmes

In pursuit of its objectives, the Centre has two interlinked programmes to be carried out in the spirit of technical cooperation among developing countries:

1. Research and development which entails the preparation and implementation of projects and studies covering production, utilization and trade of CGPRT crops in the countries of Asia and the South Pacific.
2. Human resource development and collection, processing and dissemination of relevant information for use by researchers, policy makers and extension workers.

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The CGPRT Feed Crops Supply/Demand and Potential/Constraints for their Expansion in South Asia

"CGPRT Centre Works Towards Reducing Poverty Through Enhancing Sustainable Agriculture in Asia and the Pacific"

CGPRT NO. 42

The CGPRT Feed Crops Supply/Demand and Potential/Constraints for their Expansion in South Asia

Proceedings of a Workshop Held in Bogor, Indonesia September 3-4, 2002

Edited by
Budiman Hutabarat

CGPRT Centre
Regional Co-ordination Centre for
Research and Development of Coarse Grains,
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Table of Contents

Foreword

A regional workshop on "The CGPRT Feed Crops Supply/Demand and Potential/Constraints for their Expansion in South Asia" was held during 3-4 September 2002 in Bogor, Indonesia, to discuss findings and strategies achieved in a two-year research project "Prospects of Feed Crops in South Asia (FEED)".

The national experts of participating countries, India, Nepal, Pakistan and Sri Lanka, presented reports of the country studies and the commentators from each country provided additional information. A resource person from the Department of Animal Science and Animal Nutrition Research and Development Centre, Kasetsart University, Thailand, presented experience, expertise and recent advances in the feed crop sector, in particular the utilization of CGPRT crops as feed to deal with livestock sector growth in Thailand. The workshop had Q/A and open discussions and was concluded by a consolidated discussion by Dr. S.S.E. Ranawana who served as a regional advisor.

I am pleased to publish these proceedings as a record of the workshop, which was very active and fruitful owing to the enthusiastic discussions by the participants.

I thank those speakers who participated in the workshop and provided draft summaries. I also thank Dr. Budiman Hutabarat, Dr. S.S.E. Ranawana and Mr. Matthew L. Burrows for their efforts in compiling and editing this volume. Finally, I express my sincere appreciation to the Government of Japan for funding the project and supporting the workshop.

I sincerely hope this volume will provide useful information to the readers and to those countries located in South Asia.

February 2003

Nobuyoshi Maeno
Director
CGPRT Centre

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Acknowledgements

The product of a study such as this one is possible only through the involvement and contribution of many people, whom should have all been put in the acknowledgment list. This is an immense and impossible task. I would instead like to draw a list of individuals who have been involved in this project in one way or another, with no intention of neglecting the role of others who may have been left out of the list. Dr Haruo Inagaki, the former director of UN-ESCAP CGPRT Centre should be put first on the list as he was the one who gave me the confidence to lead this project and selected me as the program leader of research and development. His fatherly guidance at the Centre has induced my motivation to assume and carry out the duty. That enthusiasm has continued and nurtured throughout the period when Dr Nobuyoshi Maeno held the directorship of the Centre. He gave me continuous encouragement during my participation at the Centre. My debt of gratitude is countless to both of them.

From the history of this study, I learned that Dr Pantjar Simatupang, my predecessor along with Dr Mohammad Chowdhury were very instrumental in its formulation and initiation. To both of them I owe many thanks for providing me the new challenge and opportunity to carry on the project. I am indebted to Dr Sivali S. Ranawana, the regional advisor to the project for his continuous advice and support.

I should recognize the contribution made by the national experts: Dr P.S. Pathak from India, Dr B.L. Maharjan from Nepal, Dr A.G. Khan from Pakistan, and Mr. K.E. Karunatilake. Without their cooperation, the project and its workshop would have been unlikely. Dr N.N. Singh of India, Dr S.B. Panday of Nepal, Dr A.M. Haqqani of Pakistan, and Mr. H. Samaratungga of Sri Lanka, were all outstanding as commentators to the respective country reports and I highly appreciate their involvement. I benefited greatly from the involvement of Mr. Kiran Pyakuryal, the former Chief of the Rural Development Section, UN-ESCAP in the regional workshop. He willingly accepted the invitation to make official closing remarks to the workshop.

The participation of Ir M. Sola MM and Messrs. K. Nadeak, Widjatmiko, R.H.M. Manurung from the Directorate General of Food Crop Production Development; Dr S. Partoharjono and Ir Suwandi MS. from CRIFC; Drs E.M. Lokollo and Mat Syukur from CASERD; and Dr A. Djajanegara from CRIAS in the regional workshop was highly appreciated. Special thanks are also due to the Centre's staff: Messrs. S. Yokoyama, Y. Balerin, M.L. Burrows, Ms F. Prihastini, Messrs. H. Zulfikar and M. Arif for their participation and contribution. Mr. Burrows also generously helped me edit the material of this publication. Finally, I am grateful to Ms. Babay Putra who assisted me untiringly throughout my involvement with the centre.

Bogor, February 2003

Budiman Hutabarat
Program Leader
Research and Development
CGPRT Centre

Opening Session

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Opening Address

Nobuyoshi Maeno[*]

Dear participants,
Good morning and welcome to Bogor,

First of all, on behalf of the CGPRT Centre, I would like to express my sincere appreciation for your participation in this workshop.

The CGPRT Centre, as one of the subsidiary bodies of UN ESCAP, has been implementing various activities to contribute to alleviating poverty through promoting the sustainable development of agriculture, based on CGPRT crops in Asia and the Pacific region.

CGPRT crops are a very important component of the farming system in the region, particularly in the marginal areas where economically, ecologically and socially less favorable conditions prevail, and many farmers' activities and lives rely on CGPRT crops. Therefore, it is crucial to promote the sustainable production of CGPRT crops.

However, we also recognize that increasing production alone will not contribute to alleviating poverty. It is vital to expand the income generation opportunities of the rural poor. In this context, the Centre places the priorities of its activities in exploring income generation opportunities through expanding market opportunities of CGPRT crops.

As you know well, CGPRT crops are versatile crops and they can provide an extraordinary range of end uses, not only as food for direct human consumption but also as materials for a diverse range of end-products, including industrial uses.

Feed is an alternative end product of CGPRT crops, which is the reason why we implemented this project.

The development of animal husbandry and demands for feed vary greatly from country to country. Therefore, we need to analyze them comparing among countries within the region. However, due to the limitation of the fund, the project initially focused on South Asian countries, namely India, Nepal, Pakistan and Sri Lanka. I appreciate the participation of these four countries and would like to implement a similar project in Southeast Asian countries very soon.

We also have the participation of the representatives from Thailand and Indonesia in this workshop and I would like to express my cordial welcome and thanks to them.

During the last year, owing to the dedication of national experts and the regional advisor, we have been able to accomplish relevant studies, and now we are in the final stage of completing our report of each country.

In this workshop, we will observe the presentations of country reports and related comments from the participating countries' representatives.

I do believe that suggestions and comments from all of you will give us insightful ideas to reinforce our final reports. Therefore, I hope for your active participation and discussion, which is the main objective of this workshop.

Finally, I would like to express my sincere appreciation to the Government of Japan for its support in funding the project.

Thank you very much.

[*] Director, CGPRT Centre, Bogor, Indonesia.

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Introduction

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Prospect of Feed Crops to Support the Livestock Revolution in South Asia: Framework of the Study Project

Budiman Hutabarat[*]

Background

Accompanying the gigantic surge in global cereal production during the 1971-1995 period, there has been an inconspicuous revolution in the global livestock system and through its subsystem of production, consumption, and impact on economic growth. In developing countries, there was a dramatic rise in consumption of animal-origin food products. It was a result of demand changes as caused by changes in the diets of billions of people in the region, through population growth, urbanization, and income growth. It is in line with Bennett's Law prediction in the economic theory of consumption that suggested that as income grows, the dietary pattern becomes more diversified with better quality (higher price) of food staples. This desire is inherent among most populations of the world. This general phenomenon creates three stylish archetypical consumption bundles according to the level of income per capita. The first bundle occurs at lower per capita income levels where grains dominate. The second bundle occurs at mid-range per capita income levels where animal (livestock and fish) products dominate, followed by grains. The third bundle occurs at higher per capita income levels, where animal products prevail followed by other food products, then horticulture and vegetable products, and finally, grains. In other words, demand for animal products increases while demand for grains as food decreases as per capita income grows.

The stylish path of dietary change explains why demand for livestock and fish products in Asian developing countries has been increasing rapidly in recent years. While per capita consumption of cereals increased by only 0.8 per cent per year, consumption per capita of milk, meat and fish increased by 2.4, 4.9 and 3.1 per cent per year, respectively (Delgado *et al*., 1997). For developing countries as a whole, total meat consumption grew 5.4 per cent per year and total milk consumption grew 3.1 per cent in the period 1982 to 1994. In India, total meat consumption grew 3.6 per cent per year, while in the rest of South Asia it grew by 4.8 per cent during the same period (FAO, 1998; Delgado *et al*., 1999). The dramatic increases in the total consumption of animal food products throughout developing countries are caused by rapid population growth coupled with increases in per capita income that result in more diversified food staples.

As meat demand increases, feed grain utilization also increases because feed grains are raw materials for animal feed. This provides a new market opportunity for CGPRT crops. Feed grain utilization per capita has been increasing rapidly at 3.4 per cent per year. It should also be noted that the Asian total population is still growing at around 1.5 per cent per year. As a whole, demand for feed grains (indirect demand) is increasing by around 5 per cent per year, whereas total demand for direct consumption of cereals is increasing by around 2.3 per cent per year. Accordingly, total demand for those cereals, which are used both for human consumption and

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feed, especially maize, sorghum and millet, could increase by around 6 per cent per year. A large difference in the growth rates implies a rapid change of demand structure of those commodities toward more for feed and less for direct human consumption. In fact, maize has been mostly used for feed in many Asian countries.

In addition to demand induced factors, technological changes also contribute to the rapid expansion of demand for animal feed. Increasing land scarcity reduces pasture land availability and hence induces gradual change in livestock farming systems from extensive - out of barn systems, in which the animals are not provided with manufactured feeds, to intensive - inside barn systems, in which animals are fed with manufactured feeds. The same is also true for fish farming. Intensive fish farming has been increasing as a response to increasing scarcity of both natural fish stocks and ponds. Intensification of livestock and fish farming is a major source of increasing demand for feeds in Asian countries.

Another technological factor that induces demand for manufactured feeds is the adoption of modern breeding lines in livestock and fish farming. The modern breeding line animals require manufactured feeds in an intensive within barn or cage farming system. It should also be noted that intensive farming with manufactured feeds and modern breeding lines, is extremely important to improve product quality. In other words, technological change is also a response to meet changes in demand patterns for livestock and fish products.

Animal feeds are dominated by coarse grains, pulses, roots and tubers or the products of these CGPRT crops. CGPRT products are generally either income inelastic or have negative income elasticity. This implies that direct demand for CGPRT products declines with increases in per capita income. This is why CGPRT product prices and market opportunities generally decline over time. The low price and declining demand are the two inherent causes of persistent stagnation or marginalization of most CGPRT farming. This is also the main reason why CGPRT farming is generally dominated by subsistence farmers in Asia. The rapidly emerging demand for feed crops is, therefore, beneficial to reverse the secular marginalization trend of CGPRT farming. It creates a strong demand-pull for the rapid expansion of CGPRT production in many Asian countries.

Increasing demand and prices of CGPRT products would enhance farm household welfare. It would induce commercialization of CGPRT farming and would also facilitate farm diversification, which has the potential to increase and stabilize farm incomes. Rapid expansion of CGPRT farming would create employment and contribute to the development of the rural economy. The rapidly growing livestock industry, supported by domestic feed crop farming and the processing industry, has long been considered to be the most appropriate path of agricultural diversification towards a balanced structural change of the whole economy of most Asian developing countries.

The ample opportunity to expand feed crop farming, however, may create a policy dilemma for some governments. With limited resources, land and water in particular, expanding CGPRT farming may result in a reduction in main staple food production. Some governments may consider this opportunity as a threat to national food security. In some countries, development of feed crop farming may be constrained by various policies, which have been in place to expand food crop farming. Supporting infrastructures may also be insufficient to fully tap the great opportunity for enhancing feed crop farming. In short, it is extremely important to elucidate the real opportunities, constraints and policy options for developing feed crop farming in Asian developing countries through comprehensive research.

Objectives

The general objectives of this project are to elucidate and analyze the potential, weaknesses, opportunities, constraints and policy options for the development of feed crop farming in South Asian developing countries in balance with the rapid development of the livestock and fish culture industry in Asia. More specifically, the objectives may be further broken down:

(i) To analyze historical dynamics and future trends of demand and supply for feed crop products.
(ii) To evaluate potential, weaknesses, opportunities and constraints for expanding feed crop farming in the participating countries.
(iii) To propose possible cooperation schemes for trade and development of feed crops/products among Asian countries, and
(iv) To formulate policy options to promote sustainable development of feed crop farming in the participating countries.

Subject of study

The main subjects of the project are as follows:

1. Feed crop production and supply and its determinants.
2. Feed crop consumption and demand and its determinants.
3. Feed crop imports and exports and their determinants.
4. The development potential and constraints of feed crops with emphasis placed on CGPRT crops.

Intended impacts and results

1. The project will result in a clearer understanding of the dynamics and future trends of demand and supply for feed crop products in the participating countries.
2. Clearer understanding will be gained on potential, weaknesses, opportunities and constraints for expanding feed crop farming in the participating countries.
3. The results of this study may be a valuable reference for setting up a regional cooperation scheme among ESCAP member countries, and
4. The strategies and policy options formulated through this project will be valuable for choosing operational strategies to promote the sustainable development of feed crop farming in the participating countries.

Basic concepts and methodological framework

In view of preserving comparison among participating countries, the study adopts the same concept and develops the same analysis tools of econometrics, utilizing time series data. The analysis is further complemented with management analysis, devised to delve further into the econometric results.

Feed

Feed is the range of food or feeding stuffs available to an animal. Feeding stuffs is one of the range of potential feeds available to farm livestock. Amongst these would be fresh forages, conserved forages (e.g. hay or silage), concentrates and succulent feeds. Feed can also be classified as: conventional feedstuffs and non-conventional feedstuffs. Conventional feedstuffs are feedstuffs that have been traditionally used for decades or even centuries. They are normally abundant and are purposely cultivated to support animal production. The examples are maize, rice, sorghum, wheat, barley, cassava, fishmeal, and copra meal. Non-conventional feedstuffs are defined as by-products derived from the industry due to processing of the main products and those feeds which have not been traditionally used in animal feeding and/or not normally used in commercially produced rations for livestock, respectively.

Concentrate

Concentrate is animal feeding stuffs, which have a high feed value relative to their volume. It is a low-fiber, high-energy feed that is concentrated by a factory-blended source of nutrients needed to increase the nutritional adequacy of feed supplements.

Feed crops

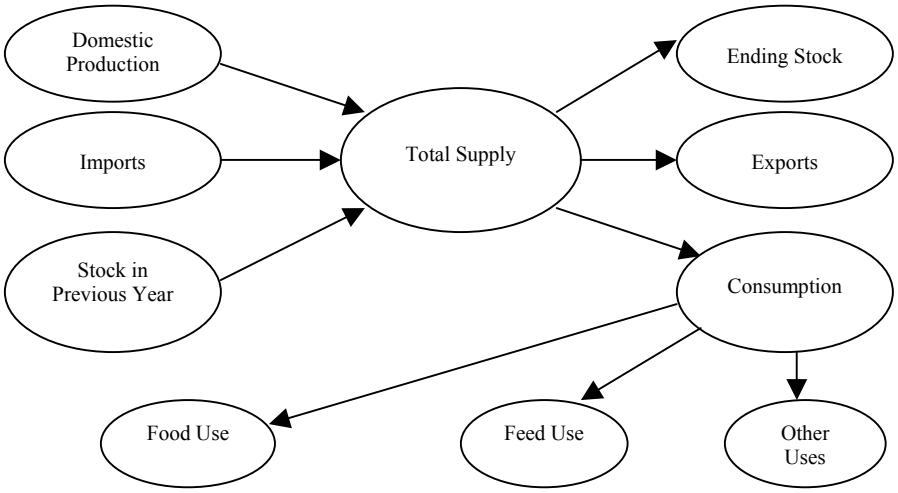
Feed crops are the crops that are utilized as fresh or processed for feeding animals.

Supply and demand of feed crops

Since the study is interested in investigating the prospects of feed crop development, it is important to establish empirically the impact of price mechanisms and other determinants such as technological factors, population and income in the production and consumption of feed crops. In addition, it is equally crucial to evaluate whether the effort is feasible from a managerial point of view, as commodity development programs entail complicated decision-making in the production, marketing, and processing stages. The study will be conducted by utilizing standard economic theory of supply and demand, complemented with information from farmer and crop growers' groups in the framework of SWOT analysis.

Total supply of a commodity in particular, is basically a summation of domestic production with some imports and its stock in the previous year, as depicted in Figure 1.

Figure 1. Supply of and demand for feed crops



The total supply is then used for consumption, some exports, and some to be stocked at the end of the year. Total consumption is made up from food use by humans, feed to animals (livestock and fish), and other uses.

Model formulation

The model used to generate parameters of equations is based on a system of supply and demand relationships. The system is closed in equilibrium, where total supply equals total demand in a particular country. This is adopted and modified from the World Food Model (WFM) and IMPACT model proposed respectively by Yanagishima (2002), Rosegrant *et al*. (1995), and Rosegrant (1999).

Domestic production

Crop production is assumed as the product of estimated harvested area and yield response functions. Harvested area is specified as a function of crop's own price, the price of other competing crops, and a trend growth factor:

$$AH_{it} = \alpha_i PP_{it}^{\varepsilon_{ii}} \prod_j \left(PP_{jt}^{\varepsilon_{ij}} \right) \left(1 + g_{it}\right) \quad (1)$$

For $_{i, j}$ = All cereals included in the model

Yield is a function of the commodity prices, the prices of some inputs (such as fertilizer and labour), and a trend growth factor reflecting technology improvements:

$$YH_{it} = \beta_i PP_{it}^{\varepsilon_{ii}} \prod_k PI_{kt}^{\varepsilon_{jk}} \left(1 + g_{it}\right) \quad (2)$$

Hence production is:

$$QH_{it} = AH_{it} x YH_{it} \tag{3}$$

Where
AH	=	crop area
YH	=	crop yield
QH	=	quantity produced
PP	=	producer price
PI	=	price of factor or input k
i, j	=	commodity index
t	=	time index
g	=	growth rate
ε	=	price elasticity
α, β	=	area and yield intercepts

Total demand

Total use of a commodity is the sum of food, feed and other uses

$$QC_{it} = QF_{it} + QL_{it} + QE_{it} \tag{4}$$

For food use

$$QF_{it} = \gamma_i PC_{it}^{\varepsilon_{ii}} \prod_j \left(PC_{jt}^{\varepsilon_{ij}} \right) x \left(INC_t \right)^{\eta_i} POP_t \tag{5}$$

Where
$$INC_t = INC_{t-1} x \left(1 + g_t\right) \text{ and} \tag{6}$$
$$POP_t = POP_{t-1} x \left(1 + g_t\right)$$

Demand for feed

Other than milled rice:

$$QL_{it} = \gamma_i \prod_j PP_{jt}^{\varepsilon_{ij}} G.AC_t \left(1 + g_{it}\right), \text{ where } G.AC_t = \Sigma_m w_m QH_{it} \tag{7}$$

for m = all meats in the model and milk and
w's = use of feed cereal per unit of meat

Milled rice:

$$QL_t = \gamma \prod_j PP_{jt}^{\varepsilon_j} R.QH_t \left(1 + g_{it}\right) \quad (8)$$

for j = all the cereals considered in the model

Demand for other uses

$$QE_{it} = \gamma_i \left(QF_{it} + QL_{it}\right)^{\alpha_i} QH_{it}^{\delta_i} \left(1 + g_{it}\right) \quad (9)$$

for i = all the cereals included in the model

Ending stock

For a net importing country,

$$ES_{it} = a_i \left(QC_{it} / PC_{it}\right)^{\alpha} \quad (10)$$

For a net exporting country,

$$ES_{it} = b_i \left(QH_{it} / PP_{it}\right)^{\beta} \quad (11)$$

Where
- QC = total demand
- QF = demand for food
- QL = demand for feed
- QE = demand for other uses
- PC = consumer price
- INC = per capita income
- POP = total population
- GAC = basic feed requirement of cereals
- RQH = rice production
- ES = ending stock

Trade equation

Import and export equations are subject to the country's net trade position. Gross imports for a net importing country and gross exports for a net exporting country are determined on the basis of commodity balances, while alternate specifications are used to compute the "minor" flows-gross imports for a net exporting country and gross exports for a net importing country.

Gross imports

For a net importing country, imports are required to balance the domestic market,

$M_{it} = QC_{it} + ES_{it} - QH_{it} + X_{it} - ES_{it-1}$.

For a net exporting country, imports are the larger level of a demand specified minimum access (MQ) or an amount related to total (QC).

$$M_{it} = \text{Max}\left(MQ_{it,} QC_{it}\right)^{\alpha} \tag{12}$$

or M_{it} maybe estimated as $M_{it} = a_0 QC_{it}^{\alpha 1} \left(PW_{it} / PP_{it}\right)^{\alpha 2} INC_t^{\eta}$

α_i , η = elasticities of import demand with respect to total consumption, prices, and income

Gross exports

For a net exporting country, exports are the exportable surplus remaining after domestic demand has been satisfied,

$$X_{it} = QH_{it} + ES_{it-1} + M_{it} - QC_{it} - ES_{it} \tag{13}$$

For a net importing country, exports are linked to the change in world price relative to domestic price,

$$X_{it} = b_0 QH_{it}^{\beta 1} \left(PW_{it} / PP_{it}\right)^{\beta 2} INC_t^{\eta} \tag{14}$$

Where M = import volume
X = export volume
PW = world price
MQ = specified minimum access level under the Uruguay Round
β_i, η = elasticities of export supply with respect to total production, price and income

Equilibrium

Total supply = total demand

$$QH_{it} + ES_{it-1} + M_{it} = QC_{it} + ES_{it} + X_{it} \tag{15}$$

Future trends in production and consumption:

The supply and demand models estimated previously, produce estimated elasticity that might be employed to forecast changes in production and consumption in the future. By further investigating the general form of functions,

$$Y = f(X_1, X_2, X_3, \ldots\ldots, X_n) \tag{16}$$

Where Y = dependent variable
X_i = Explanatory or pre-determined variable; i = 1, ……., n

Then it is possible to obtain changes in Y, which is caused by changes in each of the explanatory variables and the elasticity with respect to each of these variables. This is shown through equation (17):

$$dY = \varepsilon_1 dX_1 + \varepsilon_2 dX_2 + \varepsilon_3 dX_3 + ... + \varepsilon_n dX_n \quad (17)$$

Where ε_i = the elasticity of each of the independent variables with respect to Y in the equation being considered,

dY = Percentage change in Y
dX_i = Percentage change in the exogenous variable i

By using formulae 17, the change in supply and demand could be estimated by combining a point elasticity estimate with a forecast of the change in the explanatory variable.

Planning strategy

Solely technical matters do not only determine the expansion of technology and its adoption as shown in area and production increases. Often it is also curtailed by management problems at the farms, the market and processing industry, and the administrative levels. Each decision maker, at every level, should have a common goal as to how the performance of an organization can be improved to guarantee the successful achievement of production and agroindustrial development of feed crops. The question being faced is why is the business that he is involved in stagnant, given the tendency of mounting competition? Whenever a number of alternatives are under consideration in the planning process, a very careful analysis of the external and internal dimensions of influence is vital. Every important strategic decision should be subjected to an analysis, whereby attention should be given to aspects such as:

Whether the decision can be executed with the existing condition?
What opportunities are available now and in the foreseeable future?
What are the threats from competitors, regulatory bodies, technological changes, or shifts in customer preferences?
What are the unique strengths and internal abilities and how should they be used as leverage in developing competitive advantage?
What are the weaknesses, and how can they be improved?

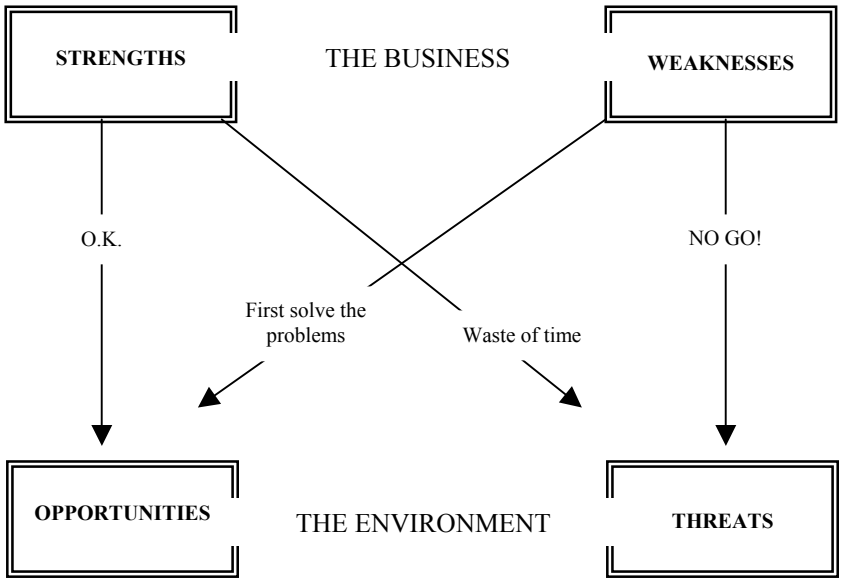
This can be identified and analyzed in SWOT (strengths, weaknesses, opportunities, and threats) analysis. The analysis can be applied to each stage of decision-making: production, marketing, or processing.

SWOT analysis is a management tool that should be used by management on a regular basis. The analysis is a simple but very effective analytical method for an organization to measure its own *Strengths and Weaknesses* and to identify, in the target environment, the characteristics of that environment that can be classified as either *Threats or Opportunities.*

All elements associated with an activity have to be analyzed carefully and the decision maker will rate them as either a strength or weakness, or a threat or opportunity. While working on the analysis, the decision maker will find out that it is often not easy to label an element to each of the groups.

The strategic judgment of SWOT analysis is what it is really all about and makes it possible to judge whether a decision maker will be able to expand current production, or that first, solutions have to be found for a number of problem areas. The analyst will place the business and the environment in one “frame” and draw lines between the four squares:

Figure 2. Decision-making through SWOT analysis



If the majority of the strengths of the business correspond with the opportunities of the market, then the decision maker will not find too many problems on his way. He can start developing an entry strategy.

If the list of weaknesses is very long and the list of strengths too long, the list of environmental strengths will be very long as well. The business should not get involved with expanding production of the commodities being analyzed.

If however, the strengths of the market correspond with the weaknesses of the business or if, due to the weaknesses of business the list of threats is too long, the company will first have to work on improvements in the organization before becoming involved with expanding its activities. Whilst finding solutions for the weaknesses of the business, the list of weaknesses will become shorter, the list of strengths will become longer and automatically, a lot of the threats in the environment will become opportunities.

If the weaknesses can not be solved, the business will have to decide not to get involved in production expansion, or they may have to look for other commodities or activities where the situation can be completely different. A new analysis will have to be undertaken in this case.

With the SWOT analysis in hand and the proper conclusions drawn, the analyst is now ready to take a justified decision and develop a strategy that should lead to successful product expansion.

Participating countries and organization and implementation

The participants in this project are India, Nepal, Pakistan and Sri Lanka, which are among the low-income group of ESCAP member countries in the South Asia subregion. The four countries neighbour one another and hence, could take the advantage of regional cooperation for the development of CGPRT crops. As proposed, this study is conducted mainly in upland semi-arid agro-ecological areas, which are the focus area of the CGPRT Centre.

The project is implemented in collaboration with partner institutes of those participating countries, where the CGPRT Centre develops country study guidelines in cooperation with the regional advisor, as a resource person for the project. The Centre is also responsible for the coordination of planning and implementing the project and in disseminating the findings. The total duration of the project is one year and a half, starting from July 2001 to December 2002. The project activities consist of three elements: (i) Country study, (ii) Workshop, and (iii) Publication and dissemination.

The country studies are conducted by the respective national experts based on the guidelines prepared by the Centre in close consultation with the regional advisor. The guidelines set the scope, concepts, and method of the country studies and the project schedule. The national experts are requested to produce draft reports of country studies and present them in the regional workshop. Then they shall finalize the country reports by accommodating all relevant and valid suggestions and criticism raised at the workshop to produce final reports for publication. The final reports should also include executive summaries. From the materials contained in the country reports, complemented by other sources, an integrated report is prepared by the Centre in cooperation with the regional advisor. Publication and dissemination of the reports is completed by the Centre. As part of the dissemination, in addition to the regional workshop, where selected policy-makers and researchers are invited, the national experts are also requested to present the findings of their country studies in their own countries.

The organization of the project was as follows:

Overall Coordinator and Supervisor:	Dr Nobuyoshi Maeno, Director, CGPRT Centre
Team Leader:	Dr Budiman Hutabarat, Program Leader, Research and Development, CGPRT Centre
Regional Advisor:	Dr Sivali Sirimevan Ekayana Ranawana, Professor, Livestock and Avian Sciences, Wayamba University, Gonawila, Sri Lanka
National Experts:	
India:	Dr Prem Shankar Pathak, Indian Grassland and Fodder Research Institute, Jhansi, India
Nepal:	Dr Bekha Lal Maharjan, Nepal Agricultural Research Council, Patan, Nepal
Pakistan:	Dr Abdul Ghaffar Khan, Animal Nutrition, Animal Science Institute, National Agricultural Research Centre, Islamabad, Pakistan
Sri Lanka:	Mr Kulugammana Ellapitagedara Karunatilake, Agro Enterprise Development and Information Service (AgEDIS), Department of Agriculture, Paradeniya, Sri Lanka

Prior to the implementation of the project, the coordination pre-planning meeting involving the regional advisor and the team leader along with the director of the Centre was held at the Centre on 27-28 August 2001 to discuss agendas as follows:

(i) Brief review by the director of CGPRT Centre.
(ii) Review of the project objective.
(iii) Technical guidelines for country studies.
(iv) Report outline.
(v) Planning meeting, and
(vi) Other matters.

The team leader and regional advisor are then to refine the results of the pre-planning meeting. These revised materials are used and discussed later in the planning meeting in the forms of:

(i) Report of the preplanning meeting that contains tentative references to the planning meeting, schedule of the country study, outline of country and integrated reports.
(ii) General reference of the workplan.
(iii) Basic concepts and analytical framework.

This was discussed further in more detail, later at the planning meeting that was conducted at the Centre on 27-28 September 2001. All the national experts, the regional advisor and team leader along with the director of the Centre were present at the meeting. The regional advisor presented the overview of the project that includes the background and justification, schedule of tasks and the proposed outline of country reports. The team leader explained about conceptual framework and model formulation for empirical estimation, and the national experts were asked to finalize their workplan of the country study and start the country study in October 2001.

Upon completion of writing the country study report, the regional workshop was conducted at the Centre on 3-4 September 2002, to critically review the reports and to seek comments and suggestions for improving the quality of the country reports. Based on recommendations from the collaboration of institutions in the respective countries, the Center accepted the nominations of commentators to the country reports. The names of commentators are as follows:

(i) Dr Narsingh Narain Singh, Directorate of Maize Research, Indian Agricultural Research Institute (IARI), New Delhi, India.
(ii) Dr Shambu Bahadur Panday, Nepal Agricultural Research Council (NARC), Kathmandu, Nepal.
(iii) Dr Abdul Majeed Haqqani, National Agricultural Research Council (NARC), Islamabad, Pakistan.
(iv) Mr Hemachandra Samaratunga, Other Field Crops Research and Development Institute, Department of Agriculture, Paradeniya, Sri Lanka.

The commentators were also participants in the workshop and presented their comment papers.

Report outputs from the project

Three types of publication are produced from the research project: (i) country reports, (ii) an integrated report, and (iii) proceedings of the workshop. The country reports bear the same titles except for the name of the country as follows:

1. Prospects of Feed Crops in India: The Role of CGPRT Crops by Prem Shankar Pathak (Working Paper No. 64).
2. Prospects of Feed Crops in Nepal: The Role of CGPRT Crops by Bekha Lal Maharjan (Working Paper No. 65).
3. Prospects of Feed Crops in Pakistan: The Role of CGPRT Crops by Abdul Ghaffar Khan (Working Paper No. 66).
4. Prospects of Feed Crops in Sri Lanka: The Role of CGPRT Crops by Kulugammana Ellapitagedara Karunatilake (Working Paper No. 67).
5. Prospects of Feed Crops in South Asian Countries: The Role of CGPRT Crops by Budiman Hutabarat and Sivali Sirimevan Ekayana Ranawana (Working Paper No. 68).
6. The CGPRT Feed Crops Supply/Demand and Potential/Constraints for their Expansion in South Asia by Budiman Hutabarat (CGPRT Monograph No. 42).

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Country Reports

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Prospects of Feed Crops in India

P.S. Pathak[*]

Abstract

Animal husbandry is the backbone of Indian agriculture. It provides livelihood opportunities to the farmers (more than 70 per cent of the population) who depend on mixed farming. Animals not only contribute to the household income, but draught power and organic manure as well as many other products. Currently, the emphasis is given to animal production to meet the demands of an increasing human population. Intensive production is being targeted from the enormous livestock population in the country to meet the demands. The estimated requirement of feeds for livestock is short by 64 per cent. Since animal production activities in India are mostly at the household levels of small and marginal farmers, feeding systems are dependent upon the indigenous practices and the requirements are met from the crop and food residues in the system.

The CGPRT sponsored project "Prospects of Feed Crops in South Asia (FEED)", was attempted during the year 2001-2002. The study was initiated to understand the demand-supply gap and identify measures to bridge it, based on the data provided by the Department of Economics and Statistics, Ministry of Agriculture and the Government of India. It is found that most of the coarse cereals are facing decline in area and productivity. It is also found that depending on the demand, productivity and production scenario, it is possible to bridge the gap between demand and supply. Accelerated production activities and policy may control the market so that the farmers receive a better price for their product.

Introduction

The global trends in animal production indicate a rapid and massive increase in the consumption of animal products. It is predicted for 2020 that meat and milk consumption will grow at 2.8 and 3.3 per cent per annum in less developed countries. Meat consumption in the least developed countries will increase from 88 - 188 million tons and developing countries will require 223 million tons more milk. In terms of value, livestock products will equal or exceed products from crops.

India, with only 2 per cent of the worlds land area has 16 per cent of the cattle, 54 per cent of the buffaloes, 5 per cent of the sheep and 21 per cent of the goats in the world. India has a livestock population of 489.7 million, which has been growing at a rate of 1.09 per cent annually (between 1987-1992) (Table 1 and 2).

The livestock population in India is the largest among the countries of Asia and the Pacific. Due to land use changes and livelihood demands there has been wide variations in the growth trends between livestock species. The annual growth rates for different species of livestock are shown as cattle 0.50 per cent, buffalo 1.0 per cent, sheep 1.0 per cent, goats 1.0 per cent, pigs 0.0 per cent and poultry 18.2 per cent between 1988-1992, which further shows a decline in all the species except poultry by 2002 (Table 2). Livestock contributes 6.06 per cent

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to the National GDP. The livestock sector contributes Rs 1,830,000 million to the annual revenue i.e. 32 per cent of the agricultural output, which is 27 per cent. It also provides 70 per cent of the employment in rural areas. The present level of production of animal products (viz, milk, meat, fibre, egg) will have to be augmented in response to growing demands from the human population, which has already crossed the 1,000 million mark. India has shown tremendous progress in milk production (84.456 million tons in 2000-2001 as opposed to 57.96 million tons in 1992) during the past decade but per capita availability (226 g as opposed to 182 g per head) has to not only increase but has to be well within the reach of the population below the poverty line (40 per cent at present) (Table 3).

Table 1. Livestock population - projected estimates*

(in million)

Year	Cattle	Buffaloes	Sheep	Goat	Equine	Camel	Total
2002	215.3	91.3	51.4	129.9	0.5	1.2	489.7
2003	217.6	93.2	51.9	133.1	0.4	1.3	497.5
2004	218.8	94.1	52.2	134.6	0.4	1.3	501.4
2005	219.9	95.1	52.5	136.3	0.4	1.3	505.4
2006	221.1	96.1	52.7	137.9	0.4	1.3	509.5
2007	222.3	97.0	53.0	139.5	0.4	1.3	513.5
2008	223.5	98.0	53.3	141.2	0.3	1.3	517.7
2009	224.7	99.0	53.6	142.9	0.3	1.3	521.8
2010	225.9	100.0	53.8	144.6	0.3	1.3	526.0
2011	227.1	101.0	54.1	146.4	0.3	1.3	530.2
2012	228.3	102.1	54.4	148.1	0.3	1.3	534.5

(* Estimates based on livestock population data from 1950-1992 collected from the Livestock Census, Department of Animal Husbandry and Dairy, Ministry of Agriculture, New Delhi. The figures were projected to 2012 using growth trends).

Table 2. Growth trends in livestock population (% annual growth)

Species	Population (million)			% Annual growth	
	1988	1992	2000	1988-1992	1999-2000
Cattle	193	197	200	0.5	0.2
Buffalo	72	75	79	1.0	0.7
Sheep	52	54	56	1.0	0.5
Goat	105	110	116	1.0	0.7
Pigs	10	10	11	0.0	1.2
Poultry	260	450	1,210	18.2	21.1

Table 3. Projected requirement of milk for domestic demand and export (million tons) (based on the growth trends)

Demands	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Domestic	93.58	95.59	97.5	99.45	101.44	103.47	105.4	107.37	109.34	111.31	113.28
Export @ 5per cent	4.683	4.78	4.88	4.97	5.07	5.17	5.265	5.362	5.459	5.556	5.653
Total	98.263	100.37	102.38	104.42	106.51	108.64	110.665	112.732	114.799	116.866	118.933

Table 4. Projected estimate of annual requirement of concentrate feeds in the decade ((million tons) (based on the standard feeding practices and requirements of different species of livestock))

	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
Buffalo	41.43	42.57	43.61	44.64	45.70	46.84	47.88	48.96	50.03	51.11	52.18
Cattle	55.89	57.33	58.45	59.52	60.92	62.14	63.38	64.62	65.87	67.12	68.36
Sheep	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.16	0.16
Goat	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12	0.12
Pigs	1.39	1.47	1.53	1.59	1.66	1.73	1.79	1.86	1.93	1.99	2.06
Equine	0.97	0.98	1.00	1.00	1.01	1.03	1.04	1.05	1.06	1.07	1.08
Poultry	13.75	14.84	15.69	16.59	17.54	18.55	19.48	20.44	21.39	22.35	23.30
Total	113.68	117.44	120.52	123.59	127.09	130.55	133.84	137.19	140.55	143.91	147.27

Source: Authors' calculation.

It is meat and egg production, which is required to be up scaled to meet the increasing human need. A study conducted by Rosegrant *et al*, 1995 shows that while India had a positive balance between the demand and supply for meat and eggs during 1990, by the year 2020 it is going to face a huge deficit, except in the case of egg production.

Demand for feed stuffs and feed crops

The demand has been calculated based on the consumption behaviour and average rate of feeding of concentrates for different categories and species of livestock (Table 4). It shows a growing trend over the next ten years. It is noteworthy that maximum demand is for cattle followed by buffalo and poultry.

This demand does not necessarily show that the animals actually receive the concentrates. This is just an ideal situation. Most of the dry herds, sheep, goats and local breed of animals hardly get the required quantity of animal feed. Considering the estimates of Taneja (1999), it has been found that the deficit is only 47 per cent against this estimate, giving a 64.27 per cent deficit. The consumption of feeds has to increase in view of the emphasis on cross bred herds for milk, poultry and pig production.

To meet the demands of an increasing number of livestock and also their higher productivity, feed resources have to be augmented. Coarse cereals account for about half of the total cereals produced in the world. The five major coarse cereals, viz, maize, barley, sorghum and pearl millet account for about 44 per cent of the total cereals. Of the total coarse cereals, maize accounts for almost three quarters and barley accounts for 15 per cent. Sorghum and millets account for 11 per cent. India's production of these cereals is stagnating at around 30 million tons, which is less than 3 per cent of the world's production. At present, the country faces a net deficit of 61.1 per cent in green fodder, 21.9 per cent in dry crop residues and 64 per cent in feeds.

Livestock production and consumption

Taneja (1999) remarked, "Livestock contributed 68.6 million tons of milk, 28.2 billion eggs, 44.3 million kg of wool and 4.14 million tons of meat (1992 basis). The value of the output from the livestock at the current price was 897 billion Rs (1996-1997) excluding draught power valued at 45-95 billion Rs (in terms of fuel equivalent). Livestock production is primarily a small farm production system characterized by low input - low output, except poultry and to some extent, dairying with cross bred cows and buffaloes, which are not only sustainable but provide good economic returns. Around 80 per cent of the livestock are in marginal, small and medium holdings, having 53 per cent of the operated area. The majority of livestock owners are below the poverty line. Average herd size per farm is 3.7 heads of cattle and buffalo. Small

ruminants are mostly reared under nomadic (30 per cent) and sedentary (70 per cent) systems. Pig production is mostly under a scavenging system, practiced by the weaker section of society. Poultry production is reasonably organized, 50 per cent of poultry meat and 56 per cent of the eggs are produced under an intensive production system".

The expected rise in milk yield may be sufficient to meet the demands for milk and milk products of the growing population. However, the projected deficits of animal meat will require larger emphasis on boosting their productivity through breed improvement and feeding. The increased poultry farming will require added input of grains in the feed.

Aquaculture and inland fisheries

India is gifted with a 1,311 km long coastal line. During the year 2000-2001, India exported 440,473 tons of seafood worth US$ 1.4 billion. The exports are expected to increase to US$ 2.5 billion by 2005-2006 from an initial level of 15,732 tons worth Rs 3.9 crores in 1961-1962. The shrimp farming industry, which picked up in 1980 but slowed by 1990 has again started picking up. The world's average per capita per year availability of fish is 2.1 kg per person.

The global aqua feed tonnage for the year 2000 was considered as 15 million mt. Of this, 90 per cent was in Asia, 5 per cent in Europe, less than 2 per cent in south America, 2 per cent in North America and less than 1 per cent in Africa, the Middle East and Oceanea. In fish feed, soy meal and full fat soya are being incorporated as opposed to fish meal. The use of oil meals is likely to grow. In India, the use of fish feed and its quantity of use is difficult to estimate since it is mostly in the unorganized sector. There appears to be little competition from the livestock industry since the most common use of food grains is as broken rice or wheat flour. Although the use of oil cakes/meals is increasing, it is still at a slower pace.

The feed crops

The major components of animal feed are maize, sorghum, pearl millet, minor millets and barley, besides the broken grains of rice and wheat and also the wheat and rice bran that is derived from the processing of wheat and pulses from the mills. During the past 50 years, the share of production of coarse grains in the total grain production has been declining. For maize however, it has been showing a steady increase up to 1970 after which, it almost stabilized with a slight increase after 1990. This has been mostly due to the increase in the irrigation potential, which has contributed to a change in land use. Many crop species are combined as minor millets viz, finger millet/ragi (e*leusine coracana*), little millet (p*anicum miliare*), kodo millet (*paspalum scrobiculatum*), fox tail millet (s*etaria italica*), barnyard millet (*echinochloa frumentacea*), proso millet (p*anicum miliaceum*), savan millet (e*chinochloa colona*). They are still grown in many parts of the country.

Feed crops and feed ingredients

Coarse cereals

About half of the total world production of cereals is coarse cereals (Table 5). In India, it is only 15.6 per cent, of which about 2 per cent is utilized for feed.

Table 5. Significance of coarse cereals

		India	USA	World
Total cereals mt	Cereals total	188.43	332.44	1,872.1
	Feed	1.77	164.1	655.1
% feed to total cereals		0.94	49.37	34.99
Wheat + Rice mt	Wheat + Rice	159.02	68.8	988.67
	Feed	1.20	7.72	104.6
% feed to total cereals		0.75	11.22	10.58
Coarse cereals mt	Coarse cereals	29.41	263.64	883.46
	Feed	0.57	156.4	550.4
% feed to total cereals		1.94	59.32	62.3
% coarse to total cereals		15.61	79.3	47.19
% four coarse cereals to total cereals*		15.61	78.56	43.82

* Four major coarse cereals are barley, maize, millets and sorghum.
Maize, sorghum and millets are the major components of the coarse cereals in India with their 10.78, 8.7 and 8.47 million tons production.
Source: FAO Bulletin of Statistics, Vol. 1 No.2-2000.

Table 6. Growth rates of major crops in the world and India between 1961-1999

Commodity	Growth rates						Yield (kg/ha)	
	Area		Production		Yield			
	World	India	World	India	World	India	World	India
Wheat	0.08	1.90	2.41	5.24	2.33	3.28	2,761	2,583
Rice	0.58	0.59	2.53	2.70	1.94	2.10	3,888	3,007
Barley	0.04	-4.13	1.28	-1.96	1.24	2.26	2,393	1,882
Maize	0.74	0.61	2.79	2.28	2.04	1.66	4,358	1,655
Millets	-0.61	-1.28	0.09	0.46	0.71	1.76	748	722
Sorghum	-0.32	-1.45	0.63	0.23	0.95	1.70	1,426	826
Coarse cereals	0.20	-1.18	2.13	0.68	-1.89	1.88	3,032	995
Total cereals	0.08	0.15	2.15	2.82	-2.02	2.66	3,098	2,308

Source: FAO Bulletin of Statistics, Vol. 1 No. 2-2000.

Coarse cereals production variability was very high (15 per cent or more) compared to other cereals (less than 10 per cent).

Maize

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. It is also called the queen of cereals and occupies a 20 per cent area of the cereals. Maximum production of maize comes from the USA (48 per cent) followed by China (23 per cent). India contributes only 2 per cent to world maize production. Global maize demand is increasing rapidly (50 per cent increase) (Table 6). It is expected that the demand for maize will surpass the demand for rice and wheat globally.

Maize occupies a 26 per cent area in India and contributes 41 per cent of production out of the three coarse cereals, maize, sorghum and pearl millet. In India, it is cultivated in both seasons with a maximum in the rainy season (kharif) but the yield in winter (rabi) is more (Singh, 2001). It is expected that the hybrid technology and winter maize have a high potential for production improvement. It is primarily consumed for poultry feed (40 per cent), human food (36 per cent), livestock feed (12 per cent), starch (10 per cent) and seed (2 per cent). The quality protein maize (QPM) has very high potential for improving the nutritional balance in humans and animals.

Production of maize has remained almost stagnant at around 10.8 million tons from 1996-1997 onwards. The growth of production of maize, which increased by 2.33 per cent per annum during the eighties accelerated to 2.92 per cent per annum during the nineties. The

marginal improvement in the rate of growth of output was due to the expansion in area from (-) 0.1 per cent per annum during the eighties to 0.74 per cent per annum during the nineties. The growth of productivity, on the other hand, has slightly decelerated from 2.42 per cent to 2.16 per cent between these two periods. Front line demonstrations and field trials conducted by the ICAR are reported to have realized yields of maize up to 6.31 t per hectare. The average yield of maize at 1.73 t per hectare has reached 13.5 mt maize on a 6.5 million ha area (2.08 t/ha)

Quality Protein Maize

- High content of lysine and tryptophan and essential amino acids which are deficient in normal maize kernels
- Better balanced amino acid composition in grain
- Kernel, taste and appearance like normal maize
- Good agronomic performance
- Tolerance to major insect pests and diseases.

Sorghum

Sorghum is the most important cereal crop for poor people and grown for food, feed and industrial products. It was grown over an area of 18 million ha with 9 million tons produced in the late 1960s, in contrast to the present area of 10.4 million ha with an almost similar level of production (8.3 mt). It is important to note the current sorghum scenario in the country where the rabi sorghum area (5.64 million ha) has become larger in proportion (54 per cent) than the 4.76 million ha (46 per cent) area left under kharif. Sorghum is also grown for forage in northern India over an area of 2.6-3.0 million ha (Table 7).

Table 7. Area (million ha) and grain yield (kg/ha in parenthesis) of *kharif* and *rabi* sorghum in major *rabi* sorghum growing states

Season	Maharashtra	Karnataka	Andhra Pradesh	Total
Kharif	1.96 (1,317)	0.41 (1,391)	0.33 (725)	2.7 (1,256)
Rabi	3.18 (550)	1.52 (667)	0.44 (655)	5.14 (594)

Source: Authors' calculation.

The compound growth rate of area, production and yield between the two periods indicates a negative growth rate in area of *kharif* crop but the overall yield has always shown a positive rate of 1.78 per cent per annum. This rate slightly declined between 1980-2000 (Table 8).

Table 8. Compound growth rate of sorghum area, production and yield

Season	Period	Area	Production	Yield
Kharif	1967-1968 to 1999-2000	-2.352	-0.146	2.259
	1980-1981 to 1999-2000	-4.262	-2.294	2.058
Rabi	1967-1968 to 1999-2000	-0.636	0.685	1.329
	1980-1981 to 1999-2000	-0.932	0.521	1.462
Total	1967-1968 to 1999-2000	-1.612	0.136	1.781
	1980-1981 to 1999-2000	-2.800	-1.343	1.501

Source: Authors' calculation.

Use as animal feed

Sorghum

Sorghum grain can be nutritionally, a better feed due to its high protein and fibre content. Bagasse of sweet sorghum, bio-enriched with microorganisms can be a good cattle feed, as the demand for feed is rising at a rate of 4 per cent per annum. Indian white grain sorghum has a very low or zero tannin content in contrast to brown or red sorghum from the other countries. In poultry feed, maize can be replaced by sorghum to the extent of 50 per cent without altering the egg laying potential (81.1 per cent) and broiler weight. If inclusion of sorghum in feed is maintained at 20 per cent, 3 million tons of sorghum will be required for this purpose alone (Rana *et al*., 2001). Cattle feed manufacturers buy sorghum during July-August when its price is relatively low compared to maize but in October, maize prices fall and they switch over to maize.

Barley (hordeum vulgare)

Barley is an important coarse cereal in India. Barley is a crop useful for food grains, fodder, malt breweries, pearl barley, livestock feed and poultry feed. The barley grain contains 12 per cent protein, 1.4 per cent fat and as such, is not less than wheat in its nutritional quality (Singh, 1999). The area under barley cultivation in the country declined from 3.4 million ha in 1967-1968 to 1.8 million ha in 1980. After 1990 it has declined further to 0.85 million ha. This represents slightly more than 1 per cent of the total area under barley in the world.

The level of productivity has increased from 1 t/ha in 1960 to 2 t/ha presently. In the global context it is still much lower. It is considered that barley is a crop most fitted to dry climates, poor quality irrigation, drought conditions, poor fertility and saline - sodic conditions. Barley, along with other coarse cereals like pearl millet, ragi etc has lost much ground to wheat and other commercial crops during the course of the green revolution. Its cultivation is normally taken up by poor farmers whose land holdings are small and of low productivity, mostly in the states of Rajasthan, Haryana, M.P. and U.P.

Pearl millet (bajra)

Production of bajra, after increasing from 5.38 million tons in 1995-1996 to 7.87 million tons in 1996-1997 declined to 7.64 million tons in 1997-1998 and to 7.03 million tons in 1998-1999. The estimate for 1999-2000 was 5.58 million tons i.e. a decline of 20.6 per cent from the preceding year.

The rate of growth in area under bajra which declined by 1.0 per cent per annum during the eighties, further declined by 1.23 per cent per annum during the nineties. Nevertheless, production increased from 1.15 per cent per annum to 2.35 per cent per annum because of an acceleration in the growth of yield from 2.18 per cent per annum during the eighties to 3.63 per cent per annum during the nineties. This may be attributed to large scale adoption of hybrid varieties by the farmers in recent years as the percentage of area under the high yielding bajra has increased from 47 per cent in 1986-1987 to 67 per cent in 1996-1997, the latest year for which the information is available.

Minor millets (ragi)

Production of ragi, after declining from 2.5 million tons in 1995-1996 to 2.09 million tons in 1997-1998 had rebounded to a peak of 2.81 million tons in 1998-99 i.e. a rise of 17.4 per cent over the preceding year. Considering the longer term, the production of ragi declined from

2.78 million tons during 1980-1981 and 2.42 million tons during 1990-1991 to 2.42 million tons during 1998-1999, resulting in a trend rate of growth of (-) 0.47 per cent per annum during the eighties and (-) 0.15 per cent per annum during the nineties. The reason for this was the decline in area from 2.62 million hectares during 1980-1981 to 2.28 million hectares during 1990-91 and further to 1.75 million hectares during 1998-1999 so that the trend rate of growth of area under the crop was (-) 1.37 per cent per annum during the eighties and (-) 2.71 per cent per annum during the nineties. The average productivity of this crop has however, been higher than jowar and bajra. Its yield has increased from 1,063 kg per hectare during 1980-1981 to 1,100 kg per hectare during 1990-1991 and to 1,377 kg per hectare during 1998-1999, or an acceleration in the trend rate of growth of yield from 0.91 per cent per annum during the eighties to 2.63 per cent per annum during the nineties.

Materials and methods

Principles of economic modeling have been used to study the area, production and yield functions of these crops. *An economic model is merely a theoretical construct or analytical frame work composed of a set of assumptions from which conclusions are derived.*

Three steps are involved in model building.

- In the first step, the model builder must select the variables and relationships among them that seem most pertinent to the problem to be attempted. This step produces the economic model, which contains a set of assumptions regarding the relevant variables and the relationships among them.
- Secondly, apply the necessary corrections to the model and derive a theoretical/logical conclusion.
- Thirdly, test the conclusion against the real phenomenon. If the observed conclusions do not fall in agreement with the derived data then a new conclusion must be derived.

Analytical framework

An increase in the livestock numbers and a growing human population in developing countries has to depend upon the land use and management options for their sustenance. Three primary sources of growth as regards to livestock are prevailing in the developing countries. These are, expansion in livestock numbers, increased intensity of range and pasture utilization and better use of feed concentrates and agricultural by-products, and higher output of meat, milk or eggs per animal through improved management, breeds, and technologies. The area and production statistics for India are based on the crop cutting experiments laid in different agro-ecological zones of the country. The agricultural field experiments are laid at the different centres incorporating the trend statistics about the area, production, imports, exports and consumption through sampling methodologies. Statistics on different crops give us an idea about the supply and demand level of the crops to compete with the growing population trends. The DES (Directorate of Economics and Statistics, Ministry of Agriculture and cooperation, Govt. of India) provides yield estimations in respect to principal crops of food grains, oilseeds, sugarcane, fibres etc. which contributes about 87 per cent of the agricultural output. These estimates of crop production are obtained by multiplication of area estimates by corresponding yield estimates.

Model formulation

Trends were formulated on the basis of growth trends, by taking the moving averages on three years of the last 50 years data records (Agricultural Statistics at a Glance 2001, Directorate of Economics and Statistics, DAC, Ministry of Agriculture, Govt. of India, 1950-1951 to 2001-2002). The compartments of data trends were decided on the basis of scatter diagram analysis. A three year base for moving average was taken to incorporate the effect of probability of drought. The moving average formed graphs and based on trends in the last data compartment have been selected for model formulation. Last compartment data was considered for model formulation as it was assumed to include the latest affecting factors including Government policies in recent years. Before the formulation process, it was assumed that the current trends of acreage as well as production would have a strong association with the previous year's data, since the current status is very much dependent on the previous year's status.

The demand has been formulated on the basis of calculation that the crop produce shall be consumed (production-exports) as per the Indian agricultural policy (Ministry of Agriculture, Govt. of India, 2000) for coarse cereals, which indicates that 87.5 per cent is consumed as food, 5 per cent as feed for the animal and poultry requirement, 5 per cent is to be kept as a seed source and 2.5 per cent as waste.

The following models have been formulated:

Acreage function

$$\mathrm{Ln}(\mathrm{At}) = a + b\mathrm{Ln}(\mathrm{At}-1),$$

where At = area under production at time t-th year,

$\mathrm{A}(t-1)$ = area under production at $(t-1)$ th year,

Production function

$$\mathrm{Ln}(\mathrm{Pt}) = a + b\mathrm{Ln}(\mathrm{Pt}-1) + c\mathrm{Ln}(\mathrm{At}-1),$$

where Pt= production at time t-th year,

$\mathrm{P}(t-1)$ = production at $(t-1)$ th year, and

$\mathrm{A}(t-1)$ = area under production at $(t-1)$ th year,

Export function

Export has been worked out considering it a function of time and has been derived on the basis of past records available in Jena, *et al*. 2001. The export trend was obtained through performing scatter diagram analysis and the model of the type Ln(Export at base 1993=1) = a + b Ln(t) + Ln(t^2) , where t = time, a, b are constants and are to be determined through simple regression analysis.

The crop-wise models evolved are:

Maize

Maize acreage function

$$\mathrm{Ln}(\text{Area at time t}) = a + b\,\mathrm{Ln}(\text{Area at time t}-1)$$

Coefficients	Estimates	t- statistics
a	-.10258	-0.43693
b	1.057528	10.26747

R^2=0.937734 Adj. R^2= 0.928839

It has been found that the estimated function explains 93 per cent variation in the maize yield. There is a 1.05 per cent increase in the maize area over the previous year's acreage. This shows a significant increase in area under maize.

Maize production function

$$\mathrm{Ln}(\text{Production at time } t) = a + b\ \mathrm{Ln}(\text{Production at time } t-1) + c\mathrm{Ln}(\text{Acreage at time } t-1)$$

Coefficients	Estimates	t- statistics
A	-.18164	-0.42085
B	1.12959	2.965531
C	- 0.01894	-0.16311

R^2= 0.96971 Adj. R^2= 0.959613

The estimated model for maize production (mt) explains 97 per cent of the value of maize production. The production of a particular year increased by a 1.13 per cent increment over the previous year. The contribution of the previous year's acreage was not significant.

Maize export function

$$\mathrm{Ln}(\text{Export},\ t = 1993 = 1) = a + b\,\mathrm{Ln}(t) + c\,\mathrm{Ln}(t^2)$$

Coefficients	Estimates	t- statistics
A	-2.91735	-1.52107
b	3.239748	2.947476
c	-0.40691	-3.03019

R^2=0.696659 Adj. R^2= 0.544989

The estimated function for maize export with respect to time (1993=1) explains 70 per cent variation. The estimated model evolved was quadratic in nature and shows that the export has a 3.23 per cent increase over the previous export value but adjusted by a significant decrease of 0.4 per cent. However, based on the previous 10-year export trends, the export projection of maize in the near future is almost negligible.

Based on the above models, the projections for the future status of maize acreage and production for the coming 10-years (2002-2012) have been made.

The acreage function projection model explains 93.77 per cent variation in the area whereas elsewhere it explains 42.07 per cent, when estimated with respect to ratio of unit price of maize to paddy and previous year acreage. The projections made for maize production with respect to maize production for the previous year along with the acreage could explain 96.90 per cent variation in current maize production. Compared to elsewhere, when the ratio of production to urea, production and acreage in previous years were used as predictor variables it could explain only 54 per cent variation in the production for the same data. This shows the degree of model fitness to the data. Therefore, the model adopted is well suited for Indian perspectives.

The expected annual growth (per cent) of area was less (around 2 per cent) compared to production, which may go up to 7 per cent in 2012. This may be due to the proper potential of this crop being utilized.

Pearl millet (bajra)

Acreage function

$$\text{Ln}(\text{Area at time t}) = a + b\,\text{Ln}(\text{Area at time t} - 1)$$

Coefficients	Estimates	t- statistics
a	0.2321	0.5089
b	0.89649	4.55063

R^2=0.65308 Adj. R^2= 0.62155

The estimated function could explain 65 per cent variation in the area with bajra. The area under bajra has a significant decrease (0.9 per cent) over the previous year's bajra acreage.

Production function

$$\text{Ln}(\text{Production at time t}) = a + b\,\text{Ln}(\text{Production at time t} - 1) + c\,\text{Ln}(\text{Acreage at time t} - 1)$$

Coefficients	Estimates	t- statistics
a	4.78939	3.76455
b	-0.4073	-1.62216
c	-0.9134	-1.8969

R^2= 0.40846 Adj. R^2= 0.2605

The bajra production estimation model explains 41 per cent variation, which indicates that for this crop both the predictors (bajra production and acreage at the previous year) have an insignificant contribution in the estimation. This may be due to policy adopted by the Government of India (GOI) from time to time.

Export function

$$\text{Ln}(\text{Export at time t}) = a + b\,\text{Ln}(\text{Export at time t -1})$$

Coefficients	Estimates	t- statistics
a	1.25784	6.73143
b	0.18922	1.92435

R^2= 0.64931 Adj. R^2= 0.47397

The estimation function for the export of bajra explains 65 per cent variation in the exports. This may be due to the market and the export policy. On the basis of the above derived estimation equations for bajra acreage and production, the projection of bajra production and their different kinds of use, as per the policy of GOI, is mentioned in the reports.

Sorghum (jowar)

Acreage function

$$\text{Ln}(\text{Area at time t}) = a + b\,\text{Ln}(\text{Area at time t} - 1)$$

The estimation model for the acreage of jowar explains 99 per cent variation in the area. For this crop the percentage increase over the previous year was 1.07 per cent but adjusted by constants resulting in a minor decreasing trend.

Coefficients	Estimates	t- statistics
a	-0.19872	-3.22858
b	1.066323	45.756
R^2= 0.991476	Adj. R^2= 0.991002	

Production function

$$\text{Ln}(\text{Production at time } t) = a + b \text{ Ln}(\text{Production at time } t-1) + c \text{ Ln}(\text{Acreage at time } t-1)$$

The prediction model for jowar production explains 93 per cent variation in jowar production. The jowar acreage for the previous year has a significant contribution in prediction as compared to the previous year's production. However, this crop shows that there could be a decrease in the coming years.

Coefficients	Estimates	t- statistics
a	-0.07382	-0.30225
b	0.302552	1.429128
c	0.660797	3.952104
R^2= 0.92564	Adj. R^2= 0.909115	

Export function

$$\text{Ln}(\text{Export at time t}) = a + b \text{ Ln}(\text{Export at time t - 1})$$

The export policy of GOI and the production and domestic consumption of jowar for the previous year is responsible for the poor estimation in which the estimation model could explain only 39 per cent variation in the exports.

Coefficients	Estimates	t- statistics
a	0.790913	0.721344
b	0.678602	1.775328
R^2= 0.386638	Adj. R^2= 0.263965	

The projections of jowar acreage and production were made on the basis of evolved estimation models. It has been observed that the acreage and the production are both decreasing considerably. Based on previous trends, exports are also decreasing.

Barley

Production function

$$\text{Ln}(\text{Production at time } t) = a + b \text{ Ln}(\text{Production at time } t-1)$$

The estimation model for barley acreage explains 86 per cent variation in the area. The area shows a slight increasing trend over the previous year. This shows a reduction in acreage for the projected years.

Coefficients	Estimates	t- statistics
a	0.115905	2.997303
b	0.734915	9.700764
R^2= 0.862518	Adj. R^2= 0.853352	

The acreage was derived by taking the national yield average of the current year for barley.

Export function

$$\text{Ln}(\text{Export at time t}) = a + b\,T\,(1995 = 1)$$

The barley export estimation shows 79 per cent R^2, while taken as a exponential trend (base 1995=1). As the production of barley declines, exports also decline.

Coefficients	Estimates	t- statistics
a	-0.91008	-1.61126
b	-0.55984	-2.71446

R^2=0.786513 Adj. R^2= 0.67977

The projection of barley in the coming decade shows that it may become a less prioritized crop with dismal growth unless and until the Government of India takes some steps to encourage this crop as a feed source for animal and poultry besides its use for the brewery.

Ragi (eleusine coracana)

Acreage function

$$\text{Ln}(\text{Area at time t}) = a + b\,\text{Ln}(\text{Area at time t} - 1)$$

The prediction model used taking the previous year area under ragi, could explain 93 per cent. The area under this crop also declines significantly from the previous year.

Coefficients	Estimates	t- statistics
a	0.15381	2.813426
b	0.704944	7.953899

R^2= 0.926756 Adj. R^2= 0.912107

Production function

$$\text{Ln}(\text{Production at time t}) = a + b\,\text{Ln}(\text{Production at time t} - 1) + c\,\text{Ln}(\text{Acreage at time t} - 1)$$

The estimation model for ragi production explains 72 per cent variation in the production. Acreage for the previous year was the significant predictor variable in the estimation.

Coefficients	Estimates	t- statistics
a	0.73079	0.486679
b	-0.15452	-0.41116
c	0.486679	2.536539

R^2= 0.724842 Adj. R^2= 0.587262

Export function

$$\text{Ln}\left(\text{Export at time t}\right) = a + b\ \text{Ln T}\left(1993 = 1\right)$$

This estimation function explains 72 per cent variation in ragi exports. The exports show declining trends in the coming years. The projections made for this crop show that the acreage remains almost the same but the production increases slightly. Exports also show declining trends, as almost all of the coarse cereals are scientifically constituted as animal feed products.

Coefficients	Estimates	t- statistics
a	3.98036	5.522167
b	-0.587401	-3.173712

R^2= 0.715757 Adj. R^2= 0.644696

Comparison of the models

From an Indian perspective, the change in public policy is made according to the needs of the people in terms of five-year plans. The present estimates for acreage and production have been compared with the models for acreage and production studied elsewhere by applying them on the same set of data (Table 9).

Table 9. Model comparison with model formulated elsewhere (R^2 value)

Crop	Acreage		Production	
	w. r. to previous year acreage (Current study)	w. r. to ratio of unit price of crop to paddy and acreage of the previous year (Study elsewhere)	w. r. to production and acreage of the previous year (Current study)	w. r. to unit price of urea to maize, production of previous year and time (Study elsewhere)
Maize	93.77	42.71	96.97	53.88
Bajra	65.30	22.57	40.85	49.30
Jowar	99.15	88.11	92.56	49.30
Barley			86.25	37.59
Ragi	92.68	22.58	72.48	57.74

Source: Authors' calculation.

The models formulated in the study were more accurate than those tried elsewhere. They were derived through standard regression analysis (Draper and Smith, 1981). However, the models studied in this report were compared with those tried elsewhere, incorporating the prices of the respective crops in an Indian context as per the report of the "Commission for Agricultural Costs and Prices" shown for the crops sown during the 2000-2001 season on the same set of data. The export estimation was made on the basis of the last 10 years data records (Jena, *et al*., 2001). Maximum accuracy of the model was obtained in most of the cases except in one case (bajra production) where the gap in explaining the variation was too small. Therefore, the models formulated are better from an Indian perspective.

Pricing policies

Real prices of coarse cereals were stagnant after the mid seventies but that of rice and wheat declined. Coarse cereal prices declined at a rate of 1.48 per cent per annum while that of rice and wheat declined by 1.6 per cent and 1.97 per cent respectively. These differences in

growth rates should be seen in the light of low or negative growth of coarse cereal production and high growth in the production of rice and wheat. With an increase of 3-5 per cent per annum in the latter cereals and little growth in coarse cereals, it may be said that price is maintained at a level that is keeping pace with demand, or demand is adjusting to price. However, for rice and wheat, very high growth has led to a decline in the real price. As a result of these factors, the price gap between the coarse cereals and wheat and rice reduced gradually. Coarse cereal prices generally remained lower than wheat and rice prices.

The price variability of coarse cereals was compared to the heavily supported wheat and rice. It was observed that prices of coarse cereals fluctuated more than wheat, rice, oil seeds, pulses and cotton. The variability in millet price was 35.56 per cent compared to 14.66 for oil seeds, 25.09 for cotton and 25.06 per cent for wheat.

International price comparison indicates that the price of coarse cereals was much lower in the world market with the exception of millets. This means that as WTO processes are implemented, Indian coarse cereals could face competition from other countries that may have comparative advantage. If however, subsidies in western countries are removed or lowered, India may have comparative advantage. Otherwise, farmers will be left with less profitable crops and only subsistence farmers could survive the adverse effects of globalization. This is because of the use of family labour on their farms. Farmers with a marketable surplus would face decline in income.

Consumer price behaviour

The prices of these commodities have been increasing but the major component of the oil cakes and oil meals in the concentrate determine price behaviour. In the case of most of the small dairy units, household production often replaces the expensive concentrates. Since most of the coarse cereals are priced low, they are used in an even higher proportion of the home made concentrate mixtures.

The consumer price behaviour of the commodities shows great diversity in the case of coarse grains as opposed to the other cereals. The changes in the support price during the past 10 years shows an almost similar trend for coarse cereals and paddy (Table 10). In the case of wheat, it has shown a higher change indicating the pressure on the growers and the input costs. The percentage change in yield shows a better situation for coarse cereals except sorghum. However, the change in return per ha is greatest for ragi followed by wheat. The return from other coarse cereals is in no way less than paddy, but still emphasis on crops is determined by the easy availability of inputs like water for irrigation, fertilizers, good soils etc.

Table 10. Changes in support prices (MSP) of different commodities and in gross returns

Commodity	MSP (Rs./kg)		% Change	Yield (t/ha)		% Change	% Change in return/ha
	1990-91	2000-01		1990-91	2000-01		
Paddy	2.05	5.10	148.8	2.588	2.904	12.2	179.21
Wheat	2.15	5.80	169.8	2.216	2.615	18.01	218.34
Sorghum	1.80	4.45	147.2	0.793	0.795	0.21	147.74
Bajra	1.80	4.45	147.2	0.638	0.736	15.36	185.20
Ragi	1.80	4.45	147.2	1.100	1.428	29.86	221.00
Maize	1.80	4.45	147.2	1.515	1.743	15.05	184.43
Barley	1.80	4.30	138.9	1.596	1.905	19.34	185.08

Source: Authors' calculation.

Supply of feed and feed crops

Production behaviour

In the previous pages, where the estimates of production have been calculated through the model, we find that the per cent annual expected growth for maize has a rising trend for both area and production. It has been found that the production increase at the base year 2002 is expected to double, the area will also increase. The production behaviour of sorghum gives a reverse trend to maize. For bajra, both area and production show a declining trend. Barley too is showing decline in both area and production.

Producer price behaviour

The existing price trend of coarse cereals in the domestic and international market indicates that wheat and rice are the preferred commodities as a staple, domestically as well as globally, whereas, coarse cereals will provide cutting edge competition for cattle feed and industrial uses. A proposal relating to the use of ethanol, to the extent of 5 per cent with petrol as a fuel, is under the consideration of the Govt. of India. This may induce firmness in the price of coarse cereals, provided that the manufacture of ethanol from coarse cereals is found to be cost effective in comparison to other sources. Yet the production of coarse cereals needs to be regulated to such an extent that these crops are competitive in trade as well as to the farmers.

Production response to market forces

In the case of coarse cereals, before discussing the issue we should try to understand the habitat requirement of these crops, climate preference, soil type, availability of irrigation and other inputs. The high rate of variance in productivity of coarse cereals is yet another factor determining increase/decrease in the acreage. However, it is more interesting to consider the market wholesale price index and the minimum support price offered by the Government (Table 11). The market price for coarse cereals is higher compared to the support price but the uncertainty of the market behaviour/trends does not attract the farmers to take the risk compared to crops like paddy and wheat. The changes in land use and land cover due to increasing sources of irrigation and urbanization/projects also determines the crop choice. The present emphasis on crop and land use diversification has a potential for boosting the production of these crops if the market and the processing industry are supportive. It is again emphasized that these crops, with their potentials, should attract the attention of the planners.

Table 11. Minimum support price and market whole sale price (Rs/100 kg) of commodities in 2000-2001

Price	Paddy	Wheat	Barley	Maize	Bajra	Sorghum	Ragi
Market price	530	725	800	720	600	700	750
Support price	510	620	450	445	445	445	445

Source: Authors' calculation.

Development of production technology

There are certain key points for higher productivity of coarse cereals:

- Selection of improved, high yielding varieties suitable for specific soil and moisture conditions.
- Use of proper sowing time and planting geometry. Use of seed drills to get line sowing and proper seed rate. Treating the seed for fungicides before sowing. In heavy rainfall areas, transplant it using 20 day old seedlings. Assure the use of biofertilizers i.e., 3 g

Azospirillum per kg seed at the sowing time. Apply recommended fertilizer doses. Irrigate the crop at critical stages of water stress.

- Keep the plot weed free. Attend thinning 20 days after sowing. One to two interculturing and one hand weeding 30-35 days after sowing.

These are some tips to assure high productivity.

Production projection

While the productivity of most of the coarse cereals has shown similar change compared to rice and wheat, area has been declining under most of these crops with the exception of maize. The only scope for their growth is through high level research and development input. The percentage change in productivity between 1990-1991 to 2000-2001 of most of these crops shows that for ragi and barley the change has been more than for paddy and wheat. Still the production of these crops has not increased due to the decline in acreage. It is expected that by the use of hybrid technology, grain production can be enhanced in the case of maize and sorghum. These two crops have the potential for meeting the increased demands. Barley, as a crop, needs emphasis for its potential utilization to meet the demand from industry and also livestock production as a feed crop.

The emphasis on proper land use and water conservation being given now, may support the crops more suited for the degraded lands and poor soils with lesser irrigation water requirement. Under such policy initiatives, coarse cereals have a future.

Measures for closing supply and demand gaps

The current requirement of animal feed is estimated at 117.44 million tons for all species of livestock, including poultry, and is increasing at a rate of 2.62 per cent. The present level of production is estimated at 41.96 million tons thus showing a deficit of 64.27 per cent (Planning commission discussion papers 2001). This gap is likely to continue. In another estimate, Taneja (1999) has shown a 47 per cent shortage of the concentrates. Grains and concentrates contribute only 3 per cent to the total feed resources in the country. Taneja also remarked that only lactating animals receive better feeding through the supplementation of byproduct concentrates (oilcake, bran, chunnies etc.). Sheep and goats are generally maintained on grazing and browsing and no concentrates are fed. Farmers neither have the knowledge nor feed to feed their livestock as per nutrient requirements. The present level of availability is 42 million tons of raw material that is processed/made available to the livestock industry. It is also estimated that, of this availability, 25 per cent is milled as compound feed and the rest fed, as such, to the animals by the farmers. In India, the annual production of compound feed by CLFMA members is around 3.2 million tons while other lesser organized sectors and cooperatives account for around 4-5 million tons. With the increasing potential in the poultry and dairy sector, the future demand for compounded feed is expected to grow at 12 per cent.

With growing concern for quality animals and high productivity, feed use is likely to increase. It was understood that substantial deficits can be made up with the use of non-conventional concentrates of agro industrial and forest origin, which was estimated at 11.02 million tons in 1990-1991. Farmers may also increase their use of other grains like wheat, broken rice and others for feeding the productive animals. The National Dairy Development Board and Indian Dairy Corporation are making efforts to increase the level of production of milk and also the animal feeds to support them. Many state dairy corporations and the milk societies also make efforts to provide feed to the members.

Dairy production in India is becoming more organized but meat production is still disorganized and dispersed. It is due to this reason that the estimates of demand and supply are based on population trends.

Research and development

Upstream

Indian Council of Agricultural Research, New Delhi has a number of institutes to address research on these crops. Some of them are as follows:

Commodity	Research Institute Involved
Maize	Directorate of Maize Research, IARI Campus, Pusa, New Delhi
Sorghum	National Research Centre for Sorghum, Hyderabad
Barley	AICRP on Barley Improvement, DWR Karnal
Sorghum	AICRP on Sorghum Improvement, Hyderabad
Millets (Ragi)	AIC Small Millets Improvement Project, UAS, Bangalore
Maize	AICRP on Maize, DMR, New Delhi
Pearl millet	AICRP on Pearl Millet,, RAU, Jodhpur
Coarse cereals	AICRP on Under Utilized Crops, New Delhi

Downstream

Besides those at the Central Government and State Government level there are Directorates of Minor Millets Development. These crops are also researched in the State Agricultural Universities in different states. The Zonal Agricultural research stations under the State Agricultural Universities also provide region specific research backup on these crops. The growing poultry industry in the organized sector and also pigery will demand maize grain and also the millets which will have a larger scope in times to come. Since these often come under the organized sector as industry, research and development support for CGPRT crops will also accelerate.

International trade

The sustainability of coarse cereals in the agricultural economy of the country, it is speculated, depends largely on increasing capital intensity and export potential for competitiveness in the agricultural market of the country and the world. To put it another way, linkage to the world export market will make this sector more competitive and sustainable and will lift it out of the current condition whereby production is stagnant.

During the past decade, sorghum and pearl millet have shown a consistent export performance whereas the performance of maize, barley, ragi and cereals have only picked up from 1993, 1995, 1992 and 1992 respectively. Even though the percentage share of total coarse cereal exports in the total export performance of the country is not significant, it can not be denied that the export of coarse cereals in absolute terms recorded increasing growth over the years.

Farmer participation in feed crop development

Potentials

Most of the feed crops are grown under subsistence farming conditions in the dry lands that are dependent upon the monsoon rains. The soil conditions preferred are mostly the

degraded and marginal agricultural lands. Thus, they are subjected to the vagaries of the monsoon and also poor soil fertility. These soils also suffer due to micronutrient deficiencies, which limits the production. Maize is an exception since it also covers high productive lands in the upper Gangetic alluvial plains. When considering the growing demand for feed crops and also their use as nutri-cereals in the diet of human beings, the growth potential is very high. In the case of maize, the growth is phenomenal. Based on this and the feed structure, the availability scenarios have been tested. As per the guidelines of the Ministry of Agriculture (5 per cent of the grains), 5 per cent of all coarse grains + 20 per cent of maize, as per the Planning Commission paper, the projections are presented. It shows that it is possible to produce 25.4 million tons of feed from cereals (with 20 per cent maize) during the year 2002. When oilseed cakes are added, 43.8 million tons can be easily supplied. Another supply from non-edible oil cakes and meals makes up 11 million tons, thus making the total up to 55 million tons annually. Considering other factors of feed requirement for the livestock it may be possible to meet the demand, which can be about 66 million tons annually. However, the requirements for increased productivity will demand better nutrition for which efforts have to be continued.

Constraints

Farming technology is still very primitive and a lack of improved varieties are major constraints in many coarse cereal growing areas. The cropping systems and crop mixtures to support high production are not known to farmers. The uncertain environmental conditions and lack of contingency planning are the major constraints. A poorly developed market and lack of support price are yet more constraints. These crops deserve special treatment since the area used to grow them is decreasing in response to high productive crops and also the increase in better inputs including irrigation.

Advantages

These crops require a low input and therefore can be cultivated with less investment. The low rainfall, poor soil fertility and the uncertain monsoon can be an advantage to growing these crops. Their increased production can also support better nutrition for humans and livestock. The growing emphasis on nutri-cereals may bring further advantage to the farmers. Alternate uses for sorghum and other millets can also diversify the market and assure better market prices for these commodities.

Problems

Proper policy implementation for the development of the market and support for the farmers are the major problems facing the farmers. The slow growth of research emphasis for the development of high yielding varieties is yet another problem.

Response to market development

Stability in market prices has to be assured in order to make these crops more remunerative to the farmer. Import restrictions to safeguard the interest of coarse cereal growers in the country is important when considering the comfortable level of production of these crops. If the customs duty on imports of these crops is raised, the domestic market prices can be controlled and undesirable imports can be reduced. Thus, proper execution of market intervention mechanisms in consonance with administered prices (MSP) in respect to coarse cereals on a par with wheat, rice, pulses, oil seeds, cotton and jute is a must to provide a better market and also promote its production growth by the farmers.

Response to manufacturing development

The total availability of feed is 42 million tons, however the installed capacity of the feed mill is only 5.1 million tons, which is actually processing just 3.2 million tons. The other cooperative factories manufacture 4-5 million tons of balanced concentrates. Other units manufacture about 2.5 million tons of feed. The demand for feed milling is growing at an annual rate of 12 per cent. If this growth is emphasized, the production sector can be assured of a remunerative price. This has been observed in the state of Gujarat for crops like groundnut and coarse cereals.

Conclusions and recommendations

Demand for coarse cereals in India has been shrinking with some exceptions like maize. The consumer is becoming used to superior cereals. However, a class of consumers is sticking to coarse cereals and therefore price is stagnant as supply is adjusting to the demand. Production has kept pace with demand on declining areas under coarse cereals, mainly because of high-yielding varieties. Continued supply of high-yielding varieties helped reduce the cost of production and this helped coarse cereals (pearl millet) to be able to compete with cash crops like groundnut. World export prices (F.O.B.) are much cheaper than prices in India. The major use of coarse cereals in the world is for animal feed as opposed to food use in India. The above conclusions lead to the following policy needs:

- Promote coarse cereals for feed and other uses.
- In view of food security concerns, provide coarse cereals at subsidized rates to the poor. Otherwise, the poor farmers and labourers will suffer the most if supply declines and price increases (Bapna, 2001).
- Investment in Research and Development on these crops should increase. Greater investment in the development of coarse cereal HYV, possessing resistance to drought and insect-pests, to reduce the cost of production is needed and diversification of the cultivation of these crops in the areas rendered surplus.
- Negotiate with coarse cereal exporting countries under the WTO Agreement on Agriculture for a reduction in subsidies given by them to their farmers, and
- Provision of supply of coarse cereals at subsidized rates to Below Poverty Line (BPL) families to ensure access to food as a measure of food security. Sorghum is grown for food, cattle fodder, feed and also provides raw material for the manufacture of a wide range of industrial products.

Improving sorghum productivity

- Area under Kharif sorghum has declined sharply whereas area decline in Rabi sorghum is comparatively slow. A wide range of HYVs of sorghum have been bred to cater the requirement of food, fodder, feed and industrial usages. Special HYV sorghum has been bred for forage. Improved sorghum production technology modules have been developed for different agro-climatic regions/sorghum based cropping systems through sustained research over the years. Community drier is a newly found and most eco-friendly IPM measure for the control of grain moulds in sorghum.
- Every part of the sorghum plant could be gainfully utilized for food and non-food usage. Moulded grain is preferred for the manufacture of potable alcohol. Sorghum malt, starch, alcohol, liquid glucose, High Fructose Syrup (HFS), malto-dextrins for

use in the baking Industry, ethanol, jaggery and adjuncts need to be promoted on a large scale.

- A check on the sorghum trade through non-regulated markets by the Agriculture Produce Market Committee to ensure the payment of a legitimate market price to sorghum growers.
- The introduction of summer cultivation sorghum to make the crop more competitive in terms of grain quality and productivity in Peninsular India.
- Large-scale popularization of inter-cropping of sorghum with pulses/oilseeds through under development incentive programmes.
- Introduction of sorghum cultivation in rice fallows.
- Sorghum is inherently produced through organic farming. Hence, suitable quality standards and provision of quality certification mechanisms shall be evolved for organically produced commodities as a measure of consumer preference and creating consumer awareness.
- Appropriate market intervention for the procurement of sorghum at administered prices shall be ensured to be on par with wheat and rice.
- Emphasis on the export of sorghum grain for cattle feed.
- Assured production of quality seeds of public bred sorghum cultivars and effective quality control of sorghum seeds sold in the market.

Improving maize production

- Maize crop should be accorded special status and separated from coarse cereals for strategic development.
- The minimum support price of maize should be made more remunerative.
- Food subsidy on maize shall also be provided, like wheat and rice on the supply of maize through PDS.
- Promotion of the cultivation of Quality Protein Maize (QPM) and single cross maize hybrids through Mission Mode.
- Enhancement of the Seed Replacement Rate (SRR) in maize by way of fast track seed production of HYV's of maize in the States of Bihar, Gujarat, Madhya Pradesh, Rajasthan and Uttar Pradesh, where the productivity of maize is less than the National average.
- Involvement of the Indian Maize Development Association (IMD) in strategic development of maize for encouraging "Contractual farming in maize" and export of value added products of maize.
- Renovation and upgrading of the machinery and capacity expansion of existing "Starch Plants' with appropriate fiscal support like Mission on Cotton.

Cultural and nutrient management

- Imbalance and inadequacy of fertilization of coarse cereals is omnipresent due to their inherent cultivation in marginal and degraded soils.
- Maize and barley are more susceptible to micro-nutrient deficiency, sorghum and pearl millet are moderately susceptible and ragi is least susceptible.
- Integrated use of 2.5 to 5.0 t/ha of FYM or City Compost supplements zinc requirement by 25-50 per cent while 10-15 t/ha FYM is adequate to correct the micro-nutrient deficiency in coarse cereal.

- Coarse cereals do not respond to copper and molybdenum application in Indian conditions.
- Regular application of 20-30 kg/ha of sulphur before sowing significantly enhances the productivity of most coarse cereals.
- Diversification of agriculture is receiving priority in view of a decline in productivity due to depletion of ground water resources and the agenda of WTO on agriculture.
- Optimum use of micro-nutrients ensures the quality of the produce as well as reduces the toxicity of trace elements like selenium in forages on problem soils.
- The use of multi micro-nutrient mixtures should be restricted to certain crops with expert's recommendations to save extra costs and reduce heavy metal pollution in the soil and environment.

Post harvest management

- Adaption of coarse cereals to poor habitats and resources, and a lack of awareness of the food value of coarse cereals among urbanites/irrigated areas are responsible for the limited progress of these crops.
- All of the cereal grains are plant seeds and, as such, contain a large centrally located starchy endosperm encapsulated with hull, bran and embryo or germ usually near the bottom of the grain.
- Hull in grain is indigestible by man, bran often being dark coloured repels consumer preference, germ, being rich in oil, is enzymatically active sometimes producing rancidity under certain conditions. This needs to be removed through post-harvest management.
- Development of coarse cereal based nutri-foods, particularly for the urban population by ICAR/CFTRI/Private sector food companies is required, as is the development of improved mills for the milling of coarse cereals.
- Research on storage and enhanced shelf-life of coarse cereals.
- Research on eco-friendly packaging technology for coarse cereal products.
- Starchy and proteinous endosperm of grains offer food value which is achieved by proper milling and pre-milling operations. Proper post-harvest management is crucial to improve food value and nutritional aspects as well as induce trade competitiveness in the commodity.

Environmental issues and crop diversification

- Coarse cereal cultivation is confined to arid and semi-arid regions across the globe. Arid climate is characteristic of low rainfall, high summer temperatures with very low winter temperatures and associated with high wind velocity and high evapo-transpiration.
- A high tree canopy with a perennial grass canopy on the soil surface neutralizes the harshness of the climate and creates ecological equilibrium for the survival of living beings. Multi-purpose trees are an integral part of arid and semi-arid farming systems and the livelihood of the people of these regions. Cyclic droughts often occur in arid and semi-arid regions. Improvement in pearl millet productivity in crucial arid districts namely, Bikaner, Barmer and Jaisalmer of Rajasthan which is in the range of 25-157 kg/ha on 1.32 million ha could be achieved to the level of the productivity of pearl millet in East Rajasthan with plausible diversification of this area by introducing novel agroforestry systems. Research is needed for creating competitiveness in coarse

cereals. Development of IPM modules for coarse cereals with greater emphasis on cultural practices.

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Comments on CGPRT Report on Prospects of Feed Crops in India – A Country Report

N.N. Singh[*]

The feed sector in India is expected to grow phenomenally. The main driving force behind that is a booming livestock sector. India possesses a wealth of livestock with poor productivity. Despite being low yielding, the historical performance of the livestock sector in India has been quite impressive. The astonishing growth in the dairy sector brought the white revolution to India. The per capita availability of milk and eggs has increased considerably during the past two decades. The dairy and poultry sectors are generating enormous employment opportunities to small and marginal farm holders. While small and marginal farmers control the dairy sector, poultry is in the organized sector and sharing the full benefits with the farming community. India has also joined the group of exporting countries of dairy and poultry products. These are non-traditional export items; their quantum jump in export is further inducing growth in the livestock sector.

Feed and fodder are most critical for the growth of the livestock sector. Indian livestock is dependant on and growing in the scarcity and poor quality of feed and fodder. Despite their importance, the feed sector has not received due attention in the country. A sizable share of the feed and fodder requirement of the livestock sector is met from crop by-products. Research focus, production environment and policy support were quite meek for the feed sector. This has led to a widening gulf between demand for and supply of feed and fodder in the country. Considering these issues, the study is very welcoming. The timing of the study is also important for India, as the reform process (both economic and Research and Development) is forward looking.

The study intends to estimate the demand for the supply of feed and fodder for the emerging livestock sector. It also assesses the constraints to growth promotion of feed production. The key issue of future policies to make the feed sector a viable one is also proposed by the study. The study covered a range of issues in the feed sector of the country. There are a few comments on the report, which are listed below:

While the intentions of undertaking the study are quite relevant, the approach adopted in addressing the issues is rather weak. The methodological framework in estimating the area and production are not specified. The econometric models employed in projecting area and production need the inclusion of more variables. The area response came from past prices, risk, resource endowments, besides lagged acreage. Similarly, production is influenced by the application of fertilizers, irrigation, technology (as HYV area) and crop area among others. There is a need to estimate these response functions by overcoming the problems that arise due to autocorrelation when time series data is used. Non-inclusion of relevant variables leads to erroneous estimations of area and production.

While estimating area and production, the new economic regime has been completely overlooked. For example, in the case of maize, there are predictions that China, which is exporting maize at present, will be a net importer of maize by 2010 due to the explosion in

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livestock production. Under the scenario, India may emerge an important country for maize export. Similarly, demand for sorghum would be more for fodder than the grain. The fodder demand and supply needs projections for milch animals rather than feed. Furthermore, in all cases, the technological contribution seems to be assumed as stagnating. Specifically, in the case of pearl millet, the projections suggest an area expansion and production contraction. Growing demands for multi-purposes may encourage producers to adopt improved technologies, which eventuality augments production. It would be useful if more realistic assumptions are made before estimating the area and production.

The section on agricultural policies is too weak. Although the feed sector received less emphasis on policy dimension, there are various centrally sponsored programs that focus on feed and fodder production. For example, maize research was strengthened in 1957 and a multilocational and multidisciplinary approach was given to address all the researchable issues concerning varietal development, developing agronomic cultural practices, checking diseases and insect pests, etc. Also in 1994, further research strengthening was undertaken by elevating maize projects to the level of Directorate, adding basic and strategic research agenda in addition to the above. Maize was added to a technology mission on oil seed and pulses (TMOP&M) in 1995, with an emphasis to increase area under hybrids to enhance average productivity by up to 3 t/ha. In the early nineties, the Technology Mission on Maize through Accelerate Maize Development Programme (AMDP) emphasized increasing production to achieve self-sufficiency through production and distribution of a quality seed and by conducting frontline demonstrations of improved technologies. Soon after AMDP, an integrated cereal development programme in course cereal based copping systems (ICDP) was launched in 1995 to integrate productivity per unit area/time in six states-Gujrat, Karnataka, Maharasha, M.P., Rajasthan, Sikkim in 830 identified blocks. Large numbers of minikit demonstrations are also conducted for the propagation of new technologies. A UNDP pilot programme in the year 1997, under the umbrella of TMOP&M, started to tackle farmer's problems of production, marketing, storage etc.

A transport subsidiary for the movement of seeds (1986-87) through a central sector assistance scheme was provided with an emphasis on increasing yields by use of improved production technologies (Hybrids). Similarly, policies on feed, which influence the industry, also need to be incorporated in the report. Maize, as poultry feed, has the largest use for animal and poultry feed. Expanding the poultry sector in the 90's resulted in a significant diversion to industrial uses. It is estimated that about 5 million rural households (around 30 per cent of the poultry sector) may be involved in backyard poultry. Estimated demand of the organized sector (broiler and layer) may be as high as 3.7 mt. Demand of maize was expected to grow at 0.5 mt a year maintaining growth in the poultry sector in the 90's, but it has slowed down in the past couple of years due to excess production of parent stock and muted external demand of egg and egg powder.

Both feed production at farm level, and then processing at industry level need special attention. The question is why are prices falling in a situation of rising demand and stagnating supply. Logically, there should be a rising trend in prices and therefore, this issue needs further probing. Analytical findings will be more yielding than perceived personal biases for feed and fodder, historical trends have indelible effects, which need to be changed through more accurate analysis by considering the changing scenario, both economic and environmental. Conclusions based on proposal biases may not be effective in changing the environment. Such conclusions will also lead to invalid projections and affect the future policy decisions. Therefore, it is suggested that appropriate modeling methods be used to simulate for scenario analysis and propose appropriate policy support.

The report does not cover the domestic market and trade polices. These are important in the WTO regime. Trade policies for the feed sector (both cultivator and industry level) will alter

the feed scenario in the country. A Comprehensive review of existing policy could stimulate policy debate to correct the existing policies to promote feed and fodder production. Similarly, nothing has been reported under monetary and exchange rate policies. These are very important in the context of export-import. In previous years, the feed industry was threatened due to lowering restrictions. There is a need to comprehensively review all the production and trade polices of feed and competing sectors to craft policies to promote the production of feed and the livestock sector. The example is that the subsidized wheat export from India to South Korea is threatening the maize import (from United States of America) because the feed industry started using cheap Indian wheat for the poultry sector. It is not only affecting the maize prospects but also adversely affecting the emerging Indian poultry sector. Cheap exports of wheat to other countries is making the Indian poultry sector less competitive. These issues need to be highlighted to strengthen the feed and livestock sector.

Consumption structure has been ignored. There are many studies in India, which have dwelt on consumption patterns. Per capita use of maize as food has declined due to the availability of rice and wheat at affordable prices through PDS. Food use of maize is restricted mainly in tribal belts and hilly areas such as MP., UP., Bishar, Rasthan, HP, Uttaranchal, J&K, etc. It is a proven fact that when economic development occurs, consumers substitute away from cereal to non-cereal sources of food. Estimated food use in the country is about 4 mt which is likely to decline to 3 mt by the end of 2002. It is also true that richer sections of the society consume maize in various processed forms. The consumption basket of the rural and urban population is radically changing. The increased livestock production was evidence of demand – pull rather than supply-driven. The changing demand pattern will influence the feed demand and supply. There is little attempt on assessing the demand for feedstuffs and feed crops. Similarly, the section on supply aspects is too less attended. The main limitation is that only long term past trends have been considered for future projections. Recent trends and future scenarios have to be incorporated in the analysis. On the supply side, although mention has been made to technologies, on projections these have to be included.

A clear section is needed on the future Research and Development needs in the feed sector. New seed policy for seed production and development was adopted by the Government of India in 1988. Liberalized Foreign Investment Policy permitted 100 per cent equity participation and encouraged multinational companies. Intellectual Property Right and Plant Variety Protection bill were passed by parliament in the year 2001 to protect the interests of the companies. However, constraints in the adoption of available technologies needs to be explored. These will be helpful in designing appropriate Research and Development policies, and production, marketing and trade policies for a growth-oriented feed sector.

Feed fodder production can be characterized as the poor (small and marginal) farmer's domain and grown in a marginal environment, which is prone to degradation of natural resources. Any policy and Research and Development support in this sector will directly benefit the poor farmers living in a marginal and fragile environment. Innovative, institutional arrangements through integration are emerging in the livestock sector, which are encouraging the growth of the feed and livestock sector in selected regions in India. The success of East Asian countries was an example for integration of production marketing and processing. Policy impediments of such integration need to be addressed.

The report may cover above-mentioned dimensions. Although much has been done in the study, the analytical vigor and future vision is missing. Inclusion of that would make the projections more realistic.

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Demand and Supply of Feed Crops in Nepal

Bekha L. Maharjan[*]

Executive summary

Livestock is a key element in the agricultural production system of Nepal. Livestock farming is largely found on small, mixed farms with varying interaction between crop, livestock, fisheries and forestry. At farm level, the role of livestock is often multipurpose. Livestock is a source of nutritive products (milk, meat, eggs) and is an income and employment generating activity. Animals supply draught power without requiring fossil fuels and farmers depend on animals for transport in many rural areas. Draught animals are used for processing crops and for irrigation. Animal manure is used as fertilizer, fuel or as feed in fishponds. The multipurpose function of livestock is contributing about 15 per cent to the overall gross domestic product and 31 per cent to the agricultural gross domestic product (AGDP) of the country. The contribution of livestock is expected to grow to 45 per cent of AGDP by 2015 as envisaged in the long-term agricultural perspective plan (APP) of the country.

Increasing evidence shows that a demand driven livestock revolution is underway in developing countries with a profound implication for agriculture, environment and poverty.

The term, livestock revolution, is used to describe the massive increase in demand for foods of animal origin fueled by population growth, urbanization and income growth in developing countries over the next 20 years (IFPRI, 1999).

The livestock revolution encompasses the following distinct trends:

1. Rapid increase in consumption and production of livestock products.
2. A change in production base from local, mixed farms to market oriented, vertically integrated types.
3. Increased substitution of meat and milk for grains in the human diet.
4. Rapid rise in the use of cereal based feeds.
5. Growth of more intensive production systems closer to cities.
6. Emergence of technological changes in livestock production and processing along the industrial systems.

Lack of policy action to adjust to emerging issues will not stop the livestock revolution but it will ensure that the form it takes is less favourable for growth, poverty alleviation and sustainable agricultural development in the country.

In the period between 1982-2000, FAO estimated an average annual growth rate in demand for meat, milk and eggs in developing countries of 3.7, 3.1 and 4.3 per cent respectively (FAO, 1987). Population growth, urbanization and income growth determine the changes in demand for livestock production. An IFPRI report estimated the income elasticity of demand for meat, milk and eggs at 0.97, 0.52 and 1.07 for Asia indicating a high elasticity of demand for meat and eggs. The FAO / IFPRI predictions to year 2020 are that meat and milk consumption will grow at 2.8 and 3.3 per cent per annum in developing countries. The demand for livestock products, particularly meat and eggs, is elastic with respect to income changes indicating there would be increase in demand if there were changes in income of the customer.

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Feed resources

Inadequate feed resources, both qualitatively and quantitatively are serious constraints to increased animal production. Perspectives for the future must be sought in expanding and improving the feed base.

Feed resources can be divided into:

1. Low quality roughages (natural pasture, crop residues).
2. High quality roughages (fodder crops, legumes, trees).
3. Agro- industrial by products (oil meal, cakes and others).
4. Concentrates (compound feed of grains and agro-industrial products).
5. Supplements (vitamins, minerals and others).

In the conventional feeding regime, most of the feed energy supply for ruminants originates from rangeland, pastures and crop residues. Livestock feeding was based largely on extensive grazing on natural pastures, and to some extent on forests, crop residues and fodder crops.

About 35 per cent of animal productivity is estimated to have been lost due to the poor feeding system. The supply of total digestible nutrients (TDN) from crop by-products, forests and grazing lands, and others is estimated at 45 per cent, 30 per cent and 25 per cent respectively. Total production of digestible nutrients was 6,133 thousand mt against the requirement of 8,643 thousand mt in 2000. This indicates a deficit of TDN by 29 per cent in the country.

Reduced grazing resources due to land occupation and land degradation makes livestock increasingly dependent on crop residues. Fodder and forage production on crop land is competing with food production for human beings.

Grain feed used in developing countries increased by 3 per cent per annum due to increased demand for livestock products of milk, meat and eggs.

Demand for feed crops is a derived demand which depends on the size of the livestock population and the quantity of feed fed to animals.

Livestock population and production patterns

Major livestock populations in Nepal include cattle, goat, buffalo and poultry.

1. Cattle are the major livestock raised in all ecological regions of the country. It is estimated that 50 per cent of the cattle population is concentrated in the mid-hills and 38 per cent in the Tarai. The percentage of improved breeds in cattle is 8.25 per cent that are spread along the periphery of major highways and Tarai urban centers. Many dairy cattles are raised under intensive systems in the milk grid areas. Total population of cattle in 2001 was 6.98 million.
2. Goats are also raised in all ecological regions with 55 per cent of goats concentrated in the mid-hills. About 13.7 per cent of goats are estimated to be of improved breeds. There were 6.5 million goats in 2001.
3. Buffaloes are important livestock animals in the farming system. About 50 per cent of the total buffalo population is reported to be raised in the mid-hills. Improved breeds consist of 21.14 per cent in the case of buffalo. The buffalo population was reported to be 3.6 million in 2001.
4. Poultry is a fast growing enterprise. Commercial production of poultry meat and eggs is spreading over the major urban areas and highway areas. In the rural areas, poultry is raised under scavenging conditions, whereas in highway areas with accessibility to urban areas, poultry birds are raised under intensive production systems with the use of

commercial feeds. About 50 per cent of the poultry is estimated to be of improved breeds. The fowl population was 20 million in 2001.

5. One of the fastest growing livestock species is piggery, which is concentrated in certain areas of east Nepal. About 40.7 per cent of pigs are reported to be of improved types. The pig population was 0.912 million in the country in 2001.

The annual growth rates of the major livestock populations are given in Table 1. The annual growth rate is 1.05 per cent for cattle, 1.73 per cent for buffalo, 1.88 per cent for goat, 4.93 per cent for pigs and 4.17 per cent for fowl. The population of milk cow and milk buffalo has grown by 2.15 per cent and 2.25 per cent respectively.

Table 1. Livestock population of Nepal, 1990-2001 (unit in '000 number)

Type	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	Annual % Increment in 2001 over 1990
Cattle	6,255	6,246	6,237	6,546	6,838	7,008	7,025	7,049	7,031	7,023	6,982	1.05
Buffalo	3,044	3,058	3,073	3,176	3,278	3,302	3,362	3,419	3,471	3,526	3,624	1.73
Sheep	906	912	911	914	919	859	869	869	855	851	850	0.56
Goat	5,367	5,406	5,452	5,524	5,649	5,783	5,922	6,080	6,204	6,325	6,478	1.88
Pigs	591	599	605	612	636	670	723	766	825	877	912	4.93
Fowl	13,559	13,496	13,600	13,854	14,063	14,521	15,576	16,664	17,797	18,620	19,790	4.17
Duck	391	389	392	394	404	416	415	417	421	425	411	0.46
Milking cow	689	695	699	739	766	785	816	826	828	840	852	2.15
Milking buffalo	750	752	756	786	811	821	857	882	896	910	936	2.25
Laying hen	4,206	4,187	4,217	4,295	4,405	4,548	4,887	5,182	5,421	5,668	5,998	3.87
Laying duck	202	202	205	207	212	218	218	219	220	222	215	0.58

Source: Ministry of Agriculture and Cooperatives "Statistical Information on Nepalese, Agriculture" (2000-2001), Kathmandu 2001.

Review of production and consumption of livestock products

Meat

During 1990 to 2001 a consistent growth in livestock products of meat, milk and egg was reported. The annual growth of meat {including meat from buffalo (66 per cent), goat (25 per cent), poultry and pigs (9 per cent)} has increased by 2.89 per cent. Poultry meat in particular increased by 4.09 per cent during the period. Total production of meat was about 194,258 mt in 2000-2001. (Table 2)

Milk

Annual growth in milk production has been recorded at 2.83 per cent with 3.06 per cent in cow milk and 2.58 per cent growth in buffalo milk. Total milk production was 1,124,132 mt in the country.

Eggs

Egg production has increased by 3.39 per cent per annum. Total egg production was 507,323,000 units in 2000-2001.

Per capita consumption of milk, meat and eggs is estimated at 58 liters of milk, 10 kg of meat and 25 units of egg for the year 2000-2001.

To meet the increased requirements of livestock products, Nepal imported about 382,454 heads of buffalo, 465,506 heads of goat, 1,703,220 units of poultry birds, 929,276 liters of milk

and 2,792,000 units of eggs in 1998-1999. Similarly, some exports from Nepal were 36,348 heads of buffalo, 47,266 heads of goat, 33,169 poultry birds, 149,986 liters of milk and 717,900 units of egg to India.

Table 2. Production trend of livestock products

Products	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	Annual % Increase in 2001 over 1990
Milk production	864,831	871,234	876,594	918,609	971,373	961,560	1,012,163	1,048,040	1,072,945	1,097,023	1,124,132	2.83
Cow milk	256,398	259,230	260,786	278,065	288,822	296,620	310,183	318,680	328,920	337,455	342,738	3.06
Buffalo milk	608,433	612,004	615,808	640,544	682,551	664,940	701,980	729,360	744,025	759,568	781,394	2.58
Meat production	147,347	148,695	149,893	154,343	158,748	161,520	174,268	180,675	185,034	189,160	194,258	2.89
Buffalo	95,312	96,013	96,574	100,383	104,070	104,830	113,482	117,350	119,562	121,769	124,848	2.82
Mutton	3,029	3,044	3,032	3,055	3,067	2,860	2,900	2,903	2,873	2,860	2,856	0.49
Goat	29,372	29,844	30,377	30,702	30,908	32,040	34,550	35,640	36,235	36,930	37,769	2.60
Pig	10,242	10,407	10,447	10,642	11,027	11,800	12,374	13,090	13,924	14,646	15,239	4.43
Chicken	9,138	9,119	9,195	9,291	9,396	9,700	10,671	11,400	12,146	12,659	13,259	4.09
Duck	254	268	268	270	280	290	291	292	294	296	287	1.04
Egg production*	369,519	368,164	370,928	378,079	383,122	396,400	421,460	440,910	460,625	480,800	507,323	3.39
Hen egg	354,296	352,983	355,539	362,589	367,378	380,400	405,462	424,910	444,500	464,530	491,566	3.52
Duck egg	15,223	15,181	15,389	15,490	15,744	16,000	15,998	16,000	16,125	16,270	15,757	0.31
Wool production	767	620	620	621	625	618	623	623	615	615	613	1.82
Fish production**	8,713	9,125	8,609	8,828	9,542	10,031	11,727	12,373	14,000	14,000	15,320	6.89

Source: Ministry of Agriculture and Cooperation "Statistical Information on Nepalese Agriculture" 2000-2001, MOA, Kathmandu, Nepal, 2001.
Note: * = 000; ** = mt

Demand and supply of feed and feed crops in Nepal

The demand for commercially manufactured concentrated animal feed is being affected by the fast growth of the livestock population, particularly in dairy animals and poultry birds. A significant growth in dairy cattle farms and commercial poultry firms can be seen in the country, particularly in urban areas of Tarai and accessible areas of hills. Increasing numbers of dairy cattle, buffalo and poultry birds of improved breeds are replacing local livestock animals and birds. This has necessitated the use of blended and manufactured feeds under the intensive livestock raising systems. Many farmers in Kabhre, Chitwan, Pokhara and Bhairahawa said that they would sacrifice the personal expenses on unnecessary items and would prefer to spend limited income on the good feeds and health care of their animals.

The feed conversion ratio to produce a kilo of meat, milk and egg output has been derived at 3, 2.5 and 2.5 kg of feed respectively. The ratio does not include the feed required for body maintenance of livestock animals (Department of Livestock and APROSC, 1995). (Table 3).

Table 3. Demand for livestock feed for production of livestock products ('000 mt feed)

	1995	1996	1997	1998	1999	2000	Annual Growth rate in % (in 2000)
Milk	313	320	337	349	357	365	2.77
Meat	63	64	69	72	74	75	3.17
Egg	153	158	168	176	184	192	4.25
Total	529	542	574	597	615	632	3.24

Assumption:
Assuming all milch cattle are fed with commercial feeds
Feed requirement for body maintenance not included
Feed consumption efficiency of livestock and poultry for milk, meat and egg production estimated at 3:1, 2.5:1 and 2.5:1 respectively.
Source: Department of Livestock and APROSC "A Study on Live Animals and Animal Products Marketing in Nepal", Kathmandu, 1995.

The number of improved cattle is also increasing and farmers treat them as important assets and feed them quality feeds. The population of improved poultry is also rising which is estimated at 50 per cent of the total. Poultry birds are raised under intensive conditions by providing commercial feeds. The annual growth in demand for feeds was 3.24 per cent during 1990-2000.

Due to growth in demand for commercial feeds, the prices of feed crops have registered a significant rise. The prices of maize and soybean, the major ingredients in poultry and cattle feed increased by an annual increment of 20 and 10 per cent respectively during 1990-2000.

Prices of livestock products have increased per annum by 13 per cent in the case of milk and 10 to 17 per cent in the case of chicken and mutton. Similarly the annual increment was 9.43 per cent in the case of poultry eggs.

Due to scarcity of livestock products, Nepal tends to import a large amount of eggs, meat and milk to meet the rising demand.

The demand of animal feed in the coming decade will accelerate as the demand for livestock products increases from the rising population, growing income levels and a marked shift to consume quality animal foods against the grains. It is projected that a huge gap between the requirement and supply of feeds will appear in the country. The total requirement of feed in 2010 is estimated at 874,000 mt of feed against the current availability of 410,000 mt in 2000. The annual growth rate of demand for feed is at 3.38 per cent per annum (Table 4) for 2001 to 2010.

Table 4. Projection of animal feeds, 2000 - 2010

		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Annual Growth Rate
1	Milk Production ('000 mt)	1,128	1,161	1,197	1,233	1,269	1,308	1,347	1,386	1,428	1,470	3.03
	Requirement of feed for milk production ('000 ton)	376	387	399	411	423	436	449	462	476	490	3.03
2	Meat production ('000 mt)	193	197	202	207	212	220	227	235	242	250	2.95
	Requirement of feed for meat production ('000 ton)	77	79	81	83	85	88	91	94	97	100	2.99
3	Egg production ('000 mt)	500	520	540	562	585	607	632	657	682	710	4.20
	Requirement of feed for egg production ('000 ton)	200	208	216	225	234	243	253	263	273	284	4.20
	Total '000 mt feed	653	674	696	719	742	767	793	819	846	874	3.38

Source: Authors' calculation.

Supply of feeds

The number of feed processing industries in 2000 were 154, producing about 410,000 mt of feed. Most of the feed industries in Nepal are small and are not operating at full capacity utilization. The reason for the lower utilization of processing capacity was the non-availability of raw materials and lack of proper maintenance. There is one government feed manufacturing

plant in Hetauda with a production capacity of 2 mt per hour, which is operating at a 50 per cent capacity utilization.

Larger processing mills operated in the private sector receive their feed grain supplies either from the local traders or from India. Major ingredients for feed production are maize and soybean accounting for 42 and 11 per cent of the total ingredients respectively.

Many processing industries reported that it is not cost effective to procure maize and soybean from small producers who do not supply large quantities and raw materials are also of poor quality containing heavy moisture in the grains.

It is imperative that there should be a supply contract for maize and soybean for farmers with processing industries to guarantee the supply of quality raw materials. Appropriate institutional and policy arrangements should be worked and implemented for the betterment of both farmers and processors.

The feed crops of maize and soybean are often grown by small farmers on the poorer lands. Efforts should be made to provide the benefits to these small farmers.

Nepal's feed industry will have to face tough competition from other countries after its accession to WTO. Nepal has to improve quality and cost competitiveness in its production. As the feed ingredients are of a bulky nature, Nepal will have to face the problem of increased storage and marketing costs.

Major ingredients such as maize and soybean are mainly produced in the hill-farms and are grown as subsistence crops by small farmers in non-irrigated conditions. Maize required for feed production was about 210,000 mt in 1999. This is estimated to increase to 342,000 in 2010. This increased volume of production has to be made available either through local production or imported from abroad (Table 5).

It was reported that in 1999 the feed processing industries were importing about 40 per cent of total maize ingredient or 84,000 mt to fulfill the raw material requirement for feed production.

Table 5. Projection of maize production and uses, 2001-2010 (unit mt)

Year	Total Production of Maize (mt)	Total Area (ha)	Feed (mt)	Food (mt)	Other Use (Seed, Liquor, Wastage etc.)
2001	1,488,350	822,567	220,500	1,080,725	187,125
2002	1,533,000	827,947	231,525	1,091,532	209,943
2003	1,578,990	833,298	243,101	1,102,447	233,442
2004	1,626,360	838,621	255,256	1,113,471	257,633
2005	1,675,151	843,916	268,018	1,124,605	282,528
2006	1,725,405	849,181	281,419	1,135,851	308,135
2007	1,777,167	854,417	295,490	1,147,209	334,468
2008	1,830,482	859,624	310,264	1,158,681	361,537
2009	1,885,396	864,802	325,777	1,170,268	389,351
2010	1,941,958	869,949	342,065	1,181,970	417,923

Source: Authors' calculation.

An analytical exercise

1. The estimation of coefficients from the data under the area of feed crop maize in 1980-1999 shows that the cropped area under maize is not dependent on the relative prices of the (maize to rice) crop as the value of coefficients is quite low and negative. This result seems to be consistent under a subsistence economy where maize is being cultivated independent of prices.

2. The yield of maize is stagnant over the comparison period which is shown by the small and negative coefficient of trend variable. However, yield is found to be responsive to price of urea indicating a greater use of urea fertilizer over a decrease in relative prices of the urea to maize.
3. The price response to demand of maize for food purposes is, as expected, negative (-0.07). However, an increase in income of one per cent would lead to an increase in maize demand for food by 0.26 per cent.
4. In maize demand for feed, a one per cent increase in milk production would create a corresponding 1.25 per cent increase in maize demand for feed. However, in the case of eggs, a one per cent increase in egg production would lead to 0.02 per cent decrease in maize demand for feed at the household level. This is due to the fact that processing industries may require more maize for feeds and farmers would have to sell their maize with a corresponding decline in maize availability of feed at the household level. The results indicate that maize demand for feed does not decline with an increase in prices. This is because the processors do not maintain the stocks and have to buy, even at increased prices.
5. Coefficients relating to demand of maize for other uses indicate that a one per cent increase in maize demand for food and feed purposes would lead to a 0.89 per cent increase in demand of maize for other uses.
6. Production of soybean is also found to be not dependent on price. This is, as expected in a subsistence economy under which soybean is produced.
7. Coefficients show that a one per cent increase in the income of the people would result in a 0.46 per cent increase in soybean demand. The price response to demand for soybean is, as expected, negative indicating a decline in demand with an increase in prices.

These parameters have been used to project feed crop demand of the maize and soybean up to the year 2020. (Appendix 1)

Conclusions

To close the widening gap between demand and supply of feed crops, it is recommended that the government should facilitate the production of maize by promoting contract procurement of maize and soybean by feed processing industries which will help to augment appropriate research and infrastructures such as storage, marketing and other logistics.

The second alternative is whether Nepal can import the required feed for the livestock population which involves hard currencies and other priority investment problems.

The third alternative is to grow winter maize and soybean in Tarai, often at the cost of other food crops such as lentil and other legumes which already have an export market abroad.

The fourth alternative is to grow feed crops such as oilseed, millet and other crops on marginal terraced and small farms. This requires the increased collaborative efforts from the Government and the CGPRT Centre to increase feed crop production, employment and the living status of marginal and poor farmers. This will help diversify farm production in the poorer lands and alleviate poverty.

SWOT framework

Strengths	Weaknesses
1. Increasing demand for livestock products. 2. No interference on (ingredients) input and output prices (livestock products). 3. Huge open border market for Nepalese feed crops and feeds. 4. Increased demand for feed likely to continue. 5. Dairy and poultry sector developing and expanding under the private sector. 6. Promotion of oilseed crops in hills – a potential which can be used as a feed crop.	1. Policy planning not oriented to feed crop and feed development. 2. Technology for feed processing weak. 3. Raw material availability to processing industries not adequate. 4. Indian market prices are dominating. 5. Cost competitiveness is weak for local feed products. 6. Market is fragmented and small. 7. Cost of transport and collection is prohibitive. 8. Government facilitation on research and market development is not available. 9. About 40 per cent of the total maize used for feed, reported as imported. 10. Quality of feed crops is poor. 11. Industries not operating at full capacity. 12. Nepal Feed Association not able to play coordinating role in price, quality or other areas. 13. Import duties on ingredients very high. 14. Storage facilities for feed and feed crops very poor. 15. Tax policy is not conducive for feed development.
Opportunities	**Threats**
1. Domestic markets can be expanded with improvements in road access for livestock products and feed crops. 2. Export of livestock products such as 'yak' cheese can be promoted. 3. Private sector participation in livestock and feed development forthcoming. 4. Contract procurement of feed crops - a potential. 5. Potential for winter maize expansion in Tarai. 6. Cost reduction for livestock products, an opportunity.	1. Due to the open border, Indian prices dominate the local market prices. 2. Local prices are higher for livestock feeds and products than in India. 3. Productivity improvements are constrained by the non-availability of blended feeds for animals.

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Comments on Demand and Supply of Feed Crops and Potentials and Constraints for their Expansion in Nepal

Shambhu Bahadur Panday[*]

Comments on the introduction

First of all, on behalf of the Nepal Agriculture Research Council (NARC) I would like to acknowledge the support provided by the CGPRT Centre/ESCAP for the collaborative study on feed crops. NARC has approved a vision for 20 years in which collaborative research together with government and non-government agencies, universities and other related institutions from Nepal and other countries is one of the most prioritized areas.

NARC has also a strong mandate of generating and/or improving the available technologies as per requirements in different areas of agriculture for increased production as well as for improvement in the quality. In this regards, feed crops which have high energy contents such as maize, rice and wheat brans need to increase their production. NARC has already initiated research programs to acquire hybrids in maize, with the help of CIMMYT, Mexico and in rice with the help of IRRI, Philippines. High yielding varieties in wheat have already been selected.

Protein supplement in the diets of livestock and birds in Nepal are expensive, in particular from animal origin. Projects of this kind will certainly help find out different vegetative sources of protein supplements for the increased production. Table 1 clearly indicates that there is about 71 per cent feed availability for the livestock in Nepal. It is therefore necessary to increase feed crop production and at the same time improve the quality of the feeds from already existing feedstuffs. For example, find out the requirement for all types of livestock on the basis of the nutrient contents (CP, energy and minerals) of the feedstuff. This will help minimize the oversupply of protein and energy for different production performances of the animals. This kind of strategy, which NARC has taken, should also be mentioned in the study paper.

Nepal is preparing itself to be a member of the World Trade Organization (WTO). Livestock and poultry production should therefore have comparative advantage for the international market.

Comments on the review of current status

In the review of current status, development of the animal feed sector is well reviewed. However, in the review of the feed crops and feed ingredients, Table 3.1 “Animal feed composition”, Table 3.2 “Use of feed ingredients and amount locally available” and Table 3.3 “Number of major feed processing industries by districts in 1999-2000” (Maharjan, 2003), do not indicate the quality of the feeds supplied to the livestock and birds in Nepal. It is therefore

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advisable to have one more table concerning the nutrient content of the feeds and feed ingredients available in the country.

Comments on agricultural policies

His Majesty's Government of Nepal (HMG/N), the Ministry of Agriculture and Co-operatives do not yet have approved agricultural policies. However, they already approved a long term Agricultural Perspective Plan for 1995-2015 which is also considered as one of the policy documents of the HMG/N. The HMG/N has a Five Year Development Plan in which most of the agricultural policies are documented for that period.

The Nepal Agriculture Research Council has now approved a 20 year vision document which includes agricultural research policies and the strategies to generate agriculture and agriculture related natural resource technologies for food security as well as commercial farming.

In all those policy documents, research and development in livestock and poultry production are placed in priority order. All other policies in the chapter are well written.

Comments on trading policies likely to be affected by WTO/International agreements

This chapter has very clear documentation of the Trading Policy likely to be affected by WTO/International agreements. However, the sentence which reads "Promotional requirements: If Nepalese fruits, vegetables, medicinal plants and herbs and woolen carpets were properly advertised and promoted as manufactured on pure Himalayan climate with little application of chemicals, they would command a good number of markets outside". It is suggested that this statement should be restructured as follows: Promotional requirements: If Nepalese fruits and vegetables, medicinal plants and herbs and woolen carpets were properly advertised and promoted as manufactured on pure High Mountains and Himalayan climate with little or no application of chemicals they would command a good number of markets outside.

Comments on demand for feed and feed crops

Most of the feed ingredients for the ruminants' rations (cattle, buffalo, sheep and goat) are available within the country and are also cheaper than the ingredients used for the diets of poultry and pigs in Nepal. For the last three decades, there have been quite a good number of improved animals in the total population available in the country. Improved animals demand a higher amount of concentrate feeds for their higher production potentials. It is therefore necessary that most of the ruminant population, which are of improved status, need to be supplied with an amount of balanced concentrate feed to supplement their forage based diets. However, high quality and balanced concentrate diets should be adequately supplied for increased production of meat and eggs.

Other statements are well written in this chapter.

Comments on supply of feed and feed crops

Most of the statements written for the supply of feeds and feed crops in Nepal are good and no comment needs to be made. However, crops like maize and soybean which are the main source of energy as well as protein for livestock and birds in the country are well recognized by HMG/N Ministry of Agriculture and Co-operative, and the Nepal Agriculture Research Council. NARC has a sufficient number of inbreds for the production of hybrids in maize. NARC has already four hybrids in maize as pipeline technologies which will be released as hybrid varieties this year (2002). There is also breeding work in progress to have greater numbers of composite varieties in maize for the plain and mountain areas of Nepal. Similarly, high yielding superior varieties of soybean are available in NARC for increasing production.

Finally, there are no other significant comments on the study, which may have negative implications on demand and supply of feed crops and potentials, and constraints for their expansion in Nepal. This study has been well carried out by Dr Bekha Lall Maharjan which will certainly be a very useful reference document for the scientific and developmental purpose in Nepal. I would therefore like to congratulate Dr Bekha Lall Maharjan for being able to successfully complete the study and present in this workshop.

Reference

Maharjan, Bekha Lal, 2003. Prospects of Feed Crops in Nepal: The Role of CGPRT Crops, Working Paper No. 65, Bogor, Indonesia: CGPRT Centre.

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Prospects of Feed Crops in Pakistan

A.G. Khan[*]

Introduction

The agricultural sector in Pakistan plays an important role in the national economy by contributing about 25.9 per cent of the total Gross Domestic Product (GDP). This sector contributed Rs 167.6 billion to the GDP. The contribution of agriculture to GDP has remained almost stagnant during the last fifteen years (Table 1).

Table 1. Agriculture's contribution to gross domestic product (GDP)

Year	Total GDP	Agriculture GDP	Total Agriculture	Agriculture Contribution to GDP					Total
	Billion Rs		of GDP (%)	Major crops	Livestock	Minor crops	Fishery	Forestry	
				% share of total agriculture					
1985-86	342.2	93.4	27.3	49.5	27.7	17.9	3.8	1.1	100
1990-91	446.0	114.5	25.0	47.8	29.8	17.3	3.9	1.2	100
1995-96	577.1	148.8	25.8	41.8	36.4	17.9	3.3	0.6	100
2000-01	646.6	167.6	25.9	42.1	35.4	18.6	3.5	0.3	100

Source: Economic Survey of Pakistan 1993-94 and 2000-2001.
GDP in billion Rs at constant factor.

The share of the major crops in the total agricultural GDP is the highest, however, their contribution has been decreasing slightly for the last five years. The livestock contribution has been increasing slowly and gradually and during 2000/01 it accounted for about 35.4 per cent of the total agricultural GDP.

In Pakistan, feed crops, which are being used in livestock and poultry feeding as grains, are mainly wheat, maize, sorghum and millet. These cereal feed crops are normally grown to meet human dietary needs with primary focus on wheat and rice, which in Pakistan are mainly used as food for human consumption. However, their milling by-products; bran, rice polish and rice tips are used in animal feeding.

Wheat production in Pakistan was 11,475 thousand tons in 1981, increasing to 21,081 thousand tons in 2000. Maize increased from 970 thousand tons in 1981 to 1,652 thousand tons in 2000, sorghum decreased from 230 to 221 thousand tons and the production of millet also decreased from 214 thousand tons in 1981 to 156 thousand tons in 2000. Overall annual growth rates for wheat, maize, sorghum and millet production, for the last 20 years, were 3, 2.91, 0.22 and –2.12 per cent respectively.

Using the same timescale of 1981 to 2000, milk production rose from 9,267 thousand tons to 25,566 thousand tons, beef production increased to 986 thousand tons from 434 thousand tons and mutton climbed from 370 to 649 thousand tons. Overall annual growth rates of milk, beef and mutton production were 4.68, 4.18 and 4.28 per cent respectively.

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Poultry meat production and egg production have both increased over the period, from 52 to 322 thousand tons for poultry meat and from 2,319 million to 8,463 million eggs. The annual growth rates were 10.92 and 8.07 per cent respectively.

Annual per capita consumption has also experienced marked increases over the same 20 year period. The consumption of milk has increased from 53 kg in 1981 to 82.4 kg in 2000. Consumption of meat has risen from 10.21 kg to 14.23 kg and the number of eggs consumed has gone up from 27.66 to 61.54. The growth rates for annual per capita consumption of milk, meat and eggs were 2.06, 2.19 and 2.85 per cent respectively (Agricultural Statistics of Pakistan, 1983/84 and 2000/01).

Rosegrant *et al* (1995) predicted that Asian countries will consume more meat, milk and eggs in the next two-decades. A study conducted by Vercoe *et al* (1997), while forecasting per capita demand of ruminant meat, indicated a deficit of ruminant meat production in every Asian country. Further study suggested that more animal products are needed to be produced in Asia, either through expanded production or increased production.

To meet the ever-increasing demand for animal food products, animal production systems are in a continuous shift from conventional to commercial systems. Commercialized activities of animal production systems require nutritionally balanced feeding which requires more feed grains to be incorporated in the feed. Keeping in mind the increased demand of livestock products, the productivity of livestock, particularly poultry, must be increased which will essentially demand balanced feeds. This can only be achieved with the appropriate inclusion rate of grains. The importance of feed crops to supply grains for future increases in livestock productivity necessitates examining supply and demand of feed crops in Pakistan.

Objectives and scope of the study

The specific objectives of this study are:

1. To analyze historical dynamics and future trends of demand and supply for feed crop products in Pakistan.
2. To evaluate potentials, weaknesses, opportunities and constraints for expanding feed crop farming in Pakistan.
3. To propose possible cooperation schemes for the trade and development of feed crops/products among Asian countries.
4. To formulate policy options to promote sustainable development of feed crop farming in Pakistan. The present study is focused on the production and consumption of feed crops such as wheat, maize, sorghum and millet. Milled rice was not included in this study because it is not fed to livestock and poultry in Pakistan.

Methodological approach

Conceptual framework

Definition

In Pakistan, livestock feeds primarily consist of feedstuffs such as green fodder, dry roughages and concentrates. The most common feed stuffs used for stall fed dairy animals are green and dry fodder and concentrates which include cereal by-products, oilseed by-products but very little grains. In commercial poultry, various types of required rations are blended and marketed by commercial feed mills. Poultry rations usually contain 50 to 55 per cent grains, which also includes rice tips. Feed crops such as wheat, maize, sorghum and millet are the crops

which are usually cultivated for grain production to be utilized as food for humans and feed for livestock.

Analytical framework

Previous growth trends of demand and supply of feed crops such as wheat, maize, sorghum and millet from 1981 to 2000 have been analyzed and the projections from 2001 to 2010 have been made with the help of the formulae provided by the CGPRT Centre, Bogor, Indonesia. The study has been complemented using SWOT analysis as a management tool to identify the strengths, weaknesses, opportunities and threats to decision making for production, marketing and processing.

Review of current status

Livestock production

Pakistan is endowed with various types of livestock such as buffalo, cattle, sheep, goats and poultry. There is quite a large indigenous livestock population, which is well adapted to local environmental conditions. The world best dairy buffalo breeds i.e. Nili Ravi and Kundi are present in Pakistan. Among the cows, the Sahiwal breed is one of the best local dairy breeds in Asia. There are a number of sheep and goat breeds, which are localized in different ecologies according to their suitability and the availability of feed resources.

The total buffalo population in 1981 was 11.9 million increasing to 22.7 million in 2000. The cow population increased from 15.8 million to 22 million, sheep population went from 22.1 million in 1981 to 24.1 million in 2000 and the goat population rose from 25.8 million in 1981 to 47.4 million in 2000. The projected populations of buffalo, cow, sheep and goats in the year 2010 will be 32, 26, 25 and 65 million respectively (Agricultural Statistics of Pakistan, 2000-2001). The poultry population was only 67 million in 1981 but increased to 282 million by 2000. The projected poultry population in 2010 will be 631 million.

Milk production was 9,267 thousand tons in 1981 increasing to 25,566 thousand tons in 2000, with an average annual growth rate of 4.18 per cent. Beef production in 1981 was 434 thousand tons, increasing to 986 thousand tons in 2000 with a 4.18 per cent growth rate. Mutton production reached 649 thousand tons in 2000 from 370 thousand tons, with annual growth of 4.28 per cent. Projected beef and mutton production will be 1,460 and 971 thousand tons respectively in 2010.

Poultry meat production was only 52 thousand tons in 1981 but increased to 322 thousand tons in 2000 with an annual growth rate of 10.92 per cent. Projected poultry meat production in 2010 will be 8.46 thousand tons. Egg production was 2,319 million in 1981, which increased to 8,463 million in 2000 with an 8.07 per cent growth rate. Egg production is projected as 17,849 million in 2010.

Projected consumption of livestock products

Projected annual per capita milk consumption will be 101 kg in 2010, beef will be 8.8 kg, mutton 5 kg and poultry meat 4.9 kg (Agricultural Statistics of Pakistan, 1999-2000 and Akhtar, 1997). Projected per capita egg consumption for 2010 will be 81.5 eggs.

Aquaculture and inland fisheries

Endowed with vast marine and inland fishery resources, the fisheries sector plays an important role in the economy of Pakistan. Fish provide not only a source of protein to the ever-increasing population of Pakistan, they are also an important source of foreign exchange earnings as well. Total fish production in 1990-1999 was 654,500 mt, of which about 474,000 mt were marine fish and 179,800 mt. were inland fish (Agriculture statistic of Pakistan, 1999-2000). The foreign exchange earned from the fisheries sector amounted to $89.8 million. Per capita consumption of fish in the country is very low at about 1.8 kg/annum and the fisheries sector contribution to GDP is about 1 per cent. It is estimated that 20 per cent of all inland fish production comes from aquaculture. The overall contribution of inland fish in the total amount of fish produced in Pakistan is over 25 per cent. According to statistics from 1999-2000, total aqua cultural production was estimated to be about 35,000 mt.

Feeding practices and commercial availability of feed

The fish production system is mostly based on the exploitation of natural food present in the bodies of water and its augmentation by fertilization. The carrying capacity of these ponds therefore, is directly proportional to the availability of natural food in that system. The abundant and cheap source of fertilizer in Pakistan is organic manure. Farmers learned the technology of using manure some two decades back and since then, the farmers have been striving to obtain as higher yields as possible with the use of manure and with inorganic fertilizers. The improvement in the use of fertilizers, both in quality as well as quantity, has been further fortified, however rarely, with the use of supplementary feed (mainly composed of rice polish and oil seed cakes). These practices have shown improvements in fish production on per unit area basis. Some farmers are using pelleted feed, particularly during the fattening period of the fish prior to marketing, which may last for 2-3 months. However, the feeds are not commercially available and there is a need to prepare commercial and balanced fish feed with grains according to their weight, size and their physiological needs.

Historical development of the animal feed sector

Feed crops and feed ingredients

Feed crops are generally the cereal crops which are not specific to feed but are cultivated to meet human dietary needs. Wheat, maize, sorghum, millet and barley are the crops which are basically grown for human dietary needs but are also used as animal feed. With the advancement of the poultry industry, the more precise use of grains as feed ingredients is being effectively utilized for commercially prepared rations. Maize grains can constitute up to 20 per cent of the poultry rations. Wheat is also being used in poultry rations and in commercial dairy farming systems. Sorghum is also used in commercial poultry feed but usually not exceeding 5 per cent inclusion. Millets are not usually fed to commercial poultry but are commonly used for domestic poultry and livestock. Although milled rice is not incorporated in livestock and poultry rations, its by-products, such as rice polish, rice bran and rice tips are 100 per cent utilized in either commercial poultry rations or in livestock feeding

Average annual consumption of wheat as feed was 230.6 thousand tons during 1981/85, which increased to 385.4 thousand tons in 1996/2000 with a 3.41 per cent growth rate. The projected quantity of wheat consumption as feed will be 654 thousand tons in 2010. Average annual maize consumption was 197.46 thousand tons during 1981/85, increasing to 344.2

thousand tons in 1996/2000 with a 3.45 per cent growth rate. Projected maize used as feed will be 489 thousand tons in 2010. Average sorghum consumption was 11.2 thousand tons during 1981/85, which increased to 11.6 thousand tons in 1996/2000 with a growth rate of 0.31 per cent. The projected quantity of sorghum as feed will be 10.5 thousand tons in 2010. Average annual millet consumption was 124.6 thousand tons during 1981/85, which decreased to 88.8 thousand tons in 1996/2000. Millet used as feed is very conventional but it contributes 50 per cent as feed use in total millet consumption. The projected quantity of millet used as feed will be 88.7 thousand tons in 2010.

Commercial poultry feed formulators consider the availability of nutrients in grains based on their price and also favorable and unfavorable factors for growth and egg production. Also, substitution of one cereal for another, on the basis of above said factors, is taken into account.

Agro-based industries and by-products

In Pakistan, agro-based industries related to feed resources can be classified as follows:

1. Cereal processing industries.
2. Oil seed extraction industries.
3. Sugar industries.

Cereal processing industries basically consist of flourmills and rice processing industries. Furthermore, maize is also processed through wet milling but on a limited scale (3-4 industries). Wheat flour mills produce wheat flour as a principal food for human beings, where as wheat bran is produced as a by-product which is mainly used for livestock feeding. Maize industrial by-products include maize oil cake, maize gluten 20 per cent and maize gluten 60 per cent. Maize oil-cake and gluten 20 per cent are exclusively used in livestock rations, whereas gluten 60 per cent is mainly used in poultry rations. Oilseed extraction industries produce oilseed cake and meal. The cake is mainly used in livestock feeding whereas the meal is used in poultry feed. Other miscellaneous industrial by-products are molasses (sugar industry), fish meal, guar meal and pulses.

Livestock feed industry

In Pakistan, the feed industry is not very well established as it came into existence in the mid 1970's. Basically, 92-95 per cent of commercial feed mills produce poultry feed. In 1976, the number of feed mills in Pakistan was only 17 but this increased to 150 by 1996. The total production capacity of these feed mills was 287 thousand tons in 1976 whereas this has increased to 2,700 thousand tons in 1996. The total amount of poultry feed produced was 143 thousand tons in 1976 increasing to 1,290 thousand tons in 1996. Feed production increased by 30 per cent per annum from 1976-96 (Pakistan Poultry Industry Yearbook, 1998).

Although there is a large population of large and small ruminants in the country, the number of feed mills engaged in ruminant feed production is only 10-15. Research and development efforts of the Pakistan Agricultural Research Council for ruminant feed development and its role model has led to the establishment of these small-scale ruminant feed mills. The utilization trend of commercial feeds for dairy animals is increasing year by year.

Policies most affected by WTO agreement

Pakistan has been a founding member of the General Agreement on Tariffs and Trade (GATT) since 1948. It formally signed the Final Act Embodying the Results of the Uruguay Round of Multilateral Trade Negotiations in Marrakesh on April 15, 1994. Mainly, the UR

provided substantial new trading opportunities, strengthened international trading rules, and reinforced the institutional foundation of the world trading system. The establishment of the WTO as an "umbrella institution" is assigned the responsibility of administering and implementing the new GATT charter (GATT, 1994). Pakistan is a member of the WTO and consequently a signatory to all of the major accords established under the aegis of the UR, and now it is in the process of implementing the UR agreements. The specific implications for Pakistan can be analyzed in the following four major areas:

- Trade liberalization including tariffs and changes in agriculture and textiles.
- New issues related to services, investment, and intellectual property.
- Trade rules.
- Institutional or system issues.

The negotiations resulted in four main areas of the Agreement,

- The Agreement on Agriculture itself.
- The concessions and commitments members are to undertake; market access, domestic support and export subsidies.
- The Agreement on Sanitary and Phyto Sanitary Measures.
- The ministerial decision concerning least-developed at net food-importing developing countries.

The agricultural package also addresses many other issues of vital economic and political importance to many members. These include provisions that encourage the use of less trade distorting domestic support policies to maintain the rural economy. The agreement covers three main areas:

- Market access
- Domestic support
- Export competition.

Market access

In the area of market access, non-tariff border measures are replaced by tariffs that provide substantially the same level of protection. Tariffs resulting from this "tariffication" process, as well as other tariffs on agricultural products, are to be reduced by an average 36 per cent in the case of developed countries and 24 per cent in the case of developing countries with minimum reductions for each tariff line being required. Least-developed countries are not required to reduce their tariffs. The provisions under UR apply to a primary agricultural product that is the predominant staple in the traditional diet of the developing country, which invokes this clause of the agreement.

Domestic support

Domestic support is regulated through Aggregate Measure of Support (AMS). The total AMS quantifies the aggregate value of domestic support or subsidy given to each category of agricultural product. Commitments made by members require a 20 per cent reduction in total AMS for developed countries over six years and l3.3 per cent for developing countries over 10 years. The base period for calculation of reduction was 1988/89.

Export subsidies

Members are required to reduce the value of direct export subsidies to a level 3 per cent below the 1986-90 base period level over the six year implementation period. The quantity of subsidized exports is to be reduced by 21 per cent over the same period. In the case of developing countries, the reductions are two thirds of those of developed countries over a ten-year period (with no reductions applying to least developed countries). The Agreement on Agriculture provides for some limited flexibility in terms of export subsidy reduction commitments and contains provisions aimed at preventing the circumvention of the export subsidy commitments and sets out criteria for food aid donations and the use of export credits. Pakistan has put a ceiling binding of 100-150 per cent on agricultural items in its offer on agriculture submitted to the WTO. It was necessary because agriculture plays a important role in the economy. Its Aggregate Measure of Support is negative for wheat cotton and other basic commodities. It has also declared itself a net food importing country.

Demand for feedstuffs and feed crops

Demand/consumption of food and feed grains in terms of their consumption behavior, consumption structure, consumer price behavior, consumption response to market forces, development of their products and projections for their future consumption will be presented under these headings.

Consumption behavior

Wheat is a primary food crop because it is the staple food and represents the largest cereal crop in terms of its production in Pakistan. Total consumption of wheat, which includes food, feed and other uses was 10,292 thousand tons in 1981 which increased to 26,187 thousand tons in 2000, with a growth rate of 4.22 per cent. Use of wheat as food was 9,098 thousand tons in 1981, increasing to 23,830 thousand tons in 2000 with a growth rate of 4.28 per cent during the last twenty years (Agricultural Statistics of Pakistan, 1983-84 and 2000-2001). The share of wheat as food in total wheat consumption was 88 per cent in 1981 increasing progressively to 91 per cent in 2000. The consumption of wheat as feed for livestock and poultry in 1981 was 216 thousand tons, which increased to 527 thousand tons in 2000 with an annual growth rate of 3.41 per cent. Wheat consumption as other uses was 978 thousand tons in 1981, increasing to 1,830 thousand tons in 2000.

After wheat and rice, maize is the most important cereal crop in Pakistan. Total consumption of maize was 970 thousand tons in 1981 but rose to 1,651 thousand tons in 2000 with an annual growth rate of 2.9 per cent. Maize food consumption was 536 thousand tons in 1981, which increased to 958 thousand tons in 2000 with an annual growth rate of 2.97 per cent. The share of maize as food ranged between 55 to 60 per cent of total maize consumption during the last twenty years. Maize used as feed was 189 thousand tons in 1981 and increased to 363 thousand tons in 2000 with an annual growth rate of 3.45 per cent. Maize consumption for other uses was 254 thousand tons in 1981 but this increased to 331 thousand tons in 2000.

Sorghum grain is predominantly used as food but some of the sorghum is utilized as animal feed and for other purposes such as seed. The total consumption of sorghum in Pakistan was 216 thousand tons in 1981 increasing to 220 thousand tons in 2000 with a growth rate of 2.51 per cent. Sorghum grain used as food increased from 185 thousand tons in 1981, to 191 thousand tons in 2000. Food use of sorghum has been declining progressively during the last decade. The amount of sorghum used as feed for livestock and poultry was 11,000 tons in 1981

and it was almost the same in 2000. The share of sorghum as feed in the total consumption of sorghum remained stagnant at 5 per cent during the last twenty years. The use of sorghum as seed (other uses) was 20 thousand tons in 1981 decreasing to 18 thousand tons in 2000. The share of sorghum utilized for other uses from the total consumption remained between 8 and 10 per cent during 1981-2000.

In 1981, total consumption of millet in Pakistan was 214,000 tons. This figure decreased to 156,000 tons by 2000. Millet used as food dropped from 90,000 tons in 1981 to 66,000 tons in 2000. The percentage of millet used as food from total consumption remained nearly constant at 42-44 per cent for the period. Millet used as feed has gradually declined over the past twenty years from 107,000 tons in 1981 to 78,000 in 2000. Other uses of millet have also declined, from 17,000 tons in 1981 to 12,000 in 2000.

Consumption structure

Wheat is a staple food in Pakistan and 90 per cent is used as food whereas the remainder is used as feed and for seed purposes. Per capita consumption of wheat progressively increased throughout the last twenty years.

Per capita annual consumption of wheat and maize rose respectively, from 108 kg and 6 kg in 1981 to 173 kg and 7 kg in 2000. On the other hand, per capita annual consumption of sorghum and millet decreased from 2.2 kg and 1.1 kg in 1981, to 1.4 kg and 0.6 kg in 2000 respectively.

Consumer price behavior

Cereal grains are predominantly consumed as food or feed for livestock and poultry. The consumer price for wheat as food was taken as retail price, whereas the price of wheat used in poultry and livestock industries is considered as wholesale price. Average wheat consumer price for food was Rs: 1,946, 2,514, 3,978 and 7,120 per ton in 1981/85, 1986/90, 1991/95 and 1996/2000 respectively (Agricultural Statistics of Pakistan 2000-01). The consumer price of wheat as food has progressively increased during last twenty years. The average consumer price of wheat as feed for poultry and livestock was Rs: 1,866, 2,308, 3,808 and 6,764 per ton during 1981/85, 1986/90, 1991/95 and 1996/2000 respectively. Maize consumer prices were considered the same for food and feed use and these were taken as wholesale price. The consumer price of maize progressively increased during the last twenty years as did the consumer price of sorghum and millet (Pakistan Statistical Year Book, 2000). A comparison of consumer price behavior of wheat, maize, sorghum and millet suggested that during the last twenty years, the consumer price of millet was highest followed by maize, sorghum and wheat.

Consumption response to market force

Wheat demand for food

Ln WheatFOODt = C0 + C1 Ln WheatPCt + C2 Ln RicePCt + C3 Ln POPt + C4 Ln INCt

Estimation method: OLS

Number of observations: 20 (1981-2000)

Where PC= consumer price, POP=human population, INC= per capita income

Table 2. Wheat demand for food

Coefficients	Estimates	t-statistics
C0	1.17	0.32
C1	-0.23	-0.97
C2	0.38	1.45
C3	1.44	1.99
C4	0.01	0.01

R-squared = 0.96; D-W statistics = 1.94.

The results show that when the consumer price of wheat increased by one per cent, the corresponding demand of wheat for food decreased by 0.23 per cent. The results also indicated that a one per cent increase in rice consumer price increased the demand of wheat for food use by 0.38 per cent. Population elasticity of wheat demand for food is elastic, indicating a one per cent increase in population and a 1.44 per cent increase in wheat demand for food. Wheat demand for food use was positively responsive to per capita income of the country. The demand of wheat for food is income inelastic.

Wheat demand for feed

Ln WheatFEEDt = D0 + D1 Ln (WheatPCt /SorghumPCt) + D2 Ln EggProductiont + D3 Ln Poultrymeatproductiont

Estimation method: OLS

Number of observations: 20 (1981-2000)

Where PC = consumer price of commodity for feed

Table 3. Wheat demand for feed

Coefficients	Estimates	t-statistics
D0	-3.039906	-1.212569
D1	-0.081184	-0.539664
D2	0.563652	2.883861
D3	0.010422	0.099239

R-squared = 0.79; D-W statistics = 2.11

The results suggest that wheat demand for feed declines with an increase in relative prices of wheat to sorghum. The results indicate that an increase in egg and poultry meat production results in a significant increase in wheat demand for feed.

Wheat demand for other uses

Ln WheatOTHERt = E0 +E1 Ln (WheatFOODt + WheatFEEDt) +E2 Ln Productiont + E3AR(1)

Estimation method: OLS

Number of observations: 20 (1981-2000)

Table 4. Wheat demand for other uses

Coefficients	Estimates	t-statistics
E0	-0.618799	-0.328166
E1	0.209575	1.133747
E2	0.592656	2.073205
E3	0.329485	0.840944

R-squared = 0.88; D-W statistics = 2.03.

A one per cent increase in wheat demand for food and feed resulted in a corresponding increase of 0.21 per cent in wheat demand for other uses. A one per cent increase in wheat production resulted in a corresponding increase of 0.59 per cent in other uses of wheat.

Maize demand for food
Ln MaizeFOODt = C0 + C1 Ln MaizePCt + C2 Ln WheatPCt + C3 Ln POPt + C4 Ln INCt + C5 AR(1)
Estimation method: OLS
Number of observations: 20 (1980-1999)
Where PC = consumer price, POP = human population, INC = per capita income

Table 5. Maize demand for food

Coefficients	Estimates	t-statistics
C0	5.76	2.55
C1	-0.06	-0.62
C2	0.19	2.04
C3	1.08	2.06
C4	-0.63	-1.49
C5	0.20	0.69

R-squared = 0.97; D-W statistics = 1.93.

The results show that when the consumer price of maize increased by one per cent, the corresponding demand of maize for food use decreased by 0.06 per cent. A one per cent increase in wheat consumer price increased the demand of maize for food use by 0.19 per cent. Population elasticity of maize demand for food is elastic, indicating a one per cent increase in population resulted in a 1.08 per cent increase in maize demand for food. A one per cent increase in per capita income of the population resulted in a corresponding decrease of 0.63 per cent maize demand for food.

Maize demand for feed
Ln MaizeFEEDt = D0 + D1 Ln (MaizePCt /WheatPCt) + D2 Ln Poultrymeatproductiont + D3 Ln egg productiont + D4 AR(1)
Estimation method: OLS
Number of observations: 20 (1981-2000)
Where PC = consumer price

Table 6. Maize demand for feed

Coefficients	Estimates	t-statistics
D0	-0.633012	-0.231352
D1	-0.092924	-0.610293
D2	0.107478	0.937796
D3	0.366454	1.822847
D4	0.618789	2.612486

R-squared = 0.91; D-W statistics = 1.54.

The results indicate that when relative prices of maize to wheat increased by one per cent, the demand of maize for feed use declined by 0.09 per cent. The results show that a one per cent increase in poultry meat production would lead to a 0.11 per cent increase in maize demand for feed. A one per cent increase in egg production resulted in a 0.36 per cent increase in maize demand for feed.

Maize demand for other uses
Ln MaizeOTHERt = E0 + E1 Ln (MazieFOODt + MaizeFEED) + E2 Ln Maizeproductiont
Estimation method: OLS
Number of observations: 20 (1981-2000)

Table 7. Maize demand for other uses

Coefficients	Estimates	t-statistics
E0	-0.084290	-0.671823
E1	-0.283210	-23.45416
E2	1.064339	41.51765

R-squared = 0.99; D-W statistics = 2.44.

A one per cent increase in maize demand for food and feed resulted in a corresponding, significant decrease of 0.28 per cent in maize demand for other uses. Maize demand for other uses was positively responsive to maize production. As production of maize increased, maize demand for other uses also increased due to an increase in seed requirements.

Sorghum demand for food
Ln SorghumFOODt = C0 + C1 Ln SorghumPCt/ MilletPCt + C2 Ln INCt + C3 Ln POP + C4 LnT + C5 AR(1)
Estimation method: OLS
Number of observations: 20 (1981-2000)
Where PC = consumer price, POP = human population, INC = per capita income

Table 8. Sorghum demand for food

Coefficients	Estimates	t-statistics
C0	1.109717	0.112905
C1	0.334674	1.930366
C2	0.299954	-1.309158
C3	0.109587	0.049202
C4	-0.000262	-0.004936
C5	-0.547151	-2.288983

R-squared = 0.44; D-W statistics = 2.37

A one per cent increase in consumer prices of sorghum relative to millet resulted in a 0.33 per cent increase in sorghum demand for food. A one per cent increase in per capita income resulted in a 0.29 per cent decrease in sorghum demand for food. The results indicate that a one per cent increase in population resulted in a 0.1 per cent increase in sorghum demand as food.

Sorghum demand for feed
Ln SorghumFEEDt = D0 + D1 Ln (SorghumPCt/Wheat PCt) + D2 Ln Milk Productiont + D3 Ln PoultrymeatProductiont + D4 LnT + D5 Ln AR(1)
Estimation method: TSLS
Number of observations: 20 (1980-1999)
Where PC = consumer price

Table 9. Sorghum demand for feed

Coefficients	Estimates	t-statistics
D0	-1.987251	0.446276
D1	-0.104487	-1.020000
D2	0.418957	0.865975
D3	0.142390	2.165265
D4	-0.034958	-1.141170
D5	-0.358413	-1.942742

R-squared = 0.27; D-W statistics = 2.14.

The results suggest that when the relative price of sorghum to wheat increased by one per cent the demand of sorghum for feed use decreased by 0.1 per cent. The results also show that a one per cent increase in milk production led to a 0.41 per cent increase in sorghum demand for feed. A one per cent increase in poultry meat production led to a 0.14 per cent increase in sorghum use as feed.

Sorghum demand for other uses
Ln SorghumOTHERt = E0 + E1 Ln (SorghumFEEDt + SorghumFOODt) +
E2 Ln Ssorghumproductiont
Estimation method: OLS
Number of observations: 20 (1981-2000)

Table 10. Sorghum demand for other uses

Coefficients	Estimates	t-statistics
E0	0.342626	0.498090
E1	-0.932105	-2.154500
E2	1.396058	2.934360

R-squared = 0.48; D-W statistics = 2.10.

A one per cent increase in sorghum demand for food and feed resulted in a corresponding decrease of 0.93 per cent in sorghum demand for other uses. A one per cent increase in sorghum production resulted in a corresponding increase of 1.39 per cent in sorghum demand for other uses.

Millet demand for food
Ln MilletFOODt = C0 + C1 Ln MilletPCt + C2 Ln WheatfoodPCt + C3 Ln INCt + C4 Ln POPt + C5 Ln T + C6 AR(1)
Estimation method: OLS
Number of observations: 20 (1981-2000)
Where PC = consumer price, POP = human population, INC = per capita income

Table 11. Millet demand for food

Coefficients	Estimates	t-statistics
C0	-30.29440	-1.532438
C1	-0.652030	-3.678263
C2	1.893441	4.223438
C3	2.041702	1.471692
C4	2.093254	0.759723
C5	-0.219004	-2.181587
C6	-0.578486	-2.431763

R-squared = 0.76 d w stat=2.13

A one per cent increase in consumer prices of millet led to a 0.65 per cent decrease in demand for millet use as food. A one per cent increase in per capita income led to a 2.04 per cent increase in food use of millet. A one per cent increase in population resulted in a 2.09 per cent increase in food use of millet.

Millet demand for feed
Ln MilletFEEDt = D0 + D1 Ln (MilletPCt) + D2 Ln SorghumPCt +
D3 Ln PoultryMeatProductiont + D4 Ln EGGProductiont
Estimation method: OLS
Number of observations: 20 (1980-1999)
Where PC= consumer price

Table 12. Millet demand for feed

Coefficients	Estimates	t-statistics
D0	4.085223	0.832166
D1	-0.345860	-1.951074
D2	0.205641	0.923947
D3	-0.203564	-1.216224
D4	0.184229	0.437612

R-squared = 0.41; D-W statistics = 2.13

A one per cent increase in consumer prices of millet resulted in a 0.49 per cent decrease in its demand for feed use. As egg production increased by one per cent, the use of millet in feed increased by 0.18 per cent. Millet is used mainly in feeding rural poultry and it contributes a reasonable level to egg poultry in the country.

Millet demand for other uses
Ln MilletOTHERt = E0 +E1 Ln (MilletFOODt + MilletFEEDt) +E2 Ln MilletProductiont
Estimation method: OLS
Number of observations: 20 (1981-2000)

Table 13. Millet demand for other uses

Coefficients	Estimates	t-statistics
E0	-1.480937	-3.013701
E1	10.72367	1.605559
E2	-9.926353	-1.494669

R-squared = 0.82; Adjusted R-squired = 0.80; D-W statistics = 1.82.

A one per cent increase in millet demand for food and feed would result in a corresponding increase of 10.72 per cent in millet demand for other uses. A one per cent increase in millet production would result in a corresponding decrease of 9.92 per cent in millet demand for other uses.

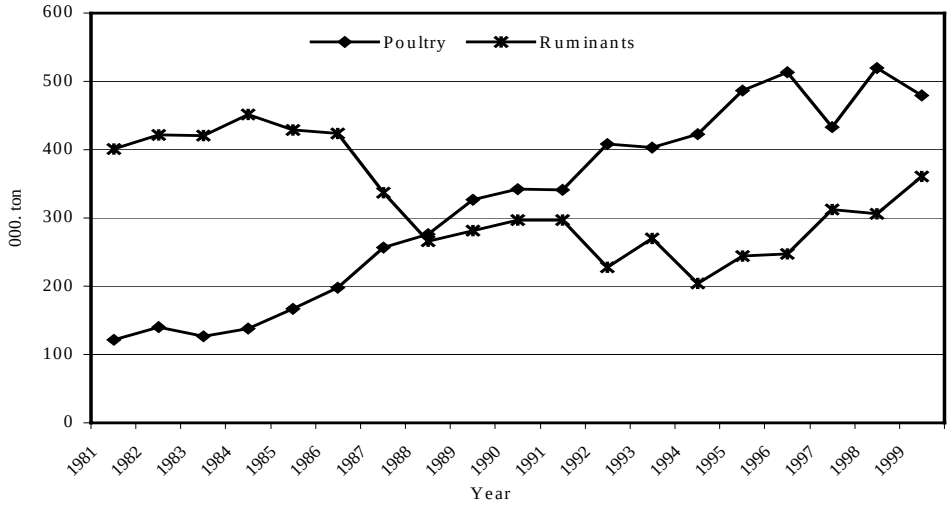
Development of products

Wheat, maize, sorghum and millet are all utilized as both food and feed. Wheat is milled in the flourmills to obtain the flour for human use and wheat bran is produced as a by-product, mostly used in livestock and poultry feeding. Sorghum and millet are used at the village level but no by-products are produced. Maize is processed in wet milling industries to produce starch, liquid glucose, cooking oil, maize oil cake, gluten feed 20 per cent and gluten meal 30 and 60

per cent. These cakes and meals of maize are used in commercial poultry rations and in livestock feeding.

During the 1980's and in 1999, about 154 and 225 thousand tons respectively, of maize grain was used in all three wet milling industries (Server, 2002 and Amir, 1986). All the cereal grains except millet, are used in poultry feed production.

Figure 1. Cereal utilization in poultry and ruminant feeding



Source: Authors' calculation.

The cereal contribution to the total feed consumed ranged between 31-33 per cent, whereas the contribution of all the other ingredients was 66-69 per cent in the consumption of total poultry feed. It is worth mentioning here that rice tips are used in commercial poultry feeds usually up to 25-30 per cent and if it's contribution is included then the total cereal share goes up to 50-55 per cent.

The contribution of cereal grains ranged between 5-11 per cent whereas the contribution of other feed ingredients was between 89-95 per cent in livestock feeding. It is summarized that most of the cereal grains are consumed in poultry feed production whereas, all the other ingredients are mainly consumed in livestock feeding.

Consumption projection

Projections for wheat, maize, sorghum and millet consumption as food, feed and other uses were made by applying the suggested model. Consumption of wheat as total, food, feed and other uses is projected as 28,031, 25,631, 523 and 1,877 thousand tons for 2005 and 34,508, 31,699, 654 and 2,155 thousand tons for 2010, respectively. Consumption of maize as total, food, feed and other uses is projected as 1,845, 1,096, 405 and 344 thousand tons for 2005 and 2,124, 1,262, 489 and 373 thousand tons for 2010, respectively.

Consumption of sorghum as total, food, feed and other uses is projected as 294.7, 265, 10.8 and 18.9 thousand tons for 2005 and 335.4, 305, 10.5 and 18.9 thousand tons for 2010, respectively. Consumption of millet as total, food, feed and other uses is projected as 153.23, 58.2, 90.4 and 4.63 thousand tons for 2005 and 139.27, 46.5, 88.7 and 4.07 thousand tons for 2010, respectively.

Projected demand for feed

The cereal requirement to produce 2,307 and 3,492 thousand tons of poultry feed are 736 and 1,095 thousand tons for 2005 and 2010 respectively. The total feed requirement for ruminants is projected as 7,771 and 8,793 thousand tons of which 280 and 147 thousand tons of cereal will be used. Total feed requirement for both poultry and livestock is calculated as 10,078 and 12,285 thousand tons for 2005 and 2010 respectively.

Supply of feedstuffs and feed crops

Production behavior

Wheat

Wheat is the major crop in Pakistan, which occupies a central position in the agricultural farming system. Wheat was cultivated on 6,984 thousand hectares in 1981 whereas the area under wheat expanded to 8,463 thousand hectares in 2000 with an annual growth rate of 1.15 per cent.

The yield of wheat was 1,643 kg/ha in 1981 increasing to 2,491 kg/ha in 2000 with a growth rate of 2.07 per cent per annum during this period. Wheat production was 11,475 thousand tons in 1981 rising to 21,081 thousand tons in 2000 with an annual growth rate of 3 per cent during the last twenty years.

Maize

After wheat and rice, maize is the third most important cereal crop in Pakistan. Maize was cultivated on 769 thousand hectares in 1981 increasing to 962 thousand hectares in 2000 with an annual growth rate of 1.22 per cent. Maize yield was 1,262 kg/ha in 1981 whereas the yield of maize increased to 1,718 kg/ha in 2000 with an annual growth rate of 1.68 per cent. Maize production was 970 thousand tons in 1981 growing to 1,652 thousand tons in 2000 with a growth rate of 2.91 per cent per annum during the last twenty years.

Sorghum

Sorghum is an important coarse grain crop in Pakistan especially in rain fed areas. Sorghum was cultivated on 394 thousand hectares in 1981 decreasing to 357 thousand hectares in 2000 with a growth rate of –0.05 per cent. The yield of sorghum was 584 kg/ha in 1981 but this increased to 617 kg/ha in 2000 with a growth rate of 0.28 per cent per annum. Sorghum production was 230 thousand tons in 1981 expending to 221 thousand tons in 2000 with a growth rate of 0.22 per cent.

Millet

Millet was cultivated on 406 thousand hectares in 1981 but the area under millet decreased to 313 thousand hectares in 2000 with a growth rate of -1.73 per cent. Millet yield was 527 kg/ton in 1981 decreasing to 497 in 2000 with growth rate of -0.39 per cent per annum for the period. Millet production was 214 thousand tons in 1981 going down to 156 thousand tons in 2000 with a growth rate of –2.12 per cent.

Production structure

The production structure of wheat, maize, sorghum and millet is of three types i.e., small farms (0.5 to under 2 ha), medium farms (2 ha to under 10 ha) and large farms (10 ha to 60 ha and above).

Production structure of wheat

In 1980, the total amount of agricultural farms in Pakistan was 4069 thousand, this increased to 5,071 thousand in 1990. Of which 3,418 thousand (84 per cent) and 4,183 thousand (82.5 per cent) farms were involved in wheat production in 1980 and 1990 respectively. The production structure shows that in 1980, the contribution to total wheat production was 10, 59 and 31 per cent from small, medium and large farms respectively. In 1990, the above-mentioned farms contributed 16, 55 and 29 per cent to the total production of wheat.

Production structure of maize

The total number of farms involved in maize production was 828 thousand in 1980 increasing to 1,067 thousand in 1990 (Census of Agriculture, 1980 and 1990). These farms were 20 and 21 per cent of the total agricultural farms. In 1980, the contribution to total maize production was 31, 55 and 14 per cent by small, medium and large farms respectively. In 1990 the contribution to total maize production was 41, 47 and 12 per cent by small, medium and large farms respectively. From 1980 to1990, the share in maize production by small farms increased from 31 to 41 per cent whereas the contribution of medium and large farms decreased.

Production structure of sorghum

The contribution of small and medium farms to sorghum production increased but the contribution of large farms decreased during 1980 to 1990.

Production structure of millet

In 1980, the contribution to total millet production by small, medium and large farms was 10, 48 and 45 per cent respectively, whereas in 1990 this contribution was 10, 52 and 37 per cent. This shows that the medium farms produced more millet in 1990 when compared to 1980.

Producer price behavior

The producer price of wheat was taken as the procurement/support price announced by the government before sowing the wheat crop (Economic Survey, 1983-84 and 2000-01). The wheat producer price was Rs 1,450/ton in 1981 and Rs 7,500/ton in 2000. The producer prices of wheat continuously increased with an overall growth rate of 9.40 per cent during the last twenty years. Maize producer prices were taken wholesale two months after harvesting. The maize producer price was Rs 1,790/ton in 1981 and Rs 8,920/ton in 2000 (Agricultural Statistics of Pakistan, 1983-84 and 2000-01). The overall growth rate of the producer price of maize was 8.92 per cent during the last twenty years. The producer price of sorghum was Rs 1,160/ton in 1981 increasing to Rs 5,469/ton in 2000. The overall growth rate was 7.72 per cent. The producer price of millet was Rs 1,330/ton in 1981 and Rs 3,035/ton in 2000. The overall growth rate of millet producer price was 3.95 per cent. The producer prices of maize were highest followed by wheat, sorghum and millet during the last twenty years.

Production response to market forces

Supply/production of any commodity is determined by commodity own prices, the prices of the competing commodity, prices of the inputs and technological developments.

Wheat acreage function
Ln WheatAHt = A0 + A1 Ln (WheatPPt-1) + A2 Ln (SugarcanePPt-1) + A3 Ln WAHt-1
Estimation method: OLS
Number of observations: 20 (1981-2000)
Where AH = area harvested, PP = producer price

Table 14. Wheat acreage function

Coefficients	Estimates	t-statistics
A0	13.11	8.35
A1	0.31	5.00
A2	-0.15	-2.08
A3	-0.63	-3.24

R-squared = 0.86; D-W statistics = 1.98.

Results of the acreage function of wheat showed that as the producer price of wheat increased by one per cent, the area increased by 0.31 per cent. In response to wheat producer prices, the area under wheat increased at a rate of 1.15 per cent per annum during the last twenty years. As the producer price of sugarcane increased by one per cent, the area under wheat decreased by 0.15 per cent. Results of the area function indicated that when the sugarcane producer price increased by one per cent it encouraged the farmers to shift 0.15 per cent of their land from wheat to sugarcane. The results of the acreage function show that area under wheat had a negative response to that of the previous year's area of wheat.

Wheat yield function
Ln WheatYieldDt = B0 + B1 Ln (WheatPPt) + B2 Ln (UreaPCt-1) + B3 WheatYieldDt-1 + B4 Ln T
Estimation method: OLS
Number of observations: 20 (1981-2000)
Where PP = producer price, PC = consumer price

Table 15. Wheat yield function

Coefficients	Estimates	t-statistics
B0	10.01	4.77
B1	0.04	0.38
B2	-0.009	-0.068
B3	-0.39	-1.43
B4	0.026	1.94

R-squared = 0.86; D-W statistics = 2.22.

The results showed that when wheat prices increased by one per cent the yield of wheat crop increased only by 0.04 per cent. When the price of urea increased by one per cent, the wheat yield decreased by only 0.009 per cent. The yield of wheat crop was negatively but non-significantly responsive to the yield of its previous year. Perhaps technological factors were not so strong for continuous yield increases but there are other factors too such as, soil moisture at the time of sowing, vacation of area by previous crop, price of substituting crop and previous years price of wheat. However, trend of yield of wheat was positive and significant during the last 20 years.

Maize acreage function
Ln MaizeAHt = A0 + A1 Ln (MaizePPt-1) + A2 Ln (SugarCanePPt) + A3 Ln MAHt-1
Estimation method: OLS
Number of observations: 20 (1981-2000)
Where AH = area harvested, PP = producer price

Table 16. Maize acreage function

Coefficients	Estimates	t-statistics
A0	2.201367	1.875999
A1	0.108685	1.940970
A2	-0.060637	-0.890541
A3	0.597203	3.002416

R-squared = 0.92; D-W statistics = 2.02.

The results revealed that an increase in the producer price of maize by one per cent would result in a corresponding increase of 0.11 per cent in maize cultivated area The results showed that sugarcane did not significantly compete with maize mainly because of the price factor. The growth in area under maize indicated that the area under maize cultivation was positively responsive to better technological factors.

Maize yield function
Ln MaizeYieldDt = B0 + B1 Ln MaizePPt-1 + B2 UreaPCt-1 + B3 Ln MaizeYieldDt-1
Estimation method: OLS
Number of observations: 20 (1981-2000)
Where PP = producer price and PC = consumer price

Table 17. Maize yield function

Coefficients	Estimates	t-statistics
B0	3.189208	2.920748
B1	0.122185	2.160395
B2	-0.009806	-0.161501
B3	0.432759	2.270878

R-squared = 0.93; D-W statistics = 1.95.

Results showed that when the producer price of maize increased by one per cent the resulting yield increased by 0.12 per cent. A one per cent increase in urea price decreased the yield of maize by only 0.009 per cent. Results showed that a one per cent increase in the previous year's yield would result in a 0.43 per cent increase in the yield of the following year. The yield of maize in previous years had significantly increased due to technological improvements.

Sorghum acreage function
Ln SorghumAHt = A0 + A1 Ln (SorghumPPt-1) + A2 Ln (MilletPPt-1) +A3 Ln SorghumAHt-1
Estimation method: OLS
Number of observations: 20 (1981-2000)
Where AH = area harvested, PP = producer price

Table 18. Sorghum acreage function

Coefficients	Estimates	t-statistics
A0	7.537991	2.758406
A1	0.109834	0.334489
A2	-0.225181	-0.350624
A3	-1.119709	-4.182830

R-squared = 0.55: D-W statistics = 1.99.

Results revealed that an increase in sorghum producer price by one per cent would result in an increase of 0.1 per cent in the sorghum growing area. The cropped area of sorghum was not found to be significantly responsive to the price of competing crops.

Sorghum yield function
Ln SorghumYieldDt = B0 + B1 Ln (UreaPCt-1/SorghumPPt-1) + B2 Ln SorghumYiedDt-1 + B3 Ln T
Estimation method: OLS
Number of observations: 20 (1981-2000)
Where AH = area harvested, PP = producer price and T = trend

Table 19. Sorghum yield function

Coefficients	Estimates	t-statistics
B0	6.654771	3.741912
B1	-0.009591	-0.345084
B2	-0.053107	-0.192380
B3	0.003261	3.114642

R-squared = 0.57; D-W statistics = 1.98.

The results showed that when the relative consumer price of urea to the producer price of sorghum increased by one per cent the yield decreased by 0.009 per cent. The yield of the sorghum was also not responsive to the previous years' crop yield.

Millet acreage function
Ln MilletAHt = A0 + A1 Ln (MilletPPt-1) + A2 Ln (SORPPt-1) + A3 Ln MilletAHt-1 + A4 Ln T
Estimation method: OLS
Number of observations: 20 (1981-2000)
Where AH = area harvested, PP = producer price and T = trend

Table 20. Millet acreage function

Coefficients	Estimates	t-statistics
A0	-3.003827	-0.186036
A1	1.715006	0.830225
A2	-0.093580	-0.069816
A3	-1.388225	-5.432415
A4	-0.087787	-0.702614

R-squared = 0.69; D-W statistics = 2.22.

The results revealed that a one per cent increase in the producer price resulted in an increase of 1.71 per cent in the millet-cultivated area. An increase in the producer price of sorghum by one per cent would result in a corresponding decrease of 0.09 per cent in the millet growing area. These results were confirmed by the previous 20 years data, which showed high unsustainability in the area of millet.

Millet yield function
Ln MilletYieldDt = B0 + B1 Ln(MilletPPt-1) + B2 Ln (UreaPCt) + B3 MilletYDt-1 + B4 Trend + B5AR(1)
Estimation method: OLS
Number of observations: 20 (1981-2000)
Where PP = producer price, PC = consumer price

Table 21. Millet yield function

Coefficients	Estimates	t-statistics
B0	-8.697084	-1.600614
B1	1.679387	1.960075
B2	-0.118273	-0.654434
B3	-0.427445	-1.942213
B4	-0.053444	-1.739288
B5	-0.609193	-2.241430

R-squared = 0.56: D-W statistics = 2.33

Results showed that a one per cent increase in the producer price of millet resulted in an increase in yield of millet by 1.68 per cent. When the urea price increased by one per cent the millet yield decreased by 0.11 per cent but it was non-significant. The trend data also showed that there was year-to-year variations in the yield of the millet crop.

Development of production technology

The efficient use of key inputs, a proper economic environment and research and development play important roles in raising the productivity of crops and improving farm incomes. If all the factors are organized properly and weather also remains favorable, rapid agricultural development can take place in a country. Production technologies in the development of agriculture are mainly 1) high yielding varietal development 2) efficient use of inputs 3) mechanization and 4) plant protection

Varieties

Wheat

Seven new varieties were introduced in 1996, namely Shahkan-95, Vandanak-95, SR-95, Kohsar, 1995, Drawar-96, Bakhtawar-95 and Kiran-96. Due to these varieties, the yield of wheat increased from 2,018 kg/ha in 1995/96 and 2,053 kg/ha in 1996/97 (Economic Survey, 1996/97). In National Uniform Yield Trials (NUYT), 73 individual sets of the varieties were distributed by NARC to the coordinating units located in different agro-ecological zones. This resulted in the development of 5 new wheat varieties for commercial cultivation namely, Ukaab-98, Iqbal-99, Mangla-97, Takbeer, 99 and Bahawalpur-97, some of which have produced good production results.

Maize

High yielding maize varieties released in 1984-96 were Sarhad white, Kissan, Azam, Pahari, Sultan, Golden Agaiti-85, Gauher and Kashmir Gold. The National Agricultural Research Centre is also involved in the development of maize hybrids which have the potential to produce 12 tons of grains/ha (Malik, 1998 and Aslam, 2001). Some high yielding varieties of sorghum and millet have been identified. These include Sorghum Pak SS-11, NES-1747, IC-1039 Mr-839, BR-123, Jowar-96, Giza-3, Red Janpur, Bagdar, PARC SS-1, PARC SS-2. Millet: 18-BY, Y-84, Cholistani Bajra, Barani Bajra, DBR-3, DB-5, C-47 PARC MC-1 and PARC-MS-2 (Aslam, 2001).

Fertilizer

In 1980-81 the off take of fertilizers was 1,079 thousand N/tons and it increased to 2,833 thousand N/ton by 2000 (Economic Survey, 2000-01). The amount of fertilizer used for wheat crops in 1980 and 1990 was 74 kg/ha and 114.79 kg/ha respectively. In 1980, 31 per cent of the

total farms utilized both chemical fertilizer and manure, 40 per cent of farms used only chemical fertilizer and only 9 per cent used just manure. However, in 1990, 28 per cent of the farms used chemical fertilizers and manure, 49 per cent used chemical fertilizers only and 6 per cent used manure. The number of farms using fertilizers, especially the chemical fertilizers, increased from 1980 to 1990 (Census of Agriculture, 1980 and 1990).

Improved seeds

In Pakistan, the Federal Seed Certificate and Registration Department regulates the quality of seeds by declaring them certified seeds. There are about 328 private sector companies, including 5 multinational companies, engaged in seed production and marketing in the country. In 2000, improved seed production was 74,000 tons, of which, 67,000 tons of wheat seeds were distributed to the farming community.

Mechanization

Mechanization of agriculture is crucial for achieving self-sufficiency in food production through increasing per unit land productivity and reducing pre-and post harvest losses. For the introduction of the latest technology in the agriculture production system, the government allowed the import of agricultural machinery (not manufactured locally) at 10 per cent custom duty. According to an estimate in 1981, total production of tractors was 16,137, which has increased to 35,038 in 2000 (Agricultural statistic of Pakistan 1988-89, 1999-00). Mechanization, the use of tractors, rotavators, combine harvesters, etc., has been widely adopted in Pakistan for use on the wheat crop. Now more than 80 per cent of maize farmers in both irrigated and rainfed areas are also using machinery, including mechanical shellers.

Plant protection

The adoption of plant protection measures helps to increase per hectare yield by protecting the crop from damage through diseases etc. It is estimated that pests and pathogens reduce agricultural production by about 25 per cent. Efforts are being made to popularize Integrated Pest Management (IPM) techniques among the farmers. In 1980, insecticides were used only on 4 per cent of the total farms, while in 1990, it increased to 25 per cent of the farms (Census of Agriculture, 1980 and 1990).

Projections of wheat

The area under wheat cultivation was 8,463 thousand hectares in 2000. The area under wheat is projected as 9,177 and 9,680 thousand hectares for 2005 and 2010 respectively. The yield of wheat is projected as 2,520 kg/ha and 2,790 kg/ha for 2005 and 2010 respectively. The projection of wheat production for 2005 and 2010 is 23,123 and 27,097 thousand tons respectively. Wheat production is projected to increase by 35 per cent between 2001 to 2010, which is in agreement with FAO (2000) projections of wheat production.

Projections of maize

The area under maize crop was 967 thousand hectares in 2000. It is projected as 1,010 and 1,072 thousand hectares for 2005 and 2010, respectively. The yield of maize is projected as 1,783 and 1,942 kg/ha for 2005 and 2010, respectively. The projection of maize production for 2005 and 2010 is 1,801 and 2,083 thousand tons respectively. Maize production is projected to increase by 27 per cent during 2001 to 2010.

Projections of sorghum

The area under sorghum is projected as 400 and 413 thousand hectares for 2005 and 2010 respectively. The yield of sorghum is projected as 624 kg/ha 633 kg/ha for 2005 and 2010 respectively. The projection of sorghum production for 2005 and 2010 is 249 and 261 thousand tons respectively.

Projectiosn of millet

The area of millet is projected as 333 and 300 thousand hectares in 2005 and 2010 respectively. The yield of millet is projected as 506 kg/ha and 529 kg/ha for 2005 and 2010 respectively. The projection of millet production for 2005 and 2010 is 169 and 159 thousand tons respectively.

Measures for closing the supply and demand gap

Government and private company initiatives

Domestic production, reduction and expansion

The analysis and predictions for Pakistan's Case Study on Feed Crops indicated that there is going to be a shortfall in the availability of wheat, maize and sorghum to meet the country's requirement for food, feed and others.

The projected results showed that domestic demand of wheat will be 28,031 and 34,508 thousand tons for 2005 and 2010 respectively, whereas the projection of wheat production will only be 23,123 and 27,097 thousand tons for 2005 and 2010. There will be gap between demand and supply of wheat. The projection for imports of wheat is based on results of the model, which indicated that wheat would be imported to the tune of 4,768 and 7,309 thousand tons in 2005 and 2010 respectively.

The projected results showed that domestic demand of maize would be 1,845 and 2,124 thousand tons whereas the projection of maize production will be 1,801 and 2,083 thousand tons for 2005 and 2010, respectively. There will be a gap between demand and supply. The gap is only 2.2 per cent of total maize production. This gap will be met by increased production through improving the production technologies, especially by cultivating high yielding varieties of hybrids of maize.

The projected results showed that domestic demand of sorghum would be 294 and 335 thousand tons, whereas the projection of sorghum production will be 249 and 261 thousand tons for 2005 and 2010 respectively. There is a gap of 18 and 28 per cent of total production of sorghum in 2005 and 2010, respectively. This gap can be met through enhanced production by cultivating improved seed varieties and the application of production technologies.

The Government has already put forward a strategy for the development of agriculture for the year 2010, where annual growth rates of about 5 per cent will be achieved through increasing the area under these crops and by increasing productivity (FAO, 2000). This would require improvement in production technology for these crops and the effective and efficient use of inputs i.e. seeds, fertilizers, weedicides, etc.

The government has also encouraged the private sector for the provision of input supply to the farmers, like seeds, balanced and compound fertilizers, weedicides, etc. Vast areas of land are available in the country, which can be farmed if water developments are made.

Research and development

Research and development is essential to meet the shortfall in food and feed grains in the country. The National Agricultural Research and Development System (NARDS) needs to be

reoriented and strengthened to meet the future shortfalls. Systems improvements are required both at the upstream and downstream levels.

Upstream

The government has put forward an agricultural strategy for the year 2010, where the emphasis is placed on self-reliance in food and feed grains and on competitiveness to produce surplus for export purposes. The policy incentives in relation to the support price given for wheat have produced positive results. Emphasis on marketing research would further help the government to provide support price incentives. The Agricultural Prices Commission and the Agricultural and Livestock Marketing Authority are jointly implementing a research and development project on the imperfections of the marketing system and to develop strategies for improvement.

A higher priority on grain crop research in the country would strengthen the Commodity Research Programs in the provinces. Furthermore, there is a move for restructuring the national agricultural research system in the country. The Ministry of Food, Agriculture and Livestock in collaboration with FAO and the Asian Development Bank are going to implement a project for the restructuring of the National Agricultural Research System. For this purpose, institutional reforms in the research and development institutions will be implemented in line with the Reforms Agenda already in place for water sector institutions.

Downstream

At the downstream level, efforts have been made to systemize the R&D activities for variety improvement, provision of quality seeds of improved varieties to farmers and restructuring the technology transfer programs. PARC is actively engaged in revitalizing its Technology Transfer Program in collaboration with the provinces, where emphasis will be placed on the provision of information regarding improved technology packages for the production of grain crops. The devolution model of the district government would also provide effective backward and forward linkages between research and extension institutions in the provinces.

The National and Provincial Rural Support Programs in the country have also started motivating the farmers, farmless families and women, and started organizing them into Village and Women Organizations. These organizations are now in place in many areas of the country. These programs are successful in linking the community organizers with the research and training institutions in agricultural and livestock sectors. These linkages will be further strengthened and expanded in the near future.

International trade

The introduction of the tariff and non-tariff measures under the WTO would provide opportunities to the country to produce more, not only to meet the domestic requirement but also to export if there is competitiveness in price. However, as the country is not yet ready to meet the implications of the WTO, there is a chance that the shortfall will have to be met from the import of grains.

Farmers participation in feed crop development

Feed crop farming

SWOT analysis was applied to determine the strengths, weaknesses, opportunities and threats of feed crop production which are given as follows:

Strengths

- Climate, fertile lands and the availability of freshwater indicate a high potential of increasing feed crops in the country. The ecological diversity further adds to the flexibility in adjusting the cropping pattern for feed crops.
- Average national yield of wheat is around 2.5 tons/ha compared to the potential of 6 tones/ha for the genotypes. This wide gap in productivity potential is yet to be achieved.
- The large population of livestock and poultry and their high growth rates of production will increase demand to grow feed crops.
- Within the Indus basin, feed crops are grown on 18 million ha of current irrigated land. For example, wheat is grown on over 8 million ha in an average year. Thus there is a potential to increase the production of feed crops by increasing the cropped area, cropping intensity and above all by increasing the productivity.
- Export potential for maize exists to neighboring countries, especially Afghanistan.

Weaknesses

- Fragmentation of landholdings and increasing numbers of small farmers.
- Lack of incentives for the support price for feed crops, excluding wheat.
- Lack of effective marketing systems and storage facilities with farmers and public/private sector institutions.
- Limited research, extension and farmer linkages.
- Fluctuation in prices due to variable demand and supply.
- Insufficient supply of freshwater in the canal command areas and poor quality groundwater in over 60 per cent of the Indus basin irrigated agriculture.
- Lack of drought resistance varieties, particularly of sorghum and millet.

Opportunities

- The country's agriculture provides an ecological opportunity of growing feed crops both in winter and summer cropping seasons due to favorable climate and availability of water.
- Grain and coarse grain crops require much less water compared to other crops and thus water productivity of feed crops is higher.
- Easy to cultivate and manage the feed crops compared to other cash crops.
- Demand for feed is higher than the supply.

Threats

- Inadequate and untimely availability of improved seeds of feed crops, except wheat and hybrid maize. The seeds of hybrid maize are costly and beyond a reach of the small holders and deprived segments of the feed crop farming community.
- Non-availability of improved production technology.
- Low productivity of feed crops due to subsistence level farming.

Response to market development

The response to market development was very encouraging in the case of wheat, in fact, there was a country surplus in wheat production in one year (2000) by giving a support price of Rs 7.50 per kg of wheat grain. Maize production and marketing is independent from the control and market forces that determine supply and demand in the market. Maize is utilized by the producers themselves, i.e., the poultry feed industry and wet milling industry. Sorghum and

millets' role in market development is less responsive as these crops do not have a proper marketing channel.

Response to manufacturing development

Rafhan Maize Products Pvt. Limited provides a buyback arrangement with maize farmers through ensuring the availability of quality inputs. This has resulted in the production of hybrid maize, where some of the farmers are now achieving grain yields of 9 to 12 tons/ha. Corn oil, starch, glucose and liquid sugar are the main products of the maize industry.

Poultry and livestock feed industry development in the country has also provided a conducive environment for the cultivation of feed crops. The poultry industry will develop further to meet the poultry requirement, which will increase the use of grains, which are essentially required in these rations. The production of coarse grains and maize received a major boost due to the development of the feed industry. Recently, fish feed industry development has also contributed to the utilization of feed grains.

Conclusions and recommendations

The findings of this study suggested that feed crops i.e., wheat, maize, sorghum and millet are primarily cultivated to be used as food but their use as feed for poultry and livestock feeding is also commonly practiced. The annual growth rates for production of wheat and maize are about 3 per cent. However, the growth rate for sorghum is almost stagnant whereas, it is negative for millet. Previously, domestic demand of wheat was met by imports from Western countries, however, since 2000, Pakistan has produced surplus wheat and is now exporting it. Livestock products, except milk, are being produced at satisfactory levels to meet the national demand.

The ever-increasing human population and improvements in per capita income have resulted in a change in the dietary pattern of the people of Pakistan and now they are consuming more animal proteins, cereal grains and their products, except sorghum and millet, whose share is declining in the food basket year by year. To meet the increasing demand for cereal crops for the human population and to produce more livestock products, there is a need to grow more cereal crops, particularly wheat and maize in Pakistan.

To achieve the targets for production of feed crops, which have been calculated through this study, the following recommendations have been made:

- Efforts should be made for the development of high yielding, disease resistance and drought resistance varieties of feed crops. There are national coordinated programs, which are making efforts towards the variety development, however, more continuous and coordinated efforts are required.
- There is a large gap between supply and demand of improved seeds available to farmers. In spite of the development of potential varieties on-station, most of the farmers do not have access to the improved seeds. This results in comparatively low yields in the field. Therefore, the public and private sector should undertake steps to produce more improved seeds and make them available to the farming community.
- Efforts should be made to provide the required quantity of fertilizer to the farming community in time.
- Institutional storage linkages should be established among research and development institutes, private companies and the farming community. Forward and backward linkages should be enhanced among all stakeholders to promote feed crop production.

- Extension departments have the primary role of informing the farmers about the latest production technologies. However, the extensionists are usually not well equipped and informed about the development of production technologies and hence, timely awareness of the farmers is less effective. There is a dire need to develop strong linkages among the researchers and extentionists.
- In Pakistan, generally, the farming community does not have the cash, especially to purchase the inputs required for desirable production and this is very specific to small farmers. The government is already providing production loans through banks, predominantly through the Agricultural Development Bank of Pakistan. However, access to these production loans is limited and thus there is a need to expand them further.
- Recently, progressive farmers have started production of improved seeds of various crops, particularly wheat. The improved seeds thus produced, are supplied to their fellow farmers. There is a need for this system to be strengthened by the patronization of the government agencies.
- Provision of credit to the farmers for storing their agricultural produce and then selling at the best time for fetching reasonable prices.
- Establishment of proper storage facilities by the private sector to ensure the maximum procurement of grains and subsequent supply to the consumers.
- Attempts should be made to notify the farming community about post harvest loses.
- The livestock sector is so far, conventional excluding poultry, therefore there is a immediate need to give attention on breed improvement and availability of balanced feed and feeding systems. Marketing for livestock products is very much required.

  The poultry sector, which includes the commercial feed mills and hatcheries, is already playing a significant role in the development of poultry production. They have all the necessary linkages with the poultry farmers. However, the ruminant sector is still operating on a conventional system and needs to be commercialized. The dairy sector is developing steadily and the milk processing industries, by collecting the milk from the producers, are facilitating them for assured buying arrangements and supply of some of the inputs. To increase livestock productivity, there is need to establish financially strong feed mills to provide

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Comments on the Analysis of Potentials, Weaknesses, Opportunities, Constraints and Policy Options for Feed Crops Farming in Pakistan

Abdul Majeed Haqqani[*]

The report is reviewed in line with the following observations:

General comments

- It is both useful and informative to generate information on a very important research agenda.
- The information collected is pertinent and helpful for achieving the goals under study.
- The topic is relevant to current and future scenario's of livestock sector development, especially the development of the animal feed crop farming sector in the country. Such developments would generate information on the issues regarding agricultural marketing, trade and policy reform initiatives.
- From an efficacy point of view, the report is good but not consistent with the plan envisaged i.e. the objectives of the study are not achieved systematically or in a professional manner. Moreover, hypotheses are neither developed nor tested.
- Pulses are not included in the study, however, 21 per cent of the total production of chickpea and 42 per cent of the total production of other pulses (lentil, mungbean and curd bean) are used as animal feed.

Specific comments

- The issue under investigation is not properly addressed. The scope, importance and justification of the research problem are not properly considered in a scientific or systematic manner.
- The objectives of the study are composite in nature. Generally, objectives deal with one issue at a time. In the report, issues are not addressed one by one.
- The methodology of the study is well written but SWOT analysis is mentioned only very briefly. It should be narrated in a proper manner.
- There are contradictory and repeating statements in the report. These statements should be removed.
- In chapter 4 and 5 the results are presented in the tables and the same table figures are narrated in the text. However, not mentioned are the implications of any results.

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Moreover, backward and forward linkages related to implications of findings are not explained. Source of data collection is missing under the tables.

- In chapter 3 (current status of livestock and historical development of the animal feed sector), the current status of the following policies is missing.
    (i) Agricultural policy
    (ii) Production policy
    (iii) Price policy
    (iv) Marketing trade policy
    (v) Monetary and exchange rate policy
    (vi) State trading enterprises
    (vii) Policy must not be affected by WTO agreement
    (viii) Policy reform initiatives

Only the titles of the above policies are given. Nothing is said/written on any of the above topics in the report

- Similarly, for land fishery agricultural resources, resource bases and ecological considerations, titles are given but nothing further has been written.
- Under feed crop farming, the author has mentioned potentials, constraints, advantages and problems. These are derived from other studies and are general statements rather than empirically evidenced findings of his own.
- The measures suggested for reducing the supply and demand gap are derived from other studies. These are also general statements rather than being based on the findings of the study and implications of the research.
- In the report, conclusions and recommendations are missing.

Consideration of the above comments made would improve the report.

CGPRT Feed Crops Supply/Demand and Potential/Constraints for their Expansion in South Asia – Sri Lankan Situation

K.E. Karunatilake[*]

Introduction

Although Sri Lanka is considered as an agricultural country, the contribution to GDP from agriculture, forestry and fisheries has declined in recent years to a value of 20.5 per cent in 2000.

Within the agricultural sectors, ignoring plantation crops, the main contributors are paddy, vegetables and subsidiary food crops (other field crops), which in the same year, had shares of 3.2 per cent, 4.3 per cent and 1.9 per cent of the GDP respectively. All of the CGPRT crops other than roots and tubers are considered as other field crops or subsidiary food crops.

The contribution of animal husbandry to the GDP was marginally less than 2 per cent with forestry and fishery together amounting to 4.6 per cent of the GDP in 2000. Animal production in the country is dominated by the poultry industry (44 per cent broiler meat, 26 per cent eggs). Other meats contribute 19 per cent (mutton 3 per cent, pork 1 per cent and beef 15 per cent) and milk production around 11 per cent.

Thirty eight percent of the population was engaged in agriculture, including animal husbandry in 1998/1999. Annual meat consumption, which was around 0.8 kg per capita in the late eighties, had increased to 4.54 kg by 1999 after just a decade. This phenomenal increase can be attributed largely to an increase in the consumption of chicken meat. The annual per capita consumption of broiler meat increased from 0.6 kg to 2.5 kg during the ten years from 1987 to 1997 and currently stands at 3.2 kg. The increase in demand for chicken is attributable to a lowered demand for beef and lowered availability and high price of fish as well as the general increase in demand for animal products accompanying the increase in income of the population. As a result, the poultry industry has grown by around 10 per cent per year during the last five years and is expected to continue at the same rate over the next decade. However, layer production grew only at about 1 per cent.

Alternate poultry species such as ducks, turkey, guinea fowls and quail are found in relatively small numbers and usually raised by small holder farmers under scavenging systems.

The urban demand for beef and mutton is met by the slaughter of local cattle and goats reared under extensive conditions in the rural areas. The consumption of beef increased with the population growth from 16 to 24 million kg between 1994 and 1998, but has decreased since then due to publicity relating to disease and religious factors.

Feeding of concentrates is largely restricted to chicken, milking cows and breeding pigs. At present, both imported and locally produced raw materials are used in the compound feed industry, which caters primarily (95 per cent) to the poultry industry.

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It has been estimated that 17 per cent of the total animal protein in the diet of the Sri Lankan people comes from fish. There has been a gradual increase in fish production, which reached 235,750 mt in 1995 and increased further to 279,900 mt in 1999. Shrimp farming and breeding of ornamental fish, both for export, are lucrative enterprises in the country. Most of the compound feed requirement for both of these industries is imported.

Of the CGPRT crops, maize and soybean are the main ingredients which are used in the animal feed industry. Other coarse grains, pulses, root and tubers, although grown in Sri Lanka, are consumed as food and are not likely to play a significant role in animal feeds in the coming decade.

History of the feed industry in Sri Lanka

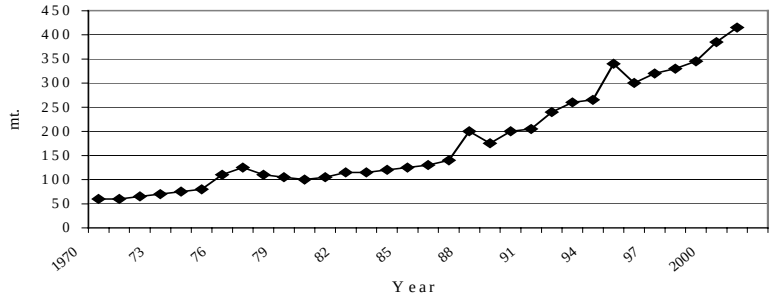
Historical background

Compound feed production in Sri Lanka began with the establishment of a government owned feed mill under the Ceylon Oils and Fats Corporation (OFC) at Seeduwa in the early 1960's. The main purpose of establishing this feed mill was to cater for the poultry sector, which gradually turned from a free-range back yard system to intensive deep litter production. From this time, the feed industry had undergone several changes but poultry feed production remained the predominant business. Although there were a few small feed mills operating during the early days with the OFC, such as the British Ceylon Corporation and Moosajees Ltd. their volume was small and produced mainly customer-mixed feed for selected farms. OFC was producing primarily layer feeds using local raw materials, only feed additives were imported during these early days. However, with further expansion in the layer industry, the volume of feed produced also increased and local raw material supply became insufficient to meet the demand. Therefore, some raw materials like fishmeal and soybean meal were imported in addition to additives. With the changing of government policies from time to time, certain restrictions were introduced to control the import of raw materials, in the form of taxes and permits. Upto the early 1980's the amount of raw material imported remained below 35 per cent of the total used in feed manufacture.

The move to large-scale imports of raw materials began with the rapid expansion of broiler production in the mid 1980's, which coincided with the privatization of the Government-owned feed mills, including OFC. During the next decade, three modern feed mills were established. The past growth in broiler production, which was well above 10 per cent during this period, was the main factor for the establishment of the new feed mills. With these developments, total feed production increased and as local raw material supply was hardly sufficient to meet the demand, large-scale imports of raw materials rose to around 80 per cent of total used. This situation remains unchanged at present.

Figure 1 shows the amount of feed produced and the trend during the last three decades in the country. A sharp increase has been reported since open economic policies were implemented. However, a six-fold increase is reported during the last three decades in feed production.

Figure 1. Compound feed production from 1970 to 2000 (mt '000)



Source: Department of Animal Production and Health

Present status

Total compound feed production in Sri Lanka, with a breakdown of different feeds, produced in 2000 is given in Table 1 and 2, and further illustrated in Figure 2.

Table 1. Animal feed production (mt) in Sri Lanka in year 2000

Poultry Commercial	350,000.00
Dairy	12,000.00
Pig	8,000.00
Other	5,000.00
Poultry self mixing	80,000.00
Total	455,000.00

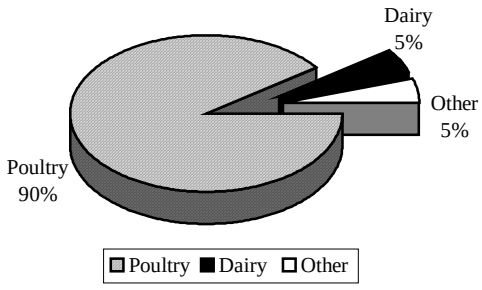
Source: Department of Animal Production and Health.

Table 2. Poultry feed production (mt) in year 2000

Broiler feed	175,000
Layer feed	136,875
Breeder feed	118,125
Total	430,000

Source: Department of Animal Production and Health.

Figure 2. Compound feed production



Source: Authors' calculation.

Poultry feed remained the main compound feed produced and the amount increased over the years. However, there was no significant increase in the production of dairy, pig and other feeds. The other feeds include fish and horse feeds. Although the volume of fish feeds produced locally did not increase, the amount imported has shown an increasing trend. The volume under self-mixing was the feed produced at farm level, which comprised 100 per cent poultry feeds for both commercial layer and breeder.

Table 3. Projected feed production

Year	Amount mt.'000
2001	415
2002	450
2003	484
2004	525
2005	570

Source: Authors' calculation.

The amount of compound feed produced has shown a continuous increase during this period, except in some years due to specific reasons such as diseases (1996), the handing over of government feed mills resulting in large scale self-mixing (1989) and restrictions on imports of raw materials (during 1978 to 1981). This increasing trend is expected to continue according to the projections. Manufacturers are required to submit their production figures to the Department of Animal Production and Health under the Animal Feed Act of Sri Lanka. However, total production should be higher than what is given in the table. For example, feed production in the year 2000 was 455,000 mt (Table 2) when the volume produced by self-mixing is included, but registered manufacturers produced only 375,000 mt. This point should be considered when estimating the requirement of raw materials for compound feed production.

As a result of the poultry sector's expansion, a two-fold increase in per capita availability of poultry meat is expected in 2010. The expected availability of eggs and meat are as follows:

Table 4. Expected availability of eggs and meat

	2000	2010
Broiler meat (kg/yr/person)	3.2	6.28
Eggs (No.)	62.1	73.3

Source: Animal Production and Health Department.

Demand for feed crops

Of the CGPRT crops, maize and soybean (in meal form) are the main ingredients which are used in the animal feed industry and the demand for which is likely to increase sharply in the future. Other coarse grains, pulses, root and tubers, although grown in Sri Lanka, are consumed as food items and are not likely to play a significant role in animal feed in the coming decade. According to Ranawana (1999) the local ingredients used include maize, rice bran/polish, broken rice, coconut poonac and minor ingredients such as gingerly poonac.

Maize requirement

A methodological approach predicts the future requirement of maize for various purposes. The amounts and expected production are given in Table 5.

Table 5. Supply and demand projection for the period of 2001-2010

Year	Estimated Production ('000 mt)	Estimated feed consumption ('000 mt)	Estimated food consumption ('000 mt)	Estimated demand ('000 mt)
2001	31.27	114.82	68.10	182.92
2002	31.61	129.75	75.30	205.05
2003	31.95	146.61	83.27	229.88
2004	32.30	165.67	92.07	257.74
2005	32.65	187.21	101.81	289.02
2006	33.0	211.55	112.57	324.12
2007	33.36	239.05	124.47	363.52
2008	33.72	270.12	137.64	407.76
2009	34.09	305.24	152.19	457.43
2010	34.45	344.92	168.28	513.20

Source: Authors' calculation.

The demand for maize is increasing with the rapid growth of the poultry industry in the country. Similarly, consumption as a human food in various forms is also increasing.

Ownership of the industry is completely in the hands of the private sector, apart from a few cooperative societies, which carry out some feed mixing mostly for their own farmers. A few large companies dominate the industry and three of them together produce 70 per cent of the total annual production. This means that more than 65 per cent of the maize requirement is consumed by these three producers alone.

Soybean requirement

Soybean in Sri Lanka is known as the poor man's meat due to its high protein content. The entire local production of soybean is used in the human food industry but it is not sufficient to fulfill the local requirement.

The animal feed industry is the major soybean consumer in the country today but only in the deflated meal form.

Table 6. Soy meal requirement for animal feed

Year	Requirement (mt)
2002	88,510
2003	94,140
2004	100,174
2005	106,651
2006	113,597
2007	121,051
2008	129,051
2009	137,643
2010	146,869

Source: Department of Animal Production and Health.

Root and tubers

The root and tuber crops that are commonly grown in Sri Lanka are manioc, potato, sweet potato, kiriala (*Xanthosoma sagittifolium*) and innala (*Solenostemon rotundifolius*)

Out of these crops only manioc (cassava) has the potential for use in the animal feed industry but, at present, it is not used due to the following technical, as well as social reasons.

i. Lack of processing technologies which remove toxic substances from the fresh product.
ii. Availability of energy sources other than (*cassava*) manioc.
iii. High demand as human food especially for low-income population.
iv. Seasonal availability and the long age status of the crop.

At present, the entire production of root and tuber crops is consumed as human food, mainly in raw form.

Supply of feed and feed crops

The gap between demand and supply of CGPRT feed crops that are grown in Sri Lanka is widening due to increasing demand but the non-expansion of local production during the last decade. A similar situation can be expected in the future if a well-planned production programme is not implemented to increase local production.

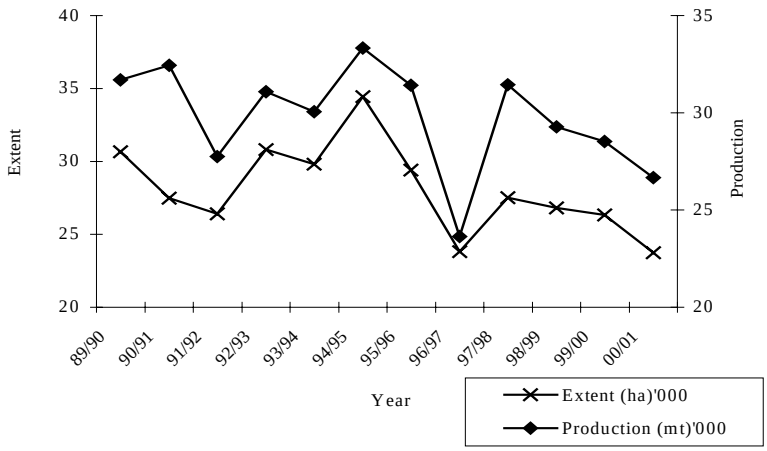
Maize

Maize is the second most common food crop grown in Sri Lanka. A decade ago, it was grown only during the (wet) maha season with the onset of the northeast monsoon rains in the high lands, mainly in the dry zone part of the country. Due to a high demand for feed and food, maize was introduced as a major crop to paddy land in the major and minor irrigation schemes, which are in the dry and intermediate zones of Sri Lanka in the early nineties. At present, it is grown in other parts of the country throughout the year to fulfil the green cob requirement but not at a commercial level.

Maize production in the maha (October – March) season

Production in the maha (wet) season depends on climatic conditions, mainly rainfall. Rainfall is the main source of water for high land maize cultivation. However, the rain does not fall in a uniform manner and there are long droughts and heavy rain spells. Due to this erratic rainfall pattern, fluctuations in extent cultivated and production were reported during the last decade (Figure 3).

Figure 3. Maize extent and production during the maha season



Source: Department of Census and Statistics.

Although maha is the main season for maize, a decreasing trend can be seen in extent as well as production.

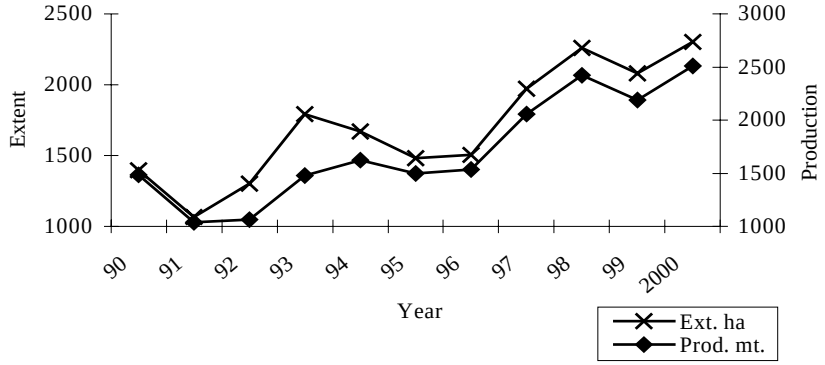
The Department of Census and Statistics carries out crop cutting surveys, only for paddy, to determine average yield in both seasons. The average yields of other crops, including maize, are estimates. According to the information available from various sources, the productivity is higher than the estimates.

Maize production in the yala (dry) season

Maize was introduced to paddy land in major and minor irrigation schemes to be grown in the yala (dry) season due to:

i. Insufficient irrigation water availability for rice growing.
ii. Increase local production to meet a major share of the national demand.
iii. Increase farmers' income by introducing an economically viable crop.

Figure 4. Maize extent and production during the yala season

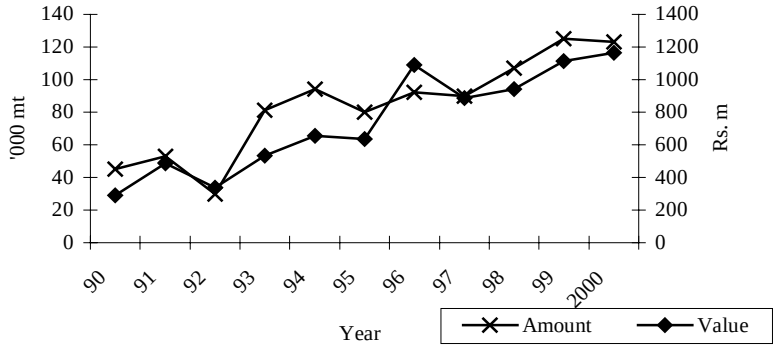


Source: Department of Census and Statistics.

A sharp increasing trend is reported both in extent and production during the yala season (Figure 4). Assured supply of irrigation water for cultivation, high demand for green cobs during the off season and the high price offered for green cobs are some of the reasons for an increasing trend in cultivated extent during the dry season.

However, total production in both seasons is less than 50,000 mt. Local production is not sufficient to fulfil maize demand. Therefore, feed millers tend to import large quantities as indicated in Figure 5. A six-fold increase has been reported since 1990.

Figure 5. Imports of maize during the last decade



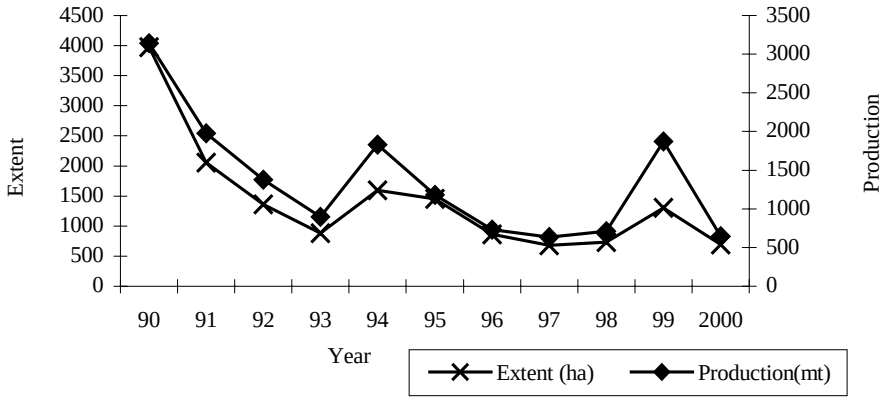
Source: Sri Lanka Custom and Central Bank of Sri Lanka.

Soybean

Soybean is also another CGPRT crop grown both in maha and yala but not on a large scale. No facilities were available for soybean oil extraction after the privatization of the Oils and Fat Cooperation which was the only, commercial level, oil extraction establishment that existed in the country in the early seventies.

Soybean marketing became a serious problem due to the non-existence of oil extraction facilities in the late eighties. Therefore, cultivated extent as well as production have decreased year by year during the last decade.

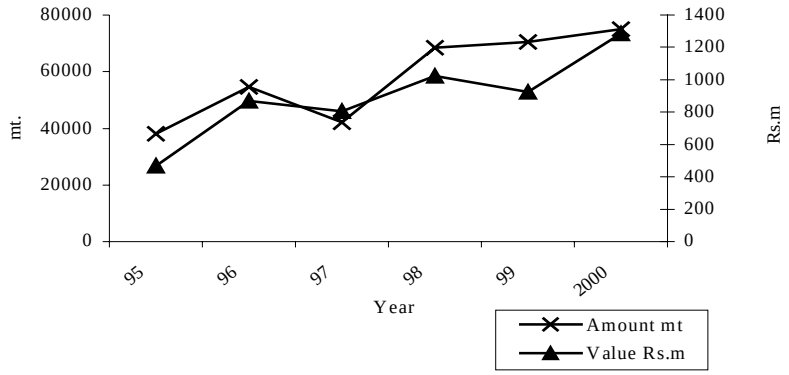
Figure 6. Soybean cultivation and production in Sri Lanka (both maha and yala)



Source: Department of Census and Statistic.

Locally produced Soybean meal, which is used in the animal feed industry, is not available due to the non-existence of oil extraction facilities in the country today. At the same time, local production in seed form is not sufficient to fulfil the demand even in the food industry. Therefore, soybean in various forms such as TVP (Textured Vegetable Protein), whole seed, soy flour and soy oil are imported for the food industry.

Figure 7. Imported amounts and value of oil cake and other solid residues



Other than those products, the entire requirement of soymeal is imported for the animal feed industry.

It is reported that the annual growth rate of the human food industry, which consumes soybean, is about 1-2 per cent. Therefore, locally produced soybean will not be utilized for the animal feed industry in the near future due to the following reasons:

- Very slow growth of cultivated extent.
- Lack of oil extraction facilities in the country.
- Non-availability of a proper marketing network in the producing areas.
- High demand from the food industry.

Measures for closing the supply and demand gap

The internal supply of feed crops, namely maize and soybean, seems to be inadequate, as indicated in the analysis of demand and supply. In practice, about 80 per cent of the maize requirement and almost all the requirement of soybean for the feed industry are imported annually. The gap between demand and supply of both crops will continue to widen unless a well planned production programme is implemented within the country. However, even if a well planned production programme is implemented, the total requirement of feed crops for the feed industry may not be supplied locally. This is mainly due to the following reasons:

i. Growing demand from the food industry.
ii. Most of the maize growers are subsistence farmers and they do not have the required basic facilities to produce quality seed for animal feed.
iii. No basic facilities are available for oil extraction from soybean seed, consequently soybean cake will not be produced anytime in the near future.
iv. Limitations to expansion of extent for both crops due to the eratic weather pattern.

Due to the above factors, the feed manufactures tend to import their requirement and this is likely to increase in the future. Therefore, it can be suggested that feed producers should be allowed to import a major share of the maize requirement and almost all of the soybean meal requirement, even in the future and at the same time implement programmes to increase local production of both crops.

The following strategies and options are recommended in order to increase the local production by increasing productivity as well as the expansion of cultivated extent.

Maize

The government can be involved in numerous ways to increase maize availability in the country. However, the most important one is creating a favourable policy environment to maximize local production and to balance import quantity without creating an unnecessary import environment for imports. Since maize can be considered as an economically viable crop, the government should give top priority to expand both extent and productivity.

A well-planned production programme which includes a package of practices should be implemented within a favourable policy environment by creating consistence production as well as import policy options. The package should consist of production technologies, marketing, storage and processing facilities for any given production system.

Area expansion – maha (wet) season

- The rain-fed extent during maha may not be increased drastically due to competitiveness for natural resources, such as water and land, with other essential food crops. However, the present 25 per cent-30 per cent maize extent of total rain-fed extent may be increased by another 30 per cent in the future.
- Both, well and imperfectly drained low lands, which are in major and minor irrigation schemes are cultivated with paddy during maha. However, it is a well known factor that the entire available extent of both systems (major 26.5 per cent, minor 33.6 per cent) is not cultivated even during maha due to various reasons. At least part of these lands could be utilized to grow maize.

Area expansion – yala (dry) season

The percentage of land which is not cultivated (major 46 per cent, minor 72.2 per cent) during yala is much higher than in maha, in both schemes. This is mainly because of insufficient rainfall in the season. However, a major share of these lands could be utilized to grow maize with a proper on-farm water management programme. It is estimated that of this uncultivated land, an extent of about 22,000 ha could be utilized to grow maize without doing any damage to the existing paddy cultivation in the yala season.

Productivity increase

Further adoption of available technology packages which include high quality seeds, balanced fertilizer, plant population, weed management and drainage improvement is suggested. Farmers at any level must be encouraged to adopt pre as well as post harvest technologies in order to produce high quality grains. A comprehensive farmer education programme must be conducted by the state sector with help from the private sector and NGO's. The following strategies are suggested:

- *Implementation of a large-scale collaborative production programme*
  This must include the private sector, Non-Governmental Organizations and farmer companies or organizations. Farmers' education and related activities are major responsibilities of the state sector.
- *Expansion of high quality seed availability for planting*.
  The hybrids as well as open polinated varieties of maize are to be distributed among growers in required quantities and at the required time. The government of Sri Lanka, under the new seed law and seed act provides basic facilities for the private sector to be engaged in seed production. However, it has to be noted that the private sector involvement in seed production of almost all of the CGPRT crops is minimal.
  The government must take action to encourage and facilitate other private sector agencies, other than the organization which is engaged in hybrid seed importation at

present, to import hybrid seeds. At the same time the Department of Agriculture must take action to release the identified local hybrid varieties for cultivation as soon as possible.

- *Expansion and strengthening of the existing forward sales contract system*.
  The small-scale maize growers are organized in groups and they sign an agreement individually or as a group with a major buyer. A state organization or financial agency can play the facilitator's role. The agreement is considered as a legal document.
- *Establishment of large-scale commercial cultivation of maize*.
  The facilities must be provided to establish large-scale maize cultivation as a nucleus farm by major investors under the package given by the Bureau of Investment (BOI). This will create a favourable environment for the mechanization and adoption of improved production technologies at a commercial level. These farms can be a demonstration for surrounding farmers.
- *Strengthening technology generation.*
  Sufficient resources, including finance, are not allocated for feed crop research on production as well as processing by the state sector. This may continue for a long period due to financial constraints. Therefore, it is suggested to have a collaborative research programme with the private sector focusing mainly on variety development (hybrid and open polinated), irrigation and fertigation, seed storage, grain quality improvement and development of equipment for processing and drying.
- *Strengthening extension services*.
  Although maize is the main highland crop in a few major provinces, extension activities are not given due consideration by the provincial administrative due to a lack of priority, insufficient manpower and inadequate manpower development.
  This situation has to be corrected by introducing output-oriented programmes under which incentives are paid for extensionists when their targets are achieved.
  The government must take a decision to strengthen and encourage commodity based private extension services, which are operated for selected commodities such as maize.
- *Establishment of rural collecting centers*.
  Maize marketing must be one of the mandates of the private sector as well as farmer compaines. However, on special occasions the government can take necessary steps to purchase agricultural commodities through government or semi-government organizations in order to solve marketing problems.
  Feed millers collect raw materials, mainly maize, through their local agents. Both of these sector organizations do not have their collecting centers in rural areas where the maize is mainly grown. The government must facilitate to establish proposed collecting centres at the rural level so that the farmers can sell their product to marketing agencies without facing transport and other related problems.
- *Machinery manufacturing for small-scale maize growers*.
  Small-scale maize growers use hardly any machinery or equipment in planting, harvesting and processing due to non-availability at the rural level.
  The private sector must be encouraged to acquire the already available technology on small scale seeder inter cultivator and medium scale threshers from the Farm Machinery Research Centre (FMRC) of the Department of Agriculture and manufacture such tools.
- *Establishment of large scale processing factories in major producing areas*.
  The government must encourage the private sector or foreign investors to establish at least two more factories, other than the existing one, to purchase maize in cab form

from the resource poor growers, then thresh and dry before the stocks are supplied to the end users with assured quality.

- *Establishment of a statutory body to act as the regulatory organization*.
  It is proposed to establish a body to regulate and coordinate all aspects of production and marketing of feed crops. A separate body could be established for maize as an initial step.
- *Establishment of a joint research and development fund*.
  A similar fund which is being implemented for the plantation (tea) crop sector, using a small percentage of import/consumer tax, can be established for the feed crop sector also to be used in research and development programmes. This may be one of the solutions for financial constraints faced by research and development agencies.
- *Continuation of a suitable tax structure for maize imports for another three years*.
  The import tax structure which was implemented up to March 2002 for maize must be continued until the expected production levels are reached. It can be withdrawn gradually for smooth implementation of international agreements such as GATT, etc. in the future.
- *Implementation of a trade agreement with regional countries.*
  The total maize requirement may not be able to be produced locally due to limitations and constraints. Therefore, it is suggested to strengthen regional trading with neighbouring countries, without harassing the opportunities for local production increases.

Soybean

Soybean requirement in the food industry can not be estimated using a methodological approach due to non-availability of reliable data. However, requirement can be estimated by considering local production as well as imports in various forms to the country in a particular year.

Since the country does not have basic facilities to produce by-products, the government is allowing importation of such by-products, needed for feed milling and the food industry in order to protect these industries. However, the local requirement in seed form (about 5,500 mt at present), mainly for the food industry, should not be imported and arrangements must be made to produce locally. The by-product requirement for the food industry should also be allowed to be imported by food producers, until the required facilities are available to produce such products locally. The gap between demand and supply can be reduced by increasing local production. The soybean production enhancement programmes should have two components. They are:

- Increase production through area expansion.
- Increase production through higher productivity.

Fewer technical problems, suitability for highland farming and direct involvement of the private sector in purchasing and facilitating in production are major strengths which enhance soybean production in the country. Some of the opportunities which help planners to plan development programmes can also be identified. They are wider adaptability, past experience of growing on a commercial scale and availability of land for irrigated farming in major and minor irrigation schemes.

Quality seed supply for planting is also a major problem of a soybean production programme. Farmers are not in a position to keep their own seed requirement for planting due to technical problems which reduce viability, even during a short storage period. In order to overcome these problems, the private sector, with the assistance of the state sector, can engage in seed production with better storage facilities.

Regional trade agreements must be strengthened with neighbouring countries for the smooth operation of soybean meal importation to fulfil the increased meal requirement for the feed industry.

A continuous farmer education programme must be conducted focusing on cultural practices, quality maintenance and storage of seed, with help from the private sector.

An incentive package should be offered to private sector entrepreneurs to initiate oil extraction as well as production of other by-products.

Most of the points which have been discussed under maize, such as forward sales contract, local collection centers, etc. are common to other feed crops including soybean.

Farmer participation in feed crop development

Farmer participation can be considered as an essential component of any commodity development programme in order to maintain smooth implementation and sustainability. At present, farmer organizations are active mainly in major irrigation schemes. Farmers have demonstrated their active participation in production programmes such as the large-scale rice "yaya" (tract) and maize "yaya" programmes, where they have experienced gainful economic activities and financial benefits for their involvement.

At present, few farmer companies are involved in maize and soybean marketing. It is a well known fact that these farmer companies are facing serious thrests as well as problems of financing, infrastructure and must overcome some of the constraints which are prevailing in a competitive environment. The government may help them by providing loans or grants (this is being practiced today) in an acceptable manner to be used as their revolving fund. Farmer companies/organizations must strengthen their involvement in the following, in order to enhance the proposed feed crop development programmes:

- Involvement in the planning process and negotiate their requirements such as a fair price, quality parameters etc.
- Establishment of a revolving fund for diverse programmes.
- Establish confidence in both farmer and buyer.
- Investment in costly components of production packages which the individual farmer can not afford to invest in (e.g.: inputs, drying and storage).

Explore the possibilities of using available unutilized or under utilized food stuffs

Due to the high level of dependency on imported raw materials, mainly maize, the feed industry as well as the poultry industry is vulnerable to fluctuations in availability and cost of maize in the world market. Meanwhile, local maize production may not be sufficient to fulfill the requirement in both the feed and food industry. Therefore, as it was suggested by Ranawana (1999), possibilities must be exploited to use the following under or unutilized feed stuffs in the feed industry:

- Rubber seed meal
- Tea refuse
- Jack seeds
- Fruit seeds
- Fish waste
- Abattoir waste

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Comments on the CGPRT Feed Crops Supply/ Demand and Potential/Constraints for their Expansion in South Asia – Sri Lankan Situation

Hemachandra Samaratunga[*]

Introduction

All of the CGPRT crops are included in the research and development programmes of the Department of Agriculture under the mandates of the Field Crops Research and Development Institute (FCRDI) and the Horticultural Crops Research and Development Institute. Coarse grains and pulses are handled by the FCRDI and root and tuber crops are handled by HORDI. At present, maize and soybean are the main ingredients used by the animal feed industry in the country. However, the supply is hardly sufficient to meet the demand on the volume of feed produced. Soybean and maize are imported therefore, to bridge the gap at present.

Demand for feed crops

Other than soybean and maize, root and tuber crops are unable play a significant role in the feed industry owing to local demand for their consumption as a food crop. It has been estimated that there will be an increase in maize production, up to 34,000 mt by year 2010, as the demand for maize increases with the rapid growth of the poultry industry.

Soybean on the other hand is not sufficient, even to fulfil the local human consumption requirement, therefore, the feed industry has to depend on imports. Among the root crops (manioc, potato, sweet potato, *Zanthasoma and Solemostemon*) manioc or cassava, has a great potential in the animal feed industry provided that the following constraints are removed as follows.

a) Improve processing technologies to remove toxic (HCN) substances.
b) Look for alternate energy/food sources for the low-income population who depend on cassava in their daily diets.
c) Avoid seasonal availability as manioc (cassava) is a long aged crop.

Supply of feed crops

Maize is in demand for consumption as green cobs and commercial expansion is necessary throughout the year to cater for the feed industry, provided that the cost of production is lowered along with improved quality. The introduction of hybrid maize and the present research and development programmes were launched to address this problem. Unpredictable climatic conditions however will affect production. Off-season maize production could be

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encouraged in areas where supply of irrigation water is assured. The present annual production is around 50,000 mt, which is hardly sufficient for the feed industry.

Soybean on the other hand could be grown in both seasons successfully. Oil extraction facilities have to be improved to sustain the production. Farmers are giving up soybean cultivation owing to liberal imports of soybean meal and other value added products. Marketing should play a major role due to the lack of marketing facilities in the producing areas which affects cultivation.

Measures required to enhance production

A well planned production programme is suggested.

a) Suitable varieties for the local food industry and animal feed industry are required.
b) Improve basic facilities of subsistence farmers to improve the quality of produce.
c) Improve oil extraction facilities of soybean where soybean cake is the by-product.
d) Agronomic practices to overcome limitations of exotic weather patterns.

Strategies suggested

Maize

- Government policy on maize imports should be reconsidered.
- Utilize part of both well and imperfectly drained low lands where rice is not grown.
- A proper water management programme in the off season where maize could be grown under irrigation.
- Comprehensive farmer education on the available technology.
- Large-scale collaborative production programme with the private sector.
- Production of high quality seeds for cultivation (both hybrid and open pollinated varieties).
- Mechanization of commercial farms is more appropriate.
- Avoid financial constraints on research and development programmes for CGPRT crops.
- Encourage collaborate research and development programmes with the private sector.
- Enhance commodity based private extension services because of inadequate manpower in the extension system.
- Encourage rural collecting centres.
- Encourage the private sector to acquire already available appropriate machinery.
- Establish large scale processing factories in the major growing areas.
- Continuation of a suitable tax structure until the expected production level is reached. Enhance a collaborative production programme with neighbouring countries as local production will not reach the expectations in the next 3-4 years.

Soybean

Extent of soybean is negligible in the country and the feed industry depends totally on imports. Seed importation should therefore be permitted for both food production and the feed industry. A solid research and development programme is essential for:

(a) Varietal improvement.
(b) Enhanced productivity.
(c) Improved quality, depending on the need (food or feed industry).

It is therefore proposed that the private sector should take up seed production for the farmer and production of soybean exclusively for the feed industry as well.

Importation of soybean meal from other neighbouring countries should be encouraged until local production achieves expected targets. Research on storage of soybean should receive priority attention as well.

Also, as suggested by Ranawana (1999) unutilized feed crops such as rubber seed meal, tea refuse, jack seeds, other fruit seeds and cassava should be exploited to be used in the feed industry.

Farmer participation in feed crop development

At present, only a few farmer companies deal with CGPRT crop marketing, especially maize and soybean. Farmer companies and other organizations involved in marketing must be strengthened, by providing loans/grants and establishing a revolving fund as well.

I certainly agree with the existing situation analyzed by Mr K E Karunatilake, country expert in Sri Lanka, and the development strategies suggested for a research and development programme on CGPRT crops, towards improvement of the feed industry in Sri Lanka.

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Utilization of Cassava/Tapioca in Animal Nutrition

Uthai Kanto[*] *and Sukanya Juttupornpong*[**]

Cassava, or tapioca, is an important economic root crop grown in Southeast Asia as well as in tropical Africa and Central America. The crop also has a very important role in the economy of Thailand, since a great number of farmers, especially those in the northeastern part of the country, rely on cassava plantation. Cassava is a perennial shrub and is categorized as follows:

Genus	Manihot
Family	Euphorbiaceae
Subdivision	Angiospermae
Class	Dicotyledonae
Order	Geraniales

The cassava, commercially grown for starch and animal feed production, is *Manihot esculenta* crantz. The plants bear tubers or roots under the ground for starch deposition. The harvesting age of cassava is 10-12 months and the yield of fresh tuber ranges from 25-60 tons/ha depending on breed, fertilizing and cultivation practices. The fresh tuber, which contains approximately 60 per cent moisture, is mainly utilized for the production of cassava starch, dried cassava chips and pellets for animal feeds.

Cassava production in Thailand

Cassava is one of the most important economic crops in Thailand. The country produces approximately 18 - 22 million tons of fresh tuber annually, of which approximately 8 million tons is utilized for cassava starch production and the remaining 10 - 14 million tons are processed into 4.5 - 6 million tons of dried cassava chips and pellets for animal feed. The chips are mainly utilized domestically while the pellets are exported chiefly to European Union (EU) countries. However, starting in 1993, the EU launched CAP reform policy which caused the reduction of cereal prices in EU countries decreasing the price of cassava and gradually reducing exportation of cassava pellets to the EU. However, more cassava chips are utilized domestically for animal feed, therefore, the production volume is still maintained and the cassava price crisis is very much relieved.

Cassava production is scattered throughout the country but the major production areas are in the northeastern and eastern parts of Thailand. Considerable volumes of cassava are also produced in the northern and western parts of the country. Planting cassava always starts in April and May with the beginning of the rainy season and harvesting is normally in October - March of the following year when the weather is dry and rain is scarce due to the winter and

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summer seasons. It is the good weather in Thailand during the cassava harvesting season that ensures Thai cassava products their high quality compared to the products of other countries.

In addition, in Thailand, cassava breeds have been developed for high yield and high starch content and have been widely distributed to the growers. For example, Kasetsart - 50 (KU - 50) which was developed by the Department of Agronomy, Faculty of Agriculture, Kasetsart University, and Rayong-9, Rayong-60 and Rayong-90 which were developed by the Department of Agriculture, Ministry of Agriculture and Co-operatives are the major cassava breeds which produce high yield and high content of starch and are commonly grown by the farmers in the country.

Cassava plants are easily grown, very suitable for infertile sandy to sandy loam soils, require very minimal care, can withstand drought conditions and can rapidly regrow when the rain starts. The plants may deplete soil fertility more rapidly than other plants, due to cassava's higher photosynthetic and higher starch production activities per unit area per year. However, proper fertilizing both by chemical and organic fertilizers not only produce optimum yield of cassava but also maintain the fertility of the soil and can sustain a decent yield for a long period of time. Use of organic fertilizers including pig and poultry manure as well as green manure for cassava production has been promoted very extensively and very promising results, in terms of both yield and improvement of soil quality, were obtained.

Plants are harvested by pulling off the tubers from the ground, which is done either manually or by a harvesting machine at the age of 10-12 months. The harvested tubers are detached from the stems by cutting and are preliminarly cleaned by removing soil/sand that has stuck to the tubers. The roots or tubers are then ready for cassava chip or cassava starch production processes.

Toxins in cassava and detoxification

Fresh cassava tuber contains a cyanogenicglycoside, linamarin, which is hydrolyzed into glucose and hydrocyanic acid (HCN) by the activity of linamarase enzyme when the tuber is damaged or broken into small pieces. The released HCN evaporates into the atmosphere and consequently the level of HCN in the cassava product is reduced.

Production of dried cassava chips is carried out by chopping the fresh tuber into small pieces and then sun drying for 3-4 days, thus, greatly reducing the HCN content in the products to levels that are non-toxic to the animals. Khajarern *et al.* (1982) have demonstrated that sun drying cassava chips for 6 days reduces the HCN content in the chips from 111.63 ppm to 22.97 ppm (Table 1). Storing of dried cassava chips also further reduces the HCN content of the cassava product. Khajarern *et al.* (1982) have shown that storing dried cassava chips for 5 days reduces the HCN content of the product from 87.14 ppm to 36.95 ppm (Table 2). Steam assisted pelleting of cassava could further reduce the HCN content in the product to 11.82 ppm (Khajarern *et al.*, 1979).

It can be concluded that the practical production of dried cassava chips involving 3-6 days sun drying and a few days of storage before shipment to the feed manufacturer or users, could lower the HCN content in the product to non-toxic levels. Additional storage of the cassava product at the feed mill would further reduce the HCN content and provide an additional safety margin for the users. The use of pelleted cassava would eliminate any risk of HCN toxicity to the animals.

From field experiences, the authors have promoted the use of cassava chips in pig and poultry feeds for the past decade. Good quality cassava chips produced in Thailand, in which the moisture content is no more than 14 per cent, have an average HCN content lower than 30 ppm and have shown no toxicity of HCN to the animals.

HCN in cassava may be eliminated by cooking, steaming, drying, ensilaging as well as by washing. The processes are not practical for the preparation of cassava products as animal feeds but some of the processes are employed in the preparation of cassava starch for human consumption.

Table 1. Effects of length of sun drying on HCN content of cassava chips

Days of Sun Drying	HCN content (ppm)
0	111.83
1	111.96
2	110.96
3	109.96
4	90.72
5	52.22
6	22.97

Source: Khajarern *et al*. (1982).

Table 2. Effects of length of storage on HCN content of cassava chips

Days of Storage	**HCN content (ppm)**
0	87.14
1	56.76
2	40.11
3	29.52
4	31.46
5	36.25

Source: Khajarern *et al*. (1982).

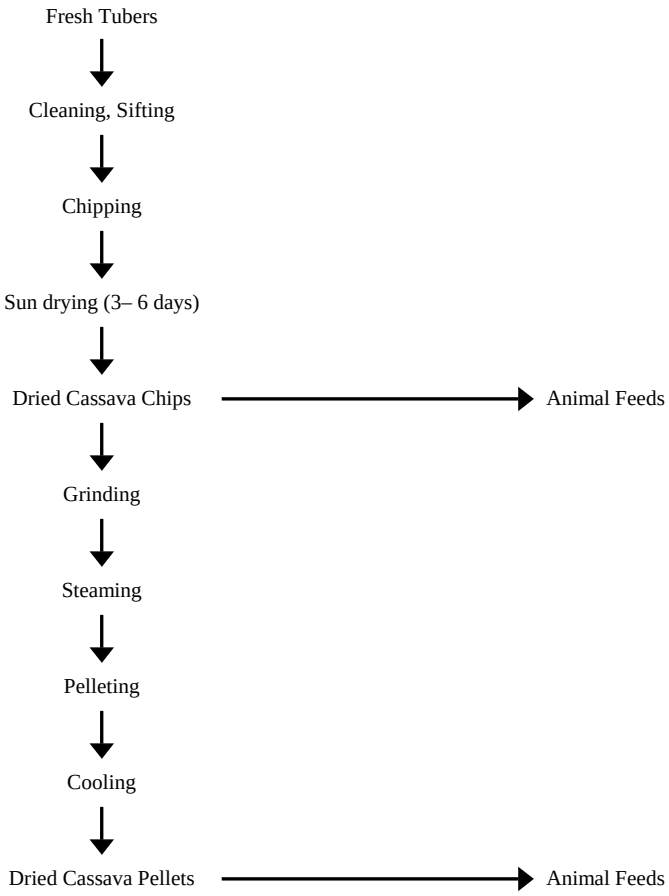
Production of dried cassava chips and pellets

Dried cassava chips and pellets are common cassava products used as animal feeds. Schematic production of cassava products is shown in Figure 1. Freshly harvested tubers are cleaned by washing or sifting and chipped into small pieces, then sun dried on concrete floors for 3-6 days depending on weather conditions and sunlight. The chips are regularly turned over by mechanical raking throughout the drying period. Dried chips normally contain 13-14 per cent moisture and are kept in the warehouse for a few days before shipment to the users.

Cassava chips may be ground, steamed and palleted into cassava pellets which are more compact, less dusty and very favorable for bulk shipment and transportation. However, some additives such as palm kernel cake, palm oil etc. should be added in order to facilitate pelleting. Some pelleting additives, which contain a lot of crude fiber, may affect the nutritional value of cassava pellets, therefore, more care should be paid to quality control when using cassava pellets in animal diets.

Dried cassava chips are bulky and dusty, and are not appropriate for bulk shipment and transportation via ship. However, the chips are very easy to determine quality and are very appropriate for the domestic uses of cassava in the feed industry.

Figure 1. Schematic flow of cassava chip and pellet production process.



Nutritive value of dried cassava chips and pellets

The chemical composition of cassava compared to corn, sorghum and broken rice is shown in Table 3. In general, cassava is an energy feed ingredient and contains very low protein (approximately 2 per cent) and low amino acids, compared to the other ingredients. Cassava products are also low in fat content and contain no pigments for poultry. The chemical composition of cassava chips and pellets produced in Thailand is shown in Table 4. In general, crude fiber and ash contents of pelleted cassava may be higher than cassava chips due to the addition of pelleting additives such as palm kernel cake or some vegetable oil for lubricants. The nutritive value of pelleted cassava varies according to the type and amount of pelleting additives included. The additives that increase the crude fiber and ash levels in the pelleted cassava lower the nutritive value of the product.

Table 3. Comparison of chemical composition of cassava, broken rice, corn and sorghum

	Cassava	Broken rice	Corn	Sorghum
Crude protein (%)	2.0	8.0	8.0	11.80
Lysine (%)	0.09	0.27	0.25	0.23
Methionine (%)	0.03	0.27	0.19	0.16
Met + Cys (%)	0.06	0.32	0.39	0.27
Tryptophan (%)	0.02	0.10	0.09	0.10
Threonine (%)	0.07	0.36	0.32	0.33
Isoleucine (%)	0.07	0.45	0.34	0.44
Arginine (%)	0.12	0.36	0.40	0.39
Leucine (%)	0.12	0.71	1.17	1.38
Phen + Tyr (%)	0.12	1.15	0.81	0.96
Histidine (%)	0.03	0.18	0.25	0.22
Valine (%)	0.09	0.53	0.46	0.55
Glycine (%)	0.08	0.71	0.33	0.33
ME - Swine (kcal/kg)	3260	3596	3300	3140
ME - Poultry (kcal/kg)	3500	3500	3370	3250
Fat (%)	0.75	0.90	4.00	3.00
Calcium (%)	0.12	0.03	0.01	0.04
Avial. Phosphorus (%)	0.05	0.04	0.10	0.10
Crude fiber (%)	4.0	1.00	2.50	3.00

Source: Authors' calculation.

Table 4. Comparison of chemical composition of cassava chips and pellets

	Cassava chips	Cassava pellets
Moisture (%)	13	13
Crude protein (%)	2	2
Crude fiber (%)	3.5 - 4.0	4.0 - 4.5
Ash (%)	2	2
NFE (%)	75 - 80	73 - 78

Source: Authors' calculation.

The crude fiber and ash content of cassava chips depends very much on the quality of the fresh tuber and processing techniques. Good quality fresh tubers which are clean and contain minimal or no alteration of stems or woody parts would produce good quality cassava chips with low crude fiber and ash content. Washing or sifting fresh tubers to eliminate contaminated sand and soil before chipping significantly lowers ash content to a minimum. Production of large cassava chips not only minimizes the dustiness during processing but also prolongs the drying period and reduces HCN content. Peeling of fresh tubers before processing lowers crude fiber and ash contents of the chips. However, peeling may not be necessary since the technique is very tedious and impractical as well as uneconomical for the preparation of cassava for animal feeds. Good quality cassava chips or unpeeled pellets normally contribute to very satisfactory performances of the animals when compared to broken rice or corn.

The nutritive value of cassava products also depends on the contents of the organic and inorganic parts of the cassava. Khajarern *et al*. (1977) have categorized the nutritive value of cassava products as chemical grade or quality score according to the following equation:

Chemical grade or quality score = OM – [ADF + (CF – 3)]

Where OM = % organic matter

ADF = % acid detergent fiber

CF = % crude fiber

Cassava products may be classified into 4 grades: A, B, C and D when the quality score is over 80, 75-80, 70-75 and lower than 70, respectively. However, there is no information on tested results of the effects of the quality score on the performances of the animals.

Phunsurin *et al*. (2002) and Lokaewnanee *et al.* (2002) have shown that the ME content of tapioca chips is very much inversely related to the levels of crude fiber in the feed ingredient (Table 5). Increasing crude fiber levels significantly ($p<.05$) decreases the ME content of the cassava chips both in pig and chicken diets. It is advisable to use prime quality cassava products in animal feeds which not only have a low fiber content and allow a larger inclusion rate in the animal diets but also have a higher nutritive value and are worth the premium price.

Table 5. Composition and nutritive value of cassava – corn equivalent mixtures (CCEM) and corn

	Corn	CCEM-1	CCEM - 2	CCEM - 3
Corn	1.00	-	-	-
Cassava	-	0.87	0.845	0.85
SBM	-	0.13	0.13	-
Extruded FFSB	-	-	-	0.15
Rice bran oil	-	-	0.25	-
DL – Methionine	-	0.001	0.001	0.001
Price (Baht/Kg)	4.70	3.34	3.60	3.77
Chemical Composition				
Crude protein (%)	8.0	7.5	7.5	7.5
ME – Swine (Kcal/kg)	3300	3251	3390	3302
ME – Poultry (Kcal/kg)	3370	3348	3479	3469
Fat (%)	3.50	0.72	3.20	3.39
Fiber (%)	2.50	4.12	4.03	3.90
Calcium (%)	0.01	0.14	0.13	0.14
Avai. Phosphorus (%)	0.30	0.07	0.20	0.22
Lysine (%)	0.25	0.43	0.43	0.44
Met + cys (%)	0.39	0.31	0.31	0.31
Tryptophan (%)	0.09	0.09	0.09	0.10
Threonine (%)	0.32	0.28	0.28	0.32

Source: Authors' calculation.

Cassava starch is highly digestible due to soft-starch and containing more than 80 per cent amylopectin. Cassava has the highest digestibility of dry matter, organic matter and energy in different parts of the digestive tract of the growing pigs when compared to corn, sorghum and barley (Reas, 1996). A cassava diet shows a significant linear decline of dry matter, organic matter and energy flow from the stomach down to the caecum resulting in almost complete digestion before the large intestine. A corn diet shows lower digestibility for each dry matter, organic matter and energy compared to cassava, but was not statistically significant. Sorghum and barley were not significantly different from each other but were significantly lower than cassava and corn in each dry matter, organic matter and energy after the small intestine. It can be concluded that cassava is an excellent energy source and can replace the cereal grains in growing pig diets.

Table 6. Utilization of broken rice , sorghum and cassava as growing – finishing pigs diets

	Diets: Broken rice	Sorghum	Cassava
Initial wt. (kg)	17.04	16.68	16.89
Final wt. (kg)	104.08	103.43	102.09
ADG (kg)	0.62	0.61	0.52
ADFI (kg)	1.84	1.93	1.72
FCR	3.00	3.19	3.30
Dressing percentage	72.31	73.22	72.31
Loin – eye area ($inch^2$)	4.55	4.55	4.62

Source: Khajarern and Khajarern (1986).

Cassava products may be contaminated with mold growth under standard production practices but there is evidence that the mold produces minimal or no aflatoxins or other

mycotoxins. Scudamore *et al*. (1997) studied the occurrence of mycotoxins in 330 samples of raw ingredients used for animal feeding stuffs in the 186 feed mills in the United Kingdom in 1992. They reported that no sample of cassava found contamination of aflatoxins as well as other mycotoxins while samples of corn, rice bran, palm kernel meal, cotonseed meal, wheat and barley found contamination of aflatoxin B1, fumonisin B1 and B2, ochratoxin A or zearalenone. Protein enriched cassava (PEC), which is produced by 2 days fermentation of cassava with *Aspergillus niger* and then followed by 2 days fermentation with *Saccharomyces cereviseae,* can totally replace corn in growing finishing pig diets (Loasriratanachai, 1986). The fungus fermentation produces heavy mold growth on the substrate but only trace amounts of aflatoxins were detected in PEC products. The results of our survey investigations have also indicated that pieces of heavily moldy cassava chips collected from cassava processors in Thailand contained only trace levels of zearalenone and no aflatoxins (Sukanya Juttupornpong, personal communication). These findings are in agreement with the practical results of using cassava in animal diets in Thailand which reported no incidence of aflatoxins as well as other mycotoxins toxicities in cassava diets fed to pigs, cattle and poultry including ducks. Cassava may be classified as a clean or free of toxin feed ingredient for animal feed.

Cost comparison of cassava products to corn

Although cassava and corn are classified as energy feed ingredients, cassava contains less protein and fat than corn. In addition, cassava contains no pigment for yolk and skin coloring in poultry. It is necessary therefore to equalize the nutritive value of cassava products before any cost comparison is made.

Cassava – corn equivalent mixture (CCEM) is a combination of cassava, SBM and synthetic amino acid to raise the protein and amino acid content in cassava so as to be equivalent to those in corn.

CCEM – 1 is a mixture of 0.87 kg of cassava + 0.13 kg of soybean meal (SBM) + 0.001 kg of dl – methionine which supplies crude protein, amino acids and ME equivalent to corn

CCEM – 2 is a mixture of 0.845 kg of cassava + 0.13 kg of SBM + 0.25 kg of rice bran oil + 0.001 kg of dl – methionine which also supplies crude protein , amino acids , ME and fat content equivalent to corn.

CCEM – 3 is a mixture of 0.85 kg of cassava + 0.15 kg of extruded full fat soybean + 0.001 kg of dl- methionine which supplies crude protein, amino acids, ME and fat equivalent to corn.

The Chemical compositions and price of CCEM –1, CCEM –2 and CCEM-3 compared to corn are shown in Table 5.

CCEM – 1 is appropriate for cost comparison of cassava to corn in swine diets where fat content is not considered as an important factor.

CCEM – 2 and 3 are appropriate for cost comparison of cassava to corn in poultry diets where fat and linoleic acid contents are very important to the productivity of the animals.

The feasibility of including cassava in animal feeds therefore depends not only on the price of cassava itself, but also on the prices of SBM, extruded FFSB, rice bran oil and dl – methionine. None of the CCEM formulations contain pigment and the additional cost of natural or synthetic pigment needs to be added when including cassava in poultry diets.

Utilization of cassava in animal rations

Studies on the utilization of cassava for animal feeds have been conducted for more than 2 decades. Oke (1978) reported that cassava products are good energy feed ingredients for both monogastric and ruminant animals. The starch in cassava is very highly digestible when compared to that of corn, due to the high content of amylopectin. Cassava can be used as a sole source energy feed ingredient in pig, poultry and ruminant diets but care should be paid to HCN and protein as well as amino acid contents in cassava products. There have been a number of studies on the use of cassava in animal rations in Thailand. The results of the studies have indicated a great potential for cassava to replace some conventional energy feed ingredients including corn, broken rice and sorghum which are commonly used in animal diets in the region.

Pigs

Khajarern and Khajarern (1986) reported that growing - finishing pigs (17 - 100 kg) fed a cassava diet had poorer average daily gain and feed conversion ratio than those on broken rice and sorghum diets but the differences were not significant. Pigs on cassava diets tend to have a lower feed intake due to the bulkiness of the diet which may lead to deterioration in animal performance.

Chalorklang *et al*. (2000 a), studied the effects of cassava meal substitution for broken rice in weaned pigs (4-8 weeks) diets. Weaned pigs on a cassava diet (Diet 4) have almost similar average daily gains and feed conversion ratios to those on the broken rice diet (Diet 1) (Table 7). Cassava starch has shown to be very easily digestible by weaned pigs and produces minimal scouring and minimal unfavorable effects to the health of the animals.

Table 7. Substitution of cassava meal for broken rice in weaned pigs (4 - 8 weeks) diets

	Diet 1	Diet 2	Diet 3	Diet 4
Levels of substitution:	0	50%	75%	100%
Levels of cassava in diets:	0	24%	34%	43%
No. of animals	8	8	8	8
Initial wt. (kg)	7.35	7.46	6.75	7.70
Final wt. (kg)	18.53	20.24	17.64	18.39
Total wt. gained (kg)	11.23	12.40	10.78	10.69
ADG (kg)	0.400	0.440	0.389	0.383
Total feed intake (kg)	16.02	16.84	14.41	15.06
FCR	1.41	1.38	1.33	1.44

Source: Chalorklang *et al*. (2000).

Wu (1991) fed weaned pigs aged 28 days (7.1 kg) with a basal protein concentrated diet (41.0 per cent protein) at 3 per cent body weight daily, together with ground cassava at 2 per cent body weight daily and found that the diet can provide ADG 451 g/day and FCR 1.23 to the animals.

Chalorklang *et al*. (2000 b) also studied the effects of cassava substitution for corn in growing-finishing pigs (30 - 100 kg) diets. Pigs on a 100 per cent cassava diet (Diet 4) had slightly better average daily gains but slightly poorer feed conversion ratios to those on 100 per cent corn diet (Diet 1) however, the differences were not significant (Table 8). Pigs on cassava diets required less number of days to attain market weight while carcass characteristics of pigs on every experimental diet were not significantly different.

Saesim *et al*. (1990) tested the effects of cassava diets and broken rice diets on the reproductive performances of breeder pigs (Table 9). The trial was conducted at the farm for a

period of over 1 year. Sows on cassava diets had very similar reproductive performances to the sows on broken rice diets. It is clearly seen that cassava can be a sole source of energy feed ingredient in pig breeder diets (Table 10).

Table 8. Substitution of cassava meal for corn in growing – finishing pig (30 – 100 kg) diets

	Diet 1	**Diet 2**	**Diet 3**	**Diet 4**
Levels of substitution:	0	**50%**	**75%**	**100%**
Levels of cassava in diets (%):	0	**25/28**	**40/44**	**53/60**
No. of animals	16	16	16	16
Initial wt. (kg)	30.63	30.79	30.07	29.22
Final wt. (kg)	99.50	98.22	101.03	101.71
Total wt. gained (kg)	68.87	67.44	70.97	71.99
ADG (kg)	0.773	0.813	0.818	0.812
FCR	3.03	3.11	3.16	3.16
No. days on test	92	83	87	86
Dressing percentage	77.23	75.42	76.14	76.51
Lean percentage	42.97	42.96	44.17	42.50
Back-fat thickness (inch)	1.08	1.17	1.17	1.20

Source: Chalorklang *et al*. (2000).

Table 9. Utilization of broken rice and cassava in breeder pig diets

	Diets: Cassava	**Broken rice**
No. of litters	647	504
Farrowing percentage	88.19	93.16
Mumified + abnormal fetus (%)	1.64	1.91
Litter size at birth	10.02	9.25
Average birth wt. (kg)	1.32	1.34
Lactating days	23.83	23.51
Litter size at weaning	8.23	8.09
Average weaning wt. (kg)	5.73	5.46

Source: Saesim *et al*. (1991).

Table 10. Substitution of cassava meal for corn in breeder pig diets

	Diet 1	**Diet 2**	**Diet 3**	**Diet 4**
Levels of substitution:	**0**	**50%**	**75%**	**100%**
Levels of cassava in diets:	**0**	**25/21**	**39/33**	**55/47**
No. of animals	10	10	10	10
Litter size at birth	7.62	8.58	8.38	7.45
No. piglets born alive/litter	7.42	7.41	6.58	7.00
Litter wt. At birth (kg)	10.56	11.21	11.21	11.11
Average birth wt. (kg/pig)	1.52	1.56	1.52	1.60
Survival rate at weaning (%)	87.26	89.18	90.03	92.64
Litter wt. At weaning (kg)	39.20	44.06	42.79	45.40
Litter size at weaning	6.51	5.79	7.52	6.31
Average weaning wt. (kg/pig)	6.72	6.66	6.95	6.36

Source: Tangchai. (2000).

Broilers

Khajarern and Khajarern (1986) demonstrated that cassava meal could be used as a sole source of energy feed ingredient comparable to corn, broken rice and sorghum in broiler diets (Table 11). Broilers on cassava diets tend to have smaller body weights and poorer feed conversion ratios than those on the other diets but the differences were not significant.

Table 11. Utilization of corn, broken rice, sorghum and cassava as broiler diets

Diets:	Corn	Broken rice	Sorghum	Cassava
No. of animals	140	140	140	140
Mortality (%)	2.14	2.14	2.80	2.86
Body wt. at 8 weeks (kg)	1.70	1.68	1.70	1.64
FCR	2.27	2.27	2.30	2.39

Source: Khajarern and Khajarern (1986).

Sriwattanaworachai (1989) compared the effects of corn, sorghum and cassava diets on the performances of 4 - 7 week old broilers. Broilers on cassava diets had slightly poorer weight gains and feed conversion ratios than those on corn and sorghum diets (Table 12) however, the differences were not significant.

Table 12. Utilization of corn, sorghum and cassava in 4 - 7 weeks broiler diets

	Diets: Corn	Sorghum	Cassava
No. of animals	150	150	150
Initial wt. (kg)	0.448	0.444	0.458
Final wt. (kg)	1.92	1.93	1.85
Av. Wt. Gained (kg)	1.47	1.47	1.40
Feed consumed (kg)	3.41	3.51	3.38
FCR	2.32	2.36	2.42
Mortality (%)	0	2.0	0.67

Source: Sriwattanawarachai *et al*. (1989).

Saentaweesuk *et al*. (2000 a) studied the effects of substituting cassava for corn in broiler diets and found that cassava can be substituted for 50 per cent of the corn or at levels of 21 per cent, 23 per cent and 27 per cent in broiler starter, grower and finisher rations respectively, without any adverse effects on the performances of the animals. Higher levels of substitution will lead to a slightly but significantly ($P < 0.05$) poorer weight gain and feed conversion ratio (Table 13). However, it is very interesting to note that the trial was conducted in open broiler housing on a small farm during a rather hot climate. Broilers on cassava diets (Diets 2,3 and 4) were stronger, required much less medication and had lower mortality rates when compared to those on a corn diet (Diet 1). The meat of broilers on cassava diets (Diet 2,3 and 4) attracted better perception from the consumers than those on the corn diets (Diet 1). The slightly slow growth of the animals and the minimum use of antibiotics may have improved the meat quality of broilers on the cassava diets.

Tathawan *et al*. (2002) found that broilers on cassava diets always had about half the mortality rate compared to those on corn diets (Table 13). Broilers on a cassava diet without antibiotic supplementation had a significantly ($p<.05$) less mortality rate than those on a corn diet with antibiotic supplementation. Cassava has demonstrated its benefits to animal health improvements and allows minimal, to no use of antibiotics in animal production. The advantage is also experienced by farmers and feed millers who have employed cassava in animal diets in Thailand.

Table 13. Substitution of cassava meal for corn in broiler (10-49 days) diets

	Diet 1	Diet 2	Diet 3	Diet 4
Levels of substitution:	**0**	**50%**	**75%**	**100%**
Levels of cassava in diets (%):	**0**	**21/23/27**	**31/35/42**	**40/47/56**
No. of animals	400	400	400	400
Initial wt. (g)	234.65	237.25	234.45	232.93
Final wt. (g)	2,079.35[a]	2,003.26[a]	1,815.25[b]	1,846.00[b]
Mortality (%)	4.50	2.00	1.98	1.50
Total wt. gained (kg)	1,844.70[a]	1,765.95[ab]	1,580.80[a]	1,613.06[bc]
Total feed consumed (kg)	3,745.22[a]	3669.83[a]	3,449.45[b]	3,564.68[ab]
FCR	2.03[c]	2.08[bc]	2.19[ab]	2.21[a]

Source: Saentaweesnk *et al*. (2000).

Hen layers

Khajarern and Khajarern (1986) demonstrated that cassava could be used as a sole source of energy feed ingredient in pullets and layers diets when compared to corn, broken rice and sorghum (Table 14 and 15). Pullets and layers on cassava diets had similar performances to the animals on corn, broken rice and sorghum diets. The animals on cassava diets had a low mortality rate and had shown no sign of any toxicity from cassava in the diet.

Table 14. Utilization of corn, broken rice , sorghum and cassava in pullets diets

Diets:	Corn	Broken rice	Sorghum	Cassava
No. of animals	200	200	200	200
Mortality (%)	1.5	1.5	1.0	2.0
Body wt. at 20 weeks (kg)	1.82	1.85	1.77	1.77
FCR	4.30	4.05	4.26	4.51

Source: Khajarern *et al*. (1986).

Table 15. Utilization of corn, broken rice, sorghum and cassava in layer diets

Diets:	Corn	Broken rice	Sorghum	Cassava
Laying percentage	66.22	72.90	62.06	69.56
Egg wt. (g)	50.55	50.30	50.02	50.05
Yolk color score (NEAPA)	3.50	4.67	4.50	4.15
Feed consumed (kg)/dozen eggs	1.40	1.28	1.48	1.33
Mortality (%)	1/96	1/95	2/95	0/95

Source: Khajarern *et al.* (1986).

Saentaweesnk *et al*. (2000 b) studied the substitution of cassava for corn in layers (22 - 37 weeks) diets (Table 16) and found that laying hens on a 100 per cent cassava diet (Diet 5) had similar production performances to those on 100 per cent corn diets (Diets 1 and 2). Increasing the levels of cassava in the diets significantly ($P < 0.5$) reduced the yolk color score. Diet 5, in which 100 per cent of the corn was substituted with cassava, needed to be supplemented with 0.2 per cent of marigold meal to provide adequate yolk pigmentation for market acceptance. Cassava is an excellent energy feed ingredient for the production of pale yolk eggs for exportation.

Table 16. Substitution of cassava meal for corn in layer (22 - 37 weeks) diets

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5*
Levels of substitution:	**0**	**0**	**50%**	**75%**	**100%**
Levels of cassava in diets:	**0**	**0**	**25%**	**36%**	**48%**
No. of animals	576	576	576	576	575
Feed intake/hen/day (g)	114.7	115	113.6	112.8	112.4
Laying percentage	60.16	61.24	58.40	59.72	59.92
Mortality (%)	0.42	0.26	0.42	0.14	0.22
Av. egg wt. (g)	57.43	57.70	57.81	57.78	58.22
Yolk color score (Roche)	9.27^{a}	9.40^{a}	8.75^{b}	8.36^{b}	8.38^{b}

* Supplemented with 0.2 per cent of marigold meal.
Source: Saentaweesuk *et al.* (2000).

Dairy cattle

Kanchanapreuttipong (2000) studied the effects of substitution of cassava for corn in dairy concentrates rations. Total substitution of cassava for corn in the rations produced very similar milk yields and milk composition of the dairy cows to those on the corn diets (Table 17). However, the percentage of feed cost/revenue was significantly reduced ($P < 0.5$) when cows

were fed the cassava diets. Cassava chips and pellets are ideal energy feed ingredients for beef and dairy cattle.

Table 17. Substitution of cassava chips for corn in dairy concentrate diets

% (kg/day) Diets:	Corn	Corn + Cassava	Cassava
Levels of substitution:	**100%**	**50%/50%**	**100%**
Butter fat	4.15 (0.80)	4.32 (0.85)	4.27 (0.83)
Milk protein	3.37 (0.65)	3.27 (0.64)	3.33 (0.65)
Lactose	4.97 (0.76)	4.93 (0.97)	4.96 (0.97)
Minerals	0.70 (0.13)	0.70 (0.14)	0.70 (0.14)
Solid non-fat	9.03 (1.74)	8.90 (1.75)	8.99 (1.75)
Total solid	13.19 (2.54)	13.23 (2.60)	13.26 (2.58)
Milk yield (kg/day)	19.23	19.64	19.44
Feed cost/revenue (%)	40.75[a]	34.33[ab]	28.17[b]

Source: Kanchanapreuttipong (2000).

Aquaculture feed

Jintasataporn *et al*. (2000) evaluated the effects of substitution of cassava for corn in hybrid catfish diets and reported that the fish on 100 per cent cassava diet (Diet 4) had similar production performances as those on 100 per cent corn diet (Diet 1) (Table 18).

It could be concluded that cassava can be used as a sole source of energy feed ingredient in every kind of animal ration including pigs, poultry, ruminants and aquaculture feeds. However, care should be paid to the use of cassava for broiler rations, since fowls are sensitive to bulkiness and to the fiber contents of the feed, therefore, cassava is recommended to replace only 50 per cent of corn in broiler diets.

Table 18. Substitution of cassava meal for corn in hybrid catfish diets

	Diet 1	Diet 2	Diet 3	Diet 4
Levels of substitution:	**0**	**50%**	**75%**	**100%**
Levels of cassava in diets:	**0**	**13%**	**20%**	**26%**
Total wt. gained (g/fish)	84.06	82.96	80.46	98.80
ADG (g)	0.70	0.69	0.67	0.82
Total feed consumed (g/fish)	144	115	147	176
FCR	1.72	1.36	1.83	1.79
Survival rate (%)	88.6	90.3	86.1	98.9

Source: Jintasataporn *et al*. (2000).

Practical experiences of using cassava in animal rations in Thailand

Cassava has been promoted as a corn replacement in pig, poultry and ruminants diets in Thailand for more than 15 years. Only a limited number of farmers adopted and practiced the technology at the beginning but the results were very successful. Extensive use of cassava in animal rations has been practiced since 1997 when animal production and the feed industries were severely affected by the economic crisis. The devaluation of the Thai currency and the reduced purchasing power of the consumers resulted in the increased cost of animal production while the current market prices of the foods from animals have been reduced. In contrast, export prices of cassava to the EU have also been reduced due to the reduction of the agricultural subsidy policy in the EU countries. The promotion of using cassava in domestic animal diets is therefore, the solution to the problems.

Cassava has been actively promoted for use in animal diets by the Animal Nutrition Research and Development Center (ANRDC), Kasetsart University, Kampaengsaen, Nakhon

Pathom with the subsidy of the Thai Tapioca Development Institute (TTDI). Seminars and workshops on the utilization of cassava and SBM in animal rations have been repeatedly conducted in various parts of Thailand. Books and videos on the utilization of cassava and SBM in animal rations have been prepared and distributed to the participants of the seminars and the workshops. Follow-up evaluation and services need to be carried out in order to correct the field problems and to ensure the success of the project. In addition, improvements to cassava chip production in Thailand have been made in order to meet the requirements of the animals. Good quality cassava chips and pellets, which are a key factors for the success of using cassava in animal diets, are increasingly available in the country and are helping to increase the acceptance of cassava in the feed industry. To date, cassava has been extensively accepted in animal rations in Thailand including growing - finishing, breeder and weaned pigs, hen and duck layers, meat type ducks, dairy and beef cattle with successful results and satisfaction to the farmers.

Cassava is an appropriate feed ingredient for pigs, ducks and cattle since the animals can tolerate high levels of dietary crude fiber and require no pigmentation in the diets (except for laying ducks). Acceptance of using cassava in animal rations was widespread among farmers ranging from small farmers (10 - 20 sows/unit) to large commercial farmers (over 10,000 sows/unit) with equally successful results. It is worthy to note that most of the farmers are satisfied with the following advantages of using cassava in their animal rations.

1. Satisfactory animal performance and carcass quality, while feed costs and animal production costs are reduced.
2. Reduction of medication and antibiotics used in animal production and the improvement of animal health induced by cassava diets.
3. Reduction of the fetid smell of the manure and reduction of environmental pollution.

On many occasions when there were no differences in the prices of corn and cassava diets, a number of farmers still maintained the use of cassava in animal rations due to the advantages of health improvements and less smell pollution by the cassava diets. A number of pigs and poultry (broiler) farms have used cassava as the main feed ingredient in the diets for production of antibiotic free pork and poultry meat.

Advantages of using cassava in animal diets

The results of the past studies and the practical field trials have indicated that good quality cassava has advantages in animal nutrition as follows:

Comparable performance but higher quality of animal products than corn diets

Good quality cassava with proper nutritional balance, obtained by good diet processing, has produced very comparable production performances to the animals on cereals diets. Farmers always reported that cassava diets consistently produced better quality animal products including meat, milk and eggs. Although no scientific explanation can be made, the favorable results may be due to a less stressful situation for the animals on cassava diets.

Higher digestible starch

Starch in cassava is very soft starch, which is readily gelatinized and digested in the digestive tract of the animals when compared to that of cereal starch. Highly digestible starch creates less stress to the animals and stimulates more growth of non-pathogenic microorganisms which produce more acidic conditions and suppress the growth of pathogenic microorganisms in the digestive tract.

Minimal/no mycotoxins contamination

It has been proven that cassava products always contain very minimal to no mycotoxins, including aflatoxin contamination, when compared to cereals, especially to corn. Cassava has been successfully fed to breeder animals and ducks which are very sensitive to mycotoxin toxicities, especially zearalenone and aflatoxins. Apparently, no aflatoxicosis as well as toxicity of other mycotoxins have been reported by the farmers who have employed cassava in animal diets for many years. Aflatoxin is a powerful stressor in animal diets which, not only reduces performances of animals, especially the feed conversion ratio, but also impairs immunity production and causes more illness to the animals. Modern high - performance animals are always more sensitive to stress, including aflatoxins in the diets. The animals, therefore, require feeds which are not only nutritionally balanced and highly digestible but also contain very minimal to no toxic substances which cause stress to the animals. Cassava is an ideal feed ingredient meeting this requirement.

Animal health improvement and green food production

Animals on cassava diets always have better health and require less or no antibiotics during production, compared to animals on cereals, especially on corn diets. The highly digestible starch and minimal, to no aflatoxin contamination is responsible for the advantages. Cassava diets can therefore provide green meat or green food production which is essential for animal production in this new millennium.

Minimal animal waste odor

The results of practical field trials have shown that manure or the feces of animals on cassava diets produce a less fetid smell or has less odor than those on cereal diets. Although the exact reasons are not known, the advantage helps to reduce pollution problems in the animal production industry very well.

Non - GMOS feed ingredient

Cassava grown in Thailand is a natural organism and has been certified as non-GMOS. Cassava products can be used in animal production for exporting, especially to EU countries.

Reduction of animal production costs

Cassava diets have reduced the cost of animal production not only by the reduction of feed cost but also by the reduction or elimination of the use of antibiotics and medication in animal production. This advantage is an important factor for the acceptance and for more utilization of cassava in animal diets in Thailand and the world.

Key factors for successful use of cassava in animal rations

Although cassava is an energy feed ingredient comparable to corn, cassava has many other typical characteristics and behaviors which really affect its utilization in animal diets. It is therefore necessary to have a thorough understanding of cassava in order to successfully use the ingredient in animal rations.

Selection of good quality cassava

Only good quality cassava (chips or pellets) which have the following specification are recommended for inclusion in animal diets.

Moisture	max.	14 per cent
Crude protein	min.	1.5 - 2.0 per cent
Crude fiber	max.	3.50 - 4.00 per cent
Ash	max.	2.00 per cent

The above specified cassava products contain 75 - 80 per cent NFE and provide very good results for animal feeding. Cassava chips that contain minimal or no stem or woody part will have crude fiber levels not exceeding the limit. A high level of sand or soil contamination would increase ash content in the cassava products. The products should be dried for at least 3-6 days and should be stored for at least 5-6 days before being included in animal rations. Cassava products should be clean and have no mold growth at sight. With enough experience, one can estimate starch content by breaking a piece of dried cassava chip.

Feed formulation

Cassava diets should be balanced for protein and essential amino acids according to the requirement of the animals. Weight by weight substitution of cassava for corn, in animal diets, will lead to a lower protein and amino acid content in the diet and cause poor growth, poor feed conversion ratio, poor carcass quality and poor productivity of the animals. More soybean meal or extruded full-fat soybean needs to be added when employing a cassava diet. Cassava-soybean diets with a proper balance of amino acids have been used successfully by pig farmers in Thailand.

Grinding and problem solving of dustiness

Cassava chips are very bulky and contain soft starch. Grinding of cassava chips is always very dusty and causes severe air pollution in the feed mill. Dust collection units of either the cyclone dust collector with filter bags or an automatic filter bag dust collector are required to prevent spreading the dust into the atmosphere. Ground cassava is still very dusty and always disturbs the feed intake of animals on mashed cassava diets. Dusty feed will stimulate animals to drink more water, which impairs feed intake and cause growth depression of the animals. The addition of 4 - 5 per cent molasses in the diet is recommended in order to eliminate the dustiness of the feed. High levels of fat addition in the diets would decrease the levels of molasses required for dustiness control in mashed cassava diets. Pelleted feed and wet feed give no problems of dustiness and do not need molass addition in the formulae.

Body fat adjustment

Cassava diets may contain very little fat and may cause hard fat accumulation in the animal body. In countries where hard carcass fat is avoided, it is advisable that cassava diets should contain at least 3 per cent soft-fat in order to correct the fat condition in the animals. High fat content feed ingredients; i.e., rice bran, extruded full-fat soybean or rice bran oil are recommended to be included in cassava diets.

Yolk and skin color of poultry

Cassava contains no pigment and the diet may cause pale egg yolk and pale skin of the poultry. Cassava diets may have to be supplemented with sources of pigment such as leucaena leaf meal, marigold meal or synthetic pigments in order to color the yolk and skin according to the requirement of the consumers. The required supplementation is approximately 30 mg of xanthophyll/kg of diet.

National program on cassava chip and pellet quality improvement and quality assurance in Thailand

Good quality cassava is an important factor for the successful use of cassava in animal diets. The government of Thailand is therefore launching a national program on the promotion of good quality cassava chips and pellet production in the country both for domestic uses and for exportation. Good quality cassava chips should conform to the following standard:

Moisture	max.	14 per cent
Crude fiber	max.	3.5 - 4.0 per cent
Sand/ash	max.	2.0 per cent
Starch (NFE)	min.	75 - 80 per cent

The products will contain very minimal levels of crude fiber and sand/ash and will be a good substitute for cereals in animal diets. Governmental offices and organizations related to cassava production, utilization and trading are involved in the program and carry out the following activities:

Department of Foreign Trade (DFT), Ministry of Commerce.

DFT is implementing a 120 million Baht soft loan to 300 commercial cassava chip/pellet processors for the installation of sand sifters into the production process, which will reduce the content of sand in the cassava products to a maximum 2 per cent. The processors also need to reduce the fiber content of the cassava products to the maximum 3.50 - 4.00 per cent. DFT together with ANRDC and TTDI will test, monitor and certify processors who consistently produce good quality cassava chips according to the above standard. The project is aimed to produce a minimum of 3 million tons of good quality cassava chips annually.

Department of Cooperatives Promotion (DCP), Ministry of Agriculture and Cooperatives.

DCP is implementing a 426 million Baht soft loan to 60 agricultural cooperatives who grow and process good quality cassava chips. The cooperatives may be directly involved in the production of good quality cassava chips or the collection of good quality cassava chips produced by members or villagers and market it to the users. Cassava growers (farmers) are encouraged to partly process the fresh roots for good quality cassava chips which will produce an additional income to the families. Normally cassava chips produced by farmers or villagers are always of prime quality and are in great demand by the animal farms and feed mills. DCP and ANRDC will continuously and regularly test, monitor and certify the cooperatives who consistently produce good quality cassava chips according to the standard. The project will produce approximately 300,000 - 500,000 tons of good quality cassava chips annually for domestic consumption and for exportation.

Animal Nutrition Research and Development Center (ANRDC), Kasetsart University and Thai Tapioca Development Institute (TTDI).

ANRDC and TTDI have been pioneers in promoting the production of clean and good quality cassava chips for the animal feed industry in Thailand since 1998. A number of cassava processors, ranging from small villagers to large commercial processors, have joined the project and have produced good, or improved the quality of cassava chips for the animal feed industry in the country. The project, has not only demonstrated the benefits of improved quality cassava for animal feed to the farmers but has also provided assurance for the solid future of good quality cassava in the animal feed industry. ANRDC and TTDI have not only provided training and supervising in techniques and practices for the production of good quality cassava chips but have also tested and monitored the quality of the products produce by direct sampling from the processors and by analyzing samples sent by the customers. Good processors, which consistently produced good quality products, were publicized directly to the farmers and to the feed industry.

ANRDC and TTDI still have continuous activities in promoting greater utilization of good quality cassava for animal feeds. Seminars and workshops on the utilization of cassava in animal nutrition are conducted throughout the country. More research on the beneficial effects of cassava diets to the health of the animals is being conducted. The results of recent advances in using cassava in animal diets and the names of certified cassava processors will be publicized via www.tapiocafeed.com.

Office of Industrial Standard (OIS), Ministry of Industry, and Department of Livestock Development (DLD), Ministry of Agriculture and Co-operatives.

OIS and DLD, which are authorized organizations to certify the standard of manufacturing practices and the standard quality of industrial products including animal feeds, have planned to improve cassava pellet production practices and to certify GMP and HACCP to processors who meet the standard. The certification is essential for the exportation of cassava products to the EU. Cassava pellet processors and exporters will be trained and monitored, and improvements made on the production process until the standards are met and certification will be provided. The activity is expected to be completed before December 31, 2001.

The government of Thailand expects that the national programs will result in increasing the production of prime quality cassava products, increasing the uses of cassava in animal feed in the country and in increasing the exportation of cassava products to the EU and other countries. The programs will also provide a sustainable marketing strategy and practice for the cassava industry in Thailand.

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Consolidated Discussion

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The Demand for Animal Products, Animal Feeds and the Scope to Expand Feed Crops in the South Asian Region

S.S.E. Ranawana[*]

Introduction

The last few decades have seen a rapid and massive increase in the consumption of animal products throughout the world (Table 1). This phenomenon has been more evident in developing countries and as a result, the focus of animal production in the world is moving from temperate to tropical areas. At the same time, the production base in these countries is also changing from the traditional local, mixed-farms to intensive, market-oriented, vertically integrated agri-businesses. Finally, the dominant type of meat produced and consumed in developing countries is also changing from ruminants to poultry and swine.

Table 1. Per capita consumption of animal products (kg per annum)

	Developed countries		Developing countries	
	1973	1993	1973	1993
Beef	26	25	4	5
Mutton/Goat	3	3	1	1
Pork	26	29	4	9
Poultry	11	20	2	5
Eggs	13	13	2	5
Dairy	188	195	29	40

Source: Authors' calculation.

A team of researchers from the International Food Policy Research Institute, the Food and Agriculture Organization of the United Nations and the International Livestock Research Institute (*see* Delgado *et al.*, 1999) have used these trends to make projections of consumption and production of animal products in developing countries up to the year 2020. They have estimated from their model that during the next two decades, meat and milk consumption will grow at 2.8 and 3.3 per cent per annum in less developed Countries (LDCs) (Table 2) and that meat consumption in LDCs will more than double compared to increases of less than 20 per cent in developed countries. At the same time, the demand for milk will increase by 223 million mt in developing countries compared to an increase of only 18 million mt in the developed world.

They have predicted that, in value terms, products from livestock will equal or exceed those from crops by the year 2020 and have termed it the "livestock revolution"

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Table 2. Past, current and projected consumption of meat and milk

	(million mt)					
	Meat			Milk		
	1983	1993	2020	1983	1993	2020
World	139	184	303	355	412	654
Developed	88	97	115	233	245	263
Developing	50	88	188	122	168	391

Source: Authors' calculation.

These projected increases in production of milk from ruminants and, in particular, meat from swine & poultry will, in turn, create a huge demand for compound feeds high in energy and protein. Ruminant concentrate rations which are used to supplement forages, are generally more flexible and can be formulated with a variety of alternate energy feeds and oil cakes. On the other hand, rations for high producing poultry and swine are more demanding and the two preferred feed ingredients used are maize and soybean meal, both CGPRT crops. Due to a number of technical reasons, both these ingredients are difficult to replace in modern pig and poultry diets and a particular demand is being created for these two ingredients. Other coarse cereals and CGPRT crops such as pulses, roots and tubers can contribute towards monogastric feeds by substituting at least partly for these two main ingredients, they are, however, likely to be more significant in dairy feeds.

At present, only a few countries in the world produce surpluses of maize and soybean meal for export (Table 3). Most other countries in the world are net importers of one or both these ingredients.

Table 3. Chief exporters of maize and soybean meal (85 per cent of world exports)

	Maize 1,000 mt		Soybean meal 1,000 mt
US	41,491	US	6,441
Argentina	6,424	Argentina	8,123
France	7,124	Brazil	10,013
		India	2,915

Source: FAO, 1997.

The actual global situation in the year 1993 and projections to 2020 for meat and feed cereals in the world are shown in Table 4 (Delgado *et al*., 1999). From the discussion above and particularly from Table 4, it can be seen that the expected increase in poultry and swine meat production in the developing world will lead to large deficits of feed ingredients, particularly cereals, in developing countries and that they will have to be imported from the developed world. There is a need, therefore, to investigate the real conditions, opportunities and constraints for feed crop farming in the South Asian region and to identify policy options to meet any shortfalls in production.

Table 4. Net balances in the trade of meat and cereals in 1993 and 2020 (projected)

	Million mt			
	Meat		Cereal	
Country/region	1993	2020	1993	2020
China	+0.9	+0.7	-0.9	-46.2
Other SEA	+0.1	+0.5	-3.2	-5.4
India	+0.1	0.0	1.3	-7.1
Other S.Asia	+0.0	-0.6	-4.5	-21.9
Developing	-0.2	-4.3	-93.3	-226.1
Developed	+0.2	+4.3	+93.3	+226.1

Source: Delgado *et al*., 1999.

Characteristics of the South Asian Countries

Physical and economic

Agriculture is the main preoccupation of people in the region with 57 per cent being dependant upon it (Devendra *et al*., 2000). Without taking into account the value of manure and draught power, agriculture contributes between 25 and 43 per cent to the GDP of these countries. The relative importance of agriculture and livestock to the economy of these countries is shown in Table 5 below.

Table 5. Agricultural and livestock indicators in South Asian countries (1993)

	India	Nepal	Pakistan	Sri Lanka	Bangladesh
Agriculture as a percentage GDP	31	43	25	20	30
Livestock as a percent agriculture	23	15	45	10	14
Livestock as a percent of GDP	7.1	6.5	11.3	2.0	4.2

Source: Devendra *et al*., 2000.

Much of the South Asian region is classified as arid or semi-arid with some sub-humid and, unlike in South East Asia, only a relatively small area is considered as humid. Most farming in the region depends on rainfall for cropping and productivity and is therefore affected by seasonal factors (Table 6). Although found in the arid or semi-arid regions and constituting a relatively smaller proportion, irrigated lands are much more productive, some areas of the Punjab in India and Pakistan, for example, compare favourably with some of the most agriculturally productive areas in the world. It can also be seen from Table 6, however, that although the productivity of rainfed areas may be lower, it supports a much higher proportion of farmers.

Table 6. Rainfed agriculture in the region

	Rainfed (RF) agriculture in South Asia			
	RF Area million ha	RF Area % total arable land	% Contribution to Agric GDP	% Population Dependant on RF
India	100	70	26	42
Nepal	2.6	84	41	75
Pakistan	5.4	27	5	12
Sri Lanka	0.5	50	20	29
Bangladesh	7.7	82	41	41

Source: Devendra *et al*., 2000.

Most cropping systems in the region are rice or wheat based with annual and perennial secondary crops (Devendra *et al*., 2000) and may be irrigated or rainfed. Meat from ruminants (cattle, sheep and goats) is produced mainly from animals raised on natural grasslands under extensive conditions. Milk, on the other hand is produced primarily on mixed crop-livestock farms using buffalo which, as a species, are able to use the crop residues produced on the farms more effectively.

Animal production in the South Asian region

Current Livestock production

The region has a large and diverse ruminant population with 69 per cent of the world's buffalo and 30 per cent of the goats. Overall a fifth of the world's ruminants are found in the region. Of the world's buffalo, Asia has 97 per cent and South Asia alone, 76 per cent. Asia produces 40 per cent of the meat in the world, but mostly in countries of South East Asia. In contrast, two thirds of the milk production in Asia is produced in South Asia which incidentally produces more than 90 per cent of the world's buffalo milk. Although more than half the eggs in the world are produced in Asia, this is again mostly in South East Asia, particularly China.

It can be seen, therefore, that there are clear differences between South and South East Asia with regard to milk and meat production, with milk dominating in the former and meat in the latter. The difference is most obvious for pigmeat production, whereas Asia produces more than half the pigmeat in the world, South Asia produces only 0.5 per cent. Indeed, 45 per cent of the pigmeat is produced in a single country, China. Aquaculture, although encouraged, has not developed to any significant extent as yet in South Asia with the possible exception of Bangladesh. On the other hand, the poultry meat sector has shown rapid increases in all South Asian countries and is expected to meet much of the increased demand for meat in the region. The current production of meat, milk and eggs in South Asia compared to other parts of the world is shown in Table 8 below (FAO, 2002).

Table 8. Livestock production in the year 2000 (million mt)

Region/Country	Meat	Milk	Eggs
World	232.0	575.0	51.0
Asia	92.0	169.0	29.0
South Asia	7.3	110.0	2.3
India	4.8	80.0	1.8
China	63.0	12.0	19.2

Source: FAO, 2002.

Trends in Livestock production, consumption in the South Asian region

The per capita consumption of animal products from 1961 to 1996 and projections to the year 2015 are shown in Tables 9 and 10.

Table 9. Per capita consumption of meat, milk and eggs and selected food items from 1961 to 1996 and projections to 2015 in South Asian countries (kg/annum)

		Bangladesh	India	Nepal	Pakistan	Sri Lanka	World
Beef + mutton	*1961*	2.8	3.1	6	6.8	3.4	9.1
	1996	2.3	3.4	8.7	11.6	1.9	11.4
	2015	2.8	3.9	9	14.4	1.8	12.5
Pigmeat	*1961*	0	0.3	0.4	0	0.1	4.7
	1996	0	0.5	0.5	0	0.1	13.7
	2015	0	0.7	0.6	0	0.2	14.8
Poultry meat	*1961*	0.4	0.1	0.4	0.2	0.8	2.4
	1996	1	0.5	0.5	2.5	3.1	9.5
	2015	3	1.8	1.1	5	5.7	12.9
Eggs	*1961*	0.4	0.3	0.9	0.1	1	3.3
	1996	0.8	1.4	0.9	1.7	2.3	7.7
	2015	2.1	3	1.3	3.1	3.7	9
Milk	*1961*	12.2	37	48	94	18	49
	1996	14.7	57	37	114	33	76
	2015	20	83	40	128	37	82

Source: Authors' calculation.

An analysis of the trends in Table 9 indicates that the per capita consumption of all foodstuffs has increased over this period. When compared to the modest increases in consumption of wheat and rice, however, the increase in consumption of meat, milk and eggs has been substantial. The intake of pulses has declined during this same period. The most marked increase has been for poultry meat and eggs with predicted increases of up to 15 times for chicken meat and 8 times for eggs in 2015 when compared to 1961. The per capita intake of milk will double and of ruminant meat increase by 50 per cent during this same period. When compared to per capita increases in the world, the region shows a much higher rate of increase for chicken meat, eggs and milk but a lower rate for pigmeat. Increases in the consumption of wheat, rice, vegetables and ruminant meat are similar in the region to world averages with both showing a noticeable decline in the intake of pulses.

These changes have not been similar, however, throughout the region. Whereas the increases in wheat and rice and the decline in pulses have been constant in all countries in South Asia, consumption of ruminant meat has only increased in India and Pakistan. Intake of milk has increased in all countries except Nepal but the increases have been mostly in India and Pakistan.

Table 10. Per capita consumption (kg/annum)

	% increase 1961-2015	per capita consumption by 2015	
	South Asia	South Asia	the world
Wheat/rice	57	165	136
Pulses	-58	9	6
Beef/mutton	53	5	12.5
Chicken meat	1,469	2.4	12.9
Eggs	827	2.9	9
Milk	99	81	82
Pigmeat	115	0.5	14.8

Source: Authors' calculation.

The increase in Chicken meat and egg consumption has been seen in all countries of the region with meat being highest in Pakistan and Sri Lanka, and eggs least in Sri Lanka. It should be noted in this connection, however, that the per capita consumption of meat and eggs in countries of the region remains well below world averages. In contrast, the per capita consumption of milk in South Asia will reach world averages by 2015 but will remain below levels in developed countries.

The demand for meat, eggs and milk in the South Asian region

Ruminant meat

The demand for ruminant meat will increase and will have to be met by increased production and imports. Currently, ruminant meat arises from two sources, animals culled from the dairy industry as well as cattle, sheep and goats raised under extensive conditions on natural forages. Since the areas of natural grazing are limited, and by now perhaps saturated and even overgrazed in many areas, the supply of ruminant meat from this source may not increase to satisfy the demand. Although the supply from the dairy industry may increase with the growth of that sector, it is expected that there will be a net deficit of ruminant meat in the region by 2010. As ruminant meat production is under intensive and grain-fed systems are not economical, feed crops are not expected to play a role in ruminant meat production in the region unless such elite meats are being produced for export.

Swine meat

Swine meat production currently in the South Asian region is negligible when compared to countries of South East Asia. Moreover, growth is also likely to be small and, if at all, limited to a few countries. Demand will increase marginally in some countries, notably India, and can be met by a production increase. Although some compound feeds may be fed to breeding stocks, the majority of animals, the fatteners, are likely to be raised on by-products and swill. The demand for feed crops from this sector in the future will not be significant.

Chicken meat and eggs

The demand for chicken meat and eggs has increased dramatically in the region in the last two decades leading to the rapid development of the poultry industry in all countries of the region. This trend is expected to continue and even accelerate in some countries. It can be expected that the increased demand for meat in the region will be met primarily from chicken meat, a significant change from the earlier dependence on ruminant meat. The unit of production in the region has also changed from the traditional backyard and small-scale deep-litter systems to intensive, large-scale agribusinesses which demand sophisticated management. In the future, the great majority of meat and eggs will be produced using highly productive birds, in intensive commercial systems, comparable to those in developed countries, which will greatly increase the demand for high-quality compound feeds. This demand has led to a parallel growth in the large-scale animal feed industry in the region. Quite often, for reasons of economy, the feed milling, production of day-old chicks, commercial production of meat and eggs and even the supply of inputs such as drugs and services are vertically integrated into one or several companies in the private sector. These trends are expected to continue.

The development and expansion of a modern feed industry to service the expanding poultry industry will need a ready supply of high-quality feed ingredients. The nature of these

feeds - highly concentrated in energy and protein - demands the use of cereals for energy and high-protein oilcakes. The preferred ingredients for this purpose worldwide are maize and soybean meal, both of which are impossible to completely replace in modern poultry diets.

Milk

The South Asian region is well known for its well established milk drinking habit, similar to that in the West but unlike other countries of East Asia. The demand for milk will continue to increase in the region in the next decade and will have to be met primarily from cattle and buffalo and to lesser extent from goats and sheep. These animals are raised on smallholder mixed crop-livestock farms. Much of the milk is produced from buffalo. Under these conditions, the main feed resources for milk production are likely to be limited to crop residues and natural forages with some improved forages, supplemented with agro-industrial by-products.

Although concentrates are fed to these animals, they are generally less demanding in the levels of energy, protein and fiber than for poultry. Feeds for these animals are, therefore, made with brans and oil cakes, the latter with levels of protein lower than soybean meal. Moreover, the ingredients may be fed straight or mixed simply so that elaborate feed mills are not needed. As milk production develops further, however, and high-producing animals are available through breeding programs, there may be some elite animals on large-scale commercial farms that will need feeds high in energy and protein. In India and Pakistan, limited amounts of grains are already being used in dairy rations. Although such systems are likely to be few and limited only to some economic environments such as peri-urban areas at present, they can be expected to expand in the future to meet the demand. Even though the proportion of feed grains in dairy rations is small, the volume is high when compared to poultry feed and the dairy industry and therefore, may place a significant demand on feed grains, even in South Asian countries.

Feed crops in the region

From the discussion above, it can be concluded that demand for feed crops will arise from both the poultry and dairy industries but that there are qualitative differences between the two.

Modern poultry feeds usually include the following ingredients:

- Energy
  - Maize.
  - Brans and other milling by-products of rice and wheat.
  - Other coarse cereals such as sorghum and millets.
  - Roots and tubers, primarily cassava.
- Protein
  - Soybean meal.
  - Other high protein oilcakes such as groundnut or sesame.
  - Animal proteins, usually from fish meal, meat and bone meal.
- Micronutrients: In the form of premixes.

The ingredients used in dairy rations are usually limited to the following:

- Energy
  - Milling by-products of rice and wheat, including brans and broken rice.
  - Coarse cereals such as maize, sorghum and millets.
  - Roots and tubers.
- Protein
  - Oil cakes, usually with moderate protein levels such as coconut or cotton seed.

It can be seen that the CGPRT crops that can provide ingredients for animal feeding are primarily maize and soybean together with sorghum, pearl and other types of millets and perhaps, cassava. The discussion, therefore, will be focused on these feed crops.

Manufacturing of animal feed in South Asian countries

The Animal Feed Industry in South Asian countries consists of the following components.

- Large-scale integrated operators who make the feed for their own operations.
- Registered commercial manufacturers of animal feeds.
- Smaller producers and "home-mixers".

The commercial feed mills in South Asian countries are mostly private sector establishments and there appears to be no shortage of investors for this purpose. The scale of operations and the level of sophistication, however, vary widely unlike in developed countries in which the size of the mills and the products themselves are more uniform. Most feed mills have been formed to manufacture feeds for poultry and these have expanded with this industry. In the case of ruminants, concentrates are usually fed only to lactating animals and even in these cases, animals are fed with agro by-products available in the area or with simple home mixes of a few ingredients or what are often called "loose mixes". Other sectors such as pigmeat (a major consumer of animal feeds in other countries), beef and intensive dairy production are not significant in the region. As a result, only around 10 to 20 per cent of the output of the commercial feed manufactured is for the dairy industry, even though, quantitatively, the amounts of concentrate fed to ruminants is very much higher than that fed to poultry. In India and Pakistan, there are manufacturers who cater specifically to the dairy industry, particularly those operated by the dairy co-operatives.

In general, the concentrate feeding systems in the region may be classified as follows:

• Chicken meat	Complete, balanced compound rations.
• Eggs	Around two thirds complete rations and a third home-mixed.
• Dairy	Majority are loose-mixes or straight feeds with perhaps 20 per cent compound feeds (mostly in India).
• Pigmeat	Breeders – complete compound rations. Fatteners – usually by-products and swill.

Feed manufacturers and their capacities

At present, none of the countries are importing compound feed but have all established manufacturing facilities. Since many of the feed mills are not registered, it is difficult to accurately estimate the capacity for feed milling in the region. Table 11 shows the estimated capacity from the registered millers.

Table 11. Estimated capacity from registered millers

	Mills	Capacity
Bangladesh	37	260,000
India	228	17,700,000
Nepal	149	500,000
Pakistan	150	650,000
Sri Lanka	17	450,000

Source: Authors' calculation.

In most cases, the installed capacity exceeds the actual quantity manufactured. While many of these mills may operate to international standards and even obtain international standards certification, others are still primitive. It can be said, however, that the industry is capable of expanding to meet the rapidly growing demand for poultry feed.

Ingredients used and their sources

The ingredients used for the manufacture of complete feeds for poultry are similar throughout the region.

Grains	Maize, broken rice, sorghum, wheat, pearl millet and other minor millets.
Brans	Rice and wheat.
Oilcakes	Soybean meal, sesame cake, mustard cake, groundnut meal, sunflower meal and rapeseed meal.
Animal protein	Fish meal, meat and bone meal.
Additives	Micronutrient premixes, antioxidants and antibiotics.

The two main ingredients used by the modern poultry industry are maize and soybean meal which can only be replaced partly in these rations with other coarse cereals and oilcakes respectively. Cattle mixtures are more flexible and other coarse grains and oilcakes with lower protein levels can be used for them. These feeds are, therefore, much more varied. Coarse grains are being used to some extent in dairy rations, particularly in India and Pakistan, where a variety of such grains are available and where there are animals with a high potential.

Many of them, however, import feed ingredients and it is expected that these imports will increase. At present, the only country that can source all its ingredients within itself is India. All other countries import maize and soybean meal (SBM) as well as their substitutes from a range of countries both within and outside the region. Some examples are shown below.

Imports of feed ingredients

Bangladesh	Maize, SBM, rice bran and sesame cake.
Nepal	Maize, mustard cake, finger millet, SBM, sesame cake and groundnut cake.
Pakistan	Maize, SBM and other oilcakes.
Sri Lanka	Maize and SBM.

In addition, all countries including India, import premixes with micronutrients and some fish meal.

Constraints to feed manufacturing in South Asian countries

Some of the difficulties faced by feed manufacturers in these countries have been identified as follows:

- Lack of a ready supply of ingredients at the desired quality.
- High prices and large seasonal variation in prices.
- Lack of infrastructure for minimal processing and storage.
- Lack of quality control standards.
- Lack of legislation for proper regulation in some countries.
- No proper marketing systems or networks for raw ingredients.

These constraints are not found in all countries since many of them are now developing good systems of feed regulation with the necessary legislative backing. In addition, the feed industry in the SA countries needs to be continuously upgraded by training technicians in modern methods of feed manufacture.

The timely availability of ingredients of a consistent quality at prices that do not vary considerably remains the primary need of the industry in order to meet the expanding demand for poultry and cattle feeds. Many manufacturers in the region faced with this problem prefer to import. What is needed is to ensure that both the manufacturer and the farmer benefit from the demand for animal feed. The main strategy, therefore, is to bridge the gap between the primary producer and the feed manufacturer with suitable structures and intermediaries who will attend to the following tasks:

- Purchase of raw material at farm gate at fair prices.
- Attend to immediate processing needs such as dehusking and drying.
- Ensure proper storage.
- Attend to any further processing required.
- Supply quality ingredients to feed manufacturers.

These different tasks may be carried out by one or several persons or organizations together with some infrastructure support. There should be forward contracts between the collector and the farmer on the one hand and the supplier of ingredients and the feed manufacturer on the other, to ensure a smooth flow of ingredients required by the feed industry.

Scope for expansion of feed crops

In a discussion of this nature, to identify the potential for and constraints against expansion of feed crops, it must be appreciated that these will be quite complex issues in a region so vast and varied as South Asia. It must also be remembered that the countries in the region are not equal either in their size or economies and that some countries will be dominant. This discussion will attempt, however, to identify some common issues. The discussion also needs to keep in mind the importance of using this opportunity to alleviate rural poverty in the region. This would mean the need to ensure the participation of smallholder farmers who cultivate marginal land under rainfed conditions and how they can participate in the supply of feed ingredients for the manufacture of animal feed.

Maize and soybean production in South Asia

Although there has been a 3 fold increase in maize production in the region since 1961, it remains a net importer of maize. Most of this increase has been in India and Pakistan where there has been a steady increase in production with a spurt in growth in the 1990s.

Table 12. Maize and soybean production in South Asian countries

	Production of maize (1,000 mt)					
	1961	1970	1980	1990	2000	Increase %
Bangladesh	7.0	3.0	1.5	3.5	4.0	57.1
India	4,300.0	7,500.0	9,300.0	9,400.0	16,000.0	372.1
Nepal	843.0	833.0	743.0	1,230.0	1,445.0	171.4
Pakistan	487.0	717.0	970.0	1,184.0	1,643.0	337.4
Sri Lanka	9.5	14.5	21.0	33.5	31.0	326.3
Total	5,646.5	9,067.5	1,1035.5	1,1851.0	19,123.0	338.67
India %	76.2	82.7	84.3	79.3	83.7	
	Production of soybean (1,000 mt)					
	1961	1970	1980	1990	2000	
Bangladesh	na	na	na	na	na	
India	5.0	14.0	442.0	2601.0	5085.0	101,700.0
Nepal	2.0	3.5	5.0	12.8	16.8	840.0
Pakistan	0.4	0.9	1.3	0.8	10.0	2,500.0
Sri Lanka	na	na	na	na	na	
Total	7.4	18.4	448.3	2614.6	5111.8	69,078.4
India %	67.6	76.1	98.6	99.5	99.5	

Source: FAO, 2002.

On the other hand, production has been stagnant in Sri Lanka and Bangladesh whilst Nepal has shown small increases. Overall production of maize remains low when compared to countries such as the USA, Brazil and China.

Production of soybean, which was negligible in India in 1960, has shown huge increases since then and India now produces considerable surpluses. Whilst modest increases in production have been shown by Nepal and Pakistan, there is no soybean grown in Sri Lanka or Bangladesh. India produces nearly all (99.5 per cent) of the soybean meal in the region and although overall production in the region is low when compared to the USA, China, Brazil and Argentina, the South Asian region as a whole, produces surpluses and is a net exporter.

Table 13. Trade in maize and soya

Trade in maize and soybean meal in South Asian countries Period: 1995 to 1997 cumulative (X 100 mt)					
	Maize Imports	Maize Exports		Soybean meal Imports	Exports
India	0	862	India	0	62,375
Nepal	50	0	Nepal	15	0
Pakistan	136	0	Pakistan	290	0
Sri Lanka	2,588	0	Sri Lanka	1,210	0
Bangladesh	122	0	Bangladesh	120	0

Source: FAO, 1997.

Chief exporters of maize in the world are countries such as the USA, Argentina and France which produce surpluses. Most other countries are net importers. In South Asia, all

countries other than Sri Lanka and Bangladesh are self-sufficient in maize with India exporting modest quantities. The country that imports most maize in the region is Sri Lanka and during the years 1995 to 1997, the region as a whole imported around 200,000 mt.

Of the 46 million tons of oilcakes traded worldwide, the majority (70 per cent) consists of soybean meal for animal feeding. The major exporters are USA, Argentina and Brazil who accounting for 85 per cent of exports. In the SA region, India is the major producer of soybean meal and all other countries import from India with Sri Lanka, once again, being the highest. During the period 1995 to 1997, the region was a net exporter of 6 million mt of soybean meal.

Soybean (meal)

In India, the huge demand for edible oils results in extensive cultivation of oilseeds which has resulted in surpluses of oilcakes including soybean meal. The trade in the oilcakes has in turn given an economic impetus to the oilseed industry. The overall production of oilcake is greater than the requirement for the region. Pakistan has also increased their production of soybean in recent years.

Soybean, from a technical point of view, is considered a relatively easy crop for farmers to grow successfully. Growing soybean as a feed crop in other countries of the region, Nepal, Sri Lanka and Bangladesh, however, will be faced with several difficulties:

- Soya will only be viable as a feed crop if an oil-extracting industry is already in place as in India and Pakistan, and if there is a ready market for this oil.
- If there is no oil-extracting industry, farmers prefer to grow other pulses as cash crops instead.
- The preferential trading agreements between South Asian countries and the bilateral free trade agreements between some will make it difficult to prevent the entry of cheaper SBM from India.

In any event, there appears to be no urgency for other countries in the region to grow soybean as a feed crop for animal feeding if considerable amounts are available for purchase from India. Cultivation of soybean may be viable in these other countries as a food crop provided again that the necessary facilities to process soybean seed are in place.

Other oilcakes from CGPRT crops

Groundnut and sesame are the other two high-protein oilcakes that can be used for poultry feeding although they can only partly substitute SBM. Limited amounts of these oilcakes are already available in most countries of the region to meet this partial substitution. Again, these crops are driven by the demand for the oil rather than the by-product and it is not feasible to promote them as feed crops alone.

The dairy industry is able to use a variety of oilcakes with lower levels of protein and higher concentrations of fiber than poultry. These include cotton seed cake and coconut cake which are used widely in ruminant rations.

Maize and other coarse cereals

The increase in demand for feed grains in the region will have to be met by increasing the production of maize and other coarse cereals and by making them available to the feed industry in sufficient quantities with acceptable quality. If not, projections are that by 2010, all countries in the region including India, will need to resort to large-scale imports. This situation should be seen as a great opportunity, which if exploited, will also provide a steady long-term income for poor, rural farmers. There is also a renewed interest in these cereals among people

looking for high-fiber, unprocessed cereals for health reasons. Governments should, therefore, accord some priority to these crops as, in the past, they have not been given the same degree of support as rice and wheat.

In developed countries, coarse cereals are the main source of energy in animal feeds. In Australia, for example, more than two thirds of the cereals fed to animals consist of barley, sorghum and maize with wheat and milling products providing only a third. In this country, 4,000 out of a total of 6,000 kilotons of feed grain were fed to dairy and beef cattle. In South Asia, the practice of feeding grain to dairy cattle has only started recently and is fed in relatively small amounts. This proportion may need to increase, however, if the animals produced from the numerous breed improvement programs are to perform optimally. Whereas maize is the preferred grain for poultry feeding, other coarse grains such as sorghum and millets could be targeted to the dairy industry in South Asia.

In South Asian countries, unlike in developed ones, coarse cereals are used primarily as food for human consumption, usually by the poorer section of society. According to Indian Government targets, 90 per cent of the coarse cereal production should be used for human food, with 5 per cent as animal feed and 5 per cent for seed. The demand for cereals from the fast growing poultry industry has resulted in this limit already being exceeded, however, and it is estimated that up to 20 per cent of the maize produced is used for animal feed. Estimates for other coarse cereals are pearl millet 50 per cent, barley, sorghum and minor millets 10 per cent.

Maize is the preferred cereal for modern poultry feeds, particularly the broiler feeds, for a number of technical reasons. There are limits to the levels at which all other coarse cereals can be included in such feeds. The rapid growth of the poultry meat sector is therefore placing an immediate demand for maize which has to be accorded a special place in any plans for increasing feed grains.

In India, the coarse grains cultivated include maize (35 per cent), sorghum (29 per cent), pearl millet (bajra, 19 per cent), barley, finger millet (ragi) and several "minor" millets (little millet, kodo millet, foxtail millet, barnyard millet, proso millet and savan millet). The area under these crops has shown a steady decline over the past decade with the exception of maize, which has increased. In the case of maize, area and production are expected to increase from 6.5 million ha and 11.9 million tons to 7.5 million ha and 17.7 million tons respectively by the year 2010. All other coarse grains have shown a decline and although the productivity has increased due to improved germplasm and technology, the overall yield is expected to stagnate up to 2010 for millets and to decline in the case of sorghum and barley.

These coarse cereals are presently grown in the region by the poorer farmers under rainfed conditions on relatively infertile land and as a result, yields are low, they are rarely grown on good land under irrigation. For this reason, the yields are less than half when compared to those in other parts of the world. When new areas of land come under irrigation with new schemes, this new land is used for rice and wheat and other cash crops including oilseeds and the coarse cereals are then pushed out to even more infertile areas. Some of the general constraints to expansion of coarse cereals in India are listed below.

- Lack of high-yielding, improved varieties; low priority for development.
- Primitive farming practices; need to optimize cropping mixtures.
- Feed crops grown under rainfed conditions are subject to the vagaries of the weather and poor soil fertility; only maize is grown on productive lands.
- Poorly developed markets and support prices; there is a need for market intervention mechanisms to ensure firmness in market prices on par with rice, wheat, pulses, oilseeds and cotton.
- Prices of coarse cereals vary much more than wheat, rice and oilseeds.

- Apart from millets, Indian prices of coarse cereals were higher than International prices.

These observations appear valid for other countries in the region as well.

Sorghum

It is felt that particular attention should be paid to increase the production of sorghum which is considered the most important cereal crop for poor farmers and can be cultivated under poorer soil and rainfall conditions. It can also be used in dairy feeds, to partially substitute maize in poultry feeds and for industrial purposes. In India, 9 million tons were produced in 1960 on 18 million ha of land but this has declined at present to 8.3 million tons on 10 million ha. In addition, although the winter (Rabi) yields are lower, the proportion grown in this season has increased since farmers prefer to use the land for more profitable crops such as oil seeds, pulses and cotton in the summer.

Some of the proposals to increase the production of sorghum in India include the following:

- Introduce summer dual-purpose varieties.
- Introduce intercropping with high value crops.
- Cultivate in fallow rice fields.
- Use of hybrid seed technology to increase yields.
- Use of winter cropping under irrigation.
- Farmer education to optimize yields.

Maize

Maize is the preferred cereal in poultry rations throughout the world and is used at levels of around 40 per cent in modern poultry feeds. Global maize demand is increasing fast and may even exceed those for rice or wheat. Unless maize production is increased significantly, countries in the region will be importing large quantities by the end of the decade. At present, Sri Lanka, Nepal and Bangladesh import maize from a number of countries. Present requirements are sourced locally in India and Pakistan.

In India, 13.5 million tons of maize were produced on 6.5 million ha in 2001. The yields are low (1.8 tons per ha) when compared to yields obtained elsewhere (8 tons/ha in the US). Despite this, when compared to other coarse grains, maize accounts for 40 per cent of the coarse grains in India on 25 per cent of the land and is the most efficient.

The challenge then is to increase yields on the available land. Maize is ideally grown under irrigation, when greater yields can be expected. However, it is likely that in the case of irrigated land, priority will be given to food crops. The main focus, therefore, should be on problems relating to the production of maize under rainfed conditions and how to overcome them. Solutions to these problems will benefit resource-poor farmers and ensure their participation in maize production for animal feeding. Some of the proposals to increase maize production in India include the following:

- Maize to be given a “special” status for strategic development.
- Provide a support price together with a food subsidy similar to those for rice.
- Promote the development and use of hybrid maize and high protein maize.
- Fast track seed production to ensure quality seeds.
- The Indian Maize Development Association should encourage contracted farming for maize linked to exports and value-added products.
- Upgrade and renovate processing plants.

In Nepal, maize is included in around 40 per cent of poultry rations. Maize is grown mostly on hill farms as a subsistence crop under rainfed conditions. The area under maize was not related to prices since it is a subsistence crop. Yield is low and stagnant. Moreover, the feed mills are not located close to the maize growers. Since the poultry feed manufacturers are interested in quality, their maize requirement was largely imported from India. The overall maize requirement was estimated at 210,000 tons in 1999 increasing to 342,000 tons by 2010. The challenge in Nepal is to increase the yields of the small maize farmers and to link them to the feed mills. The latter can be affected, as in other countries, by promoting research and development of varieties, promoting forward contracting and improving infrastructure for storage, processing and transport. It may also be necessary to grow winter maize in the Tarai even at the expense of food crops that are presently being exported.

In Sri Lanka, a rapid expansion of the poultry industry has led to greatly increased demands for feed grains in the last two decades. This situation is set to further expand in the future. Locally grown maize is available for animal feeding but not any other coarse cereals. The quantity of local maize however, is woefully inadequate to meet the food and feed requirements and at present, Sri Lanka imports 80 per cent of its maize requirement for animal feeding. After considering factors such as international maize prices, the availability of (irrigable) land and planting material, it has been concluded that Sri Lanka will not be able to grow the maize required for both food and feed by the year 2010. Since there are no other suitable substitutes, she will have no option but to import. However, present levels of production can be increased to optimum levels by taking some measures such as those shown below:

- Implementation of enlightened policies that are consistent and will allow a suitable balance between imports for the feed manufacturers and the interests of local maize farmers.
- Provision of good-quality seeds of high-yielding varieties.
- Implementation of a technology package suitable for each season and pre-determined levels of production.
- Use of fallow, well-drained paddy fields for maize cultivation.
- Use of irrigated paddy fields in the dry season where there is sufficient moisture for maize but not paddy.
- Farmer education on production of quality grain and linking prices to it.
- Forward sales contracts with groups of farmers for growing maize.
- Maize cultivation by the private or NGO sector on a large scale.
- Improve infrastructure for minimum processing, drying and storage.

Some of the common issues that need to be addressed in order to increase yields of coarse cereals in India have been identified as follows:

- Provision of appropriate high-yielding varieties suitable for soil and moisture conditions; use of hybrid-seed technology.
- Proper cultural practices in planting, fertilizing, weed control and thinning.
- Irrigation at critical stages of water stress.
- Educate and make farmers aware of the need for quality grain.
- Appropriate arrangements to purchase produce at farm gate at fair prices, to carry out minimum processing, storing and supplying feed mills.

Overall, India feels that the potential to increase production of coarse cereals to meet the increasing demands for food and feed can be achieved. This can be done with maize and

sorghum alone provided the necessary recognition and patronage is given for these crops. The efforts have to be supported by research and development. It is also felt that access to export markets will greatly stimulate the coarse cereals sector. Such exports are feasible within the region as other SA countries will face deficits of feed grains.

Cassava

Cassava is grown throughout the region for human consumption and although India is one of the largest producers, it has not been developed to the extent found in South East Asian countries. Its great advantage over grains is that the production of energy (starch) per ha is almost double. Compared to grains, however, it has several disadvantages being low in protein and other nutrients, the content of anti-nutritional substances, notably HCN, and fiber. These do not preclude its use in ruminant or even monogastric feeding. However, although numerous experiments have shown its potential as an animal feed, including its use as a substitute for maize, it is not fed to animals in any of the South Asian countries.

Thailand presents an outstanding example of the use of cassava as an energy source in animal feeds. This development has been fuelled, however, by a demand for cassava chips in Europe which grew into a lucrative export market. To meet this need, Thailand developed an agro-industrial infrastructure consisting of chipping yards, pellet factories, dockside warehouses and established a market network throughout the country. The area under cultivation increased dramatically once pelleting was introduced. Nothing similar to these facilities are presently available in South Asia.

Sri Lanka, a tropical Island with humid conditions is similar to countries in South East Asia and probably has the best conditions for growing cassava in the region. The crop has always been grown on smallholdings and fetches a good price as a food item in rural areas. Recently, opportunities have opened up to export fresh tubers to expatriate Sri Lankan workers. Under these conditions there is little available for animal feeding. Other constraints to its use as animal feed include the following:

- Lack of suitable processing technologies and facilities.
- Preference for other energy sources.
- High demand (and prices) for fresh tubers as food.
- Demand from industry.
- Seasonality and length of the crop.

For these reasons, cassava is not used as an animal feed at present. However, with the demand for feed energy increasing, if the availability of other sources is for some reason compromised, cassava will have advantages in the humid and sub-humid zones of the region. Some of the inputs needed would be State patronage, development of suitable varieties, correct cultural practices among farmers and suitable incentives for investment in processing. Above all, to make cassava a viable crop, production and processing will have to be integrated into a strategy that is compatible with that of small-scale producers.

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Closing Remarks

Kiran Pyakuryal[*]

First of all, I would like to thank the director Dr. Maeno and Dr. Budi for kindly inviting me to participate in this important regional workshop. They have been quite educative and informative sessions yesterday and today.

In the workshops, we had four country research papers, one Thai case study on cassava development and two regional synthesis and background papers. These presentations have added significantly to the knowledge about the nature, direction and technical difficulties faced to balance supply and demand of feed crops in the South Asian Countries. The studies have added value, not only for the policy framers of these countries but also, for future researchers in this field. The regional synthesis papers have also added value by comparing the conditions in the various countries thus helping to promote complimentarity and cooperation among the South Asian Countries.

The studies have reiterated, in no uncertain terms, that there is indeed a strong rising trend in the demand of livestock products in these countries. Hence, the demand for animal feed is likely to rise in all the South Asian Countries in future. In that respect, this initiative of the CGPRT Centre is timely. So far as meeting the rising demand for feed crops is concerned, there are two well-established options to each country. Whether to provide incentives to produce within the country and be self-reliant in the traditional sense or to ensure supply from outside. These two options have trade offs and there is no single or uniform solution to all the countries that have been studied. The selection of options has to be based primarily on the comparative advantage and national food security policy. Neither option is full of merits and/or demerits. In the comparative analysis, the need and potential of regional cooperation is evident. Of course regional cooperation requires both economic complimentarity and political willingness. At the moment the latter seems to be lacking.

As I said earlier, the deliberations of the past one and half days were quite educative. Some very interesting issues have been brought up and discussed which require further attention by the policy makers in charting courses of action of feed development in the South Asian region. I would like to sum up the issues as following:

a. The issue of feed production, maize and soybean in particular, were discussed extensively in the context of land productivity alone. However, it was not examined as an integral part of rural household income. Perhaps some parts of the studies need to be reoriented to examine rural household income, as they are affected by feed crops.
b. The influence and impact of the Word Trade Organization (WTO) was discussed. The discussion appeared to be giving unbalanced emphasis to the WTO. Perhaps there are many steps the countries can themselves take to improve, without giving due consideration to the impacts of the WTO.
c. The role of the Indian economy on the neighbouring countries was discussed. I think this is quite legitimate and there is indeed room to develop backward and forward linkages with the Indian economy. In Particular, the close economic linkage between Indian and Nepalese economies is well acknowledged.

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d. The issue of market led growth was mentioned in the papers. I thought it did not receive as much attention as it deserved. After all, the market is the single largest factor to determine the production and income of the farmers.
e. All the studies have used the project management tool SWOT (Strengths, Weaknesses, Opportunities and Threats). If this tool is also attempted at the regional level it may add further value to the end result.
f. It was obvious from the studies that the demand for feed is primarily led by a substantial increase in poultry farming and consumption. Future feed policies need to give due attention to this reality.
g. The issue of public-private partnership is evident in the feed sector. I think it will increase further.
h. Last but not least are the issues of small farmers, rural poverty and overall national food security. These are important issues because there is competition at the farm level, which crops to grow to maximize the micro and macro benefits.

Finally I like to extend my thanks to the Centre and the researchers for their pioneering work.

Appendices

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Appendix 1 The Analytical Model for Maize Demand and Supply for Nepal

The model consists of five basic components, which explains the behavior of producers and consumers in the national market. The behavioral equations in the model are acreage function, yield equation, maize demand for food, maize demand for feed and maize demand for other uses. The model is completed by introducing a market clearing identity of maize supply to equal demand for maize for food, for feed, and for other uses. The assumptions are that net exports and net imports are insignificant and that domestic production reasonably represents the total supply of maize in the country, which is consumed in different uses. Prices of food crops in the country are very much determined by bordering Indian market prices, and therefore, the price variable is taken here as exogenous.

The model consists of six endogenous variables, two lagged endogenous variables and eight exogenous variables. The empirical model is specified as follows:

a. Acreage Function

$$LnMAH_t = A_0 + A_1 Ln\left(MPP_{t-1} / RPP_{t-1}\right) + A_2 LnMAH_{t-1}$$

b. Yield Function

$$LnMYD_t = B_0 + B_1 Ln\left(UPP_{t-1} / MPP_{t-1}\right) + B_2 LnMYD_{t-1} + B_3 LnT$$

c. Maize Demand for Food

$$LnMFOOD_t = D_0 + D_1 Ln\left(MPP_t / RPP_t\right) + D2LnPCI_1 + D_3 LnT$$

d. Maize Demand for Feed

$$LnMFEED_t = E_0 + E_1 Ln\left(MPP_t / RPP_t\right) + E_1 LnMPRD_t + E_2 LnMFOOD_t$$

e. Maize Demand for Other Uses

$$LnMOTHR_t = F_0 + F_1\left(MFOOD_t + MFEED_t\right) + F_2 LnMAH_t$$

f. Market Clearing Identity (production of maize equals consumption)

$$MAH_t \text{ x} MYD_t = MFOOD_t + MFEED_t + MOTHR_t$$

Definition of variables

MAH = Maize area in hectares.
MYD = Maize yield in mt per hectare.
MPP/RPP = Relative price of maize to rice.
UPP/MPP = Relative price of urea to maize.
MPP = Maize retail price in Rs per mt.
RPP = Paddy wholesale price in Rs per mt.
UPP = Urea price in Rs per mt.
T = Trend (1979 = 1).

MFOOD = Maize demand for food in mt.
MFEED = Maize demand for feed in mt.
MOTHR = Maize demand for other uses in mt.
EPRD = Egg Production (in '000)
MPRD = Milk production (in '000 lt)
Ln = Natural Log
PCI = Per Capita real GDP

Estimation of the equations in the model

1. Maize acreage

$$\text{LNMAHt} = A_0 + A_1 \text{Ln}\left(\text{MPP}_{t-1} / \text{RPP}_{t-1}\right) + A_2 \text{LnMAH}_{t-1}$$

Estimation method: OLS
Number of observations: 20 (1980-1999)

Table 1. Maize acreage function

Coefficients	Estimates	t-statistics
A_0	0.170596	0.15
A_1	-0.037483	-0.91
A_2	0.988338	11.39

R-squared = 0.89; Adjusted R-squared = 0.88;
D-W statistics = 2.64; DURBIN h = 1.55 (Table value = 1.75).

The acreage function in (1) is the Nerlovian type where area under maize is regressed as a function of the lagged area, and lagged relative price of maize to its competing crop, i.e. rice. The partial adjustment hypothesis is consistent with the economy where there are rigidities that prevent complete adjustment in each period.

The estimated function (Table 1) explains 89 per cent of the variations in maize area, and h-statistics indicate the estimated function is free from autocorrelation.

The estimates of the function, provide that area under maize is mainly based on the previous years' area under the crop. Further, the cropped area is found to be not dependent on relative price of the crop as the value of coefficient for the variable (MPPt-1 /RPP t-1) is quite low and negative, but not statistically significant. These results are consistent with a subsistence economy under which maize is being cultivated in the country.

2. Maize yield

$$\text{LnMYD}_t = B_0 + B_1 \text{Ln}\left(\text{UPP}_{t-1} / \text{MPP}_{t-1}\right) + B_2 \text{LnMYD}_{t-1} B_3 \text{LnT}$$

Estimation method: OLS
Number of observations: 20 (1980-1999)

Table 2. Maize yield function

Coefficients	Estimates	t-statistics
B_0	0.338605	5.65
B_1	-0.354326	-4.88
B_2	0.542756	3.97
B_3	-0.068262	-3.18

R-squared = 0.81; Adjusted R-squared = 0.78;
D-W statistics = 2.27; DURBIN h = 0.78 (Table value = 1.76).

The estimated function (Table 2) explains 81 per cent of the variations in maize yield, and h-statistics indicate the estimated function is free from autocorrelation.

The estimated coefficient of trend variable is small and negative, suggesting stagnation in maize yields during the period under consideration. Although there have been increases in area covered by improved varieties of maize over time, 34.4 per cent in 1980/81, 50 per cent in 1990/91 and 65 per cent in 2000/01, this has not been duly reflected in the yield of the crop. This indicates that there could be a problem in the supply of other inputs, such as irrigation, fertilizer, etc.

Yield is found to be responsive to price of urea relative to that of maize. The result indicates that a decrease in relative price of urea would lead to an increase in the use of the fertilizer, and consequently an increase in yield.

3. Maize demand for food

$$\mathrm{LnMFOOD}_t = C_0 + C_1 \mathrm{Ln}\left(\mathrm{MPP}_t / \mathrm{RPP}_t\right) + C_2 \mathrm{LnPCI}_t + C_3 \mathrm{LnT}$$

Estimation method: OLS
Number of observations: 20 (1980-1999)

Table 3. Maize demand for food

Coefficients	Estimates	t-statistics
C_0	11.86746	40.38
C_1	-0.073276	-0.38
C_2	0.255591	5.64
C_3	-0.164022	-3.41

R-squared = 0.80; Adjusted R-squared = 0.76;
D-W statistics = 1.78.

The estimated function (Table 3) explains 80 per cent of the variations in maize yield and d-statistics indicate the estimated function is free from autocorrelation.

The price response to demand for maize used for food purposes is, as expected negative and small (-0.07), but not statistically significant. The main factor influencing food demand for maize comes from an increase in the income of the people. The results show that an increase of one per cent in income would lead to a corresponding increase of 0.26 per cent in maize demand for food. Further, the negative coefficient for trend in maize demand for food indicates that there is a declining trend in growth of maize consumption over time. This could have been due to an increase in rice being supplied to the hills with increased transport access.

4. Maize demand for feed

$$LnMFEED_t = D_0 + D_1 Ln\left(MPP_t / RPP_t\right) + D_2 LnMPRD_t + D_3 LnEPRD_t + D_4 LnMFOOD_t$$

Estimation method: TSLS
List of Instruments: C, MAH(-1), MYD(-1), MPP(-1)/RPP(-1), UPP(-1)/MPP(-1), PCI, MPRD, EPRD, and T
Number of observations: 20 (1980-1999)

Table 4. Maize demand for feed

Coefficients	Estimates	t-statistics
D_0	-1.341689	-1.04
D_1	0.304587	1.15
D_2	1.247187	6.01
D_3	-0.023585	-2.27
D_3	-0.254086	-1.40

R-squared = 0.93; Adjusted R-squared = 0.92;
D-W statistics = 1.84.

The estimated function (Table 4) explains 93 per cent of the variations in maize yield and d-statistics indicate the estimated function is free from autocorrelation.

The results show that the main factor influencing demand of maize for feed is livestock and poultry production in the country. About 20 per cent of maize production is reported to be utilized by the farmers to feed their animal stocks. The estimates of coefficients very well provide a quantitative explanation for the pattern of maize consumption as feed in the country. A one per cent increase in milk production is found to have affected a corresponding 1.25 per cent increase in maize demand for feed. Whereas, an increase in production of eggs by one per cent results in a corresponding decline of maize demand for feed at the household level. This is because, the increase in commercial feed production to be supplied to the poultry industry may require an increase in sales of maize by the farmers. The estimate of coefficient shows that a one per cent increase in egg production would lead to 0.02 per cent reduction in maize demand for feed used at the household level.

The results indicate that maize demand for feed does not decline with an increase in prices, but the coefficient estimated is not statistically significant. Processing industries are not in a position to maintain stock and have to purchase from India even if the prices are increased for maize. Similarly, maize demand for feed is found to be inversely related to its demand for food, but this again is not statistically significant.

5. Maize demand for other uses

$$LnMOTHR_t = E_0 + E_1 Ln\left(MFOOD_t + MFEED\right) + E_2 LnMMAH_t$$

Estimation method: TSLS
List of Instruments: C, MAH(-1), MYD(-1), MPP(-1)/RPP(-1), UPP(-1)/MPP(-1), PCI, MPRD, EPRD, and T
Number of observations: 20 (1980-1999)

Table 5. Maize Demand for Other Uses

Coefficients	Estimates	t-statistics
E_0	-2.053472	-0.96
E_1	0.894226	12.19
E_2	0.110191	0.50

R-squared = 0.98; Adjusted R-squared = 0.98;
D-W statistics = 2.31.

The estimated function (Table 5) explains 98 per cent of the variations in maize yield, and d-statistics indicate the estimated function is free from autocorrelation.

A one per cent increase in maize demand for food and feed would result in a corresponding increase of 0.89 per cent in maize demand for other uses. Maize demand for other uses could be for seed and beverage production, and for sale. However, the amount of maize kept for seed may be so small that it does not have a significant effect in influencing maize demand for other uses.

The analytical model for soybean

The model consists of two basic components, which explains the behavior of producers and consumers in the national market. The behavioral equations in the model are – supply function and demand function. The model is completed by introducing a market clearing identity of soybean supply to equal demand for soybean as a food grain. The assumptions are that net export or net import is insignificant and that domestic production (i.e. area x yield) reasonably represents the total supply of soybean in the country, which is consumed in different uses. Prices of food crops in the country are very much determined by bordering Indian market prices, and therefore, the price variable is taken here as exogenous. Due to data limitation, a sample size of only 12 years could be considered.

The model consists of three endogenous variables, one lagged endogenous variable and two exogenous variables. The empirical model is specified as follows:

g. Supply Function

$$\mathrm{LnSPRD}_t = A_0 + A_1\mathrm{Ln}\left(\mathrm{SPP}_{t-1}/\mathrm{CPI}_{t-1}\right) + \mathrm{A2LnSPRD}_{t-1}$$

h. Demand Function

$$\mathrm{LnSCON}_t = D_0 + D_1\mathrm{Ln}\left(\mathrm{PCI}_t\right) + D_2\mathrm{Ln}\left(\mathrm{SPP}_t/\mathrm{CPI}_t\right)$$

i. Market Clearing Identity (production of maize equals consumption)

$$\mathrm{SPRD}_t = \mathrm{SCON}_t$$

Definition of variables

SPRD = Soybean production in mt.
SPP/CPI = Soybean real price (deflated by consumer price index) in Rs per mt.
SCON = Soybean consumption in mt.
PCI = Per capita real GDP
SPP = Soybean wholesale price in Rs per m ton
CPI = Consumer price index

Estimation of the equations in the model

1. Soybean production

$$\mathrm{LnSPRD}_t = A_0 + A_1\mathrm{Ln}\left(\mathrm{SPRD}_{t-1}\right) + \mathrm{A2Ln}\left(\mathrm{SPP}_{t-1}/\mathrm{CPI}_{t-1}\right)$$

Estimation method: OLS

Number of observations: 12 (1988-1999)

Table 6. Soybean supply function

Coefficients	Estimates	t-statistics
A_0	1.478176	0.77
A_1	0.894720	3.91
A_2	-0.090257	-0.91

R-squared = 0.67; Adjusted R-squared = 0.60;
D-W statistics = 2.17; DURBIN h = 0.48 (Table value = 1.645).

The supply function in (Table 6) is the Nerlovian type where production of soybean is regressed as a function of the lagged production and lagged real price of soybean (deflated by the consumer price index). The partial adjustment hypothesis is consistent with an economy where there are rigidities that prevent complete adjustment in each period.

The estimated function (Table 6) explains 67 per cent of the variations in soybean production, and d-statistics indicate the estimated function is free from autocorrelation. Although the estimated d is rather small, the conclusion should be taken cautiously in view of the smallness of the sample.

The estimated function provides that soybean production in the current year is mainly based on the previous year's production. Further, production of the crop is found to be not dependent on its price. The coefficient corresponding to price is quite low and negative, but not statistically significant. The results are consistent with a subsistence economy under which soybean is produced in the country.

2. Soybean demand

$$\mathrm{LnSCON}_t = C_0 + C_1 \mathrm{Ln}\left(\mathrm{PCI}_t\right) + C_2 \mathrm{Ln}\left(\mathrm{SPP}_t / \mathrm{CPI}_t\right)$$

Estimation method: OLS
Number of observations: 12 (1988-1999)

Table 7. Soybean demand

Coefficients	Estimates	t-statistics
C_0	7.693485	6.28
C_1	0.463662	2.83
C_2	-0.491219	-1.29

R-squared = 0.34; Adjusted R-squared = 0.19;
D-W statistics = 1.94.

The estimated function (Table 7) explains 19 per cent of the variations in soybean demand, and d-statistics indicate the estimated function is free from autocorrelation.

The main factor influencing the demand for soybean is found to be the income level of the people. The results show that an increase of one per cent in income would lead to a corresponding increase of 0.46 per cent in soybean demand. The price response to demand for soybean is as expected, negative and quite high, but the coefficient is not found to be statistically significant. The coefficient of –0.49 per cent for price is quite high compared to –0.07 per cent estimated for maize. This shows that soybean demand could be highly responsive to price, as compared to cereal grains, like maize.

Projections (2000 to 2020)

The parameters estimated for the model have been used to project some variables. Some assumptions are also made. The relative price of maize to rice is taken to be constant at 1.15 for the whole projection period. Similarly, relative price of urea to maize is also taken as constant at 0.85. The per capita annual income in real terms is assumed to grow by 2.5 per cent during the period. Egg production and milk production, which are the major sources leading to demand for feed, are taken to maintain their growth for the period 1990-1999, i.e. 3.13 per cent for eggs, and 2.89 per cent for milk. The projections are presented in the data table below.

Maize production is projected to increase from 1,488,000 mt in 2001 to 1,942,000 mt in 2010. Soybean production is projected to increase from 17,301 mt to 24,872 mt in the period of 2001-2010.

Data sheet (1987 to 1999)

Year	SAH	SYD	SPRD	SPP	CPI	PCI	Projection of Soybean
1987	18,690	538	10,060	2700	50.2	4,271	16,880
1988	20,710	564	11,680	3870	53.6	4,885	
1989	20,660	621	12,840	6090	54.8	5,533	
1990	21,340	597	12,730	10,820	58.3	6,281	
1991	19,690	580	11,430	10,600	77.2	7,660	
1992	20,220	581	11,750	12,510	82.0	8,545	
1993	19,150	586	11,213	12,100	85.5	9,675	
1994	21,543	654	14,090	14,490	92.1	10,369	
1995	20,770	660	13,710	15,260	100.0	11,553	
1996	20,980	687	14,420	16,560	109.1	12,722	
1997	21,245	731	15,533	18,190	112.5	13,365	
1998	23,046	773	17,820	20,280	133.5	14,876	

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Appendix 2 Programme

Regional workshop
The CGPRT Feed Crops Supply/Demand and Potential/ Constraints for their Expansion in South Asia
3-4 September 2002
Bogor, Indonesia

		Moderator
Tuesday, 3 September 2002		
08:30-09:00	Registration	
09:00-09:15	Opening address by: Dr. Nobuyoshi Maeno, Director, CGPRT Centre	
09:15-09:30	Framework of the project by: Dr. Budiman Hutabarat, Project Leader, CGPRT Centre	
09:30-10:00	*Tea/Coffee Break*	
10:00-11:00	Country report of India by: Dr. P.S. Pathak, National Expert Comment by Dr. Narsingh Narain Singh	Dr. S.S.E. Ranawana
11:00-12:00	Country report of Nepal by: Dr. Bekha L. Maharjan, National Expert Comment by Mr. Shambhu Bahadur Panday	
12:00-12:30	Morning session discussion	
12:30-13:30	*Lunch*	
13:30-14:30	Country report of Pakistan by: Dr. Abdul Ghaffar Khan, National Expert Comment by Dr. Abdul Majeed Haqqani	Dr. Budiman Hutabarat
14:30-14:45	*Tea/Coffee Break*	

14:45-15:45	Country report of Sri Lanka by: Mr. K.E. Karunatilake, National Expert Comment by Mr. H. Samaratunga	
15:45-16:15	Afternoon session discussion	
		Moderator

Wednesday, 4 September 2002

08:30-09:25	Invited paper: "Experience, expertise and recent advances in utilization of CGPRT crops as feed in Thailand" by: Mr. Uthai Kanto Department of Animal Science and Animal Nutrition Research and Development Center Kasetsart University, Kapaengsaen, Bangkok, Thailand	Dr. Nobuyoshi Maeno
09:25-10:20	Consolidated paper: "The CGPRT feed crops production and industrial potential/constraint in South Asian Countries" by: Dr. S.S.E. Ranawana, Regional Advisor University of Wayamba, Gonawila, Sri Lanka	
10:20-10:50	*Tea/Coffee Break*	
10:50-11:50	Plenary discussion	Mr. Kiran Pyakuryal
11:50-12:05	Closing address by: Mr. Kiran Pyakuryal, Chief, Rural Development Section PRUDD, ESCAP	
12:05-13:30	*Lunch*	

Appendix 3 List of Participants

Regional workshop
The CGPRT Feed Crops Supply/Demand and Potential/ Constraints for their Expansion in South Asia
3-4 September 2002
Bogor, Indonesia

Country/Institution	Name and address
NATIONAL EXPERTS	
1. **India**	**Dr. P.S. Pathak** Director Indian Grassland and Fodder Research Institute Jhansi – 284003, India Phone no. : (91-517) 730666 (O), 730333 ® Fax no. : (91-517) 730833 E-mail : "Dr. P.S. Pathak"pspathak@igfri.up.nic.in prempathak36@lycos.com
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