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Agricultural Price Policy for Ensuring Food Security in India

Praduman Kumar and Surabhi Mittal

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भारत में खाद्य सुरक्षा सुनिश्चित करने के लिए कृषि मूल्य नीति
Agricultural Price Policy for Ensuring Food Security in India

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Chairman's Message

Academic research can inform policy making. However, since each piece of research may cover certain aspects of an issue, a comprehensive review of research may help collate the findings that may lead to policy recommendations. Further, the research available may be often very technical and less communicative to the policy makers. NABARD commenced the "Research and Policy" series to commission review papers on various themes to bring research findings on a given theme in a capsule form.

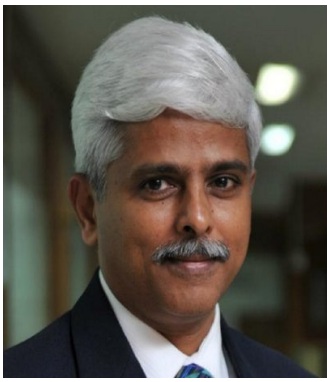
With this series, veteran scholars in different fields of specialisation have been requested to document research in their field highlighting various issues, policy relevance and prescriptions, and suggestions for future research. I am glad to present the paper on "Agricultural Price Policy" by Dr. Praduman Kumar who has been an authority on price policy and has lot of research on the subject to his credit. Dr. Surabhi Mittal has co-authored the paper.

The series will present more such authoritative papers on various issues ranging from climate change to agricultural policy in the coming months. I hope that series will be beneficial to academicians, researchers and policy makers for use at the ground level.

My best wishes to the authors and the Department of Economic Analysis and Research (DEAR) for initiating such wonderful series.

Dr. G. R. Chintala

Foreword



There is a vast body of research available on topics related to agriculture and rural development in the academic world. But, most of it is in the technical realm and not in a form which could feed into the policy. Research must first lead to better understanding of a subject and then into a robust policy, wherever it can, so that it touches the multitude of Indians across the length and breadth of our country through better public policy and efficient services. Discussion with my colleagues on this issue lead to this new series "Research & Policy". We wish that this series will provide the breadth & depth of research into an area topped up by a lucid presentation for the policy makers.

I am happy to present the first publication in this series on "Agriculture Price Policy" written by Dr. Praduman Kumar and Dr. Surabhi Mittal.

I wish this new series acts as a bridge between the researchers & policy makers.

P. V. S. Suryakumar
Deputy Managing Director

Preface

Agriculture sector proved a silver lining in the pandemic period registering a positive growth in the covid times. Yet it faces various structural challenges to be addressed to make it profitable. For, the majority of the population is still dependent on the sector. As we all know, investing in research is one of the best strategies to address problems of agriculture. Equally important is to communicate the research findings to policy makers to design and tweak policies that matter. During one of our meetings with Shri. P. V. S. Suryakumar, our DMD, we had loud thinking if we can commission a few review papers on a select themes. We thought that it is appropriate to request veteran scholars who spent prime of their life on a given research theme to attempt such a work where they will distil their understanding and the research done on the theme in a short paper. Duly encouraged by DMD and Chairman, we wrote to a dozen eminent scholars. And, the response was overwhelming resulting in Department of Economic Analysis and Research (DEAR), the research wing of NABARD, initiating the 'Research and Policy' series. The motivation is, thus, to get a few handles from research that can help effective policy intervention. This series will be definitely useful to policy makers and researchers alike.

The 'Research and Policy' series is an attempt to get a glimpse of hard core research findings in a capsule form thereby making it more effective and communicative to policy makers. The group of researchers who agreed to prepare a review of research have spent their life in the field of agricultural research. Our purpose here, as we communicated to them, was not just to get literature survey but to get researcher's heart and their experience which they gained during their long passionate innings. The paper is expected to highlight various issues, policy relevance, prescription, and suggestion for future papers on the themes of interest to NABARD.

The present paper on Agricultural Price Policy is written by Dr. Praduman Kumar, Former Professor and Head, Division of Agricultural Economics, Indian Agricultural Research Institute, New Delhi and had spent his career researching and teaching price policy. Most of us are fortunate to have benefited from his teaching. The pa-

per is co-authored by Dr. Surabhi Mittal, an accomplished Agricultural Economist of international standing.

This paper charted out how the objective of price policy has been changing over the decades. The agricultural price policies were formulated to meet the food needs (in 1960s), as a risk insurance to cover fluctuations, to influence the cropping pattern and to respond to international prices and trade requirements (mid-1980s), to help improve the targeting of India's large food subsidy outlays and decentralise public foodgrain operations (mid-1990s), and to provide MSP as a remunerative price, and not just a price that provide a safeguard against market fluctuations (since early 2000). An effective MSP programme is essential to protect the welfare of farmers. The authors have rightly covered various aspects such as domestic and international demand, climate change, technical change, link between factor-product prices, as price policy cannot be pursued in isolation. Overall, the paper is a treat to the readers.

In bringing this series as planned, I would like to express our sincere gratitude to Dr. G. R. Chintala, Chairman, NABARD for his inspiring leadership, unstinted support and guidance. We also wish to express our sincere thanks to Shri. P. V. S. Suryakumar, DMD, for being the inspiration and the driving force behind the publication of this first of its kind series. We are grateful to the authors of this series who agreed to write on themes relevant to NABARD in such a short period of time. Indeed, it has been a great privilege for us.

I also acknowledge the contributions of the officers of DEAR, NABARD especially Dr. Ashutosh Kumar, DGM; Mrs. Geeta Acharya, Manager; Ms. Neha Gupta, Shri. Vinay Jadhav, Asst. Managers and others who coordinated with the authors and the editor to bring out the series as envisaged.

Thanks are due to Dr. J. Dennis Rajakumar, Director, EPWRF and his team for their contribution in copy editing and bringing uniformity to the document.

Wishing a very Happy New Year and great years ahead.

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Acknowledgement

We are thankful to the National Bank for Agriculture and Rural Development (NABARD) for giving us the opportunity to develop this policy paper on agricultural price policies. We are highly indebted to Dr. K. J. Satyasai, Chief General Manager, Department of Economic Analysis and Research, NABARD, for his keen interest in the study and guidance. We are indebted to Dr. P. K. Joshi for his suggestions. A work of this nature cannot be undertaken without consulting the publications of various organisations involved in policy research relevant to the theme of this study. In this context, we would like to express our sincere thanks to the Directorate of Economics and Statistics (DES), the Directorate of Marketing and Inspection (DMI), the Agricultural Produce Marketing Committee (APMC), the Commission on Agricultural Costs and Prices (CACP) and National Sample Survey Office (NSSO) for providing useful information for this study. We have benefited greatly from the writings of Prof. S. S. Acharya, Dr. Ramesh Chand, Dr. S. Mahendra Dev, Dr. T. Haque, Prof. V. S. Vyas and Dr. V. M. Rao. This policy paper is drawn from the published and un-published works of the authors.

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(Contd....)

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Abbreviations

APC	Agricultural Prices Commission
APMC	Agricultural Produce Marketing Committee
DES	Directorate of Economics and Statistics
CACP	Commission on Agricultural Costs and Prices
DMI	Directorate of Marketing and Inspection
FHP	Farm Harvest Price
FCDS	Food Characteristic Demand System
FCI	Food Corporation of India
MSP	Minimum Support Price
eNAM	National Agriculture Market
NABARD	National Bank for Agriculture and Rural Development
NITI	National Institution for Transforming India
NSSO	National Sample Survey Office
PDPS	Price Deficiency Payment Scheme
PDS	Public Distribution System
TPDS	Targeted Public Distribution System
TFPG	Total Factor Productivity Growth
WTO	World Trade Organization

Executive Summary

Policy makers face the challenge of formulating suitable agricultural policy by which food security could be achieved. Price policy is an important instrument to accelerate adoption of technology, and thereby secure higher growth in agricultural sector. To formulate an effective price policy for food-security, it is indispensable to understand the degree of responsiveness of input demand and crop output supply to input-output prices and technological changes. A better understanding of demand elasticities helps to predict future demand for food and non-food commodities under different scenarios of demand shifters. Besides subsidies and price controls, the central government aims to provide remunerative prices to the farmers so as to enhance production and meet the objective of food security in the country.

This study reviews agricultural price policy in India with a due focus on how the price policy has evolved over time, the underlying rationale for price policy formulation, the institutionalisation of price policy, the issues and challenges in price policy implementation and the recent new initiatives of the government. The study presents empirical evidences of factors that impact prices and discusses price determination models that can guide policy makers for fixing crop prices. Demand and supply models are used to estimate food demand and supply elasticities. These elasticities are used to forecast the dynamics of food demand and supply to assess the status of food security.

The primary goal of agricultural price policy is to make food available to all at reasonable prices and to increase food production. The agricultural price policy has three components, namely, minimum support price (MSP), buffer stocks and public distribution system (PDS), which are interconnected. Procurement by the government at MSP for major crops is for the dual purpose of maintaining buffer stocks of foodgrains and its distribution through PDS. The MSP is the key instrument used for setting the agricultural prices.

In the 1960s, the agricultural price policies were formulated with the objective of meeting the food requirements in the country. In the mid-1980s, the objective of the price policy shifted to ensure price as a risk insurance to cover fluctuations, to influence the cropping pattern and to respond to international prices and trade

requirements. In the mid-1990s, the government had implemented key changes in food grain policy with measures to improve the targeting of India's large food subsidy outlays and had begun to decentralise public food grain operations. Since the early 2000, the agricultural policy has started viewing MSP as a remunerative price, and not just a price that provide a safeguard against market fluctuations.

Overall, it is believed that agricultural price policy has been largely successful in providing reasonable level of margins over the total costs to the farmers for major cereals like rice and wheat. This has also encouraged farmers' investment in yield-enhancing technology to increase production and enable sufficient procurement for buffer stocks. Several scholars have also discussed the problems encountered in considering the cost of production for the purpose of determination of MSP. These studies argue that agricultural price policy is market distorting and inadequate to address the problems faced by the farmers, and creates economic inefficiency, increases subsidy burden on government and inhibits crop diversification.

Studies have shown that MSP policy has not played its intended role in the overall price policy. Thus, they have questioned if relying on the MSP as the remunerative prices is the right price policy for all farmers. If MSP is the intended remunerative price, then what should be done to make it an effective price that would have the desired effect on supply response and make most of the farmers to benefit from it? If not, what are the alternative mechanisms to ensure that farmers get the remunerative price? In recent times, new initiatives have been introduced either in terms of new MSP or new marketing models. The new MSP is 1.5 times the cost of production. There has been development and upgradation of 22,000 agricultural markets, known as Grameen Markets, to be linked to Agricultural Produce Market Committee (APMC) mandis, National Agriculture Market (eNAM) and Price Deficiency Payment Scheme (PDPS). The study also presents an analysis of how the farm harvest price (FHP) could also be seen as an effective price as it is based on domestic production, global prices and trade policies, and could be a better indicator of the price received by farmers. The new MSP is not uniformly different or higher than the existing MSP, and thus the anticipated income gains to the farmers might not be realised just by increasing the MSP as per the new formula. The yield differences across states for the same crop also led to differences in full realisation of benefits arising from the price increase. Along with announcing remunerative prices, it is equally important to create efficient

agriculture production by reducing cost of production and improving average yields. Overall, an effective MSP programme is essential to protect the welfare of farmers.

Among the factors that impact the prices, climate change has been found to have a negative effect on acreage, yield and production, leading to a rise in food prices and reduction in consumer demand. Input subsidy and technology are the important instruments for the agricultural development in the country. Input-price subsidy has a weak effect on commodity supply. It is technology that has a significant impact on food supply. Input subsidy to farmers and price subsidy to consumers would not be feasible in the long run as they involve a substantial share of public resources. Government's intervention would be necessary to ensure food and nutritional security of poor consumers and small landholders. This would require a strong social safety net programme for the targeted population, especially for the poor. In the long run, technological interventions would be necessary to mitigate the effect of drought, and therefore more research efforts and investment on alternative coping-mechanisms would be necessary to protect the poor from the drought impact.

The market surplus models indicate that the short run response of the marketed surplus to the changes in the terms of trade for agriculture is highly inelastic due to the dominance of subsistence consumption, and also movements along a given production function instead of response by technological change and horizontal expansion. The policy makers face the dilemma of choosing between marketed surplus and prices, and thus a viable solution cannot be found in the adjustment of price policy alone without an appropriate adjustment in non-price factors.

The price policy plays a crucial role in improving the pace of adoption of modern technology. We need a price policy model that can be used for fixing the prices for agricultural inputs and commodities. This study discusses models that measure the adjustments needed in producer price in relation to factor price inflation, infrastructure development and technological change in case of a single crop or system of crops.

To stabilize the production and net income of farmers, there is a need to adjust the product price in relation to factor prices, keeping in view producer and consumer welfare. In developing the price policy model, one needs to have reliable empirical evidences about the degree of responsiveness of demand and supply to product prices, irrigation, technological change and investment in research. These elasticities could

be used to compute cost of production. The adjustment in crop prices below the level at which income elasticity is negative would generate a negative growth in net income and would not provide incentive to the farmers for adoption of improved technology. Price adjustment above the limit where net income elasticity is positive and elastic would give an abnormal high rate of profit to crop growers, but this may lead to serious repercussions on balanced cropping pattern. An adjustment in crop price between the limits at which net income elasticities ranges between 0 and 1 may provide optimal income to the farmers to induce the adoption of improved technology. It is suggested that output prices also need to be revised based on unit rise in input price index.

Greater emphasis should be given to non-price interventions through public investment with a view to supplement price policy measures. The policies that could help to maintain total factor productivity growth (TFPG) in the long run would be able to keep a balance between domestic production and demand for cereals, pulses, edible oils and sugar. The public policies such as investment in irrigation, rural literacy and agricultural research and extension are crucial to increase food supply. The input subsidy has a positive effect on input-use, crop supply and farm income, but technology shifters have a positive and strong influence on commodity supply and a substantial negative effect on farmers' income in the absence of MSP policy.

With regard to food security, the demand for food is continuously growing and is driven by the rising population, growing economy, increasing urbanization and changing tastes and preferences. The demand for food is also influenced by the commodity prices; thus, price policy and prices have strong implications for both food and nutritional security. To project the future demand and supply, factors such as the degree of demand and supply elasticities, income distribution, regional dietary pattern, dietary diversification, changing cropping pattern and prices of own and substitute food crops are crucial. Also, dynamic factors like changing tastes and preferences, eating out of home, international trade, urbanisation, population growth and income growth rates have important implications. In the past discussions related to food security, a major focus had been given to cereals and pulses only, but with the increased accent on nutrition security, due importance needs to be given to analysis on high-value commodities, livestock and dairy products.

To meet the food and nutritional requirements of the growing population, the nation would have to increase its current levels of food production with an increased

emphasis on better natural resources management, achieving technological breakthroughs and climatic and environmental concerns. With the availability of high-yielding and short-duration varieties of improved legumes, there is a need to incorporate them in the rice-wheat cropping system so as to meet the future food grain demand without degradation of the natural resource base.

Overall, the price policy should be able to maintain intercrop price parity and ensure rational utilisation of inputs and natural resources. Also, it should enhance diversification to meet the growing food and nutritional security. Agricultural price policy should be able to protect the interest of both producers and consumers without increasing subsidy burden.

Agricultural Price Policy for Ensuring Food Security in India

1. Introduction

The significant element in the agricultural strategy followed in the post-Green Revolution period is the application of modern technology. Since modern technology is capital intensive, farming has become market oriented and is sensitive to the cost of inputs and price of outputs. The role of price policy for adoption of modern technology becomes crucial. Thus, both technological change and prices are seen as important instruments for accelerating growth in the agricultural sector. Once an appropriate technology becomes available, then price policy assumes significance in stimulating production through the allocation of desired level of resources. The policy makers face the challenge of formulating a suitable agricultural policy by which food security may be achieved. To formulate an effective price policy for food-security, it is important to understand the degree of responsiveness of input demand and crop output supply to input-output prices and technological changes. A better understanding of demand elasticities helps to predict future demand of food and non-food commodities under different scenarios of demand shifters, and thereby could help policy planners to take appropriate policy decisions.

Subsidies and price controls are used by the government to enhance production and meet the objective of food security in the country. Agricultural policies in India also use remunerative prices to the farmers as one of the important means to achieve the objective of food security and uplift farmers' income. Farmers' net incomes have not been rising due to high cost of inputs and decelerating total factor productivity growth (TFPG). Climate change has led to an increase in different types of risks — adverse effects on agricultural production, rise in the prices of agricultural commodities and change in the commodity demand. The benefits of higher prices are not getting passed to most farmers, especially small holders; rather, they are grabbed by middlemen/traders.

The food inflation may not impact the demand for staple food due to the public distribution system (PDS) and price inelasticity, but it adversely affects the demand for high-value food commodities. The food demand behavior can be explained using a

set of demand elasticities for major food commodities. If food inflation remains high, there is a possibility of reversal of dietary diversification, thus, accentuating undernourishment. Government's intervention would be necessary to ensure food and nutritional security of the poor.

In this background, this study reviews agricultural price policy in India with a due focus on how the price policy has evolved over time, the underlying rationale for price policy formulation, the institutionalisation of price policy (Section 2), the issues and challenges in price policy implementation (Section 3) and the recent initiatives of the government (Section 4). This study further explores various factors that impact prices (Section 5), price determination models that could be used by policy makers for fixing prices (Section 6), and demand and supply models used to estimate the food demand and supply elasticities (Section 7). Using these elasticities, it then makes an attempt to forecast food demand and supply to assess the status of food security (Section 8) and outline a few policy suggestions (Section 9).

2. Objective of Price Policy

The primary goal of agricultural price policy has been to make food available to consumers at reasonable prices as well as to increase food production. The minimum support price (MSP) is the key instrument used for setting agricultural commodity prices.

In the 1960s, the agricultural price policies were formulated with the objective of meeting the food requirements in the country and managing food scarcity. The broad framework of the policy was specified in the terms of reference of the Agricultural Prices Commission (APC), which was set up in 1965, that is, to advise the government on a regular basis for evolving a balanced and integrated price structure. In the 1980s, the APC was renamed as Commission for Agricultural Costs and Prices (CACP), and the objective shifted away from maximising the cereal production to diversified production pattern consistent with the overall needs of the economy (Acharya 1997; Rao 2012).

In the mid-1980s, the objective of the MSP was broadened. Accordingly, the price policy aimed not only to provide farmers with price as a risk insurance to cover fluctuations, but to influence cropping pattern and respond to international prices and trade requirements. The political environment for cereals policy changed in the

1990s, when India started opening its economy for trade and signed the World Trade Organisation (WTO) agreement. The agricultural prices dominated the discourse on agriculture issues and farmer's welfare, and this enhanced the direct intervention of the government to ensure remunerative prices for farm produce (Chand 2018).

The agricultural price policy has three components, namely, MSP, buffer stocks and public distribution system (PDS), which are interconnected. Procurement by the government at MSP for major crops is for the dual purpose of maintaining buffer stocks of foodgrains and its distribution through PDS.

India's food security through PDS is crafted with the aim to attain food self-sufficiency by making basic foodgrains available to all its citizens at an affordable price. The Food Corporation of India (FCI) was set up under the Food Corporations Act 1964 to provide farmers remunerative prices while ensuring availability of foodgrains at reasonable prices to the vulnerable sections of the society. The FCI also maintains buffer stocks to ensure the country's food security. To enable this large target of procurement and maintaining a buffer stock, the government announces MSP for major crops keeping in view the need to protect the interest of farmers. The MSP is fixed for basic food and non-food commodities. This price support policy acts as insurance to farmers against any sharp fall in the farm prices, and thus brings about stability in real farm income.

Since the mid-1990s, the government has implemented key changes in food grain policy by targeting large food subsidy outlays and decentralising the public food grain operations. The former PDS was transformed into the Targeted Public Distribution System (TPDS), which focused on subsidised food for those living in poverty and had a range of programmes aimed at groups such as the poorest of the poor, the unemployed and school children. The government also begun the process of decentralising responsibilities for public sector purchasing, movement and storage of foodgrains to the states to improve efficiency and reduce budgetary costs. However, it was in the early 2000 that the agricultural policy started seeing MSP as a remunerative price and not just a price that provide a safeguard against market fluctuations.

Contrary to the general belief, the cost of production was not the sole basis for arriving at the level of MSP (Acharya 1997, 2016). The MSP of various agricultural commodities in India is decided based on the recommendations of CACP. The

recommendations use data at the district and state level, and account for factors like cost of production, change in input prices, trends in market prices, demand and supply situations, inter-crop price parity, international prices and so on. To fix the MSP, other factors like acreage, yield, production, imports, exports, stocks, availability, cost of processing and marketing are also considered (Mittal and Mukherjee 2008).

3. Issues with Price Policy

Overall, it is believed that agricultural price policy has been largely successful in providing reasonable level of margins over the total costs to farmers for major cereals like rice and wheat. It seems to have also encouraged farmers' investment in yield-enhancing technology to increase production and enable sufficient procurement for buffer stocks (Dev and Rao 2010).

Several scholars have discussed the problems encountered while considering the cost of production for the purpose of determination of MSP (Kahlon and Tyagi 1983; Acharya 2001; Acharya and Agarwal 1994; Deshpande and Naika 2002; Mittal and Mukherjee 2008; Haque 2015; Chand 2018; Mittal *et al.* 2018). These studies see agricultural price policy as inadequate and ineffective for the farmers. Some studies, on the other hand, argue that prices are market distorting, create economic inefficiency, increase subsidy burden on government, underutilise the potential of crop diversification, and thus they are infeasible and unsustainable.

In the debate on price policy, several issues have been often discussed and highlighted. A brief account of them are as follows:

- Though MSP is declared for 20 to 24 commodities, the actual procurement is mainly done for rice and wheat, sometimes oilseeds, onions, and recently pulses and potato (in Uttar Pradesh). The *Situation Assessment Report* of the National Sample Survey Organisation (NSSO) shows that a small fraction of farmers is realising the MSP. The main challenges for ensuring MSPs are inadequate markets and collection centres, lack of appropriate infrastructure and storage facilities, social safety net programmes confined to rice and wheat only, and imperfect information due to a weak price monitoring and forecasting system (Mittal *et al.* 2018). To preserve the interest of the consumers, whose food requirements are subsidised through the PDS, the farmers are offered lower MSP in the time of a bumper harvest and are given marginally better

price in times of shortage. Thus, the determination of the MSP through the method of cost evaluation needs to be revised more rigorously so that farmers could earn more than subsistence incomes.

- Since the MSP is provided for select cereal crops, this has led to the increased production of certain major cereal staples, and correspondingly constrained diversification of agricultural production away from a cereal-based system.
- The MSP provides a long-term price guarantee to the farmers. It would lose its insurance value if the level were allowed to fluctuate, especially downwards. Any mechanical linkage with the cost of production would make the MSP prone to fluctuations.
- The MSP is calculated from costs of production, and there is a considerable variation in the costs amongst farms. In such a situation, if the average cost is used to arrive at the MSP, the cost of many farmers would not be covered. The cost of production is higher than the all-India average in some of the poorer states due to low productivity, and prices realised do not cover all costs.
- Cost-plus approach to price determination of crops ignores the demand dimension and does not encourage production of a commodity for which high-yielding technology is available and farmers need to be given signals for its adoption. Apart from the cost of production, there are several other factors like changes in input prices, demand, supply, behaviour of market prices, inter-crop price parity, general price level and international price (for tradable commodities), which need to be considered for arriving at an appropriate level of support price.
- Time of the announcement of the MSP is another important aspect of the effectiveness of price support policy. The price policy can influence farmers' decision to allocate area under crops based on the prices of alternative crops, but this is only possible if prices are announced much in advance to the sowing season.
- Price volatility is higher for perishable commodities such as vegetables, fruits, milk, meat, eggs and fish for which MSPs are not announced. It is important to ensure market stability and remunerative prices to the producers of these

commodities. Sometimes, the government intervenes in non-MSP crops like potato and onion, through either procurement or export/import decisions to stabilise their prices. Recently, the Government of Haryana announced an MSP-like scheme for four vegetables, namely, tomato, potato, onion and cauliflower. The compensation mechanism would be of similar type as of the price deficiency mechanism. There are apprehensions that higher MSPs would disincentivise production of non-MSP crops. Farmers would tend to go for more assured and higher MSP crops rather than non-MSP crops. This policy distortion would generate surplus of MSP crops at the cost of non-MSP crops. A strong market structure that assures remunerative prices coupled with effective crop insurance could provide income insurance to the producers of all crops.

4. New Price Policy Initiatives

Studies have shown that MSP policy has not played its intended role in the overall price policy. The question arises if relying on MSP for remunerative prices would be the right price policy for all the farmers. If MSP is the intended remunerative price, then what should be done to make it an effective price to have the desired effect on supply response and to ensure that most of the farmers get the benefit of this price policy? If this is not, then what are the alternative mechanisms to ensure that farmers get the remunerative price? In recent times, new initiatives either in terms of new MSP or new marketing models have been introduced. Some of these initiatives include the following:

In the *Union Budget 2018-19*, the Government of India accepted the Swaminathan Committee's recommendations and farmers' demand for new MSP, which now stands at 1.5 times the cost of production. The government has also announced the development of mechanisms to ensure that farmers receive at least MSPs of their produce (Mittal *et al.* 2018). There are apprehensions that this would have strong budgetary implications due to increased food subsidy bill. Some fear that this would also have inflationary pressure on food commodities. There is a counter argument that the new MSP would raise farmers' incomes, increase demand for non-farm commodities to boost economic growth and improve marketing efficiencies. To make the proposed policy effective, the government proposed to develop and upgrade 22,000 agricultural markets, known as Grameen Markets, to link these with the Agricultural Produce and Market Committee (APMC) *mandis* and National Agriculture Market

(e-NAM). This platform aims to remove price manipulation and traders' cartel, and provide a lower price spread between the producers and the consumers. It is expected that this would help producers with better price realisation. Upgrading the existing local market with the necessary infrastructure is important, as it would ensure that the benefits of the new price policy penetrate to the last mile.

The MSP is restricted to only selected crops and regions, and not all the farmers are able to benefit from it. To address this issue, price stabilisation fund and price support schemes have been introduced. Under the price support scheme, the state can procure about 25% of output of pulses, oilseeds and cotton, if their prices go below the MSP. Losses arising from this intervention is shared between the concerned states and the Centre. The price stabilisation fund needs to be used by the Ministry of Consumer Affairs, Food and Public Distribution, Government of India, to procure pulses and stabilise their prices in the market. It is often argued that it is neither feasible nor desirable that the government should procure all the commodities produced and sold in the country, when its prices fall below the floor price, thus, a new mechanism must be devised to protect producers against the risk of prices falling lower than the MSP. The MSP can be implemented through the system of deficiency price payment (Chand 2018).

A market assurance scheme was also proposed, which allows procurement by government machinery from the farmers at MSP in the event of farm harvest prices (FHP) falling below MSP. The National Institution for Transforming India (NITI) Aayog also proposed price deficiency payment scheme. Under this scheme, if the farmers' sale price is below a modal price, then they would be compensated the difference between MSP and actual price, subject to a ceiling that may not exceed 25% of the MSP. If actual market price received by the farmer for the produce sold in a recognised market falls below the MSP, the seller should be compensated through the deficiency price payments. With deficiency payments, farmers would receive a direct government payment covering the difference between the market price at which they sell their grain and the price level supported by the government such as the MSP.

The deficiency payment would, in theory, allow the government to support producers with lower price, benefit consumers and reduce distortion of domestic markets. However, a major impediment to this approach is devising a mechanism for administering deficiency payments that reaches all producers and is not susceptible

to fraud. One possibility would be to build on the relatively recent initiative to create a system of verifiable and negotiable warehouse receipts that is being promoted. Private participation in stocker's scheme is also proposed. This scheme relates to the procurement at MSP by the private entrepreneurs. A transparent mechanism needs to be developed, so that private sector entities could empanel themselves for procurement if prices fall below MSP. The mechanism could also be developed to compensate the private sector.

4.1 Can Farm Harvest Price be the New MSP?

The farm harvest price (FHP) is the price at which the farmers sell their produce at the farm gate. This price is determined based on domestic production, global prices and trade policies. The farm prices have been defined as the average wholesale price at which the commodity is disposed of by the producers at the village site during the specified harvesting period. The FHP may be considered more suitable for the present purpose because these prices are a better indicator of the price received by farmers than wholesale prices.

To study the effectiveness of the price policy during the harvest periods, the deviations of FHP from the MSP for major crops were worked out (Table 1). For majority of crops and states, the FHP remains higher than the MSP; this suggests that the price realised by farmers at the farm gate is higher than what they would have realised, had they sold their produce at the procurement price at *mandis*. For crops and states where the FHP is less than the MSP, it indicates losses to the farmers and failure of the present price policy. When the MSP is less than the FHP, the government intervention is needed either to procure from farmers at MSPs or compensate them the differences.

One of the key challenges for making MSP effective is its actual administration in all the states. Though MSP is declared for several commodities, the actual procurement is mainly done for rice and wheat, sometimes oilseeds and onions, and recently pulses and potato (in Uttar Pradesh). The *Situation Assessment Report* of the NSSO shows that a small fraction of farmers is realising the MSP. The main challenges of ensuring MSPs are: (1) inadequate markets and collection centres; (2) lack of appropriate infrastructure and storage facilities; (3) social safety net programmes confined to rice and wheat only; and, (4) imperfect information due to a weak price monitoring and forecasting system (Mittal *et al.* 2018).

Table 1: Cropwise Summary of the Deviation of FHP from the MSP, 2014-15

Crops	States with FHP Less Than MSP	States with FHP More Than MSP
Bajra	Andhra Pradesh, Maharashtra, Orissa, Punjab	Madhya Pradesh, Gujarat, Jammu & Kashmir, Tamil Nadu, Haryana, Himachal Pradesh, Assam
Barley		Maharashtra, Orissa, Madhya Pradesh, Haryana, Gujarat, Andhra Pradesh, Assam, Punjab, Tamil Nadu, Himachal Pradesh
Gram		Maharashtra, Orissa, Tamil Nadu, Gujarat, Andhra Pradesh, Assam
Jowar	Bihar, Jammu & Kashmir, Uttar Pradesh, Maharashtra, Orissa, Madhya Pradesh	Andhra Pradesh, Rajasthan, Tamil Nadu
Jute	Tamil Nadu, Gujarat, Andhra Pradesh, West Bengal, Maharashtra, Orissa, Jammu & Kashmir, Kerala, Himachal Pradesh	
Maize		Gujarat, Andhra Pradesh, Maharashtra, Orissa, Tamil Nadu
Paddy	Assam, Uttar Pradesh, Karnataka	Andhra Pradesh, West Bengal, Haryana, Maharashtra, Orissa, Gujarat, Tamil Nadu, Rajasthan
Rapeseed & Mustard		Andhra Pradesh, Tamil Nadu, Madhya Pradesh, Assam
Tur	Andhra Pradesh, Madhya Pradesh, Assam, Tamil Nadu	
Cotton	Gujarat, Assam, West Bengal, Punjab	Haryana
Ragi	Assam, Punjab, Haryana, West Bengal	Gujarat, West Bengal, Maharashtra, Orissa, Himachal Pradesh
Sugarcane		Punjab, Assam, Madhya Pradesh, Gujarat, Maharashtra, Orissa, Haryana, West Bengal, Jammu & Kashmir, Himachal Pradesh
Wheat	Punjab, Madhya Pradesh, Haryana	Jammu & Kashmir, Himachal Pradesh

Note: FHP is farm harvest price and MSP is minimum support price.
Source: Compiled by Authors.

The 70th round of National Sample Survey for 2012-13 reveals that only 32.2% of paddy farmers and 39.2% of wheat farmers in the country were aware of the MSP, while only 13.5% of paddy farmers and 16.2% of wheat farmers sold their produce to government procurement agencies (Haque and Joshi 2018). The main reason is non-availability of procurement agencies at local level. Also, not all the farmers have enough marketable surpluses to go to the procurement *mandis* and bear an additional transportation cost. Haque and Joshi (2018) also mention that many farmers in the country do not really benefit from the MSPs because there is no effective procurement policy for coarse cereals, pulses and oil seeds, whereas there is a conflict between the announced price and the state-advised prices in the case of sugarcane.

It is evident that for several states and several crops, the price policy has failed to ensure that the farmers got at least the floor price for their produce. It is because in some cases the proportion of produce procured was less than the production. The level of government procurement operations in some of these states for these commodities is very low. It is, however, presumed that FHP would remain higher than MSP due to higher demand.

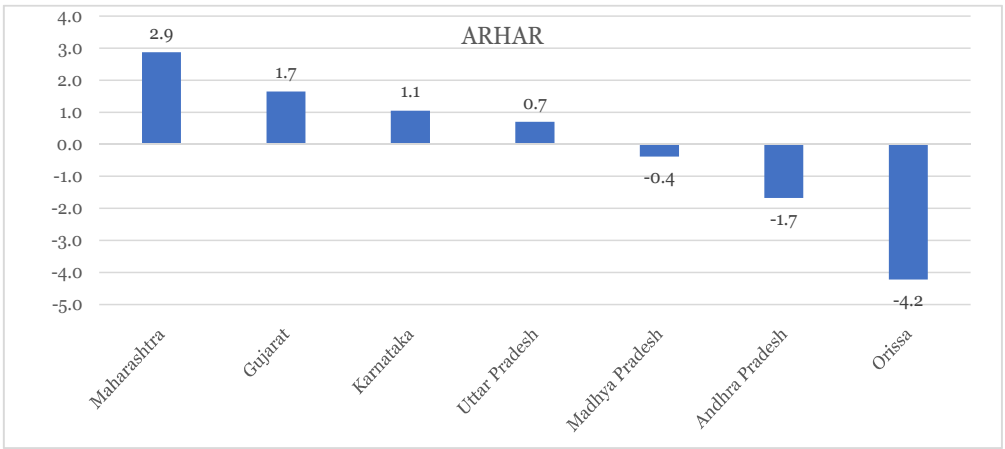
Farmers sell a major chunk of their produce in the immediate postharvest period and some surplus later in the lean period. The difference in prices at these two time periods is not accounted for in the FHP. Also, there is no clear evidence if the FHP is determined on basis of the MSP declared. What if the MSP is not announced and the FHP is independently determined?

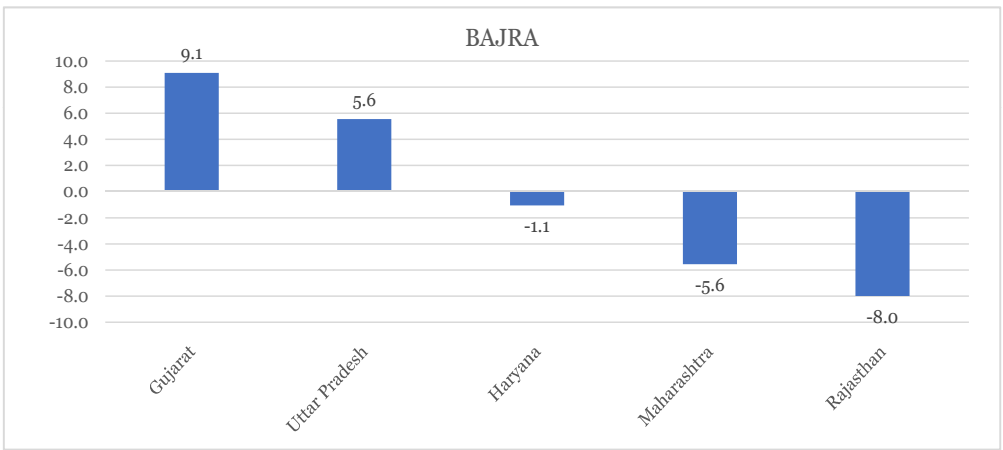
4.2 Yield Effects

The differential in prices because of higher cost of production can be neutralised with average higher yields. Figure 1 presents the deviation of state level yield from average yield in the case of 18 major crops. A negative number reflects that the yield in that state is lower than the average yield by that much amount in quintal per hectare. This implies that farmers in the states that have lower yield and have higher cost of production would be able to gain the least from an increase in the prices; thus, even a better price would not benefit farmers with lower yields.

For most of the states, the yield is less than average yields and this should be a big concern for policy makers. The per unit cost of production varies across states, and thus the calculation of a new MSP based on cost of production might fetch higher

Figure 1: Cropwise Deviation of State Level Yield from Average Yield (qtl/ha), 2014-15





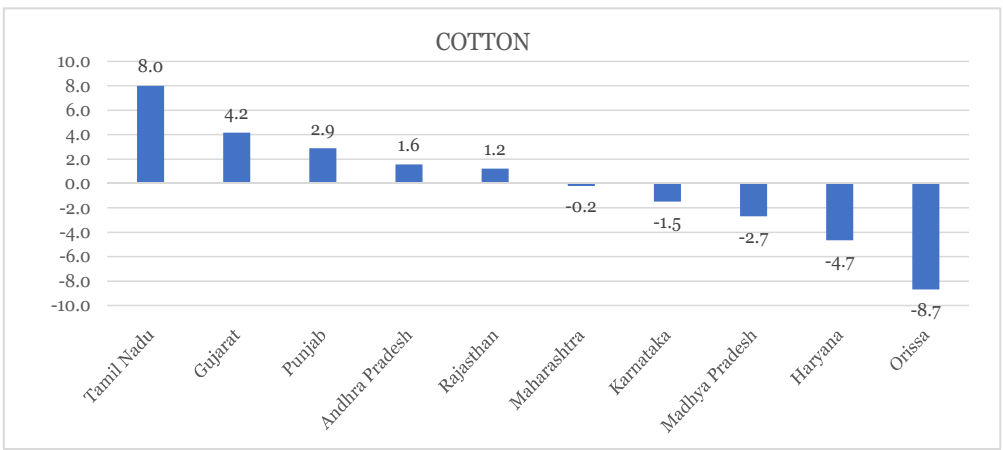


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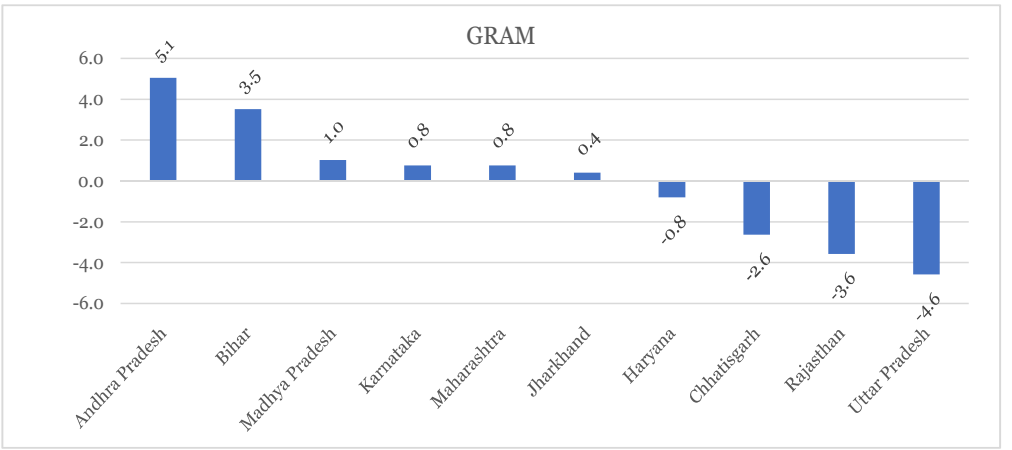
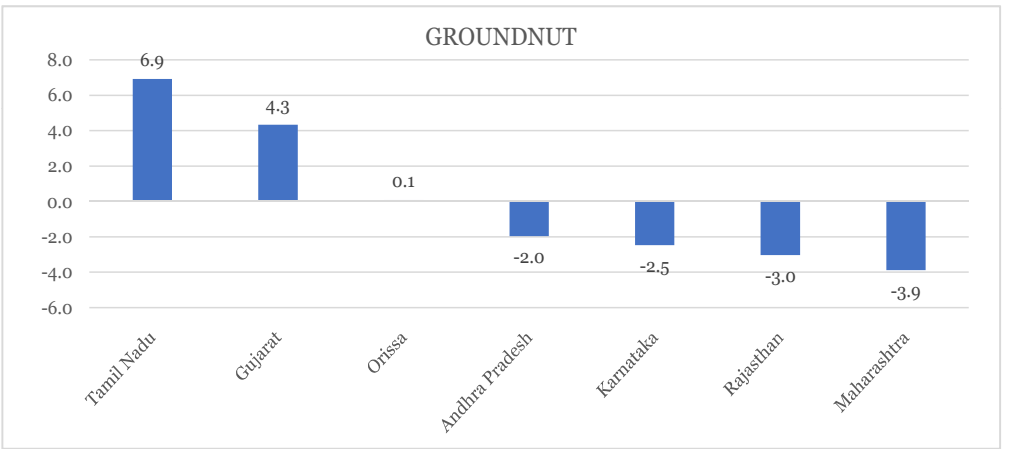
Figure 1: Cropwise Deviation of State Level Yield from Average Yield (qtl/ha), 2014-15 *(Contd...)*





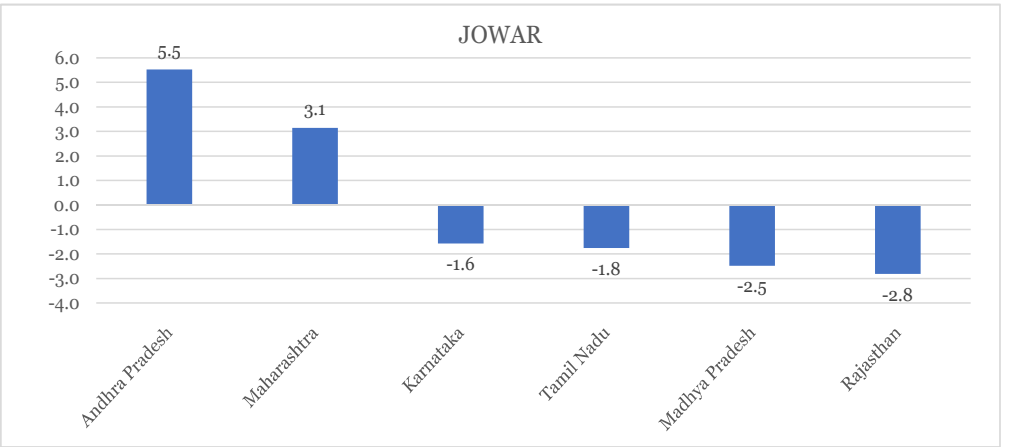


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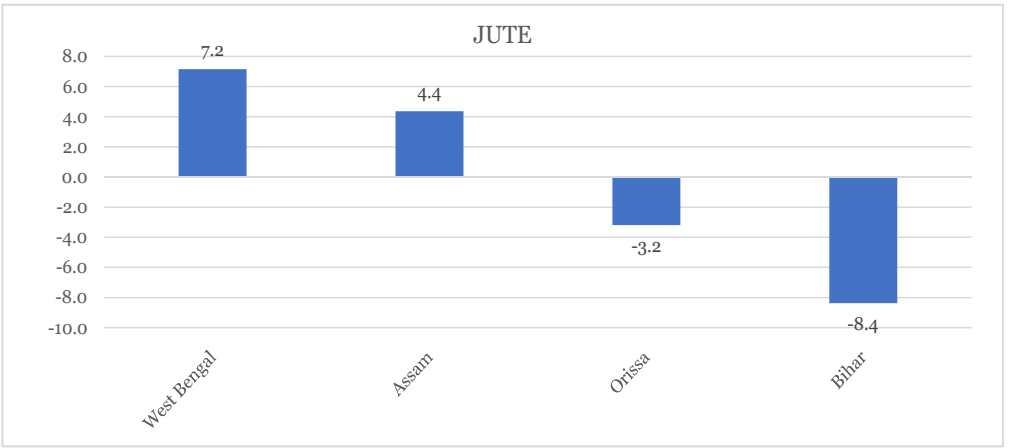
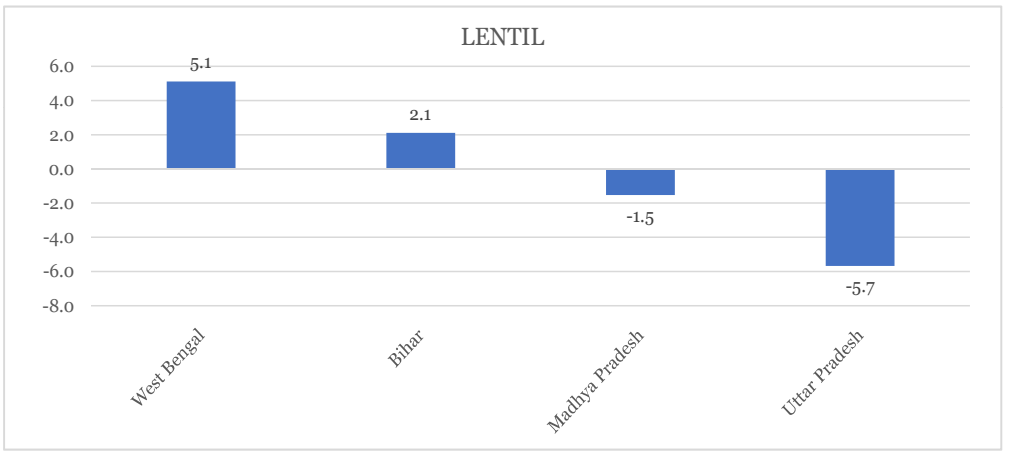
Figure 1: Cropwise Deviation of State Level Yield from Average Yield (qtl/ha), 2014-15 *(Contd...)*





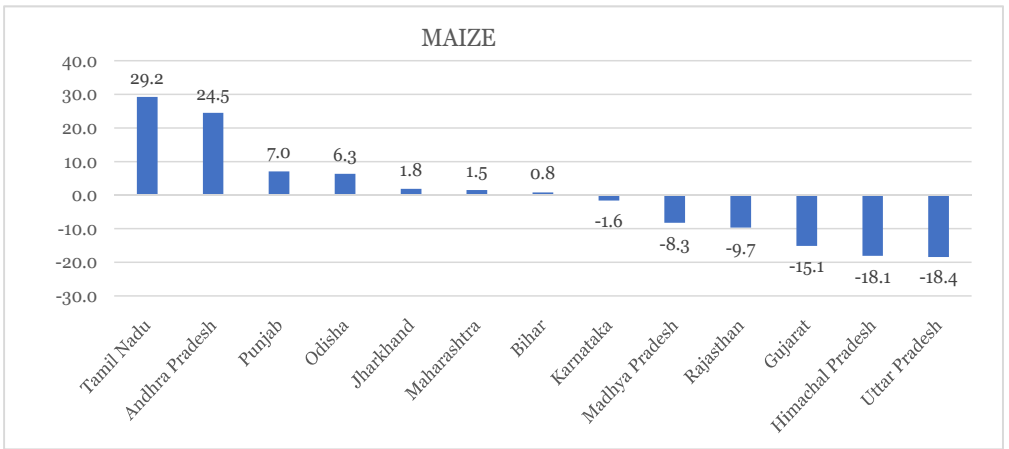


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Figure 1: Cropwise Deviation of State Level Yield from Average Yield (qtl/ha), 2014-15 *(Contd...)*

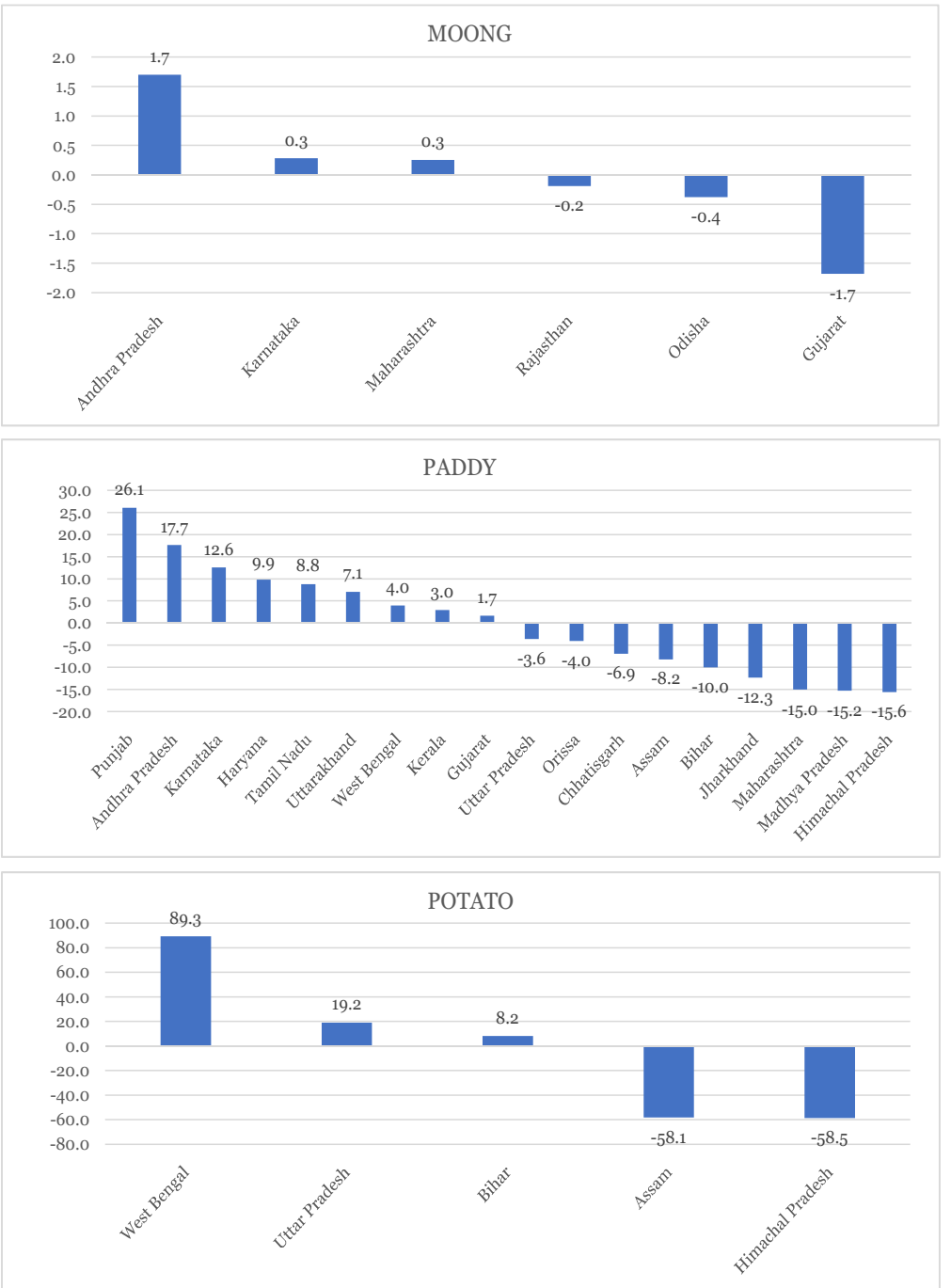

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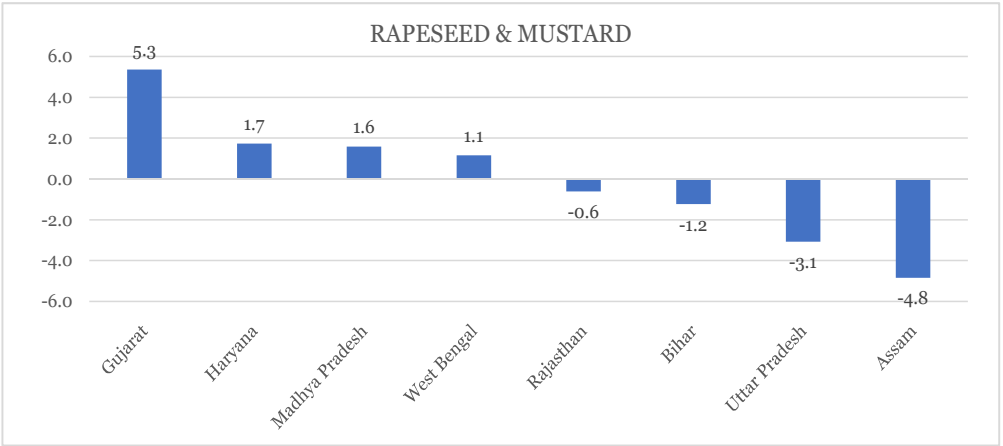
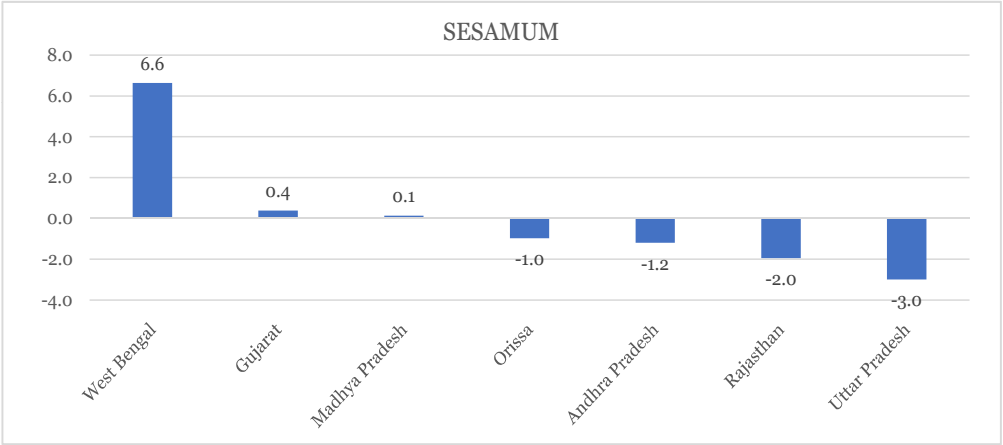
Figure 1: Cropwise Deviation of State Level Yield from Average Yield (qtl/ha), 2014-15 *(Contd...)*





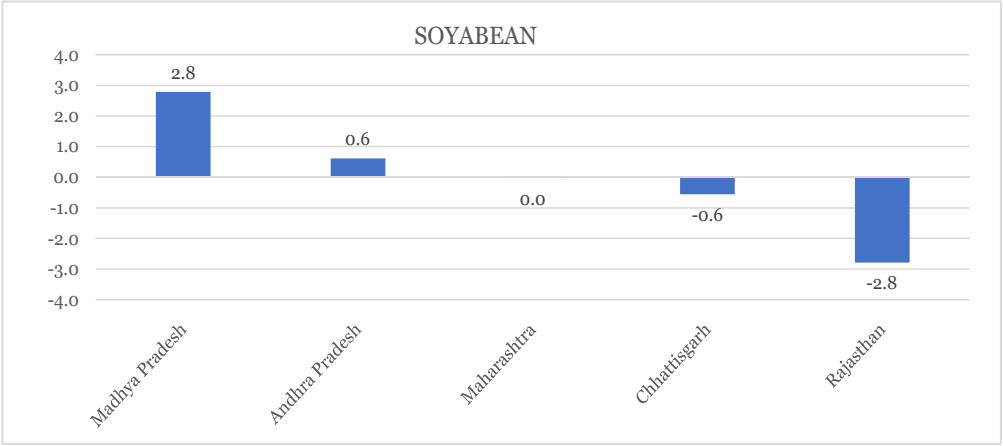


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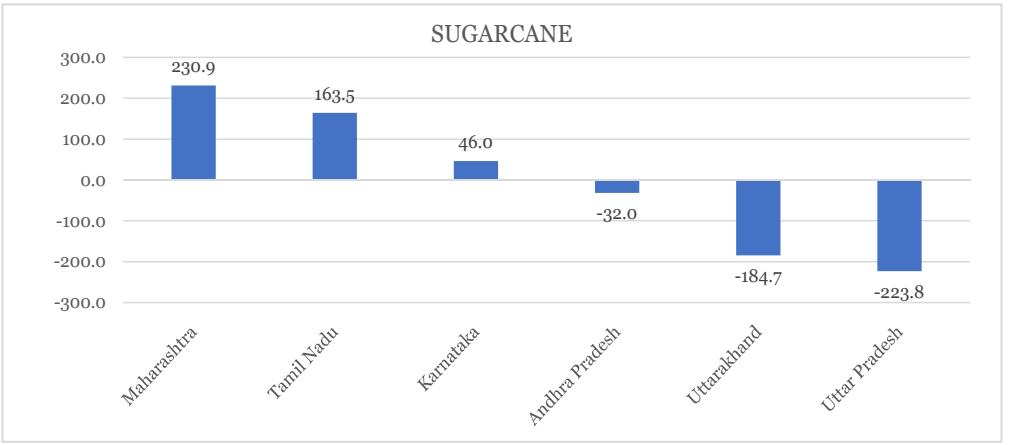
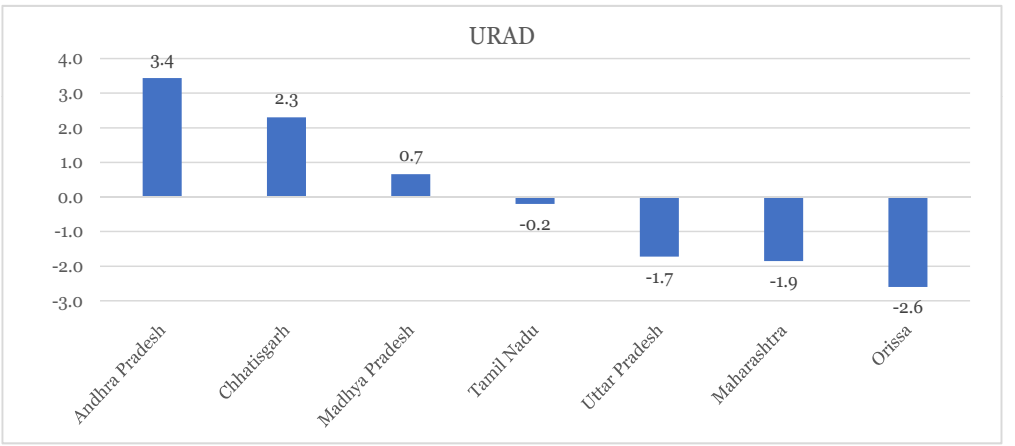
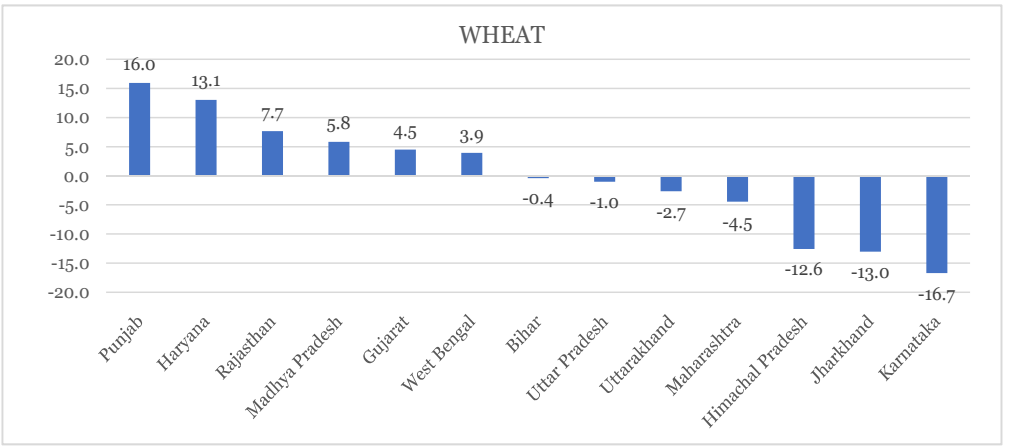
Figure 1: Cropwise Deviation of State Level Yield from Average Yield (qtl/ha), 2014-15
(Concluded)







Source: Computed by Authors

prices, but might now lead to higher incomes in states and for crops that have higher cost of production. It is recommended that inputs should be efficiently used and this would help in reducing the cost of production. An alternative is also technological change that can lead to enhancement of yield and production, and thereby help to increase the incomes of the farmers. Given the yield gaps, it is highly pertinent to maintain a steady TFPG (Kumar and Mittal 2006). As TFPG improves, the cost of production would decline and the market prices would stabilise at a lower level. Both producers and consumers would benefit. The fall in food prices would benefit the urban and rural poor more than the upper income groups, because the former spends a large proportion of their income on cereals than the latter. All efforts need to be concentrated on accelerating TFPG, while conserving natural resources and promoting ecological integrity of the agricultural system. More than half of the yield gap must be achieved from research efforts by developing location-specific and low input-use technologies with more emphasis on the regions/sub-regions where the current yield is below the national average yields. The regions/sub-regions where TFPG stagnation or decline has taken place (Kumar *et al.* 2008; Chand *et al.* 2011) must get priority in agricultural research and development.

5. Factors Impacting Prices

5.1 Climate Change and Food Security

Agriculture in India, especially during the monsoon season, is highly vulnerable to the extreme variability in climatic factors and this affects production, demand and prices of agricultural commodities (Kumar *et al.* 2014). A partial generalised

Table 2: Elasticity of Acreage, Production, Price, Income and Food Demand with Respect to Drought

	Rice	Sorghum	Pearl Millet	Maize	Pigeon Pea	Ground Nut	Cotton
Crop area	-0.437	-0.086	-0.275	-0.113	0.000	-0.055	-0.431
Yield	-0.634	-0.678	-0.765	-0.277	-0.453	-0.363	-0.405
Production	-1.071	-0.764	-1.040	-0.390	-0.453	-0.418	-0.836
Price	2.332	1.384	1.345	1.561	0.980	0.531	0.558
Gross revenue	1.261	0.621	0.305	1.171	0.527	0.113	-0.278
Demand	-0.547	-0.181	-0.176	-0.205	-0.360	-0.222	-0.690

Note: Base year is 2010.

Source: Kumar *et al.* (2014).

equilibrium model was developed and used to simulate the effects of deficit rainfall on acreage, yield, production, demand and prices of different agricultural commodities such as rice, sorghum, pearl millet, maize, pigeon pea, groundnut and cotton. The elasticities of acreage, production, price, income and food demand for base year 2010 have been presented in Table 2, and they are used to examine the drought effect on crop economy and trade potential for these commodities (Table 3).

Drought has negative effect on acreage, yield and production leading to a rise in crop prices and reduction in consumer demand. It is estimated that with 10% deficit rainfall, production of rice and pearl millet would fall by more than 10%. The corresponding fall in production would be 8.4% for cotton and 7.6% for sorghum. The production of maize, groundnut and pigeon pea would fall by about 4% each. The food prices would have an inflationary trend. Rice, being a staple commodity, would witness an increase in its prices as high as 23% followed by maize (16%), sorghum and pearl millet (13% each), pigeon pea (10%) and ground nut and cotton (about 5% each).

The supply-demand projections reveal that there would be a deficit of about 13.91 million tons (mt) in rice in 2030 in case of a 20% drought if government intends to

Table 3: Effect of Drought on Crop Economy

Drought Intensity (%)	Rice	Sorghum	Pearl Millet	Maize	Pigeon Pea	Ground Nut	Cotton
Supply of Commodities (%)							
10.00	-10.71	-7.64	-10.40	-3.90	-4.53	-4.18	-8.36
20.00	-21.43	-15.27	-20.81	-7.80	-9.07	-8.36	-16.72
30.00	-32.14	-22.91	-31.21	-11.71	-13.60	-12.54	-25.08
Price of Commodities (%)							
10.00	23.32	13.84	13.45	15.61	9.80	5.31	5.58
20.00	46.65	27.69	26.90	31.22	19.60	10.62	11.15
30.00	69.97	41.53	40.35	46.83	29.39	15.93	16.73
Value of Output (%)							
10.00	12.61	6.21	3.05	11.71	5.27	1.13	-2.78
20.00	25.22	12.41	6.09	23.42	10.53	2.26	-5.57
30.00	37.83	18.62	9.14	35.13	15.80	3.39	-8.35
Demand for Commodities (%)							
10.00	-5.47	-1.81	-1.76	-2.05	-3.60	-2.22	-6.90
20.00	-10.94	-3.63	-3.53	-4.09	-7.21	-4.43	-13.80
30.00	-16.41	-5.44	-5.29	-6.14	-10.81	-6.65	-20.69

Source: Kumar *et al.* (2014).

Table 4: Projected Supply-Demand Gap for Selected Crops Under Different Drought Situations (million tons)

Crop	2010	2030		
	Normal Rainfall	Normal Rainfall	20% Deficit	30% Deficit
Rice	0.27	15.6	-13.91	-28.66
Sorghum	0.48	0.09	-0.94	-1.45
Pearl millet	0.72	6.60	2.84	0.96
Maize	1.65	15.34	11.54	9.63
Cotton	0.00	0.00	-2.03	-3.04

Source: Kumar *et al.* (2014).

maintain price stability under deficit rainfall (Table 4). The gap would be of about 28.66 mt under a 30% deficit rainfall scenario. For sorghum and cotton also, there would be deficit in supply-demand in the event of drought of 20% to 30% intensity. In the case of rice, the projected huge deficit in supply would have two serious implications, namely, global rice prices would significantly shoot up as India would import rice to meet its domestic demand, and the market price of rice would rise in India that could have adverse effects on food security of the poor.

Government intervention would be necessary to ensure food and nutritional security of the poor. This would require strong social safety net programmes for the targeted population to ensure adequate supply of food to the vulnerable groups, especially economically weak consumers. In the long run, technological interventions would be necessary to mitigate the effect of drought, and therefore more research efforts and investment on alternative coping-mechanisms would be necessary to protect the poor from the drought impact.

5.2 Input Subsidy versus Farm Technology

The input subsidy and technology are the two significant factors for the development of agriculture. Concerns are often expressed about a decrease or an increase in input subsidy and inadequate investment in agricultural technology development. Policy makers often face the questions like what would happen to food supply, input use, food prices and farmers' income under alternative input subsidy and farm technology scenarios?, and what would be the impact of input subsidy and technological innovation on the welfare of producers and consumers? A partial unified model was designed (Kumar *et al.* 2014) and simulated to suggest the adjustments needed in price and non-price factors to answer such questions. The withdrawal of fertilizer

Table 5: Technology versus Fertilizer Subsidy — Required Growth in TFP Sources

Particular	Output price elasticity with respect to fertilizer price and TFP sources		Elasticity of TFP sources with respect to fertilizer price		Required change in TFP sources (%) to counter withdrawal of 10% subsidy on fertilisers	
	Rice	Wheat	Rice	Wheat	Rice	Wheat
Fertiliser price	0.0160	0.0215				
TFP Sources						
Literacy rate	-0.2267	-0.4837	0.0704	0.0444	0.704	0.444
Research stock	-0.0394	-0.0358	0.4051	0.6000	4.051	6.000
Extension stock	-0.0615	-0.0180	0.2595	NS	2.595	NS
Research & extension	-0.1009	-0.0538	0.6646	0.6000	6.640	6.000
Irrigated area	-0.5413	-0.5440	0.0295	0.0395	0.295	0.395
All sources	-0.8688	-1.0815	0.0184	0.0199	0.184	0.199

Note: NS means not significant.
Source: Kumar and Joshi (2014).

subsidy would have a negative impact on the supply of commodities and their prices would increase. The technological changes induce commodity supply. The positive and negative impacts can be neutralised exclusively by adjusting the TFPG sources.

If fertilizer subsidy is withdrawn and technology is exclusively depended on to ensure complete product price stability, what would be the required adjustment in technology? Presenting a scenario of 10% withdrawal of fertilizer subsidies, a study by Kumar and Joshi (2014) has revealed that investment on agricultural research and extension would have to be increased at the annual growth rate of 6%, literacy 0.4%-0.7% and irrigation 0.3%-0.4% (Table 5). These investment would induce the TFPG by 0.18%-0.20% from the base level. Sources of TFPG are the most powerful instruments that need to be manipulated, not only to neutralise factor price inflation but also to safeguard the interest of producers and consumers. Input price subsidy is likely to have a weak effect on commodity supply. Public policies like investment in irrigation, rural literacy, research and extension are crucial to increase commodity supply (Mittal and Kumar 2000; Joshi *et al.* 2015; Kumar and Joshi 2016).

Input subsidy has a positive effect on input use, crop production and farm income. Technology shifters have a positive and strong influence on commodity supply, but a substantial negative effect on farmer income because of the decline in market price

in the absence of MSP policy. Also, input subsidy to farmers and price subsidy to consumers would not be feasible in the long run as they involve a substantial share of public resources. A viable solution can only be found with appropriate adjustments in the non-price factors. An effective MSP programme is essential to protect the welfare of farmers.

5.3 Marketed Surplus and Price Policy

When a part of production is retained for home consumption, the transmission of the cost inflation to the product side is highly complex. Inflationary pressures in industrial raw materials, fuel and power, and manufactured products are, in turn, transmitted to agriculture in the form of rising costs. These mechanisms also need to be understood for any meaningful design of policies of product price adjustment. de Janvry and Kumar (1981) developed the market surplus model to measure the effects of changes in factor and product prices on the market surplus.

The estimated model of marketed surplus response to factor price changes can be used to derive the normative product price changes that are needed to reach specific consumption goals. Under pure inflation, both factor and product prices change in the same proportion, and thus there would be no change in the use of inputs and outputs supply. But pure inflation has its effect on marketed surpluses. This effect would be negative if income effects dominate the price effects in consumption. Otherwise, it is positive. As crop price increases, farmers' income increases by the same percentage; as a result, consumption increases and marketed surplus falls. Even though pure inflation is neutral on food supply and input use, it has a strong negative effect on marketed surplus. If there is no productivity change, the total marketed surplus would decline by the rate of inflation.

The response of market supply to changes in prices and non-prices factors like irrigation, acreage and productivity is important for forecasting supply of commodities and formulating suitable agricultural price policy. For crops that are completely marketed like cash crops, the elasticity of output and marketed supply would be approximately equal. On the other hand, for the subsistence crops such as paddy and wheat, where a substantial part of production is retained by the farmers for home consumption, the responsiveness of market supply must be measured separately.

The model concludes that the short run response of the marketed surplus to changes in the terms of trade for agriculture is highly inelastic due to the dominance of subsistence consumption and sizeable income effects in agriculture consumption, and movements along a given production function instead of technological change and horizontal expansion. The inflationary pressure on the cost side is either amplified by agriculture or would result in high welfare costs for non-agricultural producing consumers, particularly the poor.

Thus, the inflationary pressures on the cost side of the agriculture are highly destabilising forces that have rightly received considerable attention in the debate on the terms of trade. They have to be effectively counteracted by ensuring that the burden of adjustment is not borne by the poor. This is possible through programmes to enhance technological change and irrigation expansion instead of through compensatory price policies on the product side. Countervailing cost inflation through product price increase allows defense of the social status quo and deepening of the existing inequalities. By contrast, the spread of cost saving technology and rural education appear as a progressive force towards leveling out the price structure.

The policy makers, thus, face a dilemma while deciding the product price. If higher prices are fixed, there would be more marketed surplus but neither there would be effective demand for the product on account of lower purchasing power of domestic consumers, nor would there be possibilities for export on account of higher cost of production. If lower prices are fixed, the growth in marketed surplus would be insufficient to meet the needs of the growing population, crop income would be low, financial ability of farmers to make investment in agriculture would be weak, pressure on financial institutions for more supply of credit would increase, and agricultural production would go down. Input subsidy to farmers and food subsidy to consumer would not be feasible in the long run, as they involve substantial outlay of scarce government resources. A viable solution cannot, therefore, be found in the adjustment of price policy alone without appropriate adjustment in non-price factors. The task seems to be attainable, if efforts are made to raise the productivity through varietal improvements as well as from improvements in management of water and fertilizer, credit supply and infrastructure development along with transfer of technology. Similarly, procurement policy packages can be worked out to attain

desired growth and stability in production, prices and income (Kumar *et al.* 1985; Kumar and Mruthyunjaya 1989; Kumar 1996).

6. Price Determination Model

The role of price policy for higher adoption and larger impact of modern technology is crucial. To achieve this, we need a price policy model that can be used for determining the prices for agricultural inputs and commodities. de Janvry and Kumar (1981), Kumar (1984), Kumar *et al.* (1985) and Kumar and Mrurthyunjaya (1989) developed models to measure the adjustments needed in producer prices in relation to factor price inflation, infrastructure development and technological change in case of a single crop or system of crops.

6.1 Simultaneous Determination of Factor Prices

The simultaneous solution of equations at equilibrium in price factors gives the input price determination equation. Factor prices for human labour, animal labour and fertilizers are determined by equating the demand for and supply of inputs. The coefficients of the factor price equation give the partial effects of each of the constituent forces and are useful in projecting the factor price for a given level of exogenous variables. The crop output price, irrigation and acreage have positive effects on factor demand resulting in higher factor prices. The exogenous increase in factor supply has negative effects on own factor prices and positive effects on cross factor prices. The model is used to predict the growth in factor prices for a given growth in crop output prices and exogenous shift in factors. The factor price model may not predict efficient estimates of factor prices on account of imperfection in factor markets in developing countries, and when farmers are reluctant to risk their investment for cash inputs.

6.2 Simultaneous Determination of Crop Price

In the market, equilibrium product prices are determined by its demand and supply. The price for each crop is determined by equating output supply to its demand. The equations are solved for product prices and expressed as the function of input prices, the exogenous shifters such as technology movers, population and income growth, and indirect demand within domestic and export. The exogenous shifters play a critical role in price policy. The product prices are expressed as a function of factor prices, crop acreage, TFPG sources, irrigation, indirect demand, consumer income and population. The literacy, research and extension, investment and irriga-

tion are the supply shifters, and indirect demand, consumer income and population are the demand shifters. The shifters influence the policy variables, namely, product price, supply, demand and farmers' income.

The demand, supply, crop price and farmers' income, and the exogenous variables in the model are the function of price and non-price factors. The price factors include factor price and acreage. The non-price factors include growth in productivity through technology, population, consumer income, trade and other uses. The technology is influenced by investment in research, extension, literacy, irrigation, infrastructure and so on. The estimated supply and demand model provides the elasticity of price and non-price factors indicating the direct partial effects of each one of them on factor demand, output supply, demand and crop net income. In this model at equilibrium, paddy demand growth is equal to paddy supply growth and wheat demand growth is equal to wheat supply growth. By solving these equations simultaneously, the equilibrium price determination equations are derived.

The input prices have an inflationary effect on the market price of both rice and wheat (Table 6). With increase in the price of input, its use decreases and consequently, commodity supply decreases and commodity price increases. Across farm inputs, the highest input price effect on commodity prices was noticed in the case of wages, followed by animal labour and machine labour, and the least is of fertilizer prices. The inflationary pressure on input prices would increase the prices of both rice and wheat at the rate of 1.7% per year. Rice and wheat are the major staple cereals and constitute more than a half of the food expenditure for poor consumers, and thus have a negative welfare impact on the poor. Increase in area under crop or its substitutes would have a negative effect on crop output price. An expansion of 1.0% in acreage would lead to a decrease in commodity price by 1.47% for rice and by 1.22% for wheat. Supply shifters or technology movers (literacy, research, extension and irrigation) have negative effects on market price of a crop. At the observed past growth of technological development, the commodity prices are expected to decline at a rate of 2.3% for rice and 3.1% for wheat.

Among the inputs, irrigation is the most important one as it contributes to a considerable decline in commodity prices (1.37% for rice and 1.57% for wheat, annually). Irrigation, literacy, and research investment contribute to a higher input efficiency, increase supply and lower the unit cost and market price of commodity,

Table 6: Crop Price, Supply, Demand, and Income Elasticities with Respect to Price and Non-Price Factors, India

Factors	Price		Supply		Demand		Income	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
Price of Substitutes of Rice and Wheat								
Maize	0.060	-0.267	0.017	-0.071	0.047	-0.126	0.210	-0.911
Other cereals	-0.028	-0.107	-0.008	-0.029	-0.003	-0.046	-0.098	-0.368
Price of Inputs								
Wages (Rs/hr)	0.635	0.484	-0.629	-0.754	-0.573	-0.461	-8.309	-5.093
Animal labour	0.454	0.798	-0.246	-1.140	-0.238	-1.039	-4.596	-3.216
Machinery	0.222	0.195	-0.207	-0.217	-0.191	-0.202	-1.241	-2.288
Fertilizer	0.070	0.098	-0.049	-0.131	-0.046	-0.120	-1.290	-1.513
Other inputs	0.274	0.119	-0.322	-0.038	-0.290	-0.043	-1.375	-2.485
Area Under Crop								
Rice	-1.202	-0.352	1.512	-0.094	1.361	-0.043	-2.028	-1.202
Wheat	-0.267	-0.869	-0.073	1.439	-0.042	1.304	-0.930	-1.030
Supply Shifter (TFP Sources)								
Literacy	-0.575	-1.393	0.171	2.103	0.185	1.908	-2.001	-4.759
Research stock	-0.206	-0.126	0.190	0.142	0.175	0.132	-0.718	-0.429
Extension stock	-0.152	-0.047	0.188	-0.013	0.169	-0.006	-0.530	-0.161
Irrigated area	-1.372	-1.566	1.196	1.869	1.104	1.729	-4.778	-5.352
Demand Shifter								
Indirect demand	0.055	0.076	0.015	0.020	0.017	0.029	0.193	0.261
Consumer income	-0.001	-0.001	0.000	0.000	0.000	-0.001	-0.005	-0.005
Population	1.085	0.923	0.298	0.246	0.384	0.312	3.779	3.153
Sources								
Coarse cereal	0.032	-0.374	0.009	-0.100	0.044	-0.172	0.112	-1.279
Input price	1.654	1.694	-1.452	-2.280	-1.339	-1.865	-16.812	-14.595
Cropping pattern	-1.469	-1.221	1.439	1.346	1.319	1.261	-2.958	-2.232
Technology mover	-2.306	-3.132	1.745	4.101	1.632	3.763	-8.028	-10.702
Demand shifter	1.139	0.997	0.312	0.266	0.401	0.341	3.967	3.409
All Sources	-0.949	-2.035	2.053	3.333	2.057	3.327	-23.718	-25.399

Source: Kumar and Joshi (2014).

thus, benefiting both producers and consumers. Among the demand shifters, population plays a dominating role in generating demand and raising prices by 1.09% for rice and 0.92% for wheat, annually. Consumer income has the minimum effect on cereal prices. The positive effects of input prices and demand shifters on market prices for rice and wheat have nullified the negative effect of acreage and TFP sources.

The induced decline in the commodity price by all the sources is 0.95% and 2.03%, respectively, for rice and wheat. The income elasticity with respect to commodity price is highly elastic. In the absence of MSP, the commodity price would re-adjust in tandem with the changes in price and non-price factors.

6.3 Determination of Crop Price Based on Cost of Production Model

Supply of agricultural products is unevenly distributed due to seasonality, whereas consumption of the most of the agricultural commodities is evenly spread over the entire year. Government has limited power to maintain food prices that are substantially at variance with the forces of supply and demand. The National Commission on Agriculture suggested that prices are to be fixed considering year-to-year changes of cost of production in relation to the movements in input price index. For doing so, one needs a price model based on cost of production that can measure the adjustments in crop output prices in response to factor price inflation, and changes in non-price factors like irrigation, flow of services, technology and so on. Without following a mechanical approach, the CACP considers various factors for balancing the interests of producers, consumers and overall growth and equity in the economy for fixing the prices. Jha and Kumar (1976), de Janvry and Kumar (1981), Kumar (1984), Kumar *et al.* (1985), Kumar and Mruthyunjaya (1985) and Kumar and Mruthyunjaya (1989) developed econometric models and estimated the crop price elasticities with respect to input price inflation.

To stabilise the production and net income of farmers, there is a need to adjust the product price in relation to factor prices, keeping in view both producer and consumer welfare. If the objective of the policy maker is to maintain constant returns to the production cost over years, the crop price should be adjusted upward at a rate equal to cost push inflation; that is, 7.9% for paddy, 7.5% for wheat, 8.7% for jowar, 9.6% for bajra, 7.1% for maize, 8.5% for gram, 7.7% for sugarcane, 10.3% for cotton and 6.4% for jute. For maintaining constant monetary net income to farmers, crop prices need to be adjusted at the rate of 7%-9% for foodgrains, cotton, and jute, 4.8% for sugarcane and 16.5% for groundnut (Kumar and Mruthyunjaya 1989).

The adjustment in crop prices below the level at which income elasticity is negative would generate a negative growth in net income and would not provide incentive to the farmers for adoption of improved technology. Price adjustment above the

limit where net income elasticity is positive and elastic would give an abnormal high rate of profit to crop growers, which may lead to serious repercussions on balanced cropping pattern. An adjustment in crop price between the limits at which net income elasticities ranges between 0 and 1 may provide optimal income to the farmers to induce the adoption of improved technology.

For every 10 points rise in input price index, the product price must be revised upward annually in the range of 7.9%-9.4% for paddy, 7.8%-8.9% for wheat, 7.4%-10.1% for coarse cereals, 7.0%-7.7% for gram, 5.7%-9.6% for sugarcane, 17.4%-22.0% for groundnut, 8.3%-9.9% for cotton and 7.0%-7.1% for jute. This price policy would have its effect on the growth of net income by 8%-10% for most of the crops (Kumar and Mruthyunjaya 1989).

7. Food Security

Demand for food is continuously growing and is driven by rising population, growing economy, increasing urbanisation and changing tastes and preferences. The demand for food is also influenced by the commodity prices, and thus the price policy and prices do have strong implications for both the food and nutritional security. To project the future demand and supply, factors like magnitude of demand and supply elasticities, income distribution, regional dietary pattern, dietary diversification, changing cropping pattern and prices of own and substitute food crops play an important role. Also, dynamic factors like changing tastes and preferences, eating out of home, international trade, urbanisation, population growth and income growth have important implications. These factors are to be considered while projecting the demand and supply. In the past, a major attention has been given to cereals and pulses in discussions related to food security. Given the increased accent on nutrition security, due importance needs to be given to analysis on high-value commodities, livestock and dairy products.

7.1 Income and Price Elasticity of Food Demand

To understand the impact of changes in income and prices on food demand, the income effect, price effect and net effect were derived from the demand system based on Food Characteristic Demand System (FCDS) model (Table 7). The income effect is positive but of small magnitude for rice and wheat, and negative for coarse cereals. The price effect (sum of own and cross price elasticities) is positive for rice

Table 7: Income and Price Effects on Food Demand

Food	Income Elasticity	Own Price Elasticity	Price Effect (Sum of Own & Cross Price Elasticity)	Total Effect (Sum of Income & Price Effect)
Rice	0.024	-0.247	0.107	0.131
Wheat	0.075	-0.340	-0.010	0.065
Coarse cereal	-0.125	-0.194	0.404	0.279
Pulses	0.219	-0.453	-0.344	-0.126
Milk & milk product	0.429	-0.624	-0.780	-0.351
Edible oils	0.297	-0.504	-0.496	-0.198
Vegetables	0.259	-0.515	-0.464	-0.206
Fruits	0.361	-0.595	-0.643	-0.282
Meat, fish & eggs	0.669	-0.821	-1.222	-0.553
Sugar	0.062	-0.340	-0.020	0.042
Other food (High value)	0.748	-0.917	-2.379	-1.631

Source: Kumar *et al.* (2011).

and coarse cereals, and mild for wheat. However, the total net effect consisting of income and price effects was positive at 0.131 for rice, 0.065 for wheat and 0.279 for coarse cereals. With increase in price inflation in cereals, the demand of coarse cereals for human consumption is bound to increase. It may have an adverse impact on the manufacturing of feed concentrate that in turn may adversely influence rearing of livestock. The income has a positive and significant effect on demand for pulses (0.219), vegetables (0.259), edible oils (0.297), fruits (0.361), non-vegetarian food of meat, fish and eggs (0.669) and other high-value foods (0.748). The net price effect on food demand was found to be negative and the estimates were -0.344 for pulses, -0.780 for milk and milk products, 0.496 for edible oils, -0.464 for vegetables, -0.643 for fruits, -1.22 for non-vegetarian food and -2.379 for high-value food. The price effect would dominate the income effect, and thus pure price inflation (sum of income and price elasticities) would be negative for most of the high-value nutritive food commodities. Thus, increase in inflation of food price would adversely affect the dietary diversification towards non-cereal food commodities and may lead to under-nourishment of consumers.

Demand elasticities are used to predict food demand under different scenarios of income and useful for taking policy decisions. Demand elasticities varied widely across lifestyle and income groups due to changes in production environment and tastes and preferences (Kumar *et al.* 2011; Kumar and Joshi 2016). The elasticities were found to

be highly inelastic: close to zero for staple food (rice, wheat, coarse cereals) and negative for coarse cereals. The magnitude of elasticities declined with the rise in income and remained higher for rural households as compared to the urban. With growth in rural areas, demand for high value food would increase faster. The income elasticity was positive and inelastic, but negative for coarse cereals. The income elasticity was much higher for livestock and fruits compared to other food groups. The own price elasticities were of expected negative sign. They were of higher magnitudes for urban households compared to rural households. The price elasticities were lower for the rich households compared to poor. Poor households were affected by food inflation more than rich households.

7.2 Input Demand and Crop Output Supply Elasticity

To understand future supply of food commodities, one needs reliable evidences about the degree of responsiveness of input demand and crop output supply to input-output prices and technological changes. The crop-related data are culled from the publication of *Comprehensive Scheme for the Study of Cost of Cultivation of Principal Crops* of the Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers' Welfare, Government of India. It provides time series-cum-cross section data on yield, use of inputs and their prices. This data set is useful to estimate the translog cost function to derive factor demand and output supply elasticities for cereals, pulses, edible oilseeds, sugarcane, onion and potato (Binswanger 1974; Kumar *et al.* 2010; Kumar 2011; Kumar and Joshi 2016).

Input demand elasticity: The restricted estimates of the parameters of factor share equations derived from translog cost function were estimated jointly for human labour, animal labour, machine labour, fertilizer and other inputs mainly irrigation for crops including cereals, pulses, edible oils, fiber crops, sugarcane, onion and potato. The parameters of the share equations are used to compute elasticity of factor demand for major crops. The input demand elasticities with respect to own and cross prices were computed for human labour, animal labour, machine labour and fertilizers. The matrices of input demand elasticity are presented in Appendix Tables 1 to 5, respectively, for human labour, animal labour, machine labour, fertilizers and other inputs (irrigation, plant protection and others). As expected, all own input price elasticities of demand have statistically significant negative signs. The elasticities of factor demand differ significantly from crop to crop and within a crop, from one input

to the other, depending on the technology used. The own-price elasticities of input demand have been estimated to be maximum for machine labour (-0.95), followed by irrigation and plant protection (-0.72), fertilizers (-0.64), animal labour (-0.49) and human labour (-0.30). These estimates indicate that demand for modern inputs is sensitive to their prices. On the policy front, a reduction in the prices of machinery and fertilizer through subsidy is expected to expand fertilizer-use and mechanisation of farming, and may lead to enhancement of the crop productivity.

Human labour demand: The human labour demand elasticity with respect to wages is significant for all the crops, except maize and sugarcane (Appendix Table 1). A positive sign for cross price elasticity with respect to the price of other variable inputs shows that the pair is substitutive, and a negative sign is the indicator of a complementary relationship. Human labour and bullock labour have a substitutive relationship for most of the crops (wheat, coarse grains, cotton, jute, and sugarcane) and are complementary for pulses. Both human labour and machine labour have shown a substitutive relationship for rice, maize, pearl millet, soybean and cotton. Human labour has exhibited a substitutive relationship with fertilizers for wheat, coarse grains, pulses, oilseeds, sugarcane, onion, potato and jute, and a complementary relationship with chickpea and soybean. A substitutive relationship has been observed between human labour and irrigation for all crops, except wheat. However, for the crop sector, human labour has a substitutive relation with most of the inputs and crops. With wage inflation, human labour would be substituted by machine labour, fertilizer and irrigation. It is likely to induce efficiency in crop production, and may improve productivity and yield.

Animal labour demand: The animal labour demand elasticity with respect to animal labour wages is negative and statistically significant for all the crops, except pulses (Appendix Table 2). It ranges from -0.13 for pigeon pea to -1.09 for rapeseed and mustard. A 10% rise in animal labour wage would lead to a reduction in its use at an average rate of 4.9%. The use of animal labour has depicted a substitutive relationship with machine labour for rice and wheat. This suggests that an increase in the animal labour wage would induce mechanisation in the rice-wheat system. However, it has a complementary relationship with fertilizers in the case of wheat and substitutive relationship with irrigation for wheat and oilseeds. Looking at all the crops together, a rise in the cost of animal labour would induce use of modern inputs and machine labour to enhance the productivity of farm.

Machine labour demand: The machine labour demand elasticities range from -0.32 for wheat to -1.41 for sugarcane, with average elasticity of -0.95 (Appendix Table 3). The machine labour demand is more sensitive to its price than other inputs. A 10% increase in the price of machine labour to farmers would lead to a decline in its use by 12.6% for rice, 3.2% for wheat, 7.6% for pulses, 13.8% for oilseeds, 14.1% for sugarcane, 7.3% for cotton, and 8.1% for jute. A substitutive relationship exists amongst inputs for most of the crops.

Demand for fertilizers: The own-price elasticity of demand for fertilizers is -0.24 for rice, -0.35 for wheat, -0.81 for pulses, -1.12 for oilseeds, -0.43 for sugarcane, -0.45 for vegetables and -1.04 for cotton (Appendix Table 4). Taking all the crops together, with 10% rise in its price, the demand for fertilizers would get reduced by 6.5%, on an average. However, the reduction in the use of fertilizers with rise in fertilizer price would be substantial for oilseeds, cotton and coarse grains. Fertilizer has been found to be a weak complement and substitute for all other inputs.

Irrigation demand: The own price elasticity of irrigation demand is estimated to be -0.72. It varies substantially across crops, from -0.02 for chickpea to -1.46 for oilseeds (Appendix Table 5). With 10% increase in irrigation price, the demand for irrigation would decline by 7.1% on average, and would be maximum for oilseeds (14.6%) and minimum for vegetables (0.46%). Cross price elasticities of irrigation demand with respect to labour wages, animal labour wages, machine charges and fertilizer price have been found positive for most of the crops, indicating substitutive relationships.

To sum up, the wage rate has a negative effect on the use of human labour and a positive effect on the use of machine labour, fertilizer and irrigation. This implies that with an increase in the wages, human labour becomes more costly. Once human labour becomes costly, the process of substitution of human labour by machine labour takes place. Mechanisation induces more use of fertilizers and irrigation, and the trade-offs between these inputs improve the production efficiency and yield. Higher animal labour charges induce higher use of machine labour, as it results in the substitution of bullock-use by machine-use. Own price elasticity of demand for machine labour and fertilizer-use has been found highly negative and significant. The subsidy on tractor and fertilizer would induce higher use of modern inputs and improve farming efficiency and productivity. Fertilizer price policy has a differential effect on crops. A

gradual increase in fertilizer price has not reduced its use in rice and wheat compared to other crops. Rice and wheat crops are the technologically advanced crops and the relative profitability of these crops is high (Kumar 1998; Chand *et al.* 2011).

7.3 Supply Response Elasticities

The output supply elasticities for major crops are computed from the factor demand elasticities (Table 8). The output supply elasticities reveal the response of output prices and input prices on the supply of major crops. Among crops, the highest supply elasticity with respect to its price was for coarse grains (0.53), followed by edible oils (0.51), cotton (0.33), jute (0.25), rice (0.24), wheat (0.22), groundnut (0.22), rapeseed and mustard (0.22), pulses (0.17), sugarcane (0.12), onion and potato (0.05

Table 8: Supply Response Elasticities for Different Crops in India

Crops	Output price (P)	Input price				
		w/P	b/P	m/P	r/P	i/P
Rice	0.2357	-0.0017	-0.0004	0.0004	0.0001	0.0017
Wheat	0.2164	0.0163	-0.0288	0.0095	-0.0095	0.0125
Coarse grains	0.5333	-0.1105	0.0952	0.0198	0.2791	0.0500
Maize	0.2533	0.0006	0.0013	-0.0025	-0.0017	0.0023
Sorghum	0.5276	-0.0073	0.0085	-0.0087	0.0057	0.0018
Pearl millet	0.5053	-0.0032	0.0071	-0.0054	0.0035	-0.0020
Pulses	0.1695	-0.0007	-0.0012	0.0020	-0.0013	0.0012
Chickpea	0.2348	-0.0011	-0.0125	0.0123	0.0015	-0.0001
Green gram	0.2992	0.0024	0.0051	-0.0028	-0.0009	-0.0038
Pigeon pea	0.1869	0.0004	0.0014	0.0023	-0.0021	-0.0020
Black gram	0.1890	0.0058	-0.0116	0.0031	-0.0042	0.0069
Edible oilseeds	0.5079	-0.0011	0.0021	0.0168	0.0062	-0.0240
Soybean	0.1516	0.0005	-0.0010	0.0012	-0.0004	-0.0003
Groundnut	0.2265	0.0003	0.0000	-0.0010	0.0007	0.0000
Rapeseed & mustard	0.2178	-0.0028	-0.0049	0.0067	0.0004	0.0006
Sugarcane	0.1216	0.0021	-0.0002	-0.0020	0.0045	-0.0044
Cotton	0.3309	0.0002	0.0000	-0.0011	0.0012	-0.0003
Jute	0.2456	0.0766	-0.0368	-0.0917	0.0319	0.0200
Onion	0.0508	0.0000	-0.0006	0.0000	0.0005	0.0001
Potato	0.0508	0.0000	-0.0006	0.0000	0.0005	0.0001

Notes: w = wage (Rs/hour); b = Cost on Animal Labour (Rs/hour); m = Cost on Machine Labour (Rs/hour); P = Price of Crop (Rs/100 kg); r = Cost of Fertilizer (NPK) (Rs/kg); i = Cost of Irrigation (Rs/ha).

Source: Kumar (2011).

each). The input price response elasticities were highly inelastic, nearly zero. The crop price had a dominating response on the supply of commodities, and so favourable price policy would enhance domestic supply of food commodities (Kumar 2011; Kumar and Joshi 2016).

8. Future of Food Demand and Supply

Will India be able to produce enough to meet its growing food demand? Will the country open up for imports of food commodities over the next decade (2020-2030)? What will be the likely trends in future demand of various food commodities? Will the supply of key food commodities continue to keep pace with their demand? These are the questions that require answers in order to evolve appropriate agricultural price policy. To provide a glimpse, food supply and demand gaps for foodgrains, edible oils and sugar are presented in Table 9, and for high-value commodities such as vegetables, fruits, milk, meat, eggs, and fish are given in Table 10. In the case of high-value commodities, supply (production), demand and availability (net domestic

Table 9: Demand-Supply Projections for Major Foodgrains, Edible Oils and Sugar in India (In million tons)

Commodities	Year	Supply Projection	Demand Projection	Supply-Demand Gap
Rice	2010	95.7	98.7	-3.0
	2030	122.1	122.4	-0.3
Wheat	2010	84.2	83.0	1.2
	2030	128.8	114.6	14.2
Coarse cereals	2010	39.6	36.4	3.2
	2030	64.2	47.2	17.0
Total cereals	2010	219.5	218.1	1.4
	2030	315.1	284.2	30.9
Pulses	2010	16.2	18.0	-1.8
	2030	26.4	26.6	-0.2
Foodgrains	2010	234	236.2	-2.2
	2030	338.8	310.8	28.0
Edible oils	2010	8.2	13.6	-5.4
	2030	19.1	21.3	-2.2
Sugar	2010	27.7	27.6	0.1
	2030	40.3	39.2	1.1

Note: Base year 2010.

Source: Kumar *et al.* (2016).

supply) have been computed from production after adjusting for postharvest losses. The gap has been computed as the difference between the availability and the demand.

The total demand for an individual commodity comprises direct as well as indirect demand. The direct demand consists of food consumption at home and outside home. The indirect demand includes its use as seed and feed, industrial uses and wastages. Attempt has been made to provide credible estimates of future demand for foodgrains and other food commodities by estimating their demand at the disaggregated level in terms of income levels, rural and urban households and states/union territories (UTs), and these are added-up to derive estimates of food demand at the all-India level.

The direct demand for food is driven by population growth, income growth and changes in income distribution. The total demand for foodgrains, except for export, was arrived by adding their direct demand (human food consumption at home and outside home) and indirect demand (seed, feed, industrial uses and wastages).

In the year 2030, the total foodgrains demand will grow to the level of 311 mt comprising 122 mt of rice, 115 mt of wheat, 47 mt of coarse grains and 27 mt of pulses. Demand projections for high-value commodities include the demand for edible oils, sugar and horticultural, livestock, poultry and fishery products. The demand for edible oils will grow faster than the growth in population and foodgrains. The total domestic demand for edible oils is projected to be 21.3 mt in 2030. The requirement of edible oils will continue to remain higher than the domestic production in the country and shall depend on their import in large quantities. The sugar demand at the national level is estimated to grow to 39 mt by the year 2030.

The factor demand and output supply elasticities for cereals, pulses, edible oilseeds, sugarcane, onion and potato have been used to project domestic supply of these commodities. For fish, livestock (milk, meat), poultry (chicken meat, eggs) and horticultural commodities (vegetables and fruits), input-output data were not available, and therefore, supply projections for these commodities were made based on past growth trend in their production (Table 10).

By 2030, the demand for vegetables is projected to increase to 192 mt, fruits to 103 mt and milk to 170 mt. Fish demand including indirect demand is assessed to be in

Table 10: Demand-Supply Projections for High-Value Food Commodities in India

Commodities	Supply, demand and gap	Projections (million tons)		Post harvest losses (%)
		2010	2030	
Vegetables	Supply (S)	140.6	210.5	23.99
	Demand (D)	124.7	192.0	
	Availability (A)	106.9	160.0	
	Gap (A-D)	-17.8	-32.0	
Fruits	Supply (S)	73.5	116.4	20.00
	Demand (D)	64.8	103.0	
	Availability (A)	58.8	93.1	
	Gap (A-D)	-6.0	-9.9	
Milk	Supply (S)	116.5	188.7	5.03
	Demand (D)	111.9	170.4	
	Availability (A)	110.6	179.2	
	Gap (A-D)	-1.3	8.8	
Poultry & bovine meat	Supply (S)	4.4	8.4	4.98
	Demand (D)	5.2	9.2	
	Availability (A)	4.2	8.0	
	Gap (A-D)	-0.9	-1.2	
Eggs	Supply (S)	3.1	6.2	5.02
	Demand (D)	3.4	5.8	
	Availability (A)	2.9	5.9	
	Gap (A-D)	-0.5	0.1	
Fish	Supply (S)	7.4	13.9	15.05
	Demand (D)	6.4	11.1	
	Availability (A)	6.3	11.9	
	Gap (A-D)	-0.1	0.8	

Note: Base year 2010.
Source: Kumar *et al.* (2016).

the range of 11 mt by 2030. The national demand for eggs is projected to be 5.8 mt by 2030. The demand for eggs will grow faster than population growth and will increase pressure on the supply of coarse grains and oilcakes as feed.

The supply of rice is projected to go up to 122.1 mt by 2030. A look at the past trend reveals that the country has been marginally surplus in rice production and has been even exporting rice in small volumes (2 mt to 4 mt annually). As per these projections, India is not likely to remain rice surplus and may even become deficit in rice production to the extent of 3 mt to 5 mt in the coming years. The domestic production of wheat

is projected as 128.8 mt by 2030. A perusal at the supply-demand scenario reveals that wheat demand will continue to be met from the domestic production and there may even be some marginal surplus of about 14.2 mt by 2030. It has been observed that a shift in consumption from rice to wheat is taking place even in the traditionally rice-eating states in the country. Therefore, the surplus wheat production is likely to substitute rice leading to lower availability of surplus wheat.

The domestic production of coarse cereals is estimated to grow to 64 mt by 2030. The surplus of coarse grains is projected to be of 17 mt in 2030. This projection of demand-supply balance of coarse grains has provided some valuable insights about the possible level of self-sufficiency in coarse grains production, particularly their availability for meeting the feed requirements of the fast-growing livestock sector products in the years to come. The domestic supply of the total cereals, that is, the sum of rice, wheat and coarse grains production, is projected to be 315 mt by 2030. A look at the supply-demand balance for the cereals reveals that their demand in future will be met with national production, and there could even be a surplus of 31 mt by 2030. The domestic production of pulses is projected to be 26 mt in 2030. The supply of pulses will fall short of their demand and the country will have to continue rely on imports to meet the domestic requirements.

The domestic supply of total foodgrains, that is, the sum of rice, wheat, coarse cereals and pulses production, is projected to be about 339 mt by 2030. A look at the supply and demand balance of foodgrains reveals that their future domestic demand will be met with national production, and there is likely to be a surplus of about 28 mt in 2030.

Like pulses, the deficit in edible oils supply is projected to be about 2.2 mt by 2030, and thus the country will continue to depend on imports of edible oils even in the coming decades. The domestic production of edible oils is projected to be about 19 mt by 2030. The supply of sugar is projected to be 40 mt by 2030 and this will be enough to meet the domestic demand, besides generating a marginal surplus.

The projections of domestic supply of high-value commodities show that the supply-demand gap in the total vegetables will be substantial unless postharvest losses are minimised. Supply-demand gap in milk reveals that the country will be able to meet its domestic demand with a surplus of 8.8 mt by 2030. The total meat

production from cattle, buffalo, sheep, goat, pig and poultry at all-India level increased from 1.85 mt in 2000 to 4.2 mt in 2010. Looking at the past growth, the supply of total meat is expected to go up to 8.0 mt by 2030, but the total meat production will be short of their demand in future. The country will be able to meet the domestic demand for eggs with a marginal surplus. India is the second largest producer of fish in the world with contribution of 5.54% to the global production. The total fish production during 2010 is estimated at 8.03 mt with a contribution of 5.07 mt from inland sector and 2.96 mt from marine sector. The projected domestic fish supply is 11.9 mt in 2030. The supply-demand gap of fish is projected to be 0.4 mt to 0.7 mt, and thus the country will continue to remain self-reliant in fish supply and be able to export even at the present level of production.

9. Conclusions and Policy Suggestions

Indian agricultural policies use remunerative prices to the farmers as one of the important methods to achieve the objective of increasing farmers' income. Farmers' net incomes have not been rising due to the high cost of inputs and declining TFP. Climate changes have led to an increase in different types of risks which have adversely affected agricultural production, increased the prices of agricultural commodities and affected the commodity demand. The benefits of higher prices are not getting passed to most farmers, especially small holders, but are seized by middlemen and traders. An effective price policy for food-security requires reliable empirical evidences about the degree of responsiveness of input demand and crop output supply to input-output prices and technological changes. A better understanding of demand elasticities helps to predict future demand for food and non-food products under different scenarios of prices and income, and could help policy makers in taking important policy decisions.

The MSP is the key instrument used for setting the agricultural prices. Overall, it is believed that agricultural price policy has been largely successful in providing reasonable level of margins over the total costs to farmers for major cereals like rice and wheat. Several studies have also discussed the problems encountered in considering the cost of production for the purpose of determining MSP. Whether the MSP as the remunerative prices is the right price policy for all the farmers remains a moot question. If not, what are the alternative mechanisms to ensure that farmers get remunerative price? The instruments of MSP, food subsidy and

input subsidies have played an important role in achieving the objectives of food security and accelerated growth of the economy. But doubling farmers' income by 2022 requires a paradigm shift in transforming policies and programmes from production to income.

The origin and aim of MSP were to provide guaranteed prices to farmers in the times of uncertainty and price fluctuations. It is not possible to procure all the crops, and thus MSP might not be the most effective way to ensure remunerative prices. It has been pointed out that the MSP distorts the cropping pattern and generate a surplus of MSP crops at the cost of non-MSP crops. Price volatility is higher for perishable commodities such as vegetables, fruits, milk, meat, eggs and fish, for which MSPs are not announced. Thus, it is equally important to create a market driven economy by improving market efficiency, strengthening agro-processing, promoting trade and ensuring insurance for riskier crops.

In recent times, new initiatives either in terms of new MSP at 1.5 times the cost of production, and mechanisms like price stabilisation fund and price support schemes have been introduced. It is often argued that it is neither feasible nor desirable that the government should procure all the commodities produced and sold in the country when their prices fall below the floor price, thus, a new mechanism must be devised to protect producers against the risk of a fall in prices. The MSP can also be implemented through the system of deficiency price payment. The FHP can also be seen as an effective price, as it is determined based on domestic production, global prices and trade policies, and can be a better indicator of the price received by farmers.

Also, the new MSP is not uniformly different or higher than the existing MSP; thus, the anticipated income gains to the farmers might not be realised just by increasing the MSP as per the new formula. This also means that it would not necessarily add to the food budgets or lead to higher food inflation. The yield differences across states for the same crop also led to difference in full realisation of benefits due to increase in prices. Along with announcing of remunerative prices, it is equally important to create efficient agriculture production by reducing cost of production and improving average yields. This would contribute to farm income.

Several factors like climate change have negative effect on acreage, yield and production leading to a rise in crop prices and reduction in consumer demand. Input

subsidy has a positive effect on input use, crop production and farm income, but technology shifters have a positive and strong influence on commodity supply and a substantial negative effect on farmers' income because of the decline in market price in the absence of MSP policy.

Input subsidy and technology are the important instruments for the development of agriculture in the country. Input-price subsidy has a weak effect on commodity supply. It is technology that has a substantial impact on food supply. Input subsidy to farmers and price subsidy to consumers would not be feasible in the long run, as they involve a substantial share of public resources. A viable solution can only be found with appropriate adjustments in the non-price factors. Public policies such as investment in irrigation, rural literacy, research and extension are crucial to increase food supply.

An effective MSP programme is essential to protect the welfare of farmers. Market surplus models indicate that the short run response of the marketed surplus to changes in the terms of trade for agriculture is highly inelastic due to the dominance of subsistence consumption and sizeable income effects in agriculture consumption, and movements along a given production function instead of technological change and horizontal expansion.

Inflationary pressure on the cost side of the agricultural activities is a highly destabilising force. In order to protect the poor from the burden of adjustment, enhancing technological change and irrigation expansion should be used as means of managing production-led inflation rather than the compensatory price policies on the product side. The policy makers face a dilemma between marketed surplus and prices, and thus a viable solution cannot be found in the adjustment of price policy alone without appropriate adjustment in non-price factors.

To stabilise the production and net income of farmers, there is a need to adjust the product price in relation to factor prices, keeping in view producer and consumer welfare. If the objective of the policy makers is to maintain constant returns to the production cost over the years, the crop price should be adjusted upward at a rate equal to cost push inflation. The income elasticity of commodity with response to output price is highly elastic. In the absence of MSP, producer income would decline substantially. An effective MSP programme is essential to protect the welfare of farmers.

In developing the price policy model, one needs up-to-date reliable empirical evidences about the degree of responsiveness of demand for and supply of factor and product prices, irrigation, technological change and investment in research. These elasticities could be used to compute cost of production and income elasticity with respect to factor and product prices. An adjustment in crop price between the limits at which net income elasticity ranges between 0 and 1 may provide enough income to farmers to induce adoption of improved technology. It is suggested that output prices also need to be revised based on unit rise in input price index.

Overall, the price policy should be able to maintain intercrop price parity and ensure rational utilisation of inputs and natural resources. Also, it should enhance diversification to meet the growing food and nutritional requirements. Agricultural price policy should help in market determination of prices and should be able to protect the interests of both producers and consumers without increasing subsidy burden. The agricultural price policy needs to be revisited and some of the suggestions are:

- Policymakers could revisit the MSP for major staples like rice and wheat by encouraging producers and traders to respond to market signals rather than price floors. A pro-farmer and a stable trade policy would help in ensuring higher prices to the farmers.
- Instruments like price deficiency payment or price insurance should try to assure prices for all the crops for which MSP is declared. There should be a mechanism to compensate the farmers for loss of revenue realisation on their marketed surpluses when market price in the harvesting season is lower than the MSP.
- Government should limit the procurement to only the crops that are required for the PDS.
- Diversifying PDS to include pulses and other sources of nutrition should be encouraged, and accordingly these crops should be brought under the bracket of MSP. Better access to micronutrient rich vegetables and food would help to reduce issues of triple burden of malnourishment.
- Decentralised procurement system along with enlarging of procurement basket would provide flexibility to states to customise the basket as per the local

demand. Beside encouraging consumption basket to diversify, it would provide an impetus to local farmers to match their production to local conditions and demand. An assured procurement of these nutritious crops would encourage farmers to increase production and subsidise consumption of these crops for low income consumers.

- New market architecture and market infrastructure should be developed with a special focus on wet and cold storage, cold chains, and agro-packers and movers. These facilities contribute to controlling price crashes, ensuring higher FHPs and integrating with remunerative markets.
- Collective action in transport and marketing is necessary to reduce the transactions and marketing costs and realise the wholesale prices for marginal and small farmers who have low marketed surplus.
- Cooperatives enhance the bargaining power of producers and can be a viable alternative for private trade in both domestic and export sectors. Direct contact between producers and processing factories should be encouraged as it could ensure better prices for producers.
- Contract farming, if implemented effectively, ensures better prices to the farmers. Global literature shows that contract farming helps in getting improved technologies and better prices. The Government of India has prepared a model Contract Farming Act to overcome various problems in contract farming. It has protected the interests of farmers.

Greater emphasis must be given to non-price interventions through public investment to supplement price policy measures. The policies that can help in maintaining TFPG in the long run would be able to keep a balance between domestic production and demand for cereals, pulses, edible oils and sugar. The public policies such as investment in irrigation, rural literacy, and agricultural research and extension are crucial to increase food commodity supply. The input subsidy has a positive effect on input-use, crop supply and farm income, but technology shifters have a positive and strong influence on commodity supply.

To meet the food and nutritional requirements of the growing population, the country would have to increase its current levels of food production with an increased

emphasis on better natural resources management, technological breakthroughs and climatic and environmental concerns. With the availability of high-yielding and short-duration varieties of improved legumes, there is a need to incorporate them in the rice wheat cropping system so as to improve the sustainability of the system and to meet the future food grain demand without degrading the natural resource base.

Poverty is mainly a rural phenomenon and urban poverty is also an indirect effect of rural poverty. Due to Covid-19 lockdown, there has been a large-scale loss of livelihood and food with its attendant impact on the nutrition security of the poor. A large number of people in both rural and urban areas have moved below the poverty line. All pillars of food security, that is, production, availability, accessibility and utilisation got impacted. Given these additional constraints on the agriculture and food-nutrition security, it is even more important to have the right price policy. Science and policies must have a human face as the poor do not want charity; they want opportunity to build their future by enriched knowledge, freedom and equity, and they must be provided a congenial environment.

Table A.1: Estimates of Human Labour Demand Elasticities for Crops in India

Crops	w/P	b/P	m/P	r/P	i/P
Rice	-0.1680	-0.0177	0.0640	-0.0086	0.1303
	(-4.95)	(-0.89)	(4.02)	(-0.47)	(6.74)
Wheat	-0.3060	0.1540	0.0035	0.1693	-0.0210
	(-8.65)	(8.81)	(0.11)	(6.81)	(-0.65)
Coarse grains	-0.3923	0.1992	-0.0029	0.1549	0.0410
	(-11.56)	(11.27)	(-0.18)	(7.13)	(2.54)
Maize	-0.0178	0.0137	0.0426	-0.0476	0.0090
	(-0.45)	(0.69)	(2.63)	(-1.60)	(0.40)
Sorghum	-0.4017	0.1738	-0.0025	0.1696	0.0609
	(-16.28)	(9.74)	(-0.16)	(10.34)	(4.39)
Pearl millet	-0.3446	0.1436	0.0812	0.1055	0.0143
	(-10.74)	(6.55)	(4.97)	(7.07)	(1.03)
Pulses	-0.2332	-0.0822	0.1246	0.0656	0.1253
	(-4.21)	(-2.69)	(4.25)	(2.88)	(3.33)
Chickpea	-0.2876	0.0935	0.2659	0.0352	-0.1070
	(-5.64)	(2.92)	(8.54)	(1.47)	(-3.03)
Pigeon pea	-0.2730	-0.0755	0.1551	0.0576	0.1358
	(-4.67)	(-2.69)	(5.59)	(1.81)	(3.23)
Green gram	-0.4750	0.1261	0.0957	0.0187	0.2346
	(-7.08)	(5.59)	(2.41)	(1.37)	(4.11)
Black gram	-0.2133	0.1920	-0.0202	0.0280	0.0134
	(-5.88)	(10.62)	(-0.73)	(1.88)	(0.49)
Edible oilseeds	-0.5021	-0.0071	0.0222	0.2071	0.2799
	(-14.70)	(-0.35)	(0.76)	(10.01)	(7.37)
Rapeseed & mustard	-0.1595	0.0263	0.0342	0.0377	0.0612
	(-5.35)	(1.29)	(1.16)	(1.61)	(2.43)
Groundnut	-0.2837	0.0733	0.0152	0.1363	0.0588
	(-6.55)	(3.72)	(1.12)	(6.37)	(2.09)
Soybean	-0.1917	0.0899	0.1642	0.0838	-0.1462
	(-3.07)	(2.40)	(4.67)	(1.95)	(-3.17)
Sugarcane	-0.0768	0.0871	0.0221	-0.1073	0.0749
	(-1.84)	(4.31)	(0.92)	(-3.92)	(3.10)
Onion	-0.1077	0.0060	-0.0562	0.0691	0.0889
	(-1.96)	(0.26)	(-2.65)	(2.22)	(2.22)
Potato	-0.1077	0.0060	-0.0562	0.0691	0.0889
	(-1.96)	(0.26)	(-2.65)	(2.22)	(2.22)
Cotton	-0.3534	0.1688	0.0369	0.1117	0.0360
	(-9.68)	(8.73)	(2.45)	(5.72)	(1.26)
Jute	-0.0846	0.0884	0.0252	-0.0576	0.0287
	(-2.31)	(4.70)	(1.98)	(-2.91)	(2.35)
All crops	-0.3017	0.0354	0.0372	0.0867	0.1424

Notes: 1. Figures in the parentheses are the corresponding student t-statistics.
2. w = wage (Rs/hour); b = cost on animal labour (Rs/hour); m = cost on machine labour (Rs/hour); P = price of crop (Rs/100 kg); r = cost of fertilizer (NPK) (Rs/kg); i = Cost of irrigation (Rs/ha).

Source: Kumar (2011).

Table A.2: Estimates of Animal Labour Demand Elasticities for Crops in India

Crop	w/P	b/P	m/P	r/P	i/P
Rice	-0.0582	-0.2802	0.2439	0.0196	0.0749
	(-0.89)	(-3.97)	(6.29)	(0.39)	(1.63)
Wheat	0.3727	-0.6213	0.1856	-0.2018	0.2648
	(8.81)	(-13.26)	(3.96)	(-4.41)	(5.40)
Coarse grains	0.4698	-0.7473	0.1712	-0.0500	0.1564
	(11.27)	(-17.60)	(8.67)	(-2.13)	(8.06)
Maize	0.0377	-0.5235	0.1755	0.0039	0.3064
	(0.69)	(-8.49)	(6.06)	(0.08)	(7.44)
Sorghum	0.3269	-0.4706	0.0806	0.0050	0.0581
	(9.74)	(-11.56)	(3.64)	(0.21)	(2.73)
Pearl millet	0.3912	-0.8273	0.3102	-0.0541	0.1801
	(6.55)	(-13.50)	(9.19)	(-2.04)	(6.67)
Pulses	-0.1897	-0.1543	0.2704	-0.0118	0.0854
	(-2.69)	(-1.88)	(4.84)	(-0.33)	(1.26)
Chickpea	0.1860	-0.8796	0.5722	0.0457	0.0757
	(2.92)	(-10.96)	(9.74)	(1.28)	(1.31)
Pigeon pea	-0.1823	-0.1264	0.0246	0.1218	0.1624
	(-2.69)	(-2.03)	(0.63)	(3.15)	(3.14)
Green gram	0.2860	-0.4454	0.1353	0.0942	-0.0701
	(5.59)	(-6.88)	(3.54)	(4.38)	(-1.59)
Black gram	0.5032	-0.7677	0.1733	-0.1543	0.2456
	(10.62)	(-10.15)	(4.11)	(-6.40)	(4.47)
Edible oilseeds	-0.0176	-0.4878	-0.0043	-0.0291	0.5388
	(-0.35)	(-8.51)	(-0.07)	(-0.76)	(7.25)
Rapeseed & mustard	0.0827	-1.0879	0.6046	0.0566	0.3440
	(1.29)	(-12.93)	(6.97)	(0.93)	(4.93)
Groundnut	0.1837	-0.4647	0.1276	0.0069	0.1466
	(3.72)	(-12.16)	(6.63)	(0.22)	(4.20)
Soybean	0.1773	-0.5131	0.2671	-0.0094	0.0780
	(2.40)	(-4.75)	(5.21)	(-0.20)	(1.22)
Sugarcane	0.7560	-0.7777	-0.2332	0.2571	-0.0022
	(4.31)	(-5.50)	(-1.98)	(1.75)	(-0.02)
Onion	0.0245	-0.2293	0.0673	0.1342	0.0033
	(0.26)	(-1.91)	(1.82)	(1.91)	(0.03)
Potato	0.0245	-0.2293	0.0673	0.1342	0.0033
	(0.26)	(-1.91)	(1.82)	(1.91)	(0.03)
Cotton	0.5865	-0.9390	0.1443	-0.0924	0.3006
	(8.73)	(-12.76)	(5.06)	(-2.98)	(4.83)
Jute	0.3569	-0.5034	-0.0352	0.1454	0.0363
	(4.70)	(-8.45)	(-1.18)	(3.36)	(1.20)
All crops	0.2111	-0.4895	0.1309	0.0188	0.1287

Notes: 1. Figures in the parentheses are the corresponding student t-statistics.
2. w = wage (Rs/hour); b = cost on animal labour (Rs/hour); m = cost on machine labour (Rs/hour); P = price of crop (Rs/100 kg); r = cost of fertilizer (NPK) (Rs/kg); i = Cost of irrigation (Rs/ha).

Source: Kumar (2011).

Table A.3: Estimates of Machine Labour Demand Elasticities for Crop in India

Crop	w/P	b/P	m/P	r/P	i/P
Rice	0.3920	0.4536	-1.2564	0.0635	0.3473
	(4.02)	(6.29)	(-15.31)	(0.95)	(5.01)
Wheat	0.0070	0.1515	-0.3236	0.2307	-0.0656
	(0.11)	(3.96)	(-3.20)	(4.20)	(-0.61)
Coarse grains	-0.0132	0.3326	-0.9256	0.3456	0.2606
	(-0.18)	(8.67)	(-11.17)	(5.07)	(4.65)
Maize	0.2445	0.3661	-0.8120	-0.1563	0.3578
	(2.63)	(6.06)	(-6.64)	(-1.30)	(4.38)
Sorghum	-0.0113	0.1933	-0.6661	0.2327	0.2514
	(-0.16)	(3.64)	(-7.89)	(3.29)	(4.71)
Pearl millet	0.2849	0.3996	-0.7073	0.2058	-0.1830
	(4.97)	(9.19)	(-7.22)	(3.29)	(-3.58)
Pulses	0.4123	0.3879	-0.7598	0.0426	-0.0830
	(4.25)	(4.84)	(-6.20)	(0.76)	(-0.80)
Chickpea	0.5737	0.6210	-1.0825	-0.1851	0.0728
	(8.54)	(9.74)	(-11.58)	(-4.09)	(0.99)
Pigeon pea	0.7056	0.0463	-0.8209	0.0967	-0.0277
	(5.59)	(0.63)	(-6.19)	(0.88)	(-0.21)
Green gram	0.4379	0.2729	-0.1447	-0.1378	-0.4283
	(2.41)	(3.54)	(-0.76)	(-2.73)	(-2.61)
Black gram	-0.0834	0.2735	0.0884	-0.0026	-0.2759
	(-0.73)	(4.11)	(0.62)	(-0.04)	(-2.76)
Edible oilseeds	0.0841	-0.0065	-1.3750	-0.1327	1.4301
	(0.76)	(-0.07)	(-7.56)	(-1.34)	(7.40)
Rapeseed & mustard	0.0826	0.4650	-1.0986	0.0207	0.5303
	(1.16)	(6.97)	(-7.40)	(0.28)	(4.02)
Groundnut	0.1049	0.3512	-0.6558	0.3970	-0.1972
	(1.12)	(6.63)	(-6.63)	(5.12)	(-1.80)
Soybean	0.3830	0.3158	-0.3852	-0.4624	0.1488
	(4.67)	(5.21)	(-4.39)	(-5.82)	(1.92)
Sugarcane	0.2275	-0.2770	-1.4102	1.4267	0.0330
	(0.92)	(-1.98)	(-5.14)	(6.92)	(0.23)
Onion	-0.7099	0.2071	0.5892	0.3460	-0.4323
	(-2.65)	(1.82)	(1.93)	(1.43)	(-2.29)
Potato	-0.7099	0.2071	0.5892	0.3460	-0.4323
	(-2.65)	(1.82)	(1.93)	(1.43)	(-2.29)
Cotton	0.2143	0.2409	-0.7372	0.2360	0.0460
	(2.45)	(5.06)	(-6.35)	(2.37)	(0.53)
Jute	0.5671	-0.1965	-0.8183	0.1898	0.2580
	(1.98)	(-1.18)	(-3.48)	(1.00)	(1.76)
All crops	0.1728	0.1851	-0.9506	0.3061	0.2865

Notes: 1. Figures in the parentheses are the corresponding student t-statistics.
2. w = wage (Rs/hour); b = cost on animal labour (Rs/hour); m = cost on machine labour (Rs/hour); P = price of crop (Rs/100 kg); r = cost of fertilizer (NPK) (Rs/kg); i = Cost of irrigation (Rs/ha).

Source: Kumar (2011).

Table A.4: Estimates of Fertilizer Demand Elasticities for Crop in India

Crop	w/P	b/P	m/P	r/P	i/P
Rice	-0.0345	0.0238	0.0415	-0.2452	0.2144
	(-0.47)	(0.39)	(0.95)	(-3.57)	(4.30)
Wheat	0.3111	-0.1532	0.2147	-0.3504	-0.0222
	(6.81)	(-4.41)	(4.20)	(-5.63)	(-0.34)
Coarse grains	0.8352	-0.1143	0.4065	-1.2358	0.1085
	(7.13)	(-2.13)	(5.07)	(-10.57)	(1.47)
Maize	-0.2205	0.0065	-0.1263	0.0051	0.3352
	(-1.60)	(0.08)	(-1.30)	(0.03)	(3.54)
Sorghum	1.0489	0.0165	0.3189	-1.6839	0.2995
	(10.34)	(0.21)	(3.29)	(-12.32)	(3.69)
Pearl millet	0.9046	-0.1704	0.5029	-1.5790	0.3419
	(7.07)	(-2.04)	(3.29)	(-9.92)	(3.46)
Pulses	0.6424	-0.0500	0.1259	-0.8094	0.0911
	(2.88)	(-0.33)	(0.76)	(-5.12)	(0.51)
Chickpea	0.3440	0.2244	-0.8381	-0.2532	0.5229
	(1.47)	(1.28)	(-4.09)	(-1.32)	(2.55)
Pigeon pea	0.5161	0.4519	0.1905	-0.6957	-0.4628
	(1.81)	(3.15)	(0.88)	(-2.64)	(-1.93)
Green gram	0.2537	0.5646	-0.4091	-0.6204	0.2113
	(1.37)	(4.38)	(-2.73)	(-5.72)	(1.14)
Black gram	0.3840	-0.8063	-0.0087	-0.5932	1.0242
	(1.88)	(-6.40)	(-0.04)	(-3.66)	(5.22)
Edible oilseeds	0.9695	-0.0550	-0.1639	-1.1183	0.3677
	(10.01)	(-0.76)	(-1.34)	(-9.21)	(2.66)
Rapeseed & mustard	0.1355	0.0648	0.0308	0.2152	-0.4463
	(1.61)	(0.93)	(0.28)	(1.81)	(-3.78)
Groundnut	0.6800	0.0136	0.2873	-1.1260	0.1451
	(6.37)	(0.22)	(5.12)	(-10.49)	(1.61)
Soybean	0.3343	-0.0190	-0.7902	-0.1662	0.6412
	(1.95)	(-0.20)	(-5.82)	(-0.84)	(4.59)
Sugarcane	-0.3256	0.0899	0.4201	-0.4278	0.2434
	(-3.92)	(1.75)	(6.92)	(-4.32)	(3.84)
Onion	0.2681	0.1269	0.1063	-0.4579	-0.0434
	(2.22)	(1.91)	(1.43)	(-3.89)	(-0.42)
Potato	0.2681	0.1269	0.1063	-0.4579	-0.0434
	(2.22)	(1.91)	(1.43)	(-3.89)	(-0.42)
Cotton	0.3882	-0.0924	0.1413	-1.0416	0.6044
	(5.72)	(-2.98)	(2.37)	(-12.79)	(11.04)
Jute	-0.7601	0.4750	0.1110	0.2949	-0.1208
	(-2.91)	(3.36)	(1.00)	(1.43)	(-1.20)
All Crops	0.4051	-0.0456	0.0882	-0.6458	0.1982

Notes: 1. Figures in the parentheses are the corresponding student t-statistics.
2. w = wage (Rs/hour); b = cost on animal labour (Rs/hour); m = cost on machine labour (Rs/hour); P = price of crop (Rs/100 kg); r = cost of fertilizer (NPK) (Rs/kg); i = Cost of irrigation (Rs/ha).

Source: Kumar (2011).

Table A.5: Estimates of Irrigation and Other Inputs Demand Elasticities for Crop in India

Crop	w/P	b/P	m/P	r/P	i/P
Rice	0.3375	0.0589	0.1469	0.1389	-0.6823
Wheat	-0.0269	0.1403	-0.0426	-0.0155	-0.0553
Coarse grains	0.1458	0.2357	0.2021	0.0715	-0.6551
Maize	0.0307	0.3794	0.2124	0.2463	-0.8688
Sorghum	0.2641	0.1339	0.2416	0.2100	-0.8496
Pearl millet	0.0657	0.3044	-0.2402	0.1836	-0.3135
Pulses	0.2324	0.0687	-0.0465	0.0173	-0.2718
Chickpea	-0.1293	0.0460	0.0408	0.0646	-0.0221
Pigeon pea	0.4164	0.2061	-0.0187	-0.1582	-0.4456
Green gram	0.5628	-0.0742	-0.2245	0.0373	-0.3014
Black gram	0.0356	0.2488	-0.1771	0.1986	-0.3059
Edible oilseeds	0.4288	0.3330	0.5780	0.1203	-1.4601
Rapeseed & mustard	0.1617	0.2893	0.5799	-0.3281	-0.7028
Groundnut	0.0552	0.0549	-0.0269	0.0273	-0.1105
Soybean	-0.1780	0.0482	0.0777	0.1958	-0.1436
Sugarcane	0.1169	-0.0004	0.0050	0.1252	-0.2467
Onion	0.0920	0.0008	-0.0354	-0.0116	-0.0458
Potato	0.0920	0.0008	-0.0354	-0.0116	-0.0458
Cotton	0.0547	0.1314	0.0120	0.2642	-0.4622
Jute	0.2034	0.0638	0.0812	-0.0650	-0.2834
All crops	0.2489	0.1636	0.2153	0.0895	-0.7172

Notes: 1. Estimates were derived using homogeneity condition in the model, and so student t- statistics were not computed.
2. w = wage (Rs/hour); b = cost on animal labour (Rs/hour); m = cost on machine labour (Rs/hour); P = price of crop (Rs/100 kg); r = cost of fertilizer (NPK) (Rs/kg); I = Cost of irrigation (Rs/ha).

Source: Kumar (2011).

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