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Technological Intervention in Indian Agriculture for Enhancement of Crop Productivity

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INTRODUCTION

Agriculture provides employment to majority of Indian population and food security to the nation. India has made impressive strides on the agriculture front in the past three decades. Despite the growth in production in the Indian agricultural sector in the recent decades, crop yields remain low as compared to global averages. While India with 158 million hectares of arable land produces only 249 million tonnes of cereals, China with 110 million hectares, and USA with 163 million hectares of arable land produces 483 million tonnes and 420 million tonnes of cereals, respectively.

Within India, agriculture development varied in terms of intensity amongst the states. Green revolution, as also its immediate phase in early 1990s, witnessed equitable growth rate in agriculture. However, growth rates in agriculture NSDP decelerated in most of the states, post 2000, with no significant improvement in crop productivities. This may be attributed to structural weaknesses of the agricultural sector, which is analysed in this Study. The Study specifically focuses on analysis of impact of technological intervention in productivity with respect to rice cultivation.

INPUT USE TRENDS IN INDIAN AGRICULTURE

Input management plays a vital role in crop production and productivity. According to some research findings, the growth in per hectare input-use at constant prices decelerated from 3.66 percent per annum during 1980s to 0.94 percent per annum during the 1990s; the Mid-Term Appraisal of the Tenth Five Year Plan also attributes a part of the decline in agriculture growth to lower input-use.

Comparison of Area, Production and Productivity of Select Crops in India and World (2009)

Select Crops	World			India*				
	Production (Million Tonnes)	Area Harvested (Million Ha)	Yield (kg/ha)	Production (Million Tonnes)	Share in world production %	Area Harvested (Million Ha)	Share in world area %	Yield (kg/ha)
Paddy	684.8	158.4	4324	99.0	14.5	41.9	26.4	2178
Wheat	687.0	224.8	3055	80.7	11.7	27.8	12.3	2839
Maize	820.0	158.8	5160	17.0	2.1	8.3	5.2	2024
Pulses	63.1	68.7	919	14.2	22.4	20.9	30.5	630
Sugarcane	1668.0	23.7	70274	285.0	17.1	4.4	18.6	64486
Oilseeds: Groundnut (in shell) Area ('000 ha); Production ('000 tonnes)	24590.1	38201.3	1554	6850.0	27.9	7338.0	19.2	1071

Source: FAOSTAT 2011; * Ministry of Agriculture, Govt. of India

Fertilizer

Analysis of fertilizer use since the Green Revolution shows that the average per hectare use of fertilizer doubled in absolute terms in every decade from 1971 to 1991. Subsequently, the average growth in per hectare use of fertilizer has slowed down. With respect to type of fertilizers used, it has been generally noted that use of plant nutrients in many parts of the country is highly skewed towards nitrogenous fertilizers over the years resulting into an imbalance in the ratio of Nitrogen : Phosphorous: Potassium (NPK) use. While the recommended NPK ratio aggregated for the country as a whole is 4 : 2 : 1, the ratio was distorted to the extent of 9.5 : 3.2 : 1.0 following decontrol of prices of Phosphatic and Potassic fertilizers, which still continues to be at 5.0 : 2.4 : 1.0. This has raised considerable concerns regarding soil fertility, productivity and efficiency of fertilizer use in the country.

Overuse of fertilizers and pesticides, and declining organic content due to intensive cultivation are also largely responsible for soil degradation. For instance, over use of urea turns soil acidic; more energy is required to cultivate such degraded land, and a higher proportion of rain water is lost as run-off.

Increased use of fertilizers has also led to pollution of water resources, both

Comparison of Key Inputs in Agriculture and Productivity of Foodgrains in India vis-à-vis Leading Foodgrain Producing Countries: 2009

Countries	Arable land	Productivity	Fertiliser consumption	Irrigation water withdrawal
	Million Ha	(tonnes/Ha)	('000 tonnes)	(10^9 m3/yr)
India	158	2.6	26493	550.4
China	110	5.4	49100	286.4
USA	163	7.2	18908	153.9
Brazil	61	3.5	9045	25.4
Viet Nam	6	5.1	2090	62.2
Bangladesh	8	4.1	1610	25.2

Source: AQUASTAT, FAOSTAT, Ministry of Agriculture, Govt. of India

surface and ground water, resulting in poor quality of irrigation water, having negative impact on crop growth and productivity.

Seed

Supply of certified/quality seeds and Seed Replacement Rate (SRR) are the two important factors in enhancing productivity in agriculture. In India, about 85 percent of farmers are using farm-saved seeds that lose its vigour and thereby the productivity over a period. The genetic gains in seeds achieved during the Green Revolution period has also been decelerating. While the use of hybrid seeds in Indian agriculture has been growing, there has been low penetration of hybrid seeds in case of staples in the country. According to the Working Group Report of the Planning Commission, on Eleventh Five Year Plan, for the past two decades, there has been little change in Seed Replacement Rate in some of the states in India.

Farm Mechanisation

Farm mechanization is an important component for increasing crop production and productivity, besides reducing the drudgery of farm labourers. Farm mechanization also enables efficient use of agricultural inputs and reduces the cost of production.

Total farm power (combination of tractor, power tiller, diesel engines and electric motor and other animate and mechanical power) input per unit of cultivated land in India is still very low at 1.5 kW/Ha compared to Japan (14kW/Ha), South Korea (7kW/Ha), China (6.8kW/Ha), and USA (6kW/Ha).

Agriculture R&D and Extension Services

According to a study by the World Bank, agriculture R&D as a percentage of GDP has been 2.36 percent for developed countries, and the same is lower at 0.53 percent for developing countries of the world, further lower at 0.41 percent for developing countries of Asia, and at 0.34 percent for India. India is the fourth largest in the world in total R&D expenditure in agriculture. There are challenges associated with delivery mechanism of public research system in India. According to National Commission on Farmers (NCF), there exist large gaps between yields in research stations and farmer's fields. Close interaction between researchers and agriculture extension services has long been a challenge in India.

Extension services in India is also characterized by high ratio of farmers to a extension worker, at 914 : 1, if all posts in the Department of Extension Services, Government of India (nearly 140,000) is filled up and all the extension services officials are involved, while the desired ratio of farmers to extension worker is 300 to 500 : 1. This indicates inadequate agricultural extension services in India. A Working Group Report by International Food Policy Research Institute, and a study by the Centre for Research on Innovation and Science Policy, India, also corroborate the weak extension services machinery in India and the disconnect between the extension, research and development, and market needs.

Irrigation and Water Management

According to a joint study by International Water Management Institute and Asian Development Bank, in absolute numbers, India has the largest area under irrigation within Asia. India also has largest potential area under irrigation in Asia. However, the growth in area equipped under irrigation in the country has been considerably low. The share of area equipped with irrigation in potential area of irrigation in India is about 44 percent which is higher for China (83%).

According to the Databook for the Planning Commission, Government of India, submitted by Central Board of Irrigation and Power, Government of India, around 15 percent of ground water blocks have been over exploited in India, leading to rapid depletion of ground water levels, which is particularly observed in the case of leading food-grain producing states. In addition to the concerns over the availability of fresh ground water for potable use, this alarming over exploitation of ground water resources has been raising concerns over sustainability of irrigation in these states, and subsequent impact on crop production and productivity. The depleting level of groundwater in the country calls for review of power tariff policy for agriculture, and adoption of micro-irrigation system in the country. According to research estimates, compared to the potential of 42.23 million hectares in the country, the area under micro-irrigation is 3.87 million hectares, which is just about 9.2 percent of the potential.

STRATEGIES

Irrigation and Water Management Practices

Technological improvements in irrigation systems increase production opportunities and productivity. Water use efficiency in India is presently estimated to be only around 38 percent for canal irrigation, and about 60 percent for ground water irrigation schemes. It is estimated that with 10 percent increase in

Case Study: Technological Intervention and Rice Productivity

India is second largest producer of rice in the world, next only to China, with largest area under rice cultivation; however, India has one of the lowest productivity of rice among the leading rice producing countries in the world.

Yield of Rice in Select Countries

Countries	Yield (kg/ha)
China	6582
Japan	6521
Viet Nam	5237
Indonesia	4999
Brazil	4405
Bangladesh	4203
Myanmar	4085
Philippines	3589
Pakistan	3581
Thailand	2883
India*	2178

Source: FAOSTAT, 2011 Department of Agriculture and Cooperation, GoI

Productivity of rice in all leading Indian rice producing states is below the global average. Among the Indian states, Punjab, which falls in the Indo-Gangetic Plains, closely compares to the productivity level of Bangladesh, which is the fourth largest producer of rice in the world.

Some of the factors that might have helped these countries in achieving higher crop productivity are discussed below:

Hybrid rice production

The spread of hybrid rice in select rice producing countries, especially in Asia, has been strong as compared to India. The share of hybrid in total rice acreage has been 52 percent in China, 10 percent in Viet Nam, 7 percent in Bangladesh, 5 percent in Indonesia, and 4.4 percent in Philippines, as compared to 3.9 percent in India, in 2009.

Agricultural mechanization

Though India has made remarkable advances in the farm-machinery sector, mechanization of farm operations remains relatively low, in comparison to other rice producing countries such as China, Cambodia, Thailand and Viet Nam.

An interesting feature is that FAO datasets include only 4-wheeler tractors as farm machinery and do not include 2-wheeler tractors, although they perform at the same level as that of 4-wheeler tractors. Several studies have identified Bangladesh as one of the Asian countries having most mechanized agricultural operations, as a result of high spread of small-scale 2-wheeler tractors driven by single cylinder diesel engines. Bangladesh is reported to have over 1-million small horsepower diesel irrigation sets and nearly 400,000 two-wheeler tractors. In comparison there are only 110,000 two-wheeler tractors in India, which is low in comparison to the magnitude of agricultural operations.

Fertilizer usage

Analysis of nutrient (NPK) uptake and productivity of rice by the major producing countries in Asia reveals that nutrient management is relatively poor in India. Comparison of nutrient (NPK) intake per hectare of rice cultivation and productivity reveals that countries, such as Bangladesh, Pakistan, Indonesia, Philippines and Thailand have higher rice productivity despite lower nutrient (NPK) intake (kg/Ha). Another notable feature is fertilizer application technique; Urea Deep Placement (UDP), which is reported to be much efficient way of urea application in rice cultivation, as compared to commonly practiced broadcasting a basal application, is Practised in countries like Bangladesh.

Pest management

A research study points out Integrated Pest Management (IPM) system in Indonesia as one of the reasons for growing crop productivity. Prior to introduction of IPM in Indonesia, there was rampant usage of pesticides due to price subsidy. This overuse of pesticides not only killed the predators of the original crop pest, giving rise to the pest population, but also resulted in considerable increase in pest related hazards. The Indonesian Government worked directly with the farmers, through the frontline agricultural extension workers, to educate them on pest management based on eco-system analysis. International organizations, in several review and analysis, have judged the programme a success.

Fertilizer use in rice cultivation in Select Countries

Country	N kg/ha	P kg/ha	K kg/ha	Total Fertiliser Use (000 tonnes)	Total NPK (kg/ha)	Productivity
India	104.9	34.2	21.6	6725	160.7	2178
Bangladesh	102.1	15.1	12.2	1468	129.3	4203
Pakistan	92.3	18.4	1.0	322	111.7	3581
Indonesia	90.7	8.7	9.2	1399	108.6	4999
Philippines	46.8	7.9	2.6	260	57.4	3589
Thailand	23.5	6.2	1.3	346	31.1	2883

Source: International Fertiliser Industry Association (IFA), FAOSTAT; Exim Bank Research

the present level of water use efficiency in irrigation projects, an additional 14 million hectare area can be brought under irrigation. One of the foremost efforts to be made in this direction is to evolve irrigation management techniques that are diverse and location specific. Various types of on farm soil and water conservation technologies and engineering measures can reduce peak runoff rates and soil loss by 60 percent to 80 percent, and raise crop yields by 30 percent to 40 percent.

Growing entrepreneurship in Indian farming community, coupled with subsidized power for agriculture, is making ground water exploitation a more convenient option for irrigation. This has been adversely affecting water table in India. Even after continued support and promotion of micro-irrigation by the Government of India, the percentage of area under micro-irrigation has not been remarkable. It has been assessed that there is potential of bringing around 42 million hectares under drip and sprinkler irrigation in India. Studies have estimated that the Benefit to Cost Ratio of micro-irrigation techniques is significant.

Adoption of System of Rice Intensification (SRI)

SRI involves the use of certain management practices which together provides better growing conditions for rice plants, particularly in the root zone, than those plants grown under traditional practices. SRI is currently practiced in over 40 countries, including China, Indonesia, Cambodia, Bangladesh, Cuba, Myanmar, Nepal, Sri Lanka, Viet Nam, and West Africa. In India, SRI is being practiced mainly in southern states of Tamil Nadu, Andhra Pradesh, and Karnataka, and sporadically in North Eastern States of Tripura and Assam. The benefits of SRI include: less seed rate, less nursery area, labour saving, water saving, better aeration, enhanced yield, and control of diseases. Simplification of SRI methodology and scaling up this innovative approach throughout the country may help improve rice productivity.

Agri-Biotechnology:

Agricultural biotechnology has the potential for making huge impacts on many facets of agriculture – crop and animal productivity, yield stability, environmental sustainability, among others. Yield stability is important for all farmers, especially for farmers in subsistence agriculture, whose food and livelihood security are vulnerable to pest and disease outbreaks, droughts and other stress. Agri-biotech varieties that are disease and pest resistance provide yield stability. There is an urgent need to increase public investments in agri-biotech research to develop and introduce such varieties in Indian agricultural system.

Soil Health and Nutrient Management

Nutrient management and improving soil health enhances crop production and productivity. In many cases, imbalances can be corrected through the application of appropriate inorganic and organic fertilizers. Integrated Nutrient Management (INM) approach, through judicious use of chemical fertilizers, should be adopted not only to increase agricultural production, but also to safeguard the environment for the future.

Integrated Pest Management Approach

Integrated Pest Management (IPM) propagates alternative methods for controlling pests in a compatible manner. IPM strategies should be different for different crops, different for a region, or even for a location, depending on the varieties used, and the agronomic practices. Designing and practicing effective IPM systems is about learning and continuously finding solutions to suit the changing field situations and problems.

Farm Mechanisation

Farm mechanization is increasingly required to compensate the exodus of rural labour, besides the objective of improving farm productivity. Technological inter-vention for land leveling and drainage minimize the water use and improve water efficiency, besides providing better growing conditions. Technological intervention for irrigation or other input usage, especially with electronic monitoring, helps in appropriate distribution of inputs bsides helps in protecting the soil health. Use of such equipments, though increases the capital cost of operations, contribute to enhanced productivity – ranging from 20 percent to 50 percent, neutralizing the capital cost in the long run.

To improve farm mechanization and thereby farm productivity, we need to encourage establishment of Agri-implements Banks which will provide custom-hire machinery, besides repair and maintenance services. The Banks may also impart training on operations of such machinery.

Conservation Tillage

Another approach for enhancing crop production and productivity is conservation tillage which minimizes or eliminates tillage and maintains crop residues as ground cover. According to FAO, conservation agriculture is based on enhancing natural biological processes above and below the soil surface. Conservation tillage is in contrast to the conventional agriculture which recommends extensive soil tillage and burning of crop residues, which leads to soil degradation through loss of organic matter, soil erosion and compaction.

Efficient Extension Services

The existing Training and Visit (T&V) system of extension services is top-down in its approach and there has been little participation by the farmers. This approach needs to be corrected so that the existing agriculture extension system could be reformed and revitalized. The approach to the reforms may also include active involvement of farmers through user-group associations, extension methods including farmer-to-farmer extension, as has been practiced in many parts of the world. Mixing of public and private extension systems, including NGOs and farmer organizations would help improve extension delivery mechanism in India, especially to cater to farmers who are subsistence on agriculture.

IN SUM

Scientific and technological interventions are critical both for agricultural development and enhancing crop productivity. Technological interventions are important to meet the growing demand for food, rising resource constraints and energy costs. Innovation is also central for maintaining market competitiveness, both domestic and global.

Since Indian agriculture is heavily dependent on input usage – be it energy, water, fertilizers, or pesticides, strategies need to be adopted for sustainable management of resources to counter any negative impact on crop production and yield levels. For such sustainable productivity enhancement, with balanced use of water and fertilizers, policy support is required; especially, review of Government interventions in farm fertilizers, and farm power pricing may be needed.

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