Ind. Jn. of Agri. Econ.
Vol.73, No.1, Jan.-March 2018

Input Delivery System in Agriculture including Irrigation and Other Services and their Efficiency: The Role of Finance Sector*

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ABSTRACT

The character of farming in India is changing. There is a shift towards high value agriculture given the economic pressures and the lure of big gains. Along with capital, the extent of knowledge inputs required in farming to make the farming system robust and resilient is increasing. This is particularly important when we consider the fact that the biggest transformation is happening in the semi-arid and arid regions that are water-scarce and also subjected to high climatic variability and extreme weather conditions.

The paper discusses the drivers of future agricultural growth in India, and the key features of the emerging farming systems; the technologies that act as drivers of change in agricultural output, and are capable of improving the input use efficiency and reducing the production related risks to sustain this growth, and their cost implications; the institutional approaches that can reduce the market risks associated with the emerging farming system; and finally the role of financial sector in boosting technology adoption and reducing market risks in farming.

The following are the interventions to make the recently witnessed growth in the agricultural sector sustainable and socially viable: (i) assessing the weather induced and other production risks, and market risks in farming, prior to advancing farm loans; (ii) linking farm loans to crop insurance; (iii) design insurance products based on risk assessment; (iv) undertake research on resilient farming systems; (v) link subsidies to efficient use of technologies and resource, especially water and energy; and, (vi) offering special incentives for promotion of farming clusters.

I

INTRODUCTION

Indian agriculture is undergoing fast transformation. On the one hand, the cost (both the real economic cost and the costs incurred by the farmers) of conventional agricultural inputs such as fertiliser, pesticides, irrigation water, energy and labour, and throughputs such as land, irrigation equipments is on the rise. On the other hand, as the result of larger economic changes happening in the country-domestic economic growth, rise in per capita income, urbanisation, changing consumption patterns and globalisation of the economic system-, the nature of farm economy is rapidly changing from subsistence to commercial and from traditional to modern, with many high-value crop outputs (Government of India, 2016). Notably, the fluctuation in the price of such high value produce has also become lesser over time, a clear indication

*Keynote paper presented at the 77th Annual Conference of the Indian Society of Agricultural Economics in College of Post Graduate Studies, Central Agricultural University, Barapani, Meghalaya during October 12-14, 2017.

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of the growing demand for this produce throughout the year. While the former poses many constraints for the farming community, the latter offers many new opportunities and challenges.

In any case, the agricultural gross domestic product (GDP) in the recent years have recorded impressive growth mainly due to diversification of farming system and increasing proportion of high value crops. The analysis by Rada (2013) showed a renewal of farm total factor productivity (TFP) growth in India following the economic reforms of the 1990s, led primarily by horticultural and livestock products and by Southern and Western parts of India. The high-input farming system championed by the Indian North has been out-performed by more diverse farming systems producing higher valued commodities. Transitioning to higher valued crops has accounted for 36.5 per cent of India's growth in aggregate crop production per hectare (Rada, 2013).

With increasing demand for high value produce such as vegetables and fruits, including exotic vegetables, flowers and spices in the Indian market including smaller cities and towns, farmers are tempted to diversify their farming systems to increase the profitability of agriculture. Even from the point of view of reducing rural poverty and increasing farmer incomes substantially, this is important. The agricultural component of the "Three Year Action Plan" (as part of the Vision Document) for 2017-18 to 2019-20 prepared by the NITI *Aayog* of India envisions doubling of farmer incomes by 2022 (Government of India, 2017: pp.29-30). The key characteristics of the emerging farm economy in India are: (i) increasing role of capital and reducing role of labour in doing the farming operations; (ii) increasing farm mechanisation (for ploughing, application of inputs, weeding and harvest); (iii) use of technologies for precision farming and production environment control; (iv) increasing role of knowledge inputs on agronomic practices and produce marketing in the overall farm management; and, (v) the availability of freshwater increasingly becoming a constraint to crop production some cases, and good quality land becoming a constraint in some. With this, the risk involved in farming is also on the rise. This farming system risk includes production risk (induced by weather and diseases), technology risk and market risk.

Resource-rich farmers increasingly use precision farming (automatic, weather-controlled irrigation), technologies for control of production environment (green house and poly-house, poly-tunnel), efficient irrigation technologies (drip and sprinkler irrigation) and crop technologies to reduce the exposure of agriculture to the weather-induced shocks and diseases (known as production related shocks). However, to absorb the shocks induced by price fluctuations in the market, new approaches that involve a combination of technologies and institutional interventions are required. They include promotion of resilient farming system; the use of post-harvest technologies for storage and processing, group and corporate farming; creation of marketing infrastructure; and crop insurance. Adoption of such risky farming systems requires greater deal of financial services that can help reduce the exposure of agriculture to these production and market related shocks (crop failure, yield losses due to crop damage, diseases and loss of revenue), and vulnerability of the farming communities to these shocks.

In this paper, we discuss the drivers of future agricultural growth in India, and the key features of the emerging farming systems; the technologies that act as drivers of change in agricultural output, and are capable of reducing the production related risks to sustain this growth; the institutional approaches that can reduce the market risks; and finally the role of financial sector in boosting technology adoption and reducing market risks in farming.

II

DRIVERS OF FUTURE AGRICULTURAL GROWTH IN INDIA

Increase in Area under Cultivation of High Value Crops:

During the last decade, a significant growth in Indian agriculture has come mainly from crop diversification with a consistent growth in area under high value crops, comprising fruits, vegetables, spices and flowers both in aggregate terms and percentage terms. There is modest growth in area under cereals, especially fine cereals such as wheat and paddy while there is relatively larger growth in area under the high value crops. On an average, these crops fetch much higher prices in the market, though the price fluctuation is wide.

There are many factors that drive this agricultural transformation. First, there is a growing demand for the high value crops in India, especially fruits, vegetables and flowers, owing increase in per capita income and changing consumption pattern and significant growth in consumption of fruits, vegetables and flowers is felt from cities and towns, with a perennial demand. Second, easier access to precision irrigation technologies and technologies for control of production environment that are required for raising some of these crops (foggers, drips and sprinklers, mulching, fertigation) made possible through government subsidies and improved supply chain, had facilitated faster adoption of these crops and its penetration in the rural areas. Third, physical scarcity of groundwater in many areas (especially hard rock areas), which currently dominate irrigation in India, and increase in cost of production of water from underground sources had motivated farmers to grow crops that yield high return per unit volume of water. So when the cost of production of water becomes high, it is put to high value uses, i.e., uses that give very high incremental return per unit of water (Kumar, 2017). Fourth, the relatively higher degree of control over water application and access to pressurising devices under well irrigation also enables farmers to grow high value crops that are also water-sensitive.

It is rightly argued that the scarcity value of the resource is not felt by the farmers who use water for economic production functions due to inefficient pricing of water and energy that is characterised by heavy subsidies and zero marginal cost, and lack of restrictions on volumetric water use. As a result, the efficiency of use of water and water productivity are very low in agriculture. Nevertheless, there are millions of farmers in different regions of India (including some of the water-rich regions of eastern India and north India, and water scarce regions of south Indian peninsular and western India) who purchase water from well owners and who pay for water on hourly basis (Kumar *et al*., 2010). These farmers are confronted with positive marginal cost of using water, and have incentive to use water efficiently (Kumar *et al*., 2010; 2011). There are also farmers in the hard rock areas of India, whose primary source of water for irrigation is wells, and who have extremely limited access to water due to the limited groundwater potential. These farmers are confronted with opportunity cost of using water and hence have the incentive to use water efficiently. Because of these reasons, they take the risk and allocate the expensive water for high value uses while also using water and other inputs efficiently in order to obtain income returns large enough to recover the high input costs, which is again limited in quantitative terms. This enhances the return from farming.

The impact of induced water scarcity on the nature of farming enterprise and economic returns from farming is evident from the fact that in the water-rich areas, especially in areas which receive canal water, farmers prefer to grow cereals such as paddy, which fetch low value in economic terms. For instance, a recent analysis showed that in the newly formed state of Andhra Pradesh around 85 per cent of the paddy irrigation is from surface sources and around 92 per cent of the surface irrigation is for paddy. While one reason for this bias towards paddy and such water-intensive crops like paddy is the lack of control over water delivery, the other reason is the access to cheap water.

Use of Water Saving Irrigation Devices is Driving Area Expansion: Currently, micro irrigation systems cover nearly 4.0 m. ha of India’s irrigated land. Of this, around 1.9 m. ha is under drip systems, used mainly for fruit crops, vegetable crops, flowers and some nuts (like coconut and areca nut)(Sankaranarayanan *et al*., 2011). Considering the fact that the area under irrigated crops that are amenable to water saving micro irrigation systems is only nearly 8 m. ha, this is a remarkable achievement (Kumar, 2016). A very large share of the area under micro irrigation system including drips is in the semi-arid water-scarce regions of India, mainly covering the states of Maharashtra, Gujarat, Rajasthan, Karnataka, Andhra Pradesh, Tamil Nadu and Madhya Pradesh. With deep water table, the use of drip irrigation systems with proper irrigation scheduling in such regions for distantly spaced row crops can surely lead to reduction in consumptive use of water per unit area. One impact of this is the increase in crop yields as shown by many empirical studies involving primary data. The other impact is increase in area under cropping (wherever water is relatively scarce in comparison to land), which is also shown by several studies as farmers reallocate the saved water for irrigating more area (Molle *et al*., 2004). As a coincidence, in most of the areas witnessing adoption of water saving technologies (WSTs) have a small proportion of their arable land under irrigation which enables area expansion easy.

Land Use Efficiency/Land Use Intensity: As per official statistics, the net sown area in the country has not been increasing. However, such findings are based on the analysis of official data on cultivable land in the country. With growing pressure on land as a consequence of increasing number of operational holders, a large amount of area lying under wasteland, cultural fallows are being brought under cultivation. A lot of this land has low primary productivity. But access to well irrigation has enabled farmers to bring such low lands under cropping. There are large areas in the Thar desert of Rajasthan which were lying fallow due to the presence of desert soils, high aridity and lack of access to good quality water for irrigation. With access to canal irrigation under Indira Gandhi Nehar Project (IGNP), around a million hectare of this land is now under crop production.

With the current government's efforts to revive the idea of interlinking of rivers and to pass a National Framework Law on Inter-linking of River to address the legal and social issues arising out of the decision to transfer water from one state to another, irrigation potential is likely to witness a significant growth in the next few decades (Government of India, 2017).[1] If that materialises, both land use efficiency and land use intensity would increase considerably with many dry land areas receiving irrigation water.

In highly urbanised areas and peri-urban areas of agriculturally prosperous regions, there is the great market for horticultural crops in view of their proximity to cities which form good market for horticultural produce, and entrepreneurs get low quality land in these areas on lease for cultivating fruit trees and raising fruit and vegetable nurseries, as using high quality land for such purposes will be economically unviable due to the astronomically high land prices. But, they use such lands which were lying fallow, for growing high value commercial crops which find immediate uptake. Such practices are actually driving agricultural growth trends. Such trends were seen in Rayalaseema region of Andhra Pradesh, and western Rajasthan which are highly water-scarce, but with pockets having freshwater.

Fertiliser Use Efficiency: More than water saving, adoption of micro irrigation devices has a great impact on fertiliser use efficiency, as most of the systems use fertigation devices called venture meters. The use of this equipment enables direct application of fertiliser to the plants, increasing the nutrient use efficiency.

Use of Marginal Quality Water and Wastewater: When freshwater is becoming a major constraint for enhancing agricultural production in many areas, marginal quality groundwater is being used for irrigation. This is the source of water for future in coastal areas of arid and semi-arid regions and in some inland areas where there is plenty of marginal quality groundwater (Kumar, 2017). Western Rajasthan and western parts of north Gujarat and Kutch and coastal Saurashtra have large areas underlined by saline aquifer formations (Government of India, 2010). Currently, farmers in these regions are using this water for growing low value cereals, and some spices, oil seeds and other cash crops (cotton, cumin, castor, mustard and fennel), obtaining yields that are just half the yield obtained with good quality water. Recent studies show that if freshwater is available, farmers in these regions will be able to grow some of the high value fruits, vegetables, flowers and spices (including tomatoes, water melon, coconut, kinnow orange, pomegranate, fennel, berry, marigold and gerbera flowers and cucumber), obtaining very high returns per unit volume of water (Kumar, 2017).

One of the ways to reduce the salinity of groundwater in such areas is the careful and scientific introduction of canal water for irrigation. Return flows from canal irrigated fields and seepage from canals would not only augment groundwater but also reduce the salinity levels in the water thereby making it fit for irrigating vegetables and fruits. Through proper conjunctive use of canal water and groundwater, not only the effective water availability can be increased, but the problem of water logging in the canal command area prevented. This is already happening in many canal commands, including the IGNP, the Sardar Sarovar project and canal irrigated areas of South Western Punjab. This has enabled farmers to grow vegetables and fruits which were not feasible earlier.

A recent survey showed pockets of fresh groundwater within the saline aquifer belts in arid parts of alluvial north Gujarat and western Rajasthan which are in the proximity of large reservoirs, with groundwater getting replenished from reservoir seepage. Farmers were found to be growing vegetables in these pockets (Kumar, 2017).

Use of untreated and partially treated wastewater in agriculture is becoming rampant in the peri-urban areas of many large and small cities. In Delhi and Kanpur, the municipal corporations are supplying treated wastewater to farmers in peri-urban areas at a fee (Amerasinghe *et al*., 2013). While growing economic power would enable large cities to invest in improved wastewater treatment technologies, the treated water would end up in the peri-urban areas for producing fruits, vegetables, flowers and forage crops, in a much bigger scale than what is happening today around many cities. With greater willingness on the part farmers in naturally water-scarce regions to pay for treated wastewater for irrigating these high value crops, financially viable models in wastewater treatment and reuse would emerge in the future.

III

TECHNOLOGIES THAT INCREASE AGRICULTURAL OUTPUTS AND REDUCE PRODUCTION RISKS

3.1 *Crop Technologies and Seeds*

For many high value vegetables and flowers, the seeds used are of high yielding varieties mostly imported and are not coming from the cultivars maintained by the growers. These high quality seeds of high yielding varieties ensure very high rate of plant germination and uniform growth of the plants and the simultaneous flowering of fruits and vegetable plants (brinjal, carrot, watermelon and papaya) and flower plants (for instance, marigold), most of which is essential for fetching premium prices in the market. Similarly for some of the vegetables (like tomatoes, cabbage, chilly), healthy saplings of uniform growth are available in the nurseries. For some of the fruit trees (pomegranate, sapota, mangoes, lemon, sweet lime, kinnow, berry) the plants are mostly of grafted of hybrid varieties and are now available in the certified nurseries. Very few farmers have the knowledge to do grafting in their own farms. For banana, tissue cultured plants are now available widely and they ensure high quality plants.

3.2 *Technologies for Improving Water Use Efficiency*

There is a whole range of technologies available in the market that helps improve irrigation water use efficiency (kg/ET) in crop production. They include drip and sprinkler irrigation and plastic mulch. Within drip irrigation, there are a wide range of products now available in the market which ensure that a whole range of crops starting from distantly spaced mango (10 m X 10 m) to closely spaced brinjal, chilli, cabbage and tomatoes (1.0 m X 0.40 m) to which the technology becomes amenable. For the same kind of crop, depending on the soil type, drip equipments are available with different types of emitters (in terms of discharge) with different emitter spacing. This versatility of the technology had actually driven the growth in adoption of drip systems in India. In the case of sprinkler irrigation, the range of products available in the market includes micro sprinklers to mini sprinklers to overhead sprinklers and guns. As a result, a wide range of crops are covered by sprinkler technology, and includes wheat, bajra, sorghum, mustard, maize, ground nut and potato.

Plastic mulching is far more effective in controlling soil evaporation, and helps convert non-beneficial soil evaporation into beneficial transpiration for the plants leading to higher yield thereby increasing water use efficiency substantially (Xie *et al*., 2005). However, they are effective as a tool when used in conjunction with drip irrigation systems, as otherwise watering the plant becomes difficult once the soil is covered by the plastic sheet.

3.3 *Technologies for Improving Land Use Efficiency*

The advent of many new technologies has helped farmers to cultivate crops in terrains which otherwise were found unsuitable for cultivation, due to the following reasons: (1) excessively high sand content in the soil, making fast percolation of water and nutrients; and, (2) undulating terrain making farming operations, especially irrigation very difficult. The most important ones are sprinklers. The use of sprinklers has enabled farmers cultivate undulating and sandy areas without doing land levelling, as well illustrated by cultivation in the desert areas covered by IGNP, reducing the cost of cultivation and labour required for irrigation. While drips can be used in sloppy terrains, they are not feasible in very sandy and undulating terrains. Today, hundreds of thousands of farmers in IGNP command use diggies (a large surface storage system for storing water), pumping machinery and sprinklers for irrigating cereals and oil seeds.

3.4 *Technologies for Controlling the Production Environment*

India's extreme climatic conditions in certain regions of the country (very cold winter resulting in frost formation in certain areas of the north and north-west to very hot climate with heat waves during summer in the north, north west and western regions) makes it necessary for use of plant protection technologies. The technologies for controlling the production environment include: poly-house and net house, generally known as green house, and poly-tunnels.[2] The first two are used in extremely hot and arid conditions to protect the plans from heat stress caused by excessive solar radiation and also to control other weather parameters (such as humidity and high winds), and the last one is used in very cold weather to protect the plants from frost formation. These technologies have now enabled the farmers to grow many weather sensitive crops such as tomatoes, cucumber, chilly, cabbage, cauliflower and capsicum throughout the year. There is significant use of these technologies in north western India and western India and some arid pockets in South Indian peninsula.

3.5 *Technologies for Treating Marginal Quality Water*

The marginal quality water can also be desalinated using reverse osmosis systems at a cost much lower than that of seawater or brine, and the pH and other properties of water can also be controlled to suit the production of high value fruits, vegetables and flowers that are sensitive to even small fluctuations in the acidity of water. Though the cost of desalination of marginal quality water could still be quite high, the high income that can be derived from the production of high value crops will motivate the farmers to adopt this technology. The other technologies that are available are multi stage flash distillation process (MSFD), and can be used when heat energy is available for free. Co-generation plants with thermal or nuclear power and desalination in the coastal areas can bring down the cost of desalination substantially. The heat produced from thermal and nuclear power plants is used to heat the brine and the vapour is condensed into freshwater in the distillation chamber. There is already a thermal power plant with desalination system in Jamnagar run by Reliance Industries, supplying nearly 7mld of water to the city (Kumar, 2017).

IV

COST IMPLICATIONS FOR THE NEW AGRICULTURAL TECHNOLOGIES

The new technologies that help farmers modify their farming systems to grow high value crops have significant cost implications. Among all the technologies, micro irrigation is widely discussed. However, the emerging technology which changes the face of farming is the seed technology. The cost of seed and plants used for high value fruits, vegetables and flowers are given in Figure 1.

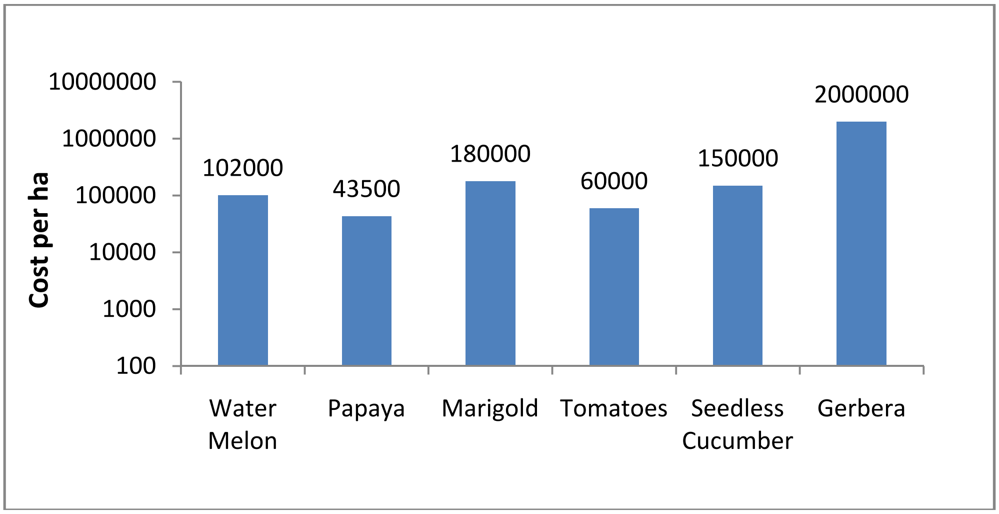

Figure 1. Cost of Seed (Rs.) per ha.

As recent field surveys carried out in western and north western India showed, farmers are currently investing substantial amount of capital for seeds and seedlings of high value vegetables (tomatoes, seedless cucumber), fruits (water melon) and flowers (marigold and gerbera), in view of the fact that they help them obtain very high yields, and produce of high quality. For water melon, the cost of seeds is Rs. 34,000 per kg and the cost of seeds per ha of cultivation of the crop is Rs.102000. For papaya, the seedling cost is Rs. 43,500 per ha, @ Rs. 15 per seedling. The seed cost is Rs. 180,000 per ha for marigold cultivation; Rs.60000 per ha in the case of tomatoes. In the case of cucumber, the cost of seeds is Rs. 6 per plant, and with a plant density of 25000 per ha, the cost is Rs 150,000 per ha of planting. In the case of gerbera flowers, the seedling cost is Rs.32.25 per plant and with a plant density of 6 per sq. m., the initial investment for planting becomes Rs. 2000,000 for a three year life of the crop (Kumar, 2017).

The capital investment for technologies for control of production environment ranges from Rs.422 per sq. m for poly house and Rs. 330 for net-house, after a 50 per cent capital subsidy from the National Horticultural Mission. With an expected life of 10 years for the poly house and 8 years for the net house and a discount rate of 9 per cent, this works out to an annual cost of Rs. 654,000 per ha for poly-house and Rs. 546,000 per ha for net-house. Such high capital investment motivates the farmers to use the facility very intensity, taking crops throughout the year (Kumar, 2017). In addition to what has been shown in Figure 1, they are many crops whose seeds cost exorbitant amounts, like that of Bt cotton.

The high cost of seeds and saplings increase the financial risk in farming, and to cover this risk, farmers have to make further investments, in precision farming technologies or micro irrigation systems or technologies that control the production environment. Again these add to the costs. The cost of drip irrigation systems for different plant spacing is given in Table 1. As one can see, when the lateral and dripper spacing becomes small, the cost increases substantially. For some of the vegetables like tomatoes, chilli, brinjal and cabbage, in which case, the dripper spacing is 0.4-0.45 m, the cost per ha will be higher than the highest figure in the table (i.e., Rs. 2.49 lac).

TABLE 1. ESTIMATED COST OF INSTALLING DRIP IRRIGATION SYSTEM FOR DIFFERENT PLOT SIZES

(*Rs.*)

Dripper spacing (m X m)	Size of the plot in ha					
	0.4	1	2	3	4	5
(1)	(2)	(3)	(4)	(5)	(6)	(7)
12 x 12	10600	16700	25200	32600	53700	71300
10 x l0	12100	18000	27700	36000	57900	76900
9 x 9	12400	22100	35500	55900	61400	81100
8 x 8	12900	19900	31300	41700	65500	86200
6 x 6	14400	30200	51200	70300	105800	13 7400
5 x 5	15100	32800	56600	83100	117100	150800
4 x 4	16900	39300	63100	100700	142200	179300
3 x 3	17900	35600	71400	96100	130800	158300
3 x l.5	19700	40200	80500	109700	146100	180900
2.5 x 2.5	20000	39800	81400	111200	199500	239600
2 x 2	21300	49800	86400	122700	164900	223400
1.5 x l.5	26100	55000	109500	165100	205900	281000
1 x l	26500	57600	96500	146500	199900	249200

Source: National committee on plasticulture applications in horticulture.

An important input whose real cost is not borne by the farmers many a times is the irrigation water. Water from public irrigation systems such as surface schemes is supplied to farmers almost free and at times a nominal price per ha per watering is charged. This is even for the costliest irrigation schemes involving huge river lift. But, the economic cost or the cost incurred by the society for creating the irrigation infrastructure and supplying water at the farmers’ fields is very high. These costs do not include the resource cost. These costs again vary from region to region, and one significant pattern which emerges vis-à-vis the cost of water is its relation with the water resources endowment of the regions where such systems are created.

If we leave states such as Mizoram, Jammu & Kashmir, Himachal Pradesh and Meghalaya, which are not known for investments in public irrigation and Jharkhand whose irrigation schemes are ongoing, the subsidy varies from a highest of Rs. 1,03,962 per ha in Andhra Pradesh to Rs. 2995 per ha in the case of Chhattisgarh. The investment in per ha terms is very high in Andhra Pradesh, and one of the reasons for this is the very high working expenses, owing to the large number of (river) lift irrigation schemes built recently by the erstwhile government of Andhra Pradesh, incurring substantial cost for energy for lifting water. The second highest irrigation cost in per ha terms is in Maharashtra (Rs. 68498/ha) which has the largest number of irrigation projects in the country, followed by Gujarat (Rs. 63,543/ha) (CWC, 2015). Rajasthan, which is the second most important state in terms of canal irrigated area, incurs considerably low expenditure on public irrigation. One important reason for this is that most of the irrigation is from IGNP canal, which transfers water to irrigate more than 1.0 m. ha of land from a barrage on Sutlej River in Punjab, whose cost was incurred by Punjab. A significant part of the project cost is not reflected in the capital expenditure against the state. In the naturally water scarce regions, cost of production and supply of irrigation water (per ha) appears to be much higher than of relatively water-rich regions (Kumar, 2017).

So far as groundwater is concerned, a common pool resource, but *de facto* a private property in India, the Indian farmers do not pay any price for using it in the form of resource fee or resource tax. The costs incurred by the well owning farmers for extracting groundwater is the cost of drilling the well and installing the pump sets, which are one-time costs, and the energy cost for pumping the water from underground. In many states the energy used for pumping groundwater is charged on the basis of connected load and only in a few states, electricity consumption is metered. In any case, electricity supply to the farm sector is heavily subsidised at the aggregate level (in terms of average subsidy per unit of electricity supplied), though the extent of subsidy varies across states (see Table 2).

As Table 2 indicates, only Tripura state has an agricultural power tariff which is higher than the average cost of power supply. In all other states, there is subsidy, and varies from Rs 1.75 in Assam to Rs. 8.67 in Jharkhand. However, the average cost of power supply also varies across states. It is highest in Jharkhand (Rs. 9.42) and lowest in Sikkim (Rs. 3.19). In the states where power subsidy prevails, the extent of subsidy varies from a highest of 100 per cent in Tamil Nadu, Punjab, Himachal Pradesh and Puducherry to a lowest of 28 per cent in Assam.

The heavy subsidy for electricity is available even in some of the water scarce states, where groundwater resources are over-exploited and depth of pumping groundwater is high such as Tamil Nadu, Andhra Pradesh (undivided), Punjab, Haryana, Gujarat, Rajasthan and Maharashtra. This means that the actual economic cost of energy required for pumping a unit volume of groundwater is very high in those states. Over and above the energy cost, the cost of depletion of the resource, i.e., water is also high.

The high cost incurred by the society (the sum of the financial cost of production and supply of irrigation water and the cost of resource depletion) for every unit of water consumed in agricultural production in such water scarce regions makes it all the more important that we maximise the economic returns per unit volume of water consumed in farming in such regions. While pricing of irrigation water and electricity (used for groundwater) to reflect the scarcity value of the resource are fiscal instruments to improve the efficiency of use of water, they are not central to the theme of this paper.

TABLE 2. POWER SUBSIDIES IN AGRICULTURE IN INDIAN STATES

Name of state (1)	Power supply cost (Rs./KWhr) (2)	Agricultural power subsidy (Rs./KWhr) (3)	Extent of subsidy in farm power (per cent) (4)
Undivided Andhra Pradesh	5.63	5.19	92.14
Assam	6.29	1.75	27.82
Bihar	7.85	3.74	47.67
Chhattisgarh	4.11	2.57	62.51
Gujarat	4.96	2.78	56.10
Haryana	6.46	6.00	92.80
Himachal Pradesh	5.26	5.25	99.78
Jammu and Kashmir	6.74	5.06	75.01
Jharkhand	9.42	8.67	91.96
Karnataka	5.05	1.98	39.24
Kerala	5.97	4.24	71.03
Madhya Pradesh	5.39	1.88	34.88
Maharashtra	5.84	3.26	55.78
Meghalaya	5.24	0.00	0.00
Punjab	5.78	5.78	99.99
Rajasthan	6.98	5.17	74.11
Tamil Nadu	6.46	6.46	100.00
Uttar Pradesh	7.06	4.82	68.25
Uttarakhand	5.10	2.82	55.18
West Bengal	6.13	1.98	32.26
Arunachal Pradesh	8.24		
Goa	3.72	2.66	71.44
Manipur	8.55	7.14	83.51
Mizoram	7.41	0.00	0.00
Nagaland	9.06		
Puducherry	4.06	4.03	99.22
Sikkim	3.19		
Tripura	5.10	- 0.44	- 8.70

Source: Author’s estimates based on Government of India (2014) as provided in Kumar (2017).

V

INSTITUTIONAL APPROACHES THAT CAN REDUCE RISK IN FARMING

5.1 *Promoting Resilient Farming Systems*

It is generally argued that introduction of high value crops into the farming system would enhance the farm returns. Such arguments miss the point about risk. There are big risks associated with many of the high value crops. These risks are related to production and markets (Kumar and van Dam, 2013). It is a well-known fact that some of the vegetables, fruits and spices are highly susceptible to diseases (pest attack, insect attack) and weather related stresses (including heat stress, frost formation). These diseases can sometimes attack the entire field at an unimaginable speed in a sense that the crop is fully destroyed before any curative measures are undertaken by the farmer. On the other hand, market failure can also cause huge distress for the producer, given the fact that wide fluctuations in the price of some of the fruits and vegetables (especially the fast-perishing ones) within short time spans is quite common. Therefore the crops introduced should be such that even in the event of production failures and market failures of the high value crops, the farmers can still earn some income from other crops that are part of the farming system. Or else, the ability of the farmer to provide resilience against such risks need to be taken cognisance of before such crops are introduced into the farming system.

From that perspective, it is important to know how resilient is the existing farmer system. The traditional farming systems are composite, with the outputs or by-products of crops used as input for livestock/dairy farming and vice versa. Also, farmers grow many crops in their fields of which only a few are high risk (and high value) ones and many are low risk and low value (like paddy). Mostly traditional farming systems have a mix of cereals, pulses, cash crops and fodder crops. They fit into the agro ecology of the area and are resilient to risks induced by natural calamities and changing market conditions (Choudhary and Sindhi, 2017). In the case of cereals such as paddy, bajra and sorghum, it is often found that even in the event of crop loss due to floods or water shortage towards the end of the growing season due to droughts farmers use the leafy biomass from the damaged fields for feeding the dairy animals which provide some cash income. Such a system provides risk coverage. Whereas in the case of vegetables and fruits, crop damage or price crash in the market can cause severe economic stress for the farmers.

5.2 *Adopting a Cluster Approach*

Often isolated cases of farmers experimenting with certain high value crops and earning high incomes are cited to build an argument that it makes more sense for a select few farmers to grow such crops as that would reduce the market risk, by preventing glut. But in many situations such inferences are based on short-term observations. What is ignored is the fact that several of the input services for growing such high value crops will be economically efficient only if a certain critical number of farmers grow these crops. Such inputs include timely provision of high quality seeds and good quality saplings, provision of high quality pesticides, insecticides and herbicides, and services of agronomists, horticulturists, scientists specialised in plant protection measures and precision farming experts. More importantly, the benefits of adopting high value crops should reach larger number of farmers, especially when the holding size is constantly reducing in the country affecting profitability. In many of the successful cases of production and marketing of horticultural crops in India (from South Gujarat, and Nasik and Nagpur divisions of Maharashtra) involve cluster approach wherein a large number of farmers take up plantation of the same crop in considerable area of land.

Even in the case of micro irrigation (MI) systems, the timely services of MI system suppliers, equipment assemblers and mechanics will be available only when large numbers of farmers from a locality adopt the system that it makes sense for these agencies to keep their outlets near the locality. If only a few farmers from a locality adopt such systems, services of input suppliers often get disrupted, and can create dissatisfaction amongst the farmers with the use of such systems. Therefore, it makes sense to promote cluster approach for some of these inputs.

Last but not the least, the suitability of the area's agro climate for growing such crops and their potential adverse impact on ecology (especially on soils and crop species) needs to be ascertained to prevent future catastrophe.

5.3 *Creation of Marketing Infrastructure and Enabling Regulations*

Lack of proper marketing infrastructure prevents farmers from remote areas from adopting many of the high value crops, and the transaction cost of finding market and taking the produce to the market regularly could be quite high. Therefore, creation of marketing infrastructure has to be treated as an input for resilient farming. Marketing infrastructure to be created would include a place (yard) for grading, sorting, packaging and labelling, and vehicles for fast transportation of the produce from the place of produce to the market destination in order to ensure quality control and longer shelf life of the produce. This is important for gaining confidence of the wholesaler.

There is also need to amend the existing laws such as the Agricultural Produce Marketing Committees (APMC) Acts of the states that restrict free movement of agricultural produce and make it mandatory for farmers to sell most of their produce in the local market, as argued by the Three Year Action Plain (2017-18 to 2019-20) for agriculture (Government of India, 2017).

5.4 *Adoption of Post-Harvest Technologies*

The post-harvest losses from fruits and vegetable production in India are one of the highest in the world. On the basis of production and wholesale market price in India, the Associated Chambers of Commerce and Industry of India (ASSOCHAM) estimated that the post-harvest losses in fruits and vegetables touched $33.745 billion in 2011-12 (ASSOCHAM, 2013). For many crops, the produce needs to be processed for uniform ripening and appearance before they are sold in the market. Such crops include banana, mangoes and papaya. Some other crops which are fast perishing can also be processed for value addition (pineapple, mangoes, strawberry, papaya, cucumber, chillies and onions).[3] Crops such as potatoes and onion, which are seasonal crops[4] but required for regular consumption in the households throughout the year, have to be kept in cold storages to prevent glut in the market and to ensure round the year supply. All these would require infrastructure, including expensive machinery for refrigeration depending on the type of processing required.

5.5 *Crop Insurance*

Many of the high value crops are susceptible to severe damage under unpredictable and extreme weather conditions which include untimely rains (for mangoes), rains under ‘cloudburst’, cyclone (of varying intensity), strong winds (banana plantation), avalanche and snowfall, and heat-wave for most of the vegetable crops that are not raised under poly-house. Some of these crops, especially in areas surrounding wildlife sanctuaries and national parks, are vulnerable to attack by wild animals. In such cases, insurance will be necessary to protect the economic interest of the farmers in a manner that he/she is able to service the loans taken from the banks and the basic minimum income is assured for survival till the next agricultural season.

5.6 *Targeted Subsidies to Areas where it Produce Maximum Welfare Benefits*

Many technologies used in agriculture today produce welfare benefits. But, is a general tendency to offer subsidies for certain farm equipments (micro irrigation systems, precision farming system, poly-house, net-house and poly tunnel) without taking into account the fact that such subsidies are essential when the private costs exceed the private benefits from the use of the system, but there are significant positive externalities induced by the use of the system on the society due to which the social benefits exceed the social cost (private cost + negative externalities). In such cases, the subsidy can be structured in such a manner that the private cost becomes less than the private benefit. However, this principle is hardly followed in agriculture sector today. Subsidies are being offered lock stock and barrel to farmers for purchase of MI equipments, poly-house and net-house, even when the private benefits are far higher than the private costs.

A major cause of concern is that in some situations, there are negative externalities such technologies can induce on the society. For instance, in a locality, which experience high rates of rural unemployment, mechanised farming of commercial crops including extensive use of irrigation equipments such as sprinklers and drips, can take rural unskilled labour force out of farms, thereby creating more problems of unemployment. This is a negative externality, and the technology may not induce any positive externality. Therefore, subsidies in such situations will not be desirable from a societal point of view.

Subsidies should be advanced in areas where social benefits are high. For instance, in a water scarce area, adoption of water saving irrigation equipments which actually produce real water saving (if used for certain crops) should be encouraged through subsidies. Similarly, in a region which suffers from food insecurity due to low production any technology which can boost the yields of cereals (be it micro irrigation system or seed technology), but is too expensive for farmers to adopt, should be subsidised through government support if the social benefits (through reduction in malnutrition problems or lowering of cereal prices) are large enough to exceed the social costs.

VI

ROLE OF FINANCIAL INSTITUTIONS FOR BOOSTING TECHNOLOGY ADOPTION, AND REDUCING MARKET RISKS

The basic characteristic of farming in India is changing. The farming is increasingly getting commercialised, with greater proportion of the farm outputs catering to the market, and with greater share of the value addition coming from high value crops. Accordingly, the nature of inputs and the level of investment required are also changing rapidly. The resource rich and enterprising farmers are able to take high risks and increase their profit margins even in harsh (climatic) conditions and even under severe scarcity of fertile land and good quality water. If the small farmers in the country have to take advantage of the new opportunities, their risk taking ability has to increase. For this, agricultural production system has to be resilient. In the coming years, financial institutions will have to support capital investments in desalination systems that treat marginal quality groundwater, wastewater treatment systems, post-harvest technologies, marketing infrastructure, technologies for controlling production environment and precision farming systems. Following are the few steps that need to be institutionalised by the financial sector.

6.1 *Assess the Production Risks and Market Related Risks*

The farming risk is not uniform across the country. There are many regions that are historically known for high incidence of droughts and some known for high incidence of floods. Some regions are hit by cyclones, avalanche fall and hailstorm. Generally, the low to medium rainfall regions in India that are semi-arid to arid experience very high variability in annual rainfall and other climate parameters (temperature, wind speed and relative humidity), and are subject to climate extremes, whereas the high rainfall regions experience much lower degree of inter-annual variability in weather parameters. Interestingly, the semi-arid and arid regions experiencing high inter-annual variability climate parameters are also agriculturally prosperous, and where high value agriculture is practiced. Sometimes, these phenomena are also highly localised.

The risks involved in different farming systems in different agro ecologies that capture the physical and socio-economic conditions of the region need to be evaluated. Particularly the risk determined by climate variability and climate extremes (droughts, floods, heat stress) (Khan *et al*., 2009), disease attacks and changing market conditions, degree of exposure of the farming system to these shocks or the capacity of the farmers to insulate the farming system against such shocks, and the ‘adaptive capacity’ need to be assessed.

Crop insurance based on assessment of weather risk has long been discussed in the Indian context (Golait and Pradhan, 2008), and is called weather indexed insurance, when the linked to the underlying weather risk, defined as an index based on historical data of rainfall, temperature, snow, heat stress, etc. (TERI, 2005).

The outcomes of such assessments, however, should not be used for preventing loans, and instead should be used to take the necessary precautionary measures for protecting the interests of the banks and the farmer. This can be in the form of advice to farmers on the appropriate farming system for his farm that ensures high degree of resilience. The general practice is to advance loans on the basis of an assessment of the repayment capacity of the applicant, if sufficient collaterals are produced by him/her.

6.2 *Link Farm Loans to Crop Insurance*

It is quite clear from the previous section that if the small and marginal farmers have to shift to high value crops and modernise their farming systems, they would require a lot of capital. When loans are advanced to farmers for purchase and installation of equipments such as precision farming systems or micro irrigation equipments or for installing poly-houses or net houses or developing expensive horticultural plantations, crop insurance and insurance coverage for the equipments being procured (irrigation equipments, technologies for control of production environment) should be made mandatory. It is all the more important for regions where the production and market risks are high. This would protect the interest of the farmers and the financial institutions. The banks and insurance companies have to work in tandem.

6.3 *Designing Insurance Products Based on Risk Assessment*

The Ministry of Agriculture has a National Agricultural Insurance Scheme, administered through the Agriculture Insurance Corporation, which covers all farmers, introduced in 1999/2000. It operates on the basis of an ‘area approach’, i.e., defined areas for each notified crop for widespread calamities and on individual basis for localised calamities such as floods, hailstorms, landslides and cyclones. Although government crop insurance is subsidised, it has very low coverage as it suffers from many inadequacies (TERI, 2005; Golait and Pradhan, 2008).[5] The insurance companies need to design products for farmers keeping in view the degree of farming risk, which goes far beyond weather risks. While risk is a function of the shock, exposure and the vulnerability of the farm household, for the same weather conditions, the degree of risk would change depending on the nature of farming system and the coping capacity of the farmer. As a general rule, higher the production related risk, higher would be the premium to be paid by the farmer, for the same amount of insurance cover. Therefore, it is important that the banks counsel the farmers to adopt farming systems that offer resilience to production risks, taking cognizance of the agro ecology (soils, rainfall, climate, and drought and flood proneness), plant diseases and market reality (access to market, demand, market behaviour, etc.), though the crop insurance will only cover production risks.

6.4 *Research on Resilient Farming System*s

The financial institutions which advance loans for crops and various equipments need to have greater understanding of innovative and resilient farming systems for different agro ecologies and the average amount of income farmers can generate out of it, so as to be able to advise the client farmers to choose from a few options available. This calls for inter-disciplinary research to generate knowledge for designs of resilient farming systems based on considerations of resource use efficiency, economic viability and social and environmental sustainability for different agro ecologies. For this, they would require a pool of experts who have knowledge of the emerging crops, and expertise in crop sciences, climate science, water management, agricultural economics and agricultural marketing.

6.5 *Link Subsidies to Efficient Use of Technologies and Resources*

The mode of provision of subsidies for purchase of capital equipments in agriculture followed in the past in many states is that subsidy is paid to the manufacturers for every unit sold. In many situations, this has resulted in farmers procuring the system only to get the subsidy benefits, and the manufacturers offering poor quality products to the farmers with no after sales services being offered. The mode of administering subsidy should change in a way that the capital subsidy is paid to the farmers in instalments. This will make sure that the farmers make prudent use of the technology procured using the loan money borrowed from the banks. Many states are struggling hard to introduce metering of electricity in the farm sector, fearing repercussion from the farming lobby. One way to make it easier is to make it mandatory for farmers applying for capital subsidies to have installed electricity meters in their farms to be eligible for government subsidy. Gujarat has already tried this method of introducing metering of agricultural power connections successfully.

6.6 *Offer Special Incentives to Farming Clusters*

The financial institutions including banks and insurance companies need to offer special incentives for promoting ‘cluster based approach’ to farming enterprise in order to make sure that the transaction cost of obtaining input delivery related services is minimised, post-harvest technology adoption becomes viable and marketing of produce becomes feasible. NITI Aayog’s action plan for agriculture also advocated group farming and contract farming in agriculture, with a view to increase the efficiency in input delivery (Government of India, 2017). The financial institutions can work directly with a farmer organisation promoted at the cluster level to advance loans for various initiatives. The banks should also be able to mobilise the services of agricultural scientists (soil scientists and crop scientists, horticulturists, post-harvest technology experts), water technologists and marketing experts to the cluster and this should be part of the financial package. Cluster based approach enhances knowledge transfer from farmer to farmer, increases the bargaining power of the producers in fixing produce prices, thereby increasing the ability to insulate against the weather and market induced shocks. The presence of such institutions would also increase the coping capacity of the farmers to the shocks induced by weather and market.

VII

CONCLUSION

The character of farming in India is changing. There is a slow and steady shift towards high value agriculture, which even the small and marginal farmers will not be able to shy away from, given the economic pressures and the lure of big cash. Many of the investments are becoming long-term (especially for horticultural plantations), and continuous monitoring is required. Along with capital, the extent of knowledge inputs required to make the farming system resilient is increasing, be it about the crops having least weather risk (Khan *et al*., 2009) or crops having high profitability or the level of inputs for getting optimum yield or about the marketing of the produce. This is particularly important as the biggest transformation is happening in the semi-arid and arid regions that are water-scarce and also subjected to high climatic variability and extreme weather conditions.

This transition needs to be properly negotiated. Technologies will have a role to play in terms of increasing the farm outputs, enhancing the input use efficiency and to a great extent reducing the production risks, and they come at huge costs that are unavoidable. While adoption of MI technologies has already become extensive in the country, there are many new generation technologies which have to find greater uptake. They include: precision farming and technologies for control of production environment. There are significant market risks in production of high value commercial crops that need to be tackled. The approaches for this are institutional in nature and include the following: (1) promoting resilient farming system; (2) adopting a cluster approach; (3) targeting subsidies to areas where they help maximise the social returns; (4) creation of marketing infrastructure; and, (5) adoption of post-harvest technologies.

The banks and insurance companies have a huge role to play to improve the viability of the farming sector in the years to come. Their approach has to be more scientific and also more holistic. The banks need to mature themselves into a resource agency and not just a money lender. The financial package has to include services of agricultural experts to ensure quality inputs to the growers for sustainable production and marketing, and appropriate models for financing. The insurance companies have to be prepared to deal with the complex issues of ‘farming risks’, which is not very old in their lexicons. Greater coordination is required between banks and insurance companies to create synergies. Following are the interventions from the financial sector to make the recently witnessed growth in the farm sector sustainable and socially viable: (i) assessing the production and market risks; (ii) linking farm loans to crop insurance; (iii) design insurance products based on production risk assessment; (iv) undertaking research on resilient farming systems; (v) link subsidies to efficient use of technologies and resource, especially water and energy; and, (vi) offering special incentives for promotion of farming clusters.

NOTES

1. As per the NITI Aayog's action plan for sustainable management of water resources, the irrigation potential would increase by 35 m. ha with the execution of water transfer links (comprising the Himalayan links and the peninsular links). The Minister for Water Resources, River Development and Ganga Rejuvenation has already tabled in Parliament a draft National Framework Law on interlinking of rivers to expedite the work in this direction

2. Drip systems are used inside the poly-house and net house to water the plants that are cultivated on raised beds, and plastic mulching is also used to reduce evaporation loss of water from the raised bed. To increase humidity, depending on the requirements, foggers are also used.

3. Chillies, cucumber and pineapple are kept under preservatives. Onion is dehydrated and kept for supply to restaurants. Mangoes are processed to make crush. Many fruits are processed to make juice and marketed in tetra-packs

4. Onion is grown in two seasons (viz., winter and summer) and potato is grown only in winter

5. It fails to provide the right incentives to farmers as crop yield is insured and not the investments. Conversely, farmers who have suffered losses as a result of weather related disaster in a particular part of a district may not be eligible to benefit from crop insurance unless the entire district is declared disaster-affected. Finally, there are high administrative costs and, consequently, long delays in making claim payments (TERI, 2005).

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