

ENGINEERING INTERVENTIONS FOR HIGHER AND SUSTAINABLE AGRICULTURAL GROWTH IN INDIA*

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Abstract

Food is a physiological necessity for the survival of human beings, the highest form of life on the planet earth. Eating food is a source of pleasure and it, therefore, demands quantity, quality and variety. Food is derived from agriculture with traps and transforms solar energy into chemical energy in the form of biomass which are processed and utilized for food, feed, fibre and fuel. Engineering interventions in the form of appropriate tools and technology facilitate in maximizing agricultural productivity and profitability on sustainable basis and with a minimum drudgery to farm workers, specially to women. There is a need for forging partnership among various stakeholders like farmers, extension workers, researchers, financial institutions, agribusiness companies, policy makers and consumers for greater synergy in farm production, value addition and marketing. Knowledge centres in rural areas are needed for an effective utilization of available agricultural technologies and experiences by the farmers, to derive benefits. The existing extension systems needs to be reoriented to address the entire value chain from production to consumption for quick delivery of improved technologies and judicious harnessing their potential for enhancing net monetary return per unit of area, time, input and energy.

1. Introduction

The first and the foremost goal of agricultural development should be to raise the income of farmers to a higher level than what it is at present to provide them a sense of well-being. As of now, there are about 820 million people in developing countries who go

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hungry every day and 70% of them are in Asia. Investment in agriculture and allied sectors promise greater return than that made in other areas by the national/state governments. Small and marginal farmers, whose potential if harnessed properly, can bring about a substantial positive changes in the agricultural scenario of the country.

Looking into the present scenario of ever increasing world population, the task to provide food and nutritional security to every human being is becoming difficult. It is further being complicated owing to environmental problems, which are cropping up due to intensive use of chemicals. Therefore, the sustainability of agricultural production is a major concern for human beings as agriculture is the prime source of food and backbone of the Indian economy. **Agriculture is sustainable when it is ecologically sound, economically viable and socially acceptable and based on a holistic scientific approach.** Biotechnology offers efficient and cost effective means to produce an array of novel, value added products and tools. It has the potential to increase food productivity, reduce the dependency of agriculture on chemicals, lower the cost of raw materials and reduce the negative environmental impact associated with traditional production methods.

Agriculture research must be reoriented to concentrate on the efficient use of land, water and people. It should lead to sufficient food production for the planet including the billion plus population of India. Agriculture has to grow at 4% for India to maintain a sustained annual GDP growth of 8-9%. Doubling the current agricultural growth level of 2.3% is indeed an ambitious target no doubt, but it is achievable if right tools and measures are adopted.

There is a need for forging partnership among various stakeholders like farmers, extension workers, researchers, agribusiness companies, financial institutions, policy makers and consumers for greater synergy in farm production and value addition. Knowledge centres in rural areas are needed for an effective utilization of available agricultural technologies and experiences by the farmers to derive the benefits.

2. Agricultural Scenario

India's economic security continues to be predicated upon the agriculture sector and the situation is not likely to change in the foreseeable future. Even now, agriculture supports 58% of population, as against about 75% at the time of independence. In the same period, the contribution of agriculture and allied sector to the GDP has fallen from 61 to 19%. As of today, India supports 16.8% of the world's population on 4.2% of the world's water resources and 2.3% of the global land. Per capita availability of resources is about 4 to 6 times less as compared to the world average. This will decrease further due to increasing demographic pressure and consequent land diversion for non-agricultural use.

Around 51% of India's geographical area is already under cultivation as compared to 11% of the world average. The present cropping intensity of 136% has registered an increase of only 25% since independence. Further, rainfed drylands constitute 65% of the total net sown area. Also there is an unprecedented degradation of land (107 million ha) and groundwater resource. There is a fall in the rate of growth of total factor productivity. This deceleration needs to be arrested and agricultural productivity has to be doubled to meet the growing needs of the population by 2050. Efficiency-mediated improvement in productivity is the most viable option to raise production.

The country recorded impressive achievements in agriculture during the three decades since the onset of green revolution in late 1960s. This enabled the country to overcome widespread hunger and starvation; achieve self-sufficiency in food; reduce poverty and bring economic transformation of millions of rural families. The situation however started turning adverse for the sector around mid nineties, with slowdown in growth rate of output which then resulted in stagnation or even decline in farmers' income leading to agrarian distress which is spreading and turning more and more serious.

Natural resource base of agriculture which provides for sustaining production is shrinking and also degrading which is adversely affecting the production capacity of ecosystem. However, demand for agriculture is rising rapidly with increase in population and per capita income and growing demand from industry sector. There is thus urgent need to identify the severity of problems confronting agriculture sector and restore its vitality and

put it back on higher growth trajectory. The problems, however are surmountable, particularly when new tools of science and technology have started offering tremendous opportunities for application in agriculture. The projected production requirements of various agricultural commodities by the year 2011-12 and growth rates needed to meet those requirements are given in Table-1.

Table-1: Projected production requirements of various agricultural commodities by 2011-12.

Commodity	Required Production, million tonnes	Required growth rates, %
• Rice	105	2.06
• Wheat	79	0.95
• Coarse cereals	48.0	5.15
Total cereals	232	2.21
• Pulse	20	2.35
Total foodgrain	252	2.21
• Milk and milk products	113.0	3.18
• Egg	62.0	6.09
• Meat	8.6	5.03
• Fish	8.6	4.39
• Edible oilseeds *	31.8	2.87
• Vegetables	109.0	2.51
• Fresh Fruits	67	3.46
• Sugar and gur	35.50	3.87

* 40% import dependency

These projections include export in the same ratio as in the base year (2004-05). India is required to raise foodgrain production by more than 2% per year to keep pace with growth in demand. Required growth rate in milk and milk products towards the end of 11th Five Year Plan is 3.18%. Even with 40% dependence on import, oilseed production need to increase by 2.87%.

Achieving 4% growth in agriculture against the present level of about 2% in the Eleventh Plan has become critical to avert any crisis in agrarian sector and fulfil the needs of growing economy. The higher growth could very well be realized through adoption of available technologies that minimize yield gaps between the experimental farms and farmers' fields. The Government is keen on devising ways and means to facilitate States in adopting these technologies promising tangible yield gains of 40-100%.

3. Sustainable agriculture

Food and fibre productivity has soared due to new technology, mechanization, chemical use, specialization and government policies that favoured maximization of production. Though these changes have many positive effects but also resulted into topsoil degradation, groundwater depletion and contamination, decline of living and working conditions of farm workers, higher cost of production, and the disintegration of economic and social conditions in rural communities. Such agricultural practices are now being questioned and the farming community and other rural population want to have sustainable agriculture to address these environmental and social concerns and have innovative and economically viable opportunities for farmers, agricultural workers, consumers, policy makers and other stakeholders in the entire food system.

The ideas, practices and policies that would define the concept of sustainable agriculture are still evolving. It integrates three main goals namely environmental health, economic profitability and social & economic equity. Sustainability rests on the principle that we must meet the need of the present without compromising the ability of future generations to meet their own needs. Therefore, stewardship of both natural and human resources is of prime importance. Stewardship of human resources include consideration of social responsibilities such as working and living condition of farm workers, needs of rural communities and consumers health & safety, both in the present and the future. Stewardship of land and other natural resources involved maintaining or enhancing this vital resource base for the long term. A systems perspective is essential to understand sustainability. It involves individual farm, local eco-system and communities that get affected by this farming system, both, locally and globally. A system approach gives us the tool to explore the inter connections between farming and other aspects of environment. It also implies inter-disciplinary efforts in research and education from researchers, farmers, farm workers, consumers, policy makers and others. Making the transition to sustainable agriculture is a process involving a series of small but realistic steps. Realization of the goal of sustainable agriculture is the responsibility of all participants in the system, including farmers, farm workers, policy makers, researchers, retailers, consumer and other stakeholders. Each group has its own part to play to strengthen the sustainable agriculture.

4. Sustainable Management of Natural Resources

Continued degradation of natural resources under intensive agriculture to attain goals of food sufficiency is one of the reasons for declining factor productivity and stagnation in food grain production in the country. The health of soils has been impaired due to emergence of multi-nutrient deficiencies and falling organic carbon levels. The soils are, generally, not replenished adequately with the nutrients removed by the crops, particularly of micro and secondary nutrients. The wider fertilizer consumption ratios for many states corroborate the nutrient imbalance in soils. The soils are, presently, operating on a negative nutrient balance of about 10 million tonnes per annum. The limiting nutrients, not allowing full expression of other nutrients, obviously, lower the overall fertilizer use efficiency and crop productivity. The farmers are resorting to addition of more and more fertilizers to obtain yields similar to previous years, especially in rice-wheat belt of Indo-Gangetic plain and thus increased inputs are adding to the production cost, marginalizing net returns to the farmers.

Site-specific integrated nutrient management, envisaging precise use of chemical fertilizers including secondary and micronutrients, organic manures, composts/vermicomposts, biofertilizers and green manures is ideal. This will maintain soil health, enhance nutrient use efficiency, provide sustained yields and ensure better economic returns to the farmers. The system is also benign environmentally in containing the emissions of green house gases and pollution of surface and ground water resources. The ICAR has generated site-specific nutrient management packages for use by the states that would enable additional 50-60 million tonnes of food grains.

The agricultural sector is going to face grim competition for supplies of fresh water, with its share dropping to 75 % from the present 83% in the near future, in the wake of growing industrial and domestic sectors. The judicious management of water resources is, therefore, going to be crucial to sustain agricultural growth in the country. Presently, the ground water is being overdrawn in Central Punjab, Haryana, Western Uttar Pradesh, Rajasthan, Tamil Nadu and West Bengal, forcing sharp fall in water table in these areas. The excess use of canal water in south-western Punjab, Haryana and Rajasthan is leading

to water logging and development of secondary salinity. The conjunctive use of water and diversification of rice-wheat is required for solving the emerging problem. Large volumes of waste waters (18.4 million m³ /day) need to be utilized for irrigation after their proper treatment, especially in peri-urban areas. The micro-irrigation economizing on water and nutrients requires to be promoted in a big way.

About 25 million hectares of acidic soils in the country have low productivity of less than 1 t/ha due to deficiencies as well as toxicities of certain nutrients. Liming and adequate fertilizer use have the potential to double productivity of these lands. Adoption of cost-effective technology to ameliorate acid soils developed by ICAR on over 25 million ha could contribute additional 25 million tonnes of food grains to the national food basket per annum. Cheap and effective liming materials required for the purpose like basic slag and lime sludges are available with steel industries and paper mills, respectively.

Nearly 8.5 million ha of soils affected due to alkalinity/salinity in the country have very low productivity and could be reclaimed with gypsum application. Over 1 million ha of such lands have been reclaimed in Haryana and Punjab, raising their productivity by about 6 tonnes/ha. The technology requires to be extended to other salt affected areas in Gujarat, Uttar Pradesh, Rajasthan, West Bengal and Andhra Pradesh. The availability of gypsum has to be organized with the dealers of agricultural inputs at a reasonable cost. The spread of technology on 5 million ha would provide additional 10 million tonnes of food grains.

Vermicomposting is an environment-friendly and useful method of conversion of rural and urban organic wastes into good quality manure. It requires less time for decomposition of the wastes as the material passing through the gut of earthworms undergoes quick enzymatic breakdown. Further, its nutritional quality is better than that of ordinary compost with higher contents of essential plant nutrients and several growth promoters from the secretions of worms and associated microbes. Vermicompost improves physical, chemical and biological environment of soils and overall crop productivity. Besides economic returns, the avocation provides employment to rural

households, especially women and hence, fits well in the Common Minimum Programme of the Government. And it is required to be promoted in a big way in rural India.

Large quantities of biodegradable waste are available through crop residues (350 million tonnes), vegetable and fruit wastes (5 million tonnes), press mud (5 million tonnes), poultry litter (1 million tonne) and city waste (57 million tonnes). Besides **these**, 5-6 million tonnes of low grade rock phosphate are also available for production of enriched vermicompost.

Farming systems combining different components of farming like crops, horticulture, livestock and fisheries provide ample opportunities of productivity enhancement (3-4 times compared to monoculture), employment, income generation and nutritional security. The systems are based on recycling of residue of one component for the production of others. These enterprises providing returns of around Rs 70,000/ha/annum need to be promoted particularly in the States of Orissa, Bihar, West Bengal, eastern Uttar Pradesh and the North-Eastern Hill States having over 12 million ha of waterlogged lands with very low productivity.

The rainfed farming practiced in over 87 million ha area of the country contributes 40% of food and supports 40% of human and 60% of livestock population. The rainfed areas are characterized by deficient and erratic rainfall, rampant land degradation and small and marginal poor farmers. In the absence of conducive environment, the rainfed areas were bypassed by the green revolution in the country. These areas still have low productivity and marketable surpluses. Enabling policy initiatives and absorption of the improved technologies could very well raise the productivity of these areas by half-a-tonne/ha. The technological interventions required are: water harvesting and ground water recharging for supplemental irrigation (117 million ha m of rainwater going waste as runoff), micro-irrigation, adequate and integrated fertilizer use (including secondary and micro-nutrients), development and introduction of suitable crops (especially hybrids of maize, pulses and oilseeds), integrated pest management, organic farming, increased credits, low premium crop insurance suiting to rainfed farmers and regular trainings to upscale skills and knowledge of farmers on various aspects of agriculture. All these interventions need

to be viewed within the perspective of participatory Watershed Plus approach for greater transparency, equity, social security and sustainability. The KVKs (Farm Science Centres) and SAUs (State Agricultural Universities) may be involved in providing vocational training to farmers in micro-enterprises and refining their skills in rainfed agriculture.

Crop diversification is becoming essential for maintaining soil health, water balance and overall productivity in many parts of the country, especially in the Indo-Gangetic plain. This has to be achieved in synchronization with the soil, climate, availability of water and market potential, etc. The rice-wheat and monoculture require to be replaced with legumes, oilseeds, vegetables, fruits, medicinal and aromatic crops and other cash crops, for which the ICAR has evolved a number of viable and productive options. There is also a need to have assured market outlet for the produce for achieving the required diversification in different agro-ecological zones of the country.

5. Integrated Soil Fertility Management

The distortion in soil fertility and deterioration in soil health are mainly due to the improper and indiscriminate use of certain fertilizers alone containing a few nutrients only without manures. When fertilizers are applied alone under intensive agriculture, the nutrients that are not supplied through fertilizers are depleted and exhausted and the status of a few nutrients supplied through the fertilizers would exceed the normal requirements leading to the distortion in the supply of nutrients and overall soil fertility. Both, under-fertilization and over-fertilization practices will distort the overall fertility and health of the soil. So, it is better to integrate soil fertility management involving manures and fertilizers in judicious combinations. It is a desirable, viable and feasible proposition to improve the fertility and health of the farmlands and to maximize the agricultural production in harmony with nature. It, therefore, leads to an integrated soil fertility management using manures and fertilizers, so that the green revolution that has been achieved can be sustained as a viable and profitable venture which would ensure the food security for the country.

6. Farm Tools and Equipment

Farm tools and equipment are needed for timely completion of various agricultural operations and precise application of inputs to have higher productivity and profitability and also to reduce the drudgery of farm workers including women. 80% of farm holdings in India are less than one hectare and, source-wise, current power use is 65% mechanical, 21 % electrical, 8% animal and 6% human. Appropriate and selective mechanization is needed for production agriculture, post-harvest management and value addition using a proper blend of conventional and renewable energy sources to achieve higher income. While mechanization would augment the agricultural production by 10%-15%, post harvest management could add 5%-10% more by reducing losses. The potential for value addition to agro-produce including byproducts is immense, 25% - 400%, depending upon the commodity and the level of processing. For example, value addition is 25% for wheat to flour; 30% for chickpea to besan; 35% for paddy to rice; 25, 150 and 400% for soybean to flour, milk and tofu (soypaneer); 400% for wheat to biscuit and 400% for potato to potato chips.

The prominent resource/ inputs (seed, fertilizer, agro-chemicals, water, fuel and labour) conserving machines are laser land leveler, sub-soiler, rotavator, zero-till drill, happy seeder, raised bed former, precision planters, sugarcane cutter planter, rotary power weeder, aero-blast sprayer, wheat straw combine & balers, etc. It is estimated that application of laser land leveler in 2 million hectares under rice-wheat system could save 1.5 million ha-m of water, 0.2 million tonne of diesel and reduce GHG (greenhouse gases) emissions equivalent to 0.5 million tonne of carbon. Use of zero-till drill results into a saving of Rs. 2000-3000/ha consisting of 70 litres of diesel, time and labour. Today, zero till drills are being used over an area of about 2 million ha resulting into a saving of about Rs. 500 crore annually. The need is to expand the area under resource/ inputs conserving technologies and machines to make farming more profitable.

The farm produce and the remaining biomass/ crop residues are processed to convert them into edible/ usable products. Appropriate post harvest technologies and equipment, that are commodity and region specific, are available to minimize losses and add value.

For example, soybean which is rich in protein (40%), oil (20%), and other health promoting nutrients and phytochemicals, if processed appropriately into different food products such as dairy analogs, bakery products, snacks, etc, could fulfill much needed protein and calorie deficiency at an affordable price (Rs. 50/kg protein as compared to about Rs. 200/kg protein from pulses) to combat protein-calorie malnutrition.

About 4 million tonnes of soymeal, containing 50% protein is exported at Rs. 11,000/tonne and at the same time the country is importing 1.8 million tonne of pulses worth Rs. 2,500 crore. Therefore, the need is to utilize soymeal protein to substitute pulse import and technologies are available to make use of soymeal for food in the form of soy-nuggets (soy-bari), soyflour, soy-fortified biscuits, snacks, etc. to provide 2 million tonnes dietary protein equivalent to 8-10 million tonnes of pulses. Similar technological interventions in paddy processing, pulse milling, oil extraction, etc are available for additional output of rice, pulse and oil at much lower cost than that from the production system.

Energy is a critical input in today's agriculture. Based on the current usage, the direct power availability is estimated at 1.5 kW/ha which needs to be enhanced to 3.5 kW/ha during the next 20 years to meet the agricultural production targets. The usage of liquid fuel in agriculture for production activities would go up to 45 million tonnes of oil in the next 20 years. There has been renewed interest in biomass as a source of energy since it is widely available, renewable, carbon neutral and has socio-economic benefits. It is estimated that about 150 million tonnes of surplus biomass would be available for conversion into fuel. Briquetting, solid-state fermentation, gasification, pyrolysis, etc are a host of technologies that are available today to efficiently convert the available surplus biomass into fuels. This biomass could generate about 15000 MW of quality power for meeting the demands in production catchments. What is required is to establish pilot plants using these technologies for decentralized power generation and then linking them with the agro-processing and other activities.

A few important farm tools and equipment for mechanization of agricultural production operations, post harvest processing and biomass based renewable energy technologies are as follows:

Tools & Equipments	Description
<i>Laser land leveler</i>	Used for leveling the land very precisely and accurately, the leveler reduces water use by 20-30% and increases crop yield by 10-15% (cost: Rs 4 lakh) with the land leveling cost of Rs. 1500-2000/ha.
<i>Rotavator</i>	Rotavator is used for seedbed preparation, weed control, mixing of soil with crop residue and fertilizer and puddling of the soil. It saves time (30-35%), water (30%) and cost of operation (20-25%) as compared to tillage by cultivator and harrow.
<i>Sub-soiler</i>	It breaks soil hard pan up to a depth of 60 cm and is used for rain water retention and suitable for dryland farming areas. Use of this implement results in increased yields by upto 30% and the cost of operation is Rs 600/ha.
<i>Zero-Till Drill</i>	Use of zero-till drill for direct sowing of wheat after rice saves time (50%) and cost (40%) as compared to the conventional practice of seedbed preparation and sowing. It costs Rs 18,000-25,000/- depending upon the size of the drill and the cost of operation is about Rs 1100/ha.
<i>Happy Seeder</i>	It combines two units, one for straw management and the other one is for sowing wheat after paddy. Machine cost is Rs.60,000/- and the cost of operation is Rs.1400-1650 per ha. Green gram can also be sown in summer after wheat harvest in standing stubble which helps in moisture conservation and soil temperature regulation.
<i>Raised Bed Former</i>	This equipment has been developed to facilitate Furrow Irrigated Raised Bed (FIRB) cropping system for wheat after soybean, maize or cotton. It reduces tillage requirement and the subsequent crop can be sown directly on the beds without field preparation. The benefits of the machine are saving of cost of operation (20-30%), seeds (25%), fertilizer (25%) and irrigation water (20-30%). The cost of the machine is Rs 40,000/-.
<i>Ridger Seeder</i>	The ridger seeder is suitable for dryland farming. It forms ridges and furrows and does sowing on the ridge or at side of the ridge or in the furrows, as desired. For <i>kharif</i> crops seeding is done on the ridges in paired-row system and for <i>Rabi</i> crops seeding is done in furrows. It is suitable for planting <i>ragi</i> , gram and <i>pearl millet</i> . There is increase of about 15% in the yield, compared to conventional method of sowing. It costs Rs.13000 and cost of operation is Rs 750/ha.
<i>Inclined Plate Planter</i>	The planter is suitable for sowing bold and small seeds such as cotton, soybean, groundnut, chickpea, sorghum, and mustard. It has six modular seed boxes with independent metering mechanisms enabling it for intercropping. Its field capacity is 0.45-0.65 ha/hr, cost is Rs. 12,000 and the cost of operation is Rs. 600/ ha
<i>Sugarcane Cutter Planter</i>	It is suitable for cutting and planting sugarcane setts and application of granular fertilizer in single operation. The machine accepts whole cane. This implement costs Rs 45,000/- and the cost of operation is Rs 1300/ha as compared to Rs 2,800/ha by conventional method. The labour requirement and time of operation are reduced by 78% and 50%, respectively.
<i>Automatic potato planter</i>	It is a two-row equipment to plant potato tubers of 20-40 mm size at 250-400 mm plant spacing. It can also be used for interculture and earthing operation. Its field capacity is 0.4 ha/ hr, cost is Rs. 20,000 and the cost of operation is Rs. 750/ ha
<i>Rotary Power Weeder</i>	It is suitable for weeding of wide spaced crops such as cotton, tapioca, sugarcane, grapes, coconut, arecanut and other orchard and plantation crops. The cost of the machine is Rs 55,000/- and its cost of operation is Rs 880/ha

	which is 35-50%, compared to manual weeding.
Self-Propelled High Clearance Sprayer	It is a self-propelled unit suitable for spraying on tall crops like cotton. The machine consists of two rear steered wheels and two front lugged wheels, which is powered with a 20 hp diesel engine and has a boom having 15 nozzles. It costs Rs 2,00,000/- and cost of operation is Rs 75/ha. It can cover about 20-25 ha area in one day.
Aero blast orchard sprayer	It is suitable for spraying in cotton, sugarcane, sunflower and horticultural crops. The sprayer has provision to change the orientation of two spouts with help of two ratchets and pawls to adjust the spouts for maximum coverage of plant canopy. It covers 5-10 ha per day and saves 50-70% time and gives effective spray on the crop.
Self-Propelled Vertical Conveyor Reaper	It is suitable for harvesting and windrowing cereals & oilseed crops. This machine costs Rs 50,000 and the cost of operation is Rs 1100/ha compared to Rs 2,000/ha by conventional method. It saves 50% labour and cost of operation and 75% operating time. The equipment gives negligible losses for paddy crop and within permissible limit for wheat.
Wheat Straw Combine	This machine cuts and gathers the left over straw from the combine harvested field and chops it into fine straw and blows it into a trailer. The capacity of the machine varies from 0.4-0.5 ha/h and it recovers 55-60% of straw in addition to 75-100 kg of grains/ha resulting into an average net saving of Rs. 1,250/ha.
Straw baler	The baler makes rectangular or round bales by collecting the loose straw from the ground for use in card board making, briquettes or for electric generation or composting. Cost of machine is about Rs.4.5 to 5.5. lakh and the cost of operation is Rs.2000 and 2200, without and with stubble shaving, respectively.
High Capacity Multicrop Thresher	It is suitable for threshing wheat, maize, sorghum, gram, pigeon pea, soybean and sunflower crops. It costs Rs 55,000/- and cost of operation is Rs 5/q. Output capacity is 533-2890 kg/h depending on the crop being threshed. It saves 50% labour and time of operation.
Greenhouse Technology	A one-hectare greenhouse costs about Rs. 1.0 crore and facilitates the production of high quality vegetables such as tomato, cucumber, gherkins, bell pepper etc with annual production of about 150-200 tonnes. An area of 1.0 lakh ha under greenhouse cultivation would provide 15 M t of vegetables in comparison to 2.5 M t under traditional cultivation practices. The need is to expand the area under greenhouse technology for high value and low volume crops in selected regions.
Drainage in vertisols	Surface and sub surface drainage (SSD) technologies can be adopted in vertisols. The cost of making surface drains using a tractor-drawn ditcher is Rs. 500-750 /ha and that of SSD system is Rs. 35,000/ha. Surface and sub-surface drainage systems result in 35-40% and 50-55% increase in soybean yield, respectively. SSD results in 15% increase in yield of subsequent rabi season chickpea crop due to improved soil physical parameters. Potential benefit if adopted in 10% waterlogged area under soybean is 0.3 M t/year of grain i.e. Rs 300 crore/annum. For large-scale adoption of drainage technology, artificial drainage grid is essential in combination with natural drainage system.

<i>Pressurized Irrigation systems</i>	Pressurized irrigation consisting of sprinkler and drip systems help to increase yield by 40-50% and also achieve water saving of 30-70% depending upon the crop. Sprinkler irrigation can be adopted for almost all crops (except rice and jute) and in various soils and topographic conditions. Drip irrigation is more effective in horticultural crops, cotton and sugarcane.
<i>Modern Rice Mills</i>	Of the 130 M t paddy, 65% is milled through 35000 modern rice mills and the remainder in 105,000 traditional hullers and shellers yielding rice outturn of 70-72% and 65-68%, respectively. Therefore, the traditional rice milling sector requires modernization to yield additional 2.0 M t of rice worth Rs. 2500 crore. The modernization will also yield additional 2.0 M t of rice bran which in turn will give 0.25 M t of high quality rice bran oil (RBO) having an economic value of Rs. 1000 crore. A 2.0 t/hr capacity modern rice mill requires an investment of about Rs. 60 lakh.
<i>Modern Pulse Mills</i>	India produces about 15 M t of pulses annually and 75% of it is milled in about 14000 Dal mills. The milling losses in these mills are 10-12% in the forms of powder/ brokens/ chuni giving only 68-70% recovery while the potential milling outturn is about 80% if proper pre-treatments are given and the mill is upgraded. Using modern dal mills, about 1.0 million tonnes of additional dal, worth about Rs. 4000 crore, for human consumption could be retrieved. Cost of a modern dal mill of 200 kg/ hr capacity is Rs. 30 lakh.
<i>Modern Mechanical Oil Expellers</i>	About 50% of the oilseeds are processed using traditional ghanis where the oil recovery is only 75%. However, the modern tapered mechanical expellers extract about 90% of oil. Therefore, there is a need to convert the traditional ghanis into the modern mechanical expellers to yield additional 0.75 M t edible oil worth Rs. 3000 crore. Cost of a modern mechanical oil expeller of 100kg/hr capacity is Rs. 15 lakh.
<i>Modern Gineries</i>	Cotton gineries need to be modernized for competitiveness in lint production. Variable speed double roller (VSDR) gins permit independently controlling the speeds of rollers so as to increase the efficiency. About 30% energy saving is realized by employing the VSDR gins in place of traditional Double Roller gins. Cost of a VSDR gin of 65 kg lint/ hr. capacity is Rs. 70,000.
<i>Evaporatively Cooled Storages (ECS)</i>	With a view to reducing post harvest losses in horticultural produce, evaporatively cooled storages (ECS) in production catchments for short duration storage and pre-cooling are essential. Establishment of 1 million ECS of 2 tonne capacity each in horticultural production catchments creates a storage capacity of 2 million tones that saves 1 M t of fruits and vegetables annually. The cost of a two-tonne capacity ECS is Rs. 50,000.
<i>Cotton Stalk Particle Board</i>	Particleboards can be manufactured from cotton plant stalks, which are presently being used as fuel by farmers. Technology for this is available.
<i>Accelerated Retting of Jute</i>	A jute retting technique has been developed and standardized that gives better quality fibre with 1-2% increase in yield and requires considerably less water (1:2.5 in comparison to 1:20 in the conventional process). The farmers would get additional Rs.100/quintal due to higher yield and quality.
<i>Small scale lac processing unit</i>	A small scale lac processing unit (100 kg/day), ideally suitable for tribal population, is available for primary processing in production catchments. Total cost of the unit is Rs. 5 lakhs. It generates an employment of 750 man-days in a year and the net profit is Rs. 25,000 per month.
<i>Fish Transport for local vendors</i>	A 150 kg. capacity transport vehicle, costing Rs. 20,000, has been developed for marketing of iced fish (1:1 ice and fish ratio on weight basis) by local vendors The spoilage of fish over a period of 8 days is negligible.

<i>Solid-state biogas plant</i>	<p>The improved fixed dome biogas plant require 75 - 100% less water, produce up to 30% more gas, require ¼th space for slurry storage/drying and cost 10% more compared to the common designs. The feeding of substrate and handling of the digested slurry is easier.</p> <p>The above is an account of the status, potentials, constraints and technological options available in different segments of Indian agriculture, for enhancing farm productivity and profitability. Perusing a host of technologies available from different sources including the ICAR Institutes and Agricultural Universities as also the strengths the different States have with regard to resources and commodities, internal market and possibilities of export, a plan for 'State specific Technological Interventions' is proposed in the document, for achieving the desired agricultural growth.</p>
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In the present scenario, India needs to produce much more than in the past from shrinking and deteriorating land and water resources to meet the future demand and compete in the global market. Technology intervention can meet the future challenged of alleviating supply side constraints and meet the growing needs for food, feed, fodder and fibre. The improved technologies would augment farm income, generate employment opportunities, conserve natural resources, restrict imports, promote export and increase value addition for higher, accelerated and inclusive agricultural growth. The existing extension system need to be reoriented to address the entire value chain from production to consumption for quick delivery of improved technologies and harnessing their potential for enhancing net monetary returns per unit of area, time, input and energy.

7. Contract and Corporate Farming

India's potential in agriculture is yet to be fully harnessed. The shortcomings range from small and fractured holdings of land to the policies per se. Corporate houses are now in direct engagement with farmers through contracts that offer the rural population a better deal than they were getting till now.

Contract farming generally involves a pre-agreed price between the company and the farmer, alongwith measures of quality, quantity, acreage to be formed, and/or duration of the contract. In this system, the contractor supplies all the inputs required for cultivation, and the farmer is responsible for land and labour. However, the terms and nature of the contract vary according to the crops grown, the agencies involved, the farmers

themselves, and the technologies and context in which contract farming is taken up. The farmer's participation is generally limited to the production.

One of the most critical issues associated with contract farming is that there will be a shift from staple crops such as rice and wheat to crops required by the food-processing industries and those catering to the overseas markets. The switch to contract farming leads to a rise in exports as well. This may affect country's food security, and increase dependency on imports. For a corporate, the object of contract farming is to integrate the supply chain and ensure timely availability of materials, both in quantity and quality. It also reduces the procurement cost by eliminating the middlemen. It is a win-win situation for both, corporates and farmers.

Not only do the corporates get produce as per their specifications, the cost is much lower. With debt rampant, and soaring seed and fertilizer cost, contract farming appears a blessing, since all the inputs along with the know-how and updates will be provided by the corporate entity, and there is also a guarantee of purchase of the produce after harvest. With agriculture increasingly seen as a risky proposition, the promise of economic security within the contract farming system is rather very attractive. The health of soil a few years hence is a legitimate concern, but many farmers may ignore this to ensure their more immediate gains from contracting with companies. The known problems notwithstanding, it appears that contract farming is soon set to become much more common in Indian agriculture.

The slow growth in farm sector gives economists and planners the jitters and the government is anxious that farming be diversified into horticulture and live-stock farming so as to achieve 4% growth in agriculture, which can reflect 8% growth in GDP. Contract farming is one of the quick-fix solution. No doubt farmers can get quick returns but at the cost of soil fertility and long-term growth. In spite of the steep increase in minimum support price (MSP), the government is finding it difficult to garner enough foodgrain stocks for public distribution system (PDS). Imports may become difficult as foodgrains production is slowing, even in the so-called surplus economies. India's cultivable area extends to over 149 million hectares, of which, 45 million hectares is

irrigated. Even if 30% of the annual rainfall is diverted to catchment area, the farmer's water needs would be fully solved. Fertility and productivity growth through traditional water farming methods should be re-discovered. India has significant bio-diversity and is home to a wide range of edible plants. Efficient agricultural input management together with a good system of water management can save and rejuvenate countless number of herbs, shrubs and plant wealth, sustaining and providing farmers with alternative sources of income.

The opponents of corporate farming argue that allowing companies to buy land will make farmers landless since the companies would offer prices which may be too tempting for the poor farmers to resist and they may not be able to negotiate fair price for their land. Land owners, therefore, would run the risk of becoming landless. Further, other stakeholders in such land other than the title holder, like women or children, may run a risk of losing access to such land and therefore food security and social status. This has serious gender implications in an already gender biased rural context. To avoid such a situation, it may be better to allow only leasing in of land by the companies and **to share the company profits with the farmers who will lease out land to the companies.**

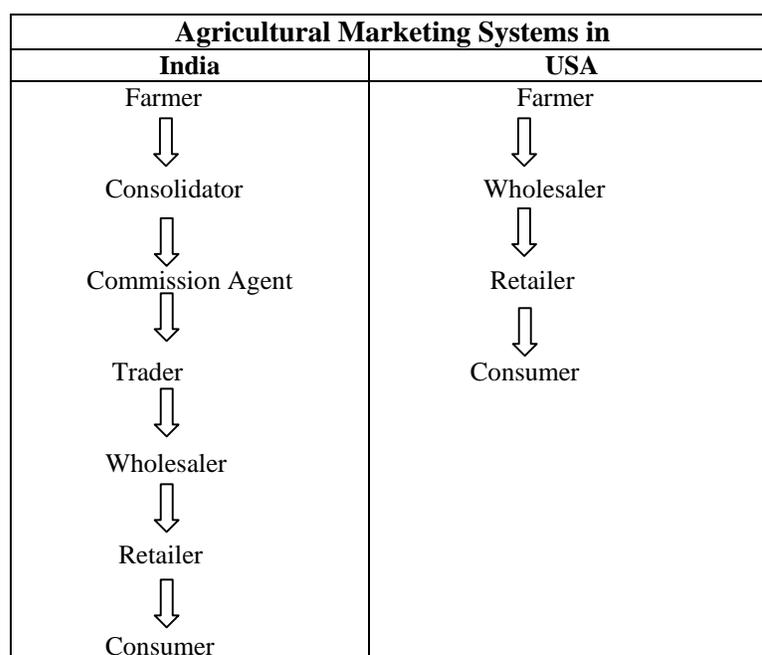
In India, agriculture is not a business carried out for profit, but a source of livelihood. Agriculture in India still engages about 60% of the workforce and contributes about 19% of the GDP. A very large number of the farmers/cultivators belong to the category of small and marginal holders. The number and proportion of such holdings have been growing over time and they depend on agriculture-based activities, to make their living. Therefore, what happens to small and marginal farmers has implication for the entire economy and peoples livelihood. Otherwise, they will only be losers in the process of globalization and liberalization. The viability of the small-holding is an important issue, and promoting agricultural diversification towards high value crop through an efficient marketing system is considered to be one of the means through which this can be achieved.

8. Agricultural Market Reforms

In the present agricultural marketing set up, while traders operating in the agricultural produce marketing centres (APMC) are well organized and educated, the farmers lack in mutual organization and end up functioning in isolation. This often leads to unfair price detection in the open auction system conducted at the APMCs. Farmers are not allowed to quote their own selling price. They become the price takers and have only two options – either to accept the bid or to take their material back home. **This often leads to distress sale.** Consequently, the farmer's plight is that prices exposed in the auction, which are theoretically the optimal prices discovered through the open bidding process, are often unfair to them. Since they do not have any alternative avenue, they are virtually compelled to sell at such price.

As per data involving some agricultural produce, farmers get only 35% of the price paid by the consumers. Although, a part of the differential, 60-65%, can be contributed to cost of transportation, packaging, sorting, grading, taxes, loading/unloading, branding, etc. Nevertheless, a large chunk is appropriated by the long chain of intermediaries ranging from 6-8 between the farmers and the end users.

In the USA, farmers get 60-65% of the price paid by the end users. The value chain in developed countries like the USA is much shorter as it is shown below:



Direct marketing (Farmer to Consumer) has been experimented in India. At present, these markets are being run at the expense of the state exchequer, as a promotional measure, to encourage marketing by small and marginal producers of fruits and vegetables without the help of middlemen. Considering the vastness of India, more and more such market need to comp up in the organized sector so that they can be developed in tune with the backward and forward linkages of the markets.

In case of milk, there has been a spectacular achievement through the white revolution by developing a cooperative society of milk producers under the aegis/brand name **Amul**. In course of the process of developing an efficient direct marketing chain through Amul, milk producers today are getting about 70% of the price paid by the consumers. In case of eggs, poultry farmers get more than 70% of the consumer of eggs being well structured and organized, and there being no APMC regulations. Hence, it is a **free market** without any regulatory restrictions.

Its implication being through reforms in the marketing process, it is indeed possible to change the entire rural economy, and this can be done without increasing the burden on the final consumer. If farmers income could be increased by reforming the agricultural produce marketing system, it can revolutionize the entire rural eco-system by improving rural purchasing power. Such a goal is achievable through setting up a national level screen based transparent institutionalized **spot market**, which can bring both farmers and end users on the same platform.

9. Rural Credit

Only 27% of cultivated households get any institutional credit. Another 22% borrow from moneylenders while the remaining 51% have no access to credit at all. This means that over half of rural Indians do not borrow an account of lack of access or because they do not have the capacity to borrow. Rural credit accounts for only 15% of all bank credit. Consequently, as much as 70% of the rural poor do not have a bank account and 87% have no access to institutional sources of credit.

Rural households need credit for a variety of reasons. They need it to meet short-term requirements for working capital and for long-term investment in agriculture and other income-bearing activities. Agricultural and non-agricultural activity in rural areas are typically seasonal, and households need credit to smooth out seasonal fluctuations in earnings and expenditures. Rural households, particularly those vulnerable to what appear to others to be minor shocks with respect to income and expenditure, need credit as an insurance against risk. In a society that has no free, compulsory and universal education or health care, and very few general social security programmes, rural households need credit for different types of consumption. These include expenditure on food, housing, health and education. In the Indian context, another important purpose of borrowing is to meet expenses for a variety of social obligations and rituals. If these credit needs of the poor are to be met, rural households need access to credit institutions that provide them a range of financial services, provide credit at reasonable rates of interest and provide loan that are unencumbered by extra-economic provisions and obligations.

10. National Food Security Mission

The Indian National Food Security Mission (NFSM) has been launched in October, 2007 following a resolution passed to this effect at National Development Council's special meeting on agriculture held on 29th May, 2007 in 305 districts of 16 states. The NFSM aims at bridging yield gaps in potential areas by introducing modern technologies and improved agronomical practices to ensure that the projects additional requirement of 20 million tones of foodgrains by 2012 could be met. The Mission is expected to boost production of rice, wheat and pulses by 10,8 and 02 million tonnes respectively during 2007-08 to 2011-12. The NFSM takes an integrated approach to farm production by involving stakeholders at District, State, and National Levels and the Panchayati Raj Institutions. Each selected district has been allowed upto Rs. 20 million for taking local initiatives, and awards have been planned at different levels to incentivise better performance among the implementing agencies.

Indian farmers grow possibly every kind of crops that is grown all over the world. The availability of various agro-climatic zones has made it possible. But the problem of food

security continues to loom large in India. There is issue of availability of food for all the people, all the time. There is a greater issue of access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active life.

The current agricultural situation is facing a peculiar situation. While on one hand, there is lot more happening at the market place with liberalization of agricultural produce marketing centre (APMC) policies, entry of corporate and heavy flow of rural credit, on the other hand, the country is faced with the situation of importing foodgrains to meet its food security needs and farmers are under distress. They are not in farming by choice rather by compulsion. There is a need to provide farming allowance to poor farmers and give them wasteland to convert into agricultural land. The physical targets of production have no meaning in agriculture, instead there should be financial targets as to how much farmer gets from per unit of land and resources. There is also a need to accelerate seeds replacement ratio, which alone can substantially enhance the foodgrain production. The time has come to enhance productivity of water bodies and sea and to reorient extension focus from knowledge alone to skills and attitude improvement of farmers. There is a crisis of human resource availability in farm sector. Focus should be on achieving higher income per unit of investment rather than on yield. Farmers should be trained on seed production programmes which can increase their incomes manifold. Youths should be attracted to agriculture.

11. Food Security and Right to Food

Food security is the access of all people to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life and food sovereignty is the right of people to determine their own policies and strategies for the sustainable production, distribution and consumption of food, with respect for their own culture and their own system of managing natural resources and rural areas.

The right to food is a human right and an essential part of the right to life. The right of every man, woman and child alone and in community with others to have physical and economic access at all times to adequate food or means for its procurement in ways consistent with human dignity. The

right of food also implies three levels of obligations to the states. There are:

- **Respect the right**, meaning States cannot take any action that would prevent people from realizing their right to food.
- **Protect the right**, meaning States have to ensure that no one deprives anyone else of the right.
- **Fulfil the right**, meaning States must facilitate actions that will strengthen people's access to and use of resources.

Finally, whenever an individual or group is unable to enjoy the right to adequate food by the means at their disposal, States/Governments have the obligation to fulfil/provide that right directly. Adequate food means an amount and variety of food sufficient to meet all of one's nutritional needs for a healthy and active life. The right to food is more than the right to basic staples or to sufficient dietary energy. Sustainable food security can be achieved by providing.

- **Incentive** through remunerative prices for agricultural produce and products
- **Innovation** through strong national agricultural education, research and extension systems, both public and private, to generate and disseminate productivity enhancing technologies and tools.
- **Infrastructure** by constructing good roads, transport system, power supply and irrigation systems.
- **Inputs** having efficient delivery system for agricultural services, especially for modern farm inputs, agro-processing and credit.
- **Institutions** including efficient liberalized markets that provide farmers with ready access to domestic and international markets and effective public institutions to provide key services. Where there cannot be developed, private sector may come in.

12. Recommendations

12.1 Scientific management of soil, water and bio resources.

12.2 Development and promotion of farmers' friendly farming system including livestock and fishery to maximize the system output.

- 12.3 Crop and site specific agricultural mechanization using a proper blend of conventional and renewable energy sources.
- 12.4 Adoption of integrated nutrient and pest management practices.
- 12.5 Post-harvest management and value addition in the production catchment.
- 12.6 Bridge the knowledge gap through effective extension.
- 12.7 Provide easy access to credit at affordable rates.

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