Vision 2030

Project Directorate for Farming Systems Research

Modipuram, Meerut-250 110 (U.P.)

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Project Directorate for Farming Systems Research

(Indian Council of Agricultural Research)

Modipuram, Meerut-250 110 (U.P.)
India

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Foreword

The diverse challenges and constraints as growing population, increasing food, feed and fodder needs, natural resource degradation, climate change, new parasites, slow growth in farm income and new global trade regulations demand a paradigm shift in formulating and implementing the agricultural research programmes. The emerging scenario necessitates the institutions of ICAR to have perspective vision which could be translated through proactive, novel and innovative research approach based on cutting edge science. In this endeavour, all of the institutions of ICAR, have revised and prepared respective Vision-2030 documents highlighting the issues and strategies relevant for the next twenty years.

With the growing challenges to meet the food security in the Country, it is pertinent to integrate our cropping fields with alternate income generating activities. Traditionally, the farming systems were sustainable; however, these farming systems are changing rapidly from one of mixed crops and livestock to intensively irrigated crops. Hence, it is required to integrate livestock/pasture into cropping systems to ensure the long term productivity of the land. This signifies the optimization of various agricultural components and their integration for multi-enterprise farming systems, development of sustainable farm practices for enhanced soil health, and resource use efficiencies under diverse farming situations and farm categories will be of paramount importance. With this mandate, the Project Directorate for Farming Systems Research (PDFSR), Modipuram has been pursuing research and development in farming systems, which is primarily an innovation-driven strategy and is geneIally farmer-centric.

It is expected that the analytical approach and forward looking concepts presented in the *'Vision 2030'* document will prove useful for the researchers, policymakers, and stakeholders to address the future challenges for growth and development of the agricultural sector and ensure food and income security with a human touch.

(Dr. S. Ayyappan)
Secretary, DARE & DG, ICAR

Preface

The Project Directorate for Farming Systems Research is an apex Institution in the country for spearheading farming systems research, human resource development and system diversification, especially for small and marginal farmers, who will be cultivating more than 91% of farm holdings by 2030. The comprehensive initiatives taken during last two decades in cropping systems research and adhoc studies on farming systems have clearly revealed that up to 4 times increase of productivity in food grain equivalent terms is achievable with logical use of available technologies in system mode. Still a need for integration of other enterprises was always felt to make more efficient use of available resources and convert them into a possible means of profitability. It was in this direction that a new beginning was made in 11th five-year plan period by changing the focus of research from cropping systems towards farming systems at national level which practically shaped and became effective from April, 2010. The earlier document published on this subject (Vision 2025) by the Directorate in the year 2005 was focused mainly on cropping systems. However, now our efforts are exclusively focused on farming systems which articulate all possible plan and strategies to address the challenges and harness the opportunities, especially for small and marginal farm holders.

I take this opportunity to record my sincere gratitude to Dr S. Ayyappan, Secretary DARE and Director General ICAR, New Delhi for his keen interest, constructive and critical comments and guidance during review and constant encouragement throughout the preparation of this document. I am grateful to Dr A. K. Singh, Deputy Director General (Natural Resource Management), Dr J. C. Dagar, Assistant Director General (Agronomy & Agro-forestry) and Dr P. S. Minhas, Assistant Director General (Soils & Water Management) for their encouragement and valuable suggestions.

Vital contributions have been made by Research Advisory Committee of PDFSR to bring the document in the present shape. I sincerely record my thanks to Dr Panjab Singh, Former Secretary, DARE & Director General, ICAR and Chairman of R.A.C. Thanks are also due to all the members of R.A.C., Programme Facilitators and Scientists of PDFSR for their suggestions and contribution in preparation of the document. I sincerely appreciate candid and untiring efforts put by Dr Kamta Prasad, Dr K. K. Singh, Dr J. P. Singh, Dr S. S. Pal, Dr V. K. Singh, Dr S. P. Singh and Dr N. Ravishankar, in drafting and bringing document in the final shape.

30th June, 2011
Modipuram

B. Gangwar
Project Director
PDFSR, Modipuram

Preamble

Long-term study on effect of various interventions/ inputs in relation to system productivity with an effort to increase total agricultural production and profits besides developing practices for sustaining resources over the time without deteriorating the ecosystem as a whole is the important feature of farming system research. To address the concerns of plateauing of yield levels in major crops, visibility of second generation problems of GRTs, deteriorating resource base (soil, water and biodiversity) in quantitative and qualitative terms in recent past and drastic shift in government policies towards globalization of agriculture; focus of future research has to change for meeting the needs of the farmers and national priority. Perspective plan of next 20 years is envisaged to play a key role in addressing the issues of farming system research in holistic manner.

The first Perspective Plan (VISION – 2020) of PDFSR (formerly PDCSR) was conceptualized and published during 1997 and the second in 2007, Perspective Plan 2025 to address the changes that had taken place. Change in approach and mandate of the Directorate had taken place during 2010 by shifting mode of research from cropping systems to farming systems which requires long term perspective planning. VISION 2030 of PDFSR is an attempt of anticipating future approach in farming systems research that would help in minimising the limitations of component-based research, sustaining the resource base and in breaking the yield plateau and our programmes and activities would be reoriented accordingly. No doubt, the cropping systems approach of agricultural research provided important findings to address the burning issues of sustainability and resource use efficiency in crop production. However, an introspection reveals that to bridge the widening gap between the desired and achieved and to bring quantitative as well as qualitative improvement in national food security, and to provide livelihood security to millions of rural masses; a form of agriculture that goes beyond cropping systems and respects the integrity of ecosystems while meeting the nutrition, income and livelihood requirement is important. Opening of global markets and privatization of agricultural trade in new WTO regime, diversification needs of agriculture because of change in food habits due to rising income levels of individuals, disproportionate increase in cultivation costs, unabated shrinking of agricultural land resources and essential ecosystem services like soil carbon sequestration, are the other vital issues which need attention of agricultural scientists.

Under such scenario, it becomes imperative to ponder afresh over the earlier research programmes and projects in order to keep pace with the need of the day and encompass the new knowledge generated globally, into our programmes. The new edition of Perspective Plan (VISION – 2030), therefore, differs from earlier one with respect to our goals, approach, programmes and activities, to achieve the new mandate of FSR in more meaningful manner. Due emphasis has been laid on some new concepts of alternative agricultural production systems such as; multi-enterprise farming systems, organic farming, crop diversification, conservation agriculture, site-specific resource management and precision agriculture along with multiple use of resources, which require in-depth studies to harness their full benefits, under the proposed umbrella of "Indian Institute of Farming Systems Research".

Hopefully, VISION 2030 provides direction to harness the science for farming systems research so as to achieve the goal of improving nutrition, income and livelihood of small and marginal farmers.

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Farming Systems Scenario

INDIAN agriculture has onus of providing national as well as household food and nutritional security to its teeming millions in a scenario of plateauing genetic potential in all major crops and declining productivity in vast tracts of rainfed/ dryland areas constituting approximately 44.2 percent of net cultivated area. Wide-spread occurrence of ill-effects of green revolution technologies (GRTs) in all intensively cultivated areas is threatening the very sustainability of the important agricultural production systems and national food security. It has also to share local as well as global responsibilities to ensure environmental safety for human kind.

A mismatch between the national foodgrain production and requirement has already crept into the system, which is further widening. The human population of India has increased to 1210.2 million at a growth rate of 1.76 per cent in 2011 over 2001 (1028.7 million) and is estimated to increase further to 1530 million by 2030 (Census of India, 2011). On the other hand our national food grain production for past 3-4 years is hovering around 234 million tonnes. This means that per capita food grain production is only about 193 kg per year. There are projections that demand for food grains would increase from 234 million tonnes in 2009-10 to 345 million tonnes in 2030 (GOI, 2009). Hence in the next 20 years, production of food grains needs to be increased at the rate of 5.5 million tonnes annually.

Simultaneously, the demand for high-value commodities such as; fruits, vegetables, livestock products, fish, poultry etc., is increasing faster than foodgrains, and is expected to increase by more than 100% from 2000 to 2030. As a result, area under horticultural crops has increased appreciably during past two decades. At present, more than 20 million ha area is reported under horticultural crops with a total production of 207 million tonnes, of which major contribution comes from fruits (60.8%) and vegetables (30.7%). The fruits are grown in approximately 5.78 million ha with a production level of 63.50 million tonnes. Likewise, total production of vegetables is about 125.90 million tonnes which comes from an area of 7.80 million ha (Agricultural Situation in India, 2009).

Of the total vegetable production, more than 65 percent comes from potato, tomato, onion, brinjal, okra, cabbage and cauliflower.

Livestock has traditionally been an integral part of farmers' household, as it plays an important role not only in the farm production but also in augmenting rural economy and in recycling of farm wastes. It is a major source of supplementing family incomes and generating gainful employment in the rural sector, particularly among the landless labourers, small and marginal farmers and farm women. However, the importance of livestock in India goes beyond the function of food production as it has been an important source of draught power, manure for crop production and fuel for domestic use. India's current livestock population is 510.6 million (with 191.2 million cattle and 102.4 million buffalo) and their contribution accounts for 26% of the agricultural GDP and has close links with crop production. Estimates indicate that milk production will also increase substantially, from present 108.5 million tonnes to 175 million tonnes by 2030 (Indian Livestock Census, 2003). However, situation with respect to feed and fodder availability may further worsen, which is already facing a shortfall of concentrate (63%), green fodder (62%) and dry fodder (22%).

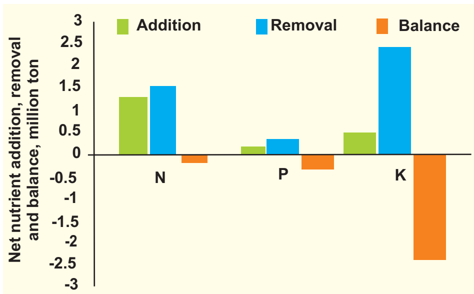
The poultry, 571.1 million in number, produces about 55.64 billion eggs and 1401 thousand tonnes of meat, and contributes approximately Rs 220 billion to our GNP and also supports the livelihood of approximately 2 million people. The present production of beef, buffalo meat, sheep meat, goat meat, pork and poultry meat is 1462, 1443, 232, 470, 612 and 1401 thousand tonnes as against a demand of 1460, 3250, 600, 850, 770 and 3930 thousand tonnes, respectively. To meet the future demand, which is estimated to be doubled by the year 2030, it is very imperative that the meat production has to be substantially enhanced. During 2008-09, the total fish production was around 7.64 million tonnes with inland and marine fisheries contributing 61.0 and 39.0 percent, respectively.

National scenario with respect to farm size is also not very promising and conducive to desired agricultural growth. The average size of the landholding has declined to 1.21 ha during 2009-10 from 2.30 ha in 1970-71, and absolute number of operational holdings increased from 70 million to 121 million. If this trend continues, the average size of holding in India would be mere 0.68 ha in 2020, and would be further reduced to a low of 0.32 ha in 2030 (Agricultural Statistics at a Glance, 2009). This is a very complex and serious problem, when share of agriculture in gross domestic product is declining, average size of landholding is contracting (also fragmenting) and number of operational holdings is increasing. Declining size of landholdings without any alternative income augmenting opportunity is resulting in fall of farm income, and causing agrarian distress. A large number of smallholders have to move to non-farm activities to augment their incomes (NCAER, 2009). Research efforts so far have paid dividends, but mainly through medium and large farm holders. However, under the changing scenario a paradigm shift in research is inevitable with more focus towards small and marginal holders in farming systems perspective.

Deteriorating Resource Base

During post-green revolution period, our endeavor to augment food problem and attain self-sufficiency in food production through large inputs of agro-chemicals, inevitable dependence on irrigation, and high cropping intensity has led to contamination of food with harmful chemicals, pollution of ground water, eutrophication of surface water, degradation of soil quality, damage to agriculturally beneficial microorganisms and deterioration of air quality. There is increasing damage to the system ecology, such as forests, bio-diversity and the atmosphere, and there are distinct possibilities for adverse changes in climate and sea level. In many regions both surface and ground water are already becoming unfit for human and animal consumption due to high concentration of NO_3-N and pesticide residues. Several pesticides have entered into the food chain and have severely endangered human/animal health. Indiscriminate exploitation of agricultural and forest ecosystems disturbs the ecological balance, disrupts the carbon cycle, depletes soil and biotic C pools, and leads to emission of C (as CO_2 and CH_4) and N (as N_2O and other oxides of N) into the atmosphere. These gases (CO_2, CH_4 and N_2O) being relatively active (green house gases) can influence the global climate.

The extent of degraded lands is as high as 51.9 percent of the reported area. Available estimates reveal that nearly 120.72 million ha of land in the country is degraded of which 13.25 million ha is due to water erosion, 3.76 million ha is

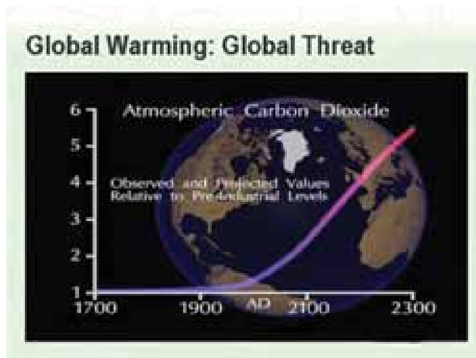


Nutrient balance in rice-wheat cropping system of IGP

due to wind erosion, 22.75 million ha is due to salinity/ alkalinity and 8.5 million ha has water logging problems. Annually India is loosing nearly 0.8 million tonnes of N, 1.8 million tonnes of P and 26.3 million tonnes of K during crop production cycle. Intensified agriculture, coupled with indiscriminate use of irrigation water and non-judicious fertilizer application, especially in irrigated areas of the country has led to various kinds of physical and chemical degradation of the soil. While depletion in soil fertility status, as characterized by emergence of multi-nutrient deficiencies, continues to be the most significant soil related problem, other important ones are spread of area under salinity, alkalinity and water logging. Multiple nutrient deficiencies have cropped up since nutrient removal by crops from soil has exceeded their replenishment through fertilizers and manures, leading to negative balance of nutrients in soil and changing soil fertility scenario dramatically. At present level of crop production, crops remove 27 million tonnes of NPK against application of 16.8 million tonnes (FAI, 2009). The fertilizer consumption may further increase up to 26.7 million tonnes by 2030 and the gap between NPK consumption and removal may increase to 13.3 million tonnes, which may be a potential threat to the soil quality and agriculture sustainability. As the food grain production increased with time the number of elements becoming deficient in soils and crops also increased. The number of elements deficient in Indian soils increased from one in 1950 to 9 in the year 2005-06 which might further increase by the year 2030 if the imbalanced fertilization continues. Moreover, ill-conceived, uncoordinated, non-integrated development policies and inappropriate land uses are posing danger directly to limited fragile natural resources of the soil and water and indirectly to the society survival.

Although irrigation will continue to be the predominant end-user of available water resources, its share is, however, projected to reduce marginally from 95.1 percent in 2001-02 to 94.5 percent in 2030. India's ultimate irrigation potential is assessed at 140 million hectares, of which 75.9 million hectares is by surface water and 64.1 million hectares by groundwater. Based on these estimates, it is projected that 48% of the gross cropped area (107 million hectares) will be under irrigation by 2030. It means that the gross area under irrigation will be nearly 1.4 times from the existing 79 million hectares. This translates to 780 billion cubic metre of water requirement for irrigation. Over-exploitation, climate change related problems and industrial growth are leading to deterioration of irrigation water quality and quantity.

Climate Change



The increasing green-house gases (GHG) resulted in global warming by 0.74°C over past 100 years and 11 of the 12 warmest years were recorded during 1995–2006. The Intergovernmental Panel for Climate Change (IPCC) projections on temperature predicts an increase of 1.8 to 4.0°C, by the end of this century. Temperature and sea level changes will affect agriculture through their direct and indirect effects on crops, soils, livestock, fisheries and pests. The brunt of environmental changes is expected to be very high in India due to greater dependence on agriculture, limited natural resources, alarming increase in human and livestock population, changing pattern in land use and socio-economic factors that pose a great threat in meeting the food, fibre, fuel and fodder requirement. There is a likelihood of a considerable impact on agricultural land-use due to snow melt, availability of irrigation, frequency and intensity of inter- and intra-seasonal droughts and floods, soil organic transformation matters, soil erosion and availability of energy as a consequence of global warming, impacting agricultural production and hence, the nations' food security. Global warming due to greenhouse effect is expected to impact hydrological cycle viz. precipitation, evapo-transpiration, soil moisture etc., which would pose new challenges for agriculture.

In Indian context, it is projected that by the end of the 21st century rainfall will increase by 15 – 31%, and the mean annual temperature will increase by 3°C to 6°C. The warming is more pronounced over land areas, with the maximum increase over northern India. The warming is also projected to be relatively greater in winter and post-monsoon seasons. Although increase in carbon dioxide is likely to be beneficial to several crops, but associated increase in temperatures, and increased variability of rainfall would adversely impact food production. Recent IPCC reports and a few other global studies indicate a probability of 10-40% loss in crop production in India with increase in temperature by the end of current century. Recent studies done at the Indian Agricultural Research Institute indicate the possibility of loss of 4-5 million tonnes in wheat production in future with every rise of 1°C temperature throughout the growing period. Losses for other crops are still uncertain but they are expected to be relatively smaller, especially for *kharif* crops. It is, however, possible for farmers and other stakeholders to adapt to a limited extent and reduce the losses. Simple adaptations such as change in planting dates and crop varieties could help in reducing impacts of climate change to some extent.

Narrowed Biodiversity

The narrowing of genetic biodiversity occurs as traditional crop varieties and local animal breeds are being replaced by modern ones. These new varieties/ breeds are certainly better matched to modern intensive agriculture, but rarely any consideration is given to preserving the bio-diversity of an agricultural ecosystem. In addition, the increased farming density tends to erode the biodiversity of flora and fauna in the agricultural ecosystems. For example, extensive adoption of rice-wheat monoculture in the Indo-Gangetic Plains has replaced the other traditional crops. Soil micro-flora is also adversely influenced on account of large-scale use of agro-chemicals and lack of recycling of crop residues in the region. The numerous eco-friendly birds such as peacock, dove, vulture, owl etc. have been vanishing gradually. Likewise, numerous forests and pasture species are now extinct.

Multiplicity of Integrated Farming Systems

Very often, almost all Indian farmers, in pursuit of supplementing their needs of food, fodder, fuel and finance, resort to adopt integrated farming systems, majority of them revolving around the crops+livestock components. Livelihood of small and marginal farmers, comprising 84% of total farmers, depends mainly on crops or livestock, which is often affected by weather aberrations. Under present scenario, in the absence of scientifically designed, economically profitable and socially acceptable appropriate integrated farming systems models, they are unable to harness the benefits of integration. An important consequence of this has been that their farming activities remain, by and large, subsistent in nature rather than commercial and many a times uneconomical.

Low Rate of Farm Resource Recycling

In the absence of adequate knowledge among farmers about techniques and benefits of recycling of farm, industrial and municipal organic wastes in agriculture, these remain unutilized. A vast untapped potential exists to recycle these solid and liquid organic wastes of municipal, industrial and farm origin. With the development of appropriate user-friendly techniques for their decontamination and recycling these may form an important component of eco-friendly plant nutrient supply system and irrigation water. Recycling of crop residues may be a potential organic source to sustain the soil health. Incorporation of crop residues of either rice or wheat increases the yield of rice and nutrient uptake and also improves the physico-chemical properties of the soil, ensuring better soil environment for crop growth.

Technology Adoption Gaps

The rate of transfer of technologies developed in agriculture is rather slow which may be attributed to lack of adequate mechanisms at government level and critical lacuna in our past approaches of research. In our efforts to develop and improve upon existing technologies, involvement of people in conceptualization and extension of technologies would appear very important. The farm family had never been the focal point of our investigations. This top down approach had given a poor perception of the problems that they tried to solve. Due to poor extension mechanisms at national as well as state levels, many farmers, especially those at lower strata of social structure, remain uninformed about many of the development schemes and the desired impact of such schemes, such as; food for work programme, rural employment guarantee scheme etc, is not obtained. One of the reasons for poor rate of transfer of agricultural technologies is poor linkages between the different clientele groups of agriculture. Practically linkages among farmers, service providers, technological and financial institutions are either weak or non-existent (NAAS, 2009).

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Farming Systems Research

THE prevailing farming situation in India calls for an integrated effort to address the emerging issues / problems. The integrated farming systems approach is considered to be the most powerful tool for enhancing profitability of farming systems, especially for small and marginal farm-holders to make them bountiful.

In fact, our past experience has clearly evinced that the income from cropping alone is hardly sufficient to sustain the farmers' needs. With enhanced consumerism in rural areas, farmers' requirements for cash have also increased to improve their standard of living. This is especially true in case of small and marginal farmers. Therefore, farmers' income and food requirements would have to be augmented and supplemented by adoption of efficient secondary/ tertiary enterprises like animal husbandry, horticulture (vegetables/ fruits/ flowers/ medicinal and aromatic plants), apiary, mushroom cultivation, fisheries etc. However, these integrated farming systems will be required to be tailor-made and designed in such a manner that they lead to substantial improvement in energy efficiencies at the farm and help in maximum exploitation of synergies through adoption of close cycles. These systems also need to be socially acceptable, environment friendly and economically viable.

Agricultural research in farming system mode by judiciously integrating more than one enterprise, with crop being the nucleus of the system, certainly leads to greater dividends than single enterprise based farming, especially for small and marginal farmers. It also leads to improvement in nutritional quality of daily diet of farmers. The average yield gaps between 27 pre-dominant and 37 diversified farming systems were examined across the agro-climatic zones through detailed survey on characterization of on-farm farming systems. The scattered adhoc studies at the national level have revealed that the diversification of farming system through integration of enterprises in varied farming situations of the country enabled to enhance total production in terms of rice equivalent yield ranging from 9.19% in Eastern Himalayan Region to as high as 366% in Western Plain & Ghat Region when compared to prevailing farming systems of the region. Even a simple intervention of replacing indigenous breed of milch animals by crossbred cows and/or buffaloes in Gujrat Plain & Hill Region and changing the pattern of cultivation of fish and rice in rice+fish system in Western Plain & Ghat Region brought about a radical change in productivity and profitability. Survey on Farming Systems in the country as a whole also revealed that milch animals (cows and buffaloes), irrespective of breed and productivity, is the first choice of the farmers as an integral part of their farming system. However, from economic point of view, vegetables and fruits (mango and banana in many parts of the country) followed by fish cultivation were the most enterprising components of any of the farming systems prevailed in the country. A number of success stories on integrated farming system models in different parts of the country suggest that farmers' income can be increased manifold by way of integration of enterprises in a farming system mode.

Considering the importance of farming systems research in India, the ICAR revised the focus of cropping systems research towards farming systems research and accordingly the Project Directorate for Cropping Systems Research became Project Directorate for Farming Systems Research during 11th plan and started working from April 2010 with the revised mandate.

Mandate

- To characterize existing farming systems to know the productivity, viability and constraints.
- To develop resource efficient, economically viable and sustainable integrated farming system modules and models for different farming situations.
- To undertake basic and strategic research on production technologies for improving agricultural resource use efficiencies in farming system mode.
- To develop and standardize package of production practices for emerging cropping/ farming concepts and evaluate their long-term sustainability.
- To act as repository of information on all aspects of farming systems by creating appropriate databases.
- To develop on-farm agro-processing and value addition techniques to enhance farm income and quality of finished products.

- To undertake on-farm testing, verification and refinement of system-based farm production technologies.
- To develop capacity building of stakeholders in Integrated Farming Systems through training.

The Directorate, since its inception has made noteworthy contributions towards development and on-farm validation of system-based crop production technologies in the different agro-climatic regions of the country. In fact, this project started with on-farm research concept in its initial phase during the year 1952-53, when a scheme was started in the name of simple fertilizer trials at farmers' fields which lead to increase in productivity during those days. In the year 1968-69, when the programme was reshaped as All India Coordinated Agronomic Research Project, it contributed appreciably for the development of package of agronomic management practices for newly introduced high yielding varieties and thus played a critical role in bringing green revolution in India. Subsequently, the Project Directorate for Cropping Systems Research was established at Modipuram by up-gradation of the same scheme in the year 1989-90 with the new name of All India Coordinated Research Project on Cropping Systems. AICRP-CS continued with 69 centers (37 on-station and 32 on-farm research centers). The research efforts over last two decades have lead to several significant findings. The summary of major achievements is listed hereunder.

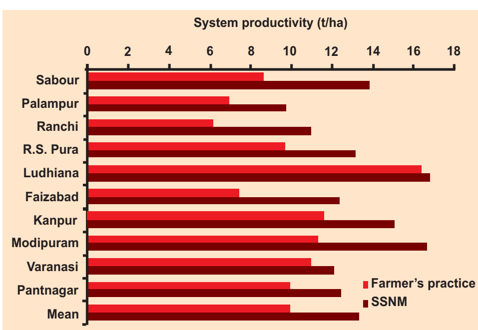
Crop diversification for sustainable productivity

- Resource efficient alternative cropping systems to rice-wheat system were developed for 11 states viz. Haryana, Punjab, U.P., Bihar, Uttaranchal, parts of Orissa, M.P., W.B., Jammu Kashmir, H.P. and Gujarat, involving potato, maize, onion, sunflower, green gram, brinjal, berseem (F), cabbage, okra, radish, potato etc, which gave average productivity of 20 t/ha as rice equivalent yield as compared to 11-13 t/ha, which led to induce the scope of increasing per unit productivity substantially.

- Likewise, efficient alternatives to pearl millet-wheat system in five states, viz.; Haryana, Gujarat, U.P., Rajasthan and Maharashtra, involving potato, green gram, cowpea, mustard, cluster bean, chickpea etc. were identified, which gave the productivity up to 12 tonnes per ha as compared to existing 8 t/ha.

- Efficient alternatives to soybean-wheat system in three states, viz.; M.P., Rajasthan and Maharastra, were developed. Diversification options involving high value crops like isabgol, groundnut, soybean, potato, turmeric etc resulted in average productivity of 15 tonnes/ha as compared to existing 12 t/ha (rice equivalent) yield.

- Integrated plant nutrient supply systems have been established to be beneficial and standardized. Substitution of 25-50% N with FYM or green manure in rice-wheat system was found to increase the productivity by 4%, which may save chemical fertilizers worth Rs. 7.0 crores. It also helped in increase of soil organic carbon by 55.9%. In rice-rice system, green manuring increased the yield by 3.6%.



Performance of site-specific nutrient management under rice-wheat cropping system

- Site Specific Nutrient Management Technology has been proven to be a potential tool in breaking the yield barrier through efficient and balanced nutrient management leading to significant productivity increase. Our results clearly show that by adoption of SSNM, across the locations, grain yields of more than 13 t/ha in rice-wheat system (with a contribution of 58% rice and 42% wheat) and 12-15 t/ha in rice-rice system (with a contribution of 48% *kharif* rice and 52% ra*bi* rice), are achievable. It also helped in increase of organic carbon by 55.9%.

- The use of different resource conservation technologies in rice-wheat system has been established to help in significant improvement of crop productivity and resource saving. Adoption of RCTs lead to an improvement in productivity of rice by 1 to 7% in mechanical transplanting, 3 to 8% in drum seeding, 1 to 2% in zero till drilling and 10 to 13% in system of rice intensification (SRI) compared to traditional hand transplanting at different locations. Similarly, in wheat, productivity increased by 5 to 29% in zero-till drilling, 4 to 11% in strip-till drilling and 3 to 23% in bed planting compared to conventional sowing at different locations.

- With the application of recommended technologies and balanced fertilization to at least 10% of the area under different cropping systems, spread over various agroclimatic regions as indicated by on-farm research on cultivator's fields, India can easily add about 5 million tonnes of food grain equivalent to rice to its food bowl.

- Through long-term studies in all the major cereal-cereal cropping systems, it has been proved that continuous use of chemical fertilizers (NPK) only and omitting P or K application leads to occurrence of deficiency of these nutrients and decline in yield of crops. However, the extent of yield reduction and occurrence of P or K deficiency is governed by the inherent soil supplying capacity and cropping system adopted.

- On-farm crop response to N, P and K application in different cropping systems has been determined. The average response of different cropping systems was 8-12 kg rice equivalent yield/kg of any of the major plant nutrients like N, P or K with mean economic responses of 7-10 Rs./Re invested on N, 4 Rs./Re spent on P and 6-8 Rs./Re spent on K.

- To improve the sustainability of rice-wheat system over the years, growing of legumes as break crop showed a marked influence on weed flora over the years and a reduction of 45 to 61% weed count was noted in succeeding rice-wheat crop cycle. To improve upon soil organic carbon and micro-nutrients application of organic manures has been proven very effective.

- In hybrid as well as inbred rice, N management through LCC proved

Leaf colour chart (LCC) based N management

superior to locally recommended N application in three splits and it was found possible to curtail 20-30 kg of fertilizer N/ha without sacrificing rice yield, when N is applied as per LCC values. N application at LCC$\leq$3 in Basmati 370 and at LCC$\leq$4 in coarse and hybrid rice was found optimum. Moreover, in LCC-based N management, basal application of N can be skipped without any disadvantage in terms of grain yield, and agronomic, physiological or recovery efficiency of fertilizer N.

- Similarly, nitrogen application as per soil supplying capacity and crop demand based on SPAD reading (35) produced highest yield of rice (4.92 t/ha) and wheat (4.55 t/ha). Skipping basal N application in both rice and wheat led to higher use efficiency of N (partial factor productivity, uptake efficiency and internal efficiency) and better crop productivity.
- Crop residue recycling in rice-wheat was found to increase rice as well as wheat yields by 13 and 8%, decrease cost effectiveness by 5 and 3% and energy efficiency by 13 and 6%, respectively, compared to residue retrieval, whereas yield advantage was to the tune of 9 and 3% compared to residue burning. Recycling improved SOC by 31 and 2% and MWD by 11 and 10%, compared to residue retrieval and burning after seven crop cycles. It also improved soil moisture content (15%), bulk density (3%), cone index (14%), total N (17%), available P_2O_5 (12%) and K_2O (8%) compared to residue retrieval.
- A comparison of yield, economics and energy of mechanical and manual transplanting revealed that the transplanting by rice transplanter provided 85 and 72% savings in labour and cost of transplanting including nursery raising, respectively; provided higher rice yield (10%), net returns (26%), benefit: cost ratio (29%) and energy efficiency (7%); compared to manual transplanting of rice.
- During 3-4 years of conversion period, crop yields under organic farming were recorded to be comparable with conventional (chemical) farming in many regions. Some of these crops and their percent improvement in yield are coarse rice (+2%), garlic (+20.4%), maize (+22.8%), turmeric (+51.5%), fodder crops (+14.4 to 89.9%) and basmati rice (-6%) at Ludhiana; *kharif* French bean (+19.0%), veg. pea (+62.1%), cabbage (+9.5%), garlic (+7.0%) and *kharif* cauliflower (-4.6%) at Bajaura; fodder berseem (+6.5%), chickpea

(+1.5%), soybean (-2.3%) and mustard (-6.6%) at Raipur; Rice (+12.9%), Wheat (+24.4%), Potato (+7.3%), mustard (+9.6%) and lentil (+2.5%) at Ranchi, groundnut (+6.9%), *rabi* sorghum (+15.8%), soybean (+9.5%), durum wheat (+32.4%), chilli (+18.8%), cotton (+35.5%), potato (+3.3%), chickpea (+3.2%) and maize (-1.1%) at Dharwad; soybean (+10.7%), isabgol (+11.2%), durum wheat (+1.1%), mustard (+3.1%) and chickpea (+4.2%) at Bhopal; okra (+1.0%), berseem (-0.2%) and veg. pea (+1.8%) at Jabalpur; *Dolichos* bean (+16.6%) at Karjat; maize (+18.2%), cotton (+38.7%), chilli (+8.2%), brinjal (+14.9%) and sunflower (+29.1%) at Coimbatore; rice (+1.9%) at Pantnagar; fodder sorghum (+32.5%), okra (+11.3%), baby corn (+11.8%) and veg. pea (+2.2%) at Modipuram; and carrot (+5.8%), tomato (+30.6%), rice on raised beds (+7.3%), french bean (+17.7%) and potato (+3.0%) at Umiam.

- Improvement of different magnitudes was recorded in respect of soil organic carbon (negligible at Pantnagar to 45.9% at Ludhiana), available-P (negligible at Pantnagar to 45.9% at Ludhiana), and available-K (up to 28.8% at Modipuram). However, available-N content was, in general, lower under organic systems.
- An improvement in some of the quality parameters of ginger (oleoresin by 11.5% and starch content by 10.6%), turmeric (oil by 10.8%, oleoresin by 12.4%, starch by 20.0% and curcumin by 21.7%), chillies (ascorbic acid content by 2.1%), cotton (ginning percentage), and vegetables (iron, manganese, zinc and copper content in tomato, French bean, cabbage, cauliflower, pea and garlic) was recorded.

With effect from April 2010 the Directorate has re-oriented its research programmes to address farming system-based issues. A good beginning was made as work on characterization of existing farming systems could be initiated in major states and 31 on-station units under AICRP-IFS could be established for designing of region-specific, resource efficient, multi-enterprise IFS models. The functioning of 32 on-farm research centres is under process of transformation and initiated the working in integrated farming systems perspective during 2011. The integrated approach for organic farming, precision farming and conservation agriculture is also considered essential which is to receive increasing attention.

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PDFSR 2030

THE Directorate/ Institute will strive hard to develop farming system based agricultural production technologies for sustainable management of farm resources and to achieve household food, nutritional and livelihood security. In our endeavour of realizing the goals of farming systems research and development, the 'farmer-first and bottom-up' approach would be the focus of entire strategy in future.

Vision

Sustainable management of farm resources in integrated manner for achieving household food, nutritional and livelihood improvement.

Mission

Food, nutrition, livelihood and environment improvement of small and marginal farmers through integrated farming systems research approach.

Focus

To accomplish the vision and the mission of the Directorate / Institute, It would concentrate on the following key areas.

- Characterization and dynamics of farming systems at macro and micro level
- Location-specific efficient farming system models
- Integrated organic farming systems
- Bio-intensive diversified complementary cropping systems using resource efficient land configurations
- System-based conservation agriculture
- Climate-resilient agriculture production systems
- Precision/ Hi-tech agriculture
- On-farm post-harvest processing and value addition
- Capacity building/ human resource development in IFS

Harnessing Science for Farming Systems Research

THE Directorate/ Institute for Farming Systems Research would strive to harness power of science in enhancing system productivity, profitability, resource use efficiency, cost-effectiveness, value addition and improving quality of food through blending of scientific and traditional knowledge. Technological challenges are becoming more complex than before as demand for food is increasing and natural resource base is shrinking. A paradigm shift in farming systems research is needed to accomplish the mission by integrating the modern tools and techniques of agriculture.

Farming System Diversification / Intensification

The increased cropping intensity will be a key strategy for future gains in crop production. Short duration pulses, oilseeds and other high value crops will find their definite niche as sequential or intercrops, rather than replacing the major cereal crops having higher yield stability. Hence, an increased cropping intensity will contribute substantially to additional demands of food and cash crops. Development of new crop varieties with more efficient photosynthetic apparatus and shorter duration would be of immense help in increasing cropping intensity. Similarly, bio -intensive diversified complementary cropping systems would enable small and marginal farmers to utilize limited land and water resources in more efficient manner. The diversified cropping systems need to be considered in farming system perspective.

Knowledge-Intensive Agriculture

Future agriculture systems would be highly knowledge intensive. It would call for more efficient use of inputs such as fertilizer, water, pesticides, weedicides and labour. The mixed cropping, strip cropping, crop rotations, growing of crops as per land capability classification, inclusion of vegetables and high value low volume crops in the cropping systems, are the other possible options in intensive agriculture. The involvement of non-monetary inputs such as time of sowing, method of sowing, split application of fertilizer, application of irrigation at critical stages, timely spray to control weeds, insect-pests and diseases play a pivotal role for increasing the per unit productivity. Delay in sowing of wheat by a week reduces yield by 3.75 q/ ha. Similarly, bi-directional sowing of wheat leads to more yield by 5.00 q/ ha. Likewise in rice, the system of rice intensification (SRI) improves productivity by 15 to 20 percent. Application of irrigation at crown root initiation improves 33 per cent wheat yield. Integration of chemical fertilizers with organic manures not only improves and sustains the yields but also saves 50% on fertilizers.

Resource Conservation Technologies

Bed planting in wheat for improved water use efficiency

Conservation Agriculture: Overexploitation of natural resources during green revolution period has resulted in degradation of underground water resources, soil health and environment. Energy requirement has increased many folds resulting in high input costs. Conservation agriculture technology development for different agro-ecosystems has a golden ray to sustain the natural resources. The concept involves minimum disturbance of soil and perfect land leveling to conserve both soil and water, besides saving labour and fuel. The crop yields increase perceptibly due to enhanced input-use efficiency. The combination of reduced cost and higher production results in better returns to the farmers. This would open up new avenues for farm research in areas such as growing paddy with minimum water and developing new plant strains suited specifically for conservation agriculture.

Precision farming: Precision farming is an emerging concept. Under precision farming, input variables such as seed, fertilizers, water, agro-chemicals are applied in right amount at right place and at right time as per demand of the crop-plants, rather than prophylactic application. Thus, it helps to improve input use efficiencies, economy, and sustainable use of natural resources, because it minimizes wastage of inputs. 'Precision Farming' is the term given to crop management methods that recognize and manage spatial and temporal variations in soil-plant-atmosphere system. In other words, precision farming may also be referred to 'Site-Specific Farming'. The practice of precision farming is viewed as comprising of four stages, information acquisition related to variability in environmental and biophysical parameters, their interpretation for input application, evaluation and control. To support precision farming, the important information technology tools are Global Positioning System (GPS), Geographical Information System (GIS) and Simulation Modeling for Decision Support System (DSS). Global Positioning System (GPS) provides accurate site information and is highly useful in locating the spatial variability.

Site-specific integrated resource management: The application of nutrients (macro and micro) on the soil-test basis certainly improves the per unit productivity and if it is coupled with the nutrient responsive genotypes gives expected potential yield. This concept has been evaluated under rice-wheat and rice-rice systems. The 16-17 t/ha paddy-wheat productivity and 14-16 t/ha paddy-paddy productivity have been achieved under SSNM. It is, therefore, pertinent to further disseminate this technology, which has potential to enhance the productivity in the range of 3-4 t/ha – a marvelous achievement.

Second-generation farm machinery: Second generation farm machines, in addition to cost cutting, are extremely helpful in adoption of conservation and precision agriculture technologies. Laser land leveling, for instance, helps save 25-35% water and enhances crop yield (25-30%) and input-use efficiency. Zero-tillage cuts down the time consumed in crop planting, enabling timely sowing and save Rs 1500/ha on fuel energy and ultimately gives more yield. The furrow irrigated raised bed planting technique reduces the requirement of water by 20% as well as costly seeds, besides improving productivity and facilitating crop diversification in spatial dimension.

Crop residue recycling: A vast potential is available to efficiently recycle organic farm wastes/crop residues, especially in rice-wheat belt of Punjab, Haryana and western Uttar Pradesh, where it is burnt *in situ*. It is adversly affecting the ecology in two ways, one by the air pollution and secondly all the macro and micro-nutrients are lost during burning. The curtailment of this practice seems priority,


Rice residue management under zero-till wheat crop

as straw may form an important component of integrated nutrient management. Scientific management of crop residues (stubbles of the previous crop), on the other hand, helps replenish the soil carbon content and promotes activity of soil micro-organisms, land fertility and helps save on fertilizers.

On-Farm Processing and Value Addition

A substantial change has already taken place in consumer preferences for graded, packaged and processed food items of daily use in urban market, especially among middle and high classes. With opening of more and more departmental stores in townships and retailing food items at competitive prices within next few years this trend will certainly filter down to rural areas also. Low-cost improved technologies are required to unleash potential and improve market efficiency and remain competitive simultaneously.

Moreover, recent trends have clearly shown the accelerated use of by-products for value addition. For example, now sugarcane is not only used for sugar production but every by-product of it is used economically by sugar mills – bagasse for electricity generation, pressmud for preparation of high value organic manure and molasses for alcohol production. Similarly, in case of paddy, husk is being used as very efficient source of fuel in boilers and bran for edible oil extraction. Many vegetable oils – earlier considered to be non-edible are being extensively used as edible after development of refining technology. It is certain that advantage of all these value addition technologies will be available to farmers also.

Integrated Farming Systems

It is imperative that future farming systems would be guided not only by the compulsion of improving food security, but also by the concerns for quality of food, environment protection, resource sustainability and farming system profitability. Therefore, we may further expect a major shift in agricultural production from food grains to oilseeds, vegetables, fruits, and flowers. Because of integration of world markets, urbanization and rising personal incomes significant shifts in cropping / farming systems and other farm enterprises may also take place due to increased production and availability of fruits, vegetables, milk and other animal products. In fact, there would be more growth in the demand for pulses and milk, relatively slow growth for cereals and decline in per capita demand for root and tuber crops. Therefore, to bridge the gap between the 'desired' and 'achieved' and to bring quantitative as well as qualitative improvement in fulfilling the national food needs, to sustain the agricultural resource base, and to provide livelihood security to millions of rural masses; a form of agricultural research that goes beyond cropping systems and that respects the integrity of ecosystems while humans meet their food need, will be unavoidable.

Kisan Gosthi on integrated farming systems

Multiple Uses of Resources

Knowledge generated for management of natural resources needs to be integrated in the system mode for effective resource recycling. Multiple use of the resources such as land and water are essential to enhance the system productivity and profitability. Farm level self-sufficiency in water and nutrient is possible through modern technological interventions such as rain water harvesting and recycling, nutrient and energy based input-output relationships. Multiple uses of water for household, irrigation, dairy, poultry, duckery and fish rearing is the best example. Small and medium size water bodies can be brought under multi-component production systems using in and around areas which will ultimately lead to improved income, nutrition and livelihood of small farm holdings. It is estimated that water productivity increases by 12 times (1.8 kg/m^3 in okra and 2.6 kg/m^3 in french bean to 40 kg/m^3 in crop + fish + poultry + duckery system) in humid areas with pond based integrated farming systems. Similarly, integration of proper waste resource recycling in the small and marginal farmers holding will pave way for reduced fertilizer usage which in turn will have positive effect of national exchequer in the form of reduced fertilizer subsidy for production and transportation of fertilizers. For example, the egg laying khaki cambell duck produces more than 60 kg of manure per bird on wet basis. The duck droppings provide essential nutrients such as carbon, nitrogen and phosphorus in the aquatic environment which stimulates natural food for fish. Besides this, 10 to 20 % of duck feed (23 to 30 g/day) are lost in the normal circumstances of feeding ducks. In the farming systems mode, feed given to ducks were also partially utilized by fish while washing the shed.

Organic Farming

Organic farming is a holistic way of agriculture, which tries to bridge the widening gap between man and nature. The concepts and principles of organic farming differ on many accounts with conventional or modern farming. Organic production systems aim at achieving optimal ecosystems, which are socially, ecologically and economically sustainable. Although the organic agriculture practices cannot ensure that products are 'completely free' of harmful residues, as they may possibly trespass into the organic production systems through general environmental pollution also, but this is one of the major aims of organic farming and all feasible methods are used to minimize pollution of air, soil, water and farm products. The spread of organic farming on 1-5 per cent area in the high productive zone and large spread in the hill states would help to strengthen the organic movement. It will further strengthen our export-oriented programme under WTO regime. However, to make organic farming economically viable, issues like improving the productivity, reducing production costs, ensuring competitive price of organic produce to the grower in domestic and international markets, area approach of process certification are to be addressed at national level.

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Issues, Strategy and Framework

Issues

A critical analysis reveals several gaps between the achieved and desired. As such, following are the issues, which need to be pursued :

(i) Optimization of components and integration in multi-enterprise farming systems for diverse farming situations and farm categories.

(ii) Degradation of land and water environment due to improper usage of fertilizers, pesticides and irrigation water.

(iii) Deterioration in the quality and quantity of soil organic matter and enhanced green house gas emission.

(iv) Hazardous effects of modern agriculture, especially on quality of food and environment.

(v) Low level of impact quantification of diversification options on productivity, stability, profitability, soil health, and water- and nutrient-use-efficiencies etc.

(vi) Inadequate exploration of crop-diversification options, their economics and sustainability using high-value low-volume crops like vegetables, spices, medicinal and aromatic crops/ plants having greater potential for domestic use and export.

(vii) Emergence of secondary and micro-nutrient deficiencies especially in intensively cultivated areas having effect on food chain and ecosystem.

(viii) Lack of adequate measures for conservation of genetic- and bio-diversity in intensive agricultural areas.

(ix) Long-term effect of mechanization and resource conservation technologies on the profitability and sustainability of different farming systems.

(x) Site-specific and precision input management for major cropping systems to optimize resource use and enhance efficiencies.

(xi) Lack of effective credit facilities and insurance mechanisms.

(xii) Lack of sufficient trained manpower for integrated farming systems research and extension at academic as well as research institutions

(xiii) Poor rate of component technology diffusion.

Strategies

The following strategies will be adopted to address the above issues:

1. Integrated Farming Systems Research

a) Multi-locational, inter-disciplinary on-station and on-farm research in coordinated mode for development of resource-efficient and economically viable integrated farming system models for different farm-size/ resource groups and diverse farming situations of the country.

b) Optimization of resource inflow and input-output relationships in different IFS models through decision support systems.

c) On-farm evaluation and refinement of low-cost storage and value addition tools and techniques for vegetables, fruits, milk and other farm products.

2. Human Resource Development

a) Advance knowledge and skill development of researchers, extension functionaries and rural entrepreneurs through well designed short term courses/ training modules for important areas of activities.

3. Organic Agriculture

a) Adequate research infrastructure will be created in order to develop region-specific organic farming techniques and disseminate findings for conversion and management of organic farms in farming system mode.

b) Low-cost production technologies for organic production systems will be developed and standardized to ensure competitive price of organic produce to the grower in domestic and international markets.

c) Basic and applied research to understand the science behind the traditional organic farming practices and blend scientific principles into them for improved yields. Basic studies on nutrient budgeting and soil quality improvement indicators (carbon sequestration, dehydrogenase activity, microbial biomass C and N), varietal improvement, bio-agents and bio-pesticide for effective control of insect-pests and diseases in major organic-based cropping systems.

d) Nutrient release pattern of different organic sources in combination and alone, developing relationship between the crop-N demand and supply, screening of crop/ vegetable varieties and to develop and assess organic based cropping systems.

e) Assessment of reported beneficial effects of organic farming with respect to crop quality.

f) On-farm development of model organic farming units (MOFUs) and their registration with accredited certification agencies.

4. Precision Farming

a) Integration of variable-rate-technology with sensor-based input management options for enhanced input-use-efficiencies in different farming situations.

b) GIS-based mapping for developing homologous groups for different farming/ cropping situations.

5. Cropping Systems and Resource Management

a) Region-specific options/ interventions for crop-diversification through substitution/ intensification/ interruption and involving high-value low-volume crops like vegetables, pulses, spices, medicinal and aromatic crops and matching production technologies.

b) Development of bio-intensive diversified complementary cropping systems to utilize limited land and water resources in more efficient manner, with special reference to small and marginal farmers.

c) Quantification of impacts of diversification options on productivity, stability, profitability, soil health, and water- and nutrient-use-efficiencies etc.

d) Site-specific nutrient management/ balanced nutrient supply systems for intensive cropping systems.

e) Development of integrated plant nutrient supply systems for higher productivity and resource sustainability, especially in intensively cultivated areas.

6. Conservation Agriculture

a) Development of technologies/ ergonomically designed low power requiring tools for tillage and crop establishment practices with least disturbances to soil/ soil cover (*in situ* crop residues).

b) Development of cost-effective technologies for *in-situ* crop residue management and efficient application of different kinds of fertilizers and weedicides.

c) Identification and standardization of new cropping systems appropriate for resource conservation techniques and protected agriculture.

d) Monitoring the dynamics of soil health, insect-pests, diseases and weeds under conservation agriculture based systems.

7. Farm-Resources Characterization

a) Farm-resource characterization through district level diagnostic surveys and using remote sensing techniques.

b) Assessment of credit delivery system and insurance in agriculture.

c) Development of farm resource maps using GIS.

8. Database Management

a) Development of user-friendly databases related to various components of farming systems and related technologies.

9. Transfer of Technology

a) Development of region-specific IFS technology extension modules and their dissemination through dedicated mass media channels.

b) Establishment of farmer-friendly IFS information kiosks in vernacular languages at Panchayat level.

c) Creation of suitable e-communication platform between farmers and scientists.

In the context of above mentioned issues and strategies, the importance of Integrated Farming Systems Research and Development (IFSRD) assumes high priority. Therefore, the role of this Directorate/ Institute becomes much more important with strengthening of scientific and technical manpower along with infrastructure particularly in areas of horticulture, animal sciences, fisheries, food processing and plant protection. The mandate assigned could be better addressed by strengthening and upgrading the status of the Directorate to the level of an Institute and be named as **Indian Institute of Farming Systems Research (IIFSR)** as recommended by last two QRTs and RACs. This will provide support for conducting basic and applied research at the headquarter and will also facilitate effective monitoring and evaluation of programmes/ activities undertaken by various centres in the country. Moreover, the Institute can also serve a nodal agency for national and internaltional level HRD with special reference to Farming Systems Research and Development.

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Epilogue

THE PDFSR (proposed IIFSR) is committed to bring new concepts of farming system based agricultural production technologies such as; multi-enterprise farming systems, integrated organic farming, farming systems diversification, conservation agriculture, site-specific resource management and precision agriculture along with multiple use of resources, to meet challenges of the rising demand for food, improving livelihood opportunities of farmers, and for ensuring sustainable farming and agricultural growth. We envision that with the 'farmer-first' and 'bottom-up' approach, the focus of our entire strategy in future will provide direction to harness the untapped opportunities of science for sustainable management of farm resources and to achieve household food, nutritional and livelihood security of small and marginal farmers, in fact, an attempt to make small and marginal as bountiful.

The paradigm shift in farming systems research will help to accomplish our mission by integrating the modern tools and techniques of agriculture. The Directorate/ Institute firmly believes that the basic and strategic research will upgrade the level of applied research, which will result in enhancing system's productivity, profitability, resource use efficiency, cost-effectiveness, value addition and improving quality of food through blending of scientific and traditional knowledge in diverse resource domains, with matching technology transfer mechanisms. Since the technological challenges are becoming more complex than before as demand for food is increasing and natural resource base is shrinking, the technology developed in the programme will counteract with emerging environmental threats such as global warming, ground water depletion and food, soil and water pollution. Location specific technologies for various farming systems in diverse ecological situations will be available. The methodologies for conducting farming systems research will be upgraded. Enhanced resource mobilization and utilization can be envisaged. As a nodal agency for HRD in Farming Systems Research and Development it can cater the national and international needs for further advancements. The involvement of development agencies will increase and we will be able to uplift the farming community, especially the smallholders and the poor living in the "low productivity hig risk" agriculture areas.

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Annexure I : **Strategic Framework**

Goal	Approach	Performance Measure
Design of location-specific IFS models for small and marginal farmers of different agro-climatic regions	• Resource characterization and constraints analysis • Design, validation and refinement of location-specific IFS models. • Developing system-based farm production technologies.	Improved resource/ input use efficiencies and system productivity
Improve income, nutrition and livelihood of small and marginal farmers	• Complimentary integration of crops, horticulture, livestock and fish culture in small and marginal holdings. • Farm-level employment generation through multi entrepreneurial IFS modules • Integration of low-cost on-farm agro-processing and value addition techniques	Improved profitability, employment generation and standard of living
Sustenance of resource base	• Developing location specific conservation agriculture technologies • Precision management of external and farm level production inputs • Practicing organic agriculture for bio-diversity management and nature's harmony	Energy auditing at farm level; improved produce, soil, water, environmental quality and bio-diversity
Strategic manpower development	• Capacity building for researchers, extension workers and other stakeholders. • Strengthening of institutional infrastructure and inter-institutional linkages.	• Increased number of trained personnel in the field of farming systems research and development. • Improved quality of Research and extension.
Improve technology delivery system for small and marginal farmers	• Use of dedicated mass media channels. • Electronic communication platform between farmers and scientists.	Improved rate of adoption of advanced farming system technologies and reduced yield gaps.

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