Vision 2050

ICAR-Indian Institute of Farming Systems Research
Modipuram, Meerut-250 110 (Uttar Pradesh)

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Message

Science led development of agriculture in India is essential for producing sufficient and quality food, feed, fodder and fibres. The earlier approaches of commodity oriented research outputs resulted in filling of stomach of fellow Indians. However, with the opening of markets and growing economy and purchasing power, people tend to search for qualitative and nutritionally rich commodities. The consumption pattern also changes with increasing awareness on health and improved life style demanding more of grams and greens rather than grains. The marginal and small holder farms play a vital role in producing diversified products with in the farm. The systems practiced by small holder farms are really interesting and needs to be studied in terms of integration of components and their sustainability.

The paramaparak krishi practiced by small holders are not only to be preserved but also should be improved with scientific interventions. The Indian Institute of Farming Systems Research under Indian Council of Agricultural Research is working on these lines in the recent past by involving large number of marginal and small households in different parts of the country. The Research and Development institution should be able to foresee the long term challenges and try to develop research programmes so that they are globally competitive and locally productive.

I am happy to know that the ICAR-Indian Institute of Farming Systems Research (IIFSR), Modipuram, a constituent institution of the Indian Council of Agricultural Research (ICAR) has prepared Vision 2050 document. The document makes a pragmatic assessment of the farming systems scenario by the year 2050. Taking due cognizance of the rapidly evolving techniques in national and international scenario, the institute, has drawn up its Strategic Framework, clearly identifying Goals and Approach.

I wish ICAR-IIFSR all success in realization of the Vision 2050.

(RADHA MOHAN SINGH)

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सत्यमेव जयते
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सचिव एवं महानिदेशक
Dr. S. AYYAPPAN
SECRETARY & DIRECTOR GENERAL

FOREWORD

Evolving needs for qualitative life including quality food envisions dramatic changes in agricultural research outputs. The major issues concerning the marginal and small holder agriculture in India in 2050 would be miniaturization of holdings, decreased availability of manpower to farm activities, increased wages, environmental pollution etc. The long term vision to address the continuously changing needs should aim to develop a farm household in holistic manner by developing freedom from external factors such as market dependence for inputs & labour. The diverse challenges and constraints as growing population, increasing food, feed, fodder and fuel needs, natural resource degradation, climate change, marginal growth rate in farmer's income and new global trade regulations demand a paradigm shift in shaping future agricultural research programmes in a sustainable and climate resilient integrated farming systems mode. Know your farm, Know your producer and Know your food will be prevailing in the marketing of outputs of a farm in the time to come and the farming systems research should focus on multi-commodity market oriented farming systems with major focus on organic production practices.

The emerging scenario necessitates complete transformation of research from supply driven IFS models to demand driven city specific models with proactive, novel and innovative research approach based on cutting edge science. In this endeavour, the Vision 2050 of Indian Institute of Farming Systems Research discusses the context, past achievements, challenges, operating environment, opportunities and way forward for providing the respectable revenue to marginal and small holders in the country.

The naturally integrated traditional farming systems were more sustainable but their productivity and profitability is not matching with growing demand especially due to population pressure. This calls for planned intensification and diversification of existing farming systems to ensure the long term productivity and sustainability. Optimization of various agricultural components in resource constraint production environment is essential. The Indian Institute of Farming Systems Research, Modipuram has been pursuing research and development in farming systems in recent years, which is primarily an innovation-driven strategy and is generally small farm centric. It is expected that the approaches of *vertical intensification of systems* and forward looking concepts of *clean India for green agriculture* presented in the *'Vision 2050'* will prove to be useful for the researchers, policymakers and stakeholders to address the future challenges. Pursuing for sustainable production, profit and prosperity of small holder agriculture with environmental and human touch should be the focus for the Institute in the coming years.

(**S. Ayyappan**)

PREFACE

The Indian Institute of Farming Systems Research is an premier institution in the country to work for the small holder farms and their systems. Transformation from simple fertilizer trial in farmer's field scheme in 1952-53 to Project Directorate for Cropping Systems Research in 1989 and then to Project Directorate for Farming Systems Research in 2010 took place based on the changing sectorial needs of the Indian agriculture. Considering the complexities involved in addressing the issues of farming systems research, the Directorate has been upgraded into full-fledged institute from 2014 with research divisions focusing on Integrated Farming Systems Management, Organic Agriculture Systems, Cropping Systems and Resource Management and Technology Transfer Refinement and Human Resource Development.

During the course of the journey, the major achievements made by the institute are mapping of pre-dominant cropping systems, documentation and demonstration of alternative efficient cropping systems, on-farm nutrient response of crops and cropping systems, standardization of component production technologies and cropping system methodologies. In the recent past, the institute, tried to develop partnership with sister institutions in the country for farming systems research and transformed the cropping systems research to farming systems mode by establishing on-station farming system models in all agro-climatic regions, on-farm farmer centric farming system modules at various locations and placed the organic package of practices for selected crops and systems in public domain. The outputs of last two decades in cropping systems research and adhoc studies on Farming Systems have clearly revealed that increase of productivity and profitability up to 4 times in equivalent food grain terms is achievable with logical use of available technologies in systems approach. Still a need for integration of other enterprises is felt to make use of available resources and convert them into a possible means of profitability.

The earlier Vision documents prepared and published in 2020, 2025 and 2030 focuses on cropping systems, multi-enterprise farming systems and integrated farming systems for small holders. However, with the changing needs of the country and availability of resources especially inputs for farming, development of vision to provide quality life through quality production were felt and Vision 2050 focuses on development of Self-Sustainable Farms and Systems. Once, our objective is to provide self-sustainable farms and systems to small holders, the aim should be free from market dependence for inputs such as seeds, nutrients, pesticides, feeds, labour etc. The approaches envisioned for achieving the self-sustainable farms and systems include topographical & vertical intensification of farming systems, planned intensification and diversification of small holder farms and systems, clean India for green agriculture and capacity building of all stake holders besides the cutting edge technologies such as precision input management and conservation agriculture. I take this opportunity to record my sincere gratitude to Dr S. Ayyappan, Secretary, DARE and Director General, ICAR for his keen interest, constructive and critical comments and guidance given during the Vision document discussion meeting. I am also grateful to Dr. A. K. Sikka, Deputy Director General (Natural Resource Management) and Dr B. Mohan Kumar, Assistant Director General (Agronomy, Agroforestry & Climate Change) for the valuable suggestions and continuous improvement of document.

The suggestions/ recommendations of QRT and RAC were very much helpful in shaping the present document. I sincerely record my thanks to Dr. Panjab Singh, Former Secretary, DARE & Director General, ICAR and Chairman of QRT and Dr I.P. Abrol, Chairman of RAC for the technical inputs in shaping the document. Thanks are also due to all the Programme Facilitators and Scientists of IIFSR for their contribution in preparation of the document.

12 January, 2015

Modipuram

(B. Gangwar)

Director, ICAR-IIFSR, Modipuram

Content

CONTEXT

The major issues foresighted to have impact on profitability of Indian agriculture are declining holding size, increasing population & wages, changing consumption pattern and reduced availability of land and water resources besides climate change. With these issues, agriculture has onus of providing household food and nutritional security to billion plus population. The declining trend of per capita land availability with shrinking operational holding size poses a serious challenge to the sustainability and profitability of existing farming systems especially in marginal and small households. A paradigm shift in agricultural research through integrating locally available farm resources along with restoration of environment is essential to address all the issues which are being faced by Indian agriculture. The farming systems approach to agricultural research and development efforts will accelerate agricultural growth and will provide opportunity to leverage poverty-prone rural India into a prosperous India.

1.1 Farming Systems Scenario

- Seventy per cent of the world small farms are in China and India. Out of the 404 million small farms in the world, China and India alone accounts for 193 (47 %) and 93 million (23 %) small farms respectively. Small farms are more diversified in nature. Out of 92 million farm households falling under marginal farm category having < 1 ha as operational holding size, 70 % of the farmers are having the area of below 0.5 ha. The average size of marginal holdings varies from 0.13 ha in Kerala to 0.61 ha in Punjab with only 8 states having the mean holding size of > 0.50 ha. As per estimates, in India, more than 95 % holdings will be under the category of small and marginal holders by 2050.
- Urbanization will continue at an accelerated pace and 50% of India's population will move to urban localities by 2050 as against present 29.5%. They will require diversified & qualitative food rather than quantitative. In order to provide quality life in terms of food and fabrics to relatively richer population in urban areas, nutritionally rich and safe food should be available in the domestic markets.
- Over 60 per cent of the world's rural population consists of youth, with half of them being young women and girls. Due to their limited access to assets (in particular land), markets, finance and education and skills training, rural youth are often unemployed or work informally. India will have the largest number of people in the working age group of 15-59 years by 2050. According to Census of India's population projections, Uttar Pradesh, Bihar, Madhya Pradesh and Rajasthan will account for more than 50 percent of the increase in India's working age population and these states account for higher proportion of small operational holdings.
- The monthly consumption and income of marginal farmers are lower than the small and semi medium farmers. However, estimates indicate that very large size of global population live below the poverty line (earning about 1.25 dollars/day) out of which one third live in India (TOI, 2012). Small holders (<2 ha) contribute about half of rice and wheat and one third of coarse, cereals and pulses production in the country. Nearly half of food grain, sugarcane, fruits and vegetables and almost two third of jute are produced at small farms (Singh et al., 2002) of India.
- Simultaneously, horticultural scenario of the country has been changing very fast, both in terms of production and productivity. India has emerged as a leading horticultural country of the world with a total annual production of 224 million tonnes of horticultural crops from almost 22 million hectare area.

- Livestock plays an important role in the national economy as well as in the socio economic development by augmenting family incomes and generating gainful employment in the rural areas. 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. It is a major component from hills to coastal regions. The contribution of crop and livestock to gross income of marginal households in various NARP zones indicates that in majority of the place crop component contributes > 50 % while at few districts such as Samba (Jammu), Aurangabad (Maharashtra), Mehsana and Panchmahal (Gujarat), livestock component contributes either equally or more.

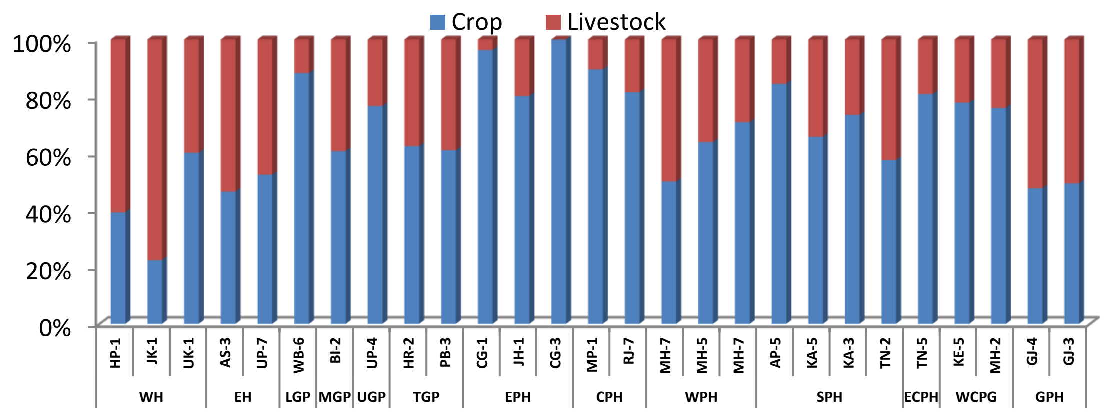


Fig 1. Per cent contribution of crop and livestock components to gross income of marginal households in various NARP zones (Benchmark data of OFR experiment 2 under AICRP on IFS)

- The feed and fodder availability is facing a shortfall of concentrate (63%), green fodder (62%) and dry fodder (22%) and it may further worsen. However, the increase in the demand for milk will be more than double by 2050 from present 108.5 million tonnes (NDDB, 2010).
- The livestock is expected to contribute substantially for poverty alleviation which is largely concentrated by the marginal and small farmers. Near about 70% of livestock market in India is owned by 67% of small and marginal farmers and land less. The livestock are the ideal enterprise for mixed farming because of their valuable contribution to human nutrition (milk and butter fat), plant nutrition (farmyard manure) and energy (bullock power).
- India is emerging as the world's 2nd largest poultry market with an annual growth of more than 14%, producing 61 MT or 3.6 percent of global egg production. The annual growth rate of egg production is 5-8%. Similarly, India ranks 6th in broiler production with an annual output of 2.39 MT of broiler meat. The per capita per annum consumption is approximately 2.4 kg, which is much lower than the National Institute of Nutrition's recommendations of 11 kg. The poultry is likely to play an important role in improving profitability of existing farming system in a holistic manner. Concerted efforts are needed to meet the future demand.
- Aquaculture and catch fishery is amongst the fastest growing industries in India. Between 1990 and 2010, Indian fish capture harvest doubled, while aquaculture harvest tripled. India exported 600,000 metric tonnes of fish products to nearly half of all the world's countries. The integration of crop-fish in production system specially in areas of high rainfall or areas dominated by pond based farming systems is considered to be key for improving nutritional security on one side and improving the profitability on the other side.

- Analysis of farming systems in marginal households indicates presence of 38 type of enterprise mixing and marginal households does practice up to 5 components [Crop + dairy + goat + Poultry + fish in West Bengal]. In the country, 59 % of marginal households are having 2 or less component integration whose annual net income is only Rs 0.57 lakhs /year from 0.82 ha area while the remaining 41 % households are having the more than 3 components integration whose income is found to be Rs 1.61 lakhs/year from 0.84 ha area. This clearly implies that greater opportunity exists for intensification and diversification of farming systems in 59 % of marginal households.

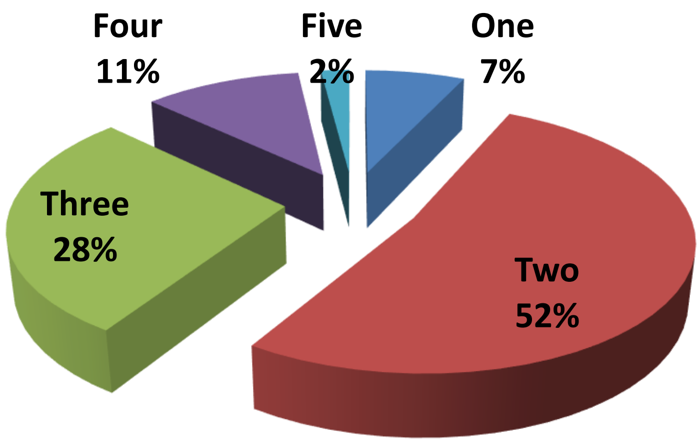


Fig 2. Number of farming system enterprises practiced by marginal households (Benchmark data of OFR experiment 2 under AICRP on IFS)

- The study conducted through on-farm centres reveals that marginal households are having the effective field workable persons of 3 to 4 as the family size is up to 7 with mean family size of 5. Even at bare minimum of 3 persons/household is considered, 1095 man/women days (8 hrs in a day) is available per household which is sufficient to take up the farming in the tiny holdings. Hence, marginal farms offers greater scope for agricultural diversification.

An Integrated Farming System (IFS) can ensure the highest standard of food production with the minimum environmental impact with even highly vulnerable climatic conditions with the available resources accessible to farmer. With operational farm holdings in India being less than one hectare, and with emphasis given to cereal production, there is a high risk of crop losses due to biotic and abiotic stresses. IFS has revolutionized conventional farming of livestock, aquaculture, horticulture, agro-industry and allied activities in many countries, including India. Research studies on integrated crop and livestock systems have clearly indicated productive and environmentally sustainable system. IFS not only provide the means of production, such as fuel, fertilizer/manure and feed, but also a healthy environment for ecological balance. IFS is a reliable way of obtaining high productivity with substantial nutrient economy in combination with maximum compatibility and replenishment of organic matter by way of effective recycling of organic residues/wastes etc. obtained through the integration of various land-based enterprises.

The upliftment of small and marginal farmers including their livelihood, nutritional and food security are the major concerns and likely to continue until and unless these problems are addressed and dealt in farming systems perspective. The experiences of the past and likely scenarios of the future pinpoint that the small holder agricultural systems can only be sustained through optimum allocation of resources and their multiple use in farming systems perspective. Therefore, to address the major issues of small holder's agriculture, the initiative on farming systems research is very crucial and needs to be strengthened. These issues will be out rightly addressed by the farming systems research (FSR) as it represents "creation of location specific appropriate combinations of farm enterprises, viz., cropping systems, livestock, fishery, poultry, forestry and the means available to the farmers to raise them profitably". FSR and management is difficult but once managed it will give answer to the problems of increasing food production, net farm income, improving nutritional status, promoting natural resource management through sustainable use of land, water and biota which are considered as indicators of agricultural development.

1.2 Past vis-a-vis Present Vision

Vision document developed for 2020 and 2025 aimed at cropping and multi-enterprise systems while 2030 aimed at promoting Integrated Farming Systems. The Vision 2050 aims for Self-Sustainable Farms and Systems for marginal and small farm holders with capacity building of all stakeholders.

CHALLENGES TO FARMING SYSTEMS

Farming systems would be guided not only by the compulsion of improving household food and nutrition security but also by the concerns of producing quality food, environment protection, resource sustainability, shift in food consumption pattern and climate change. Major shift in agricultural production form are anticipated in the future. Similarly, biotic and abiotic stresses are also posing serious threat to agriculture and the most sufferers to these stresses will be small and marginal farmers as they have fewer coping strategies/mechanism than medium or large farmers. The irony of present farming systems is that the farmers are stymieing at the grassroots for advice, basic technology and water. The main issue is that achieving the household level safe food for all. The challenges to farming systems research and development are pin pointed below.

Decreasing cultivable land, farm holding and family size

Reduction in cultivable land is mainly due to diversion of agricultural land for non-agricultural purposes such as urbanization, roads and industries. Total cultivable land has declined sharply during the last five decades (Pandey et al., 2008). At the same time, fragmentation of operational farm holding size is of great concern where the average size of the holdings shrinking and estimated to reduce further in the year 2050. Marginal decline in family size of small holders are expected (5.1 in 2010 to 4.8 in 2050) which will further reduce the availability of manpower for agriculture (Gangwar et al., 2014).

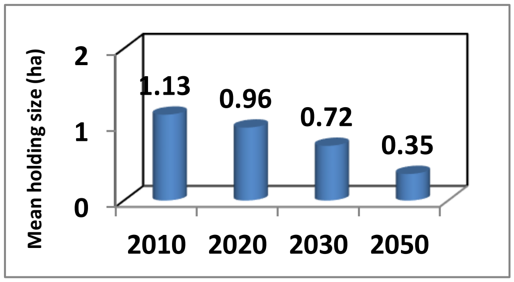


Fig 3. Expected changes in holding size of India

Increasing rural labour wages

It is really very alarming that around nine million cultivars left the agriculture during the period of last one decade of this century. The problem of farmers will be further aggravated by increase in rural labour wages of both men and women. It is expected that the labour wages will increase by 4 times for men and 6 times for women in 2050. The farming systems with integration of components are expected to involve more manpower which has to negate with farm flexible machines. |

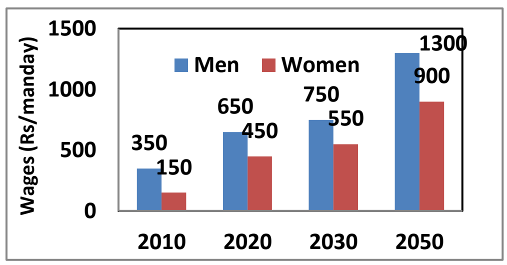


Fig 4. Expected changes in labour wages

Changing food consumption pattern

More than two-thirds of the food consumed in the country comes from irrigated farms. Due to large number of marginal to small farmers (86 % at present and expected to be >95 % in 2030), the producers are also the main consumers of the commodities they produce. Thus, the local consumption patterns play a pivotal role in farming pattern decisions. In the past, grain crops dominated the agriculture production patterns, as food grains provided a major part of the daily nutritional intake. However, a subtle change in food consumption patterns has been surfacing in the recent past in both rural and urban India. The changing food consumption

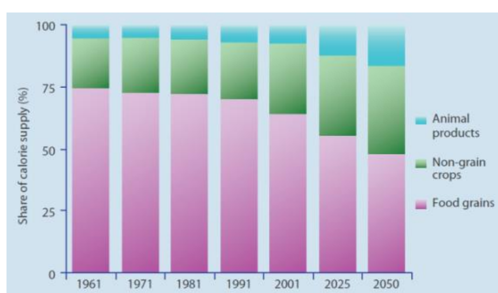


Fig 5. Expected changes in share of calories by different commodities (Amarasinghe et al.,2007)

pattern is a great concern as increase in contribution of the non-grains and animal products indicating that higher resource base will be required to produce such commodities. Therefore, efficient technologies have to be developed to meet out the food and nutritional demand.

Imbalanced fertilizer use

During post-green revolution period, the Indo-Gangetic plain zone of India has been adversely affected by use of imbalanced fertilizer, which resulted soil health degradation. Fertilizer use has jumped up many folds at the onset of the Green Revolution. The worry is compounded by food productivity not keeping up with the continuous increase in fertilizer application, while soil quality has been simultaneously degraded. Yet another aspect of the fertilizer crisis is around the use of potash. Plants need more potash than any other nutrient, but Indian soils are being continuously mined by crop plants while soils are getting depleted of potash at an alarming rate. Long-term use of synthetic fertilizer has resulted in nutrient imbalance, micro-nutrient deficiency and the deterioration of soil health, causing low agricultural productivity.

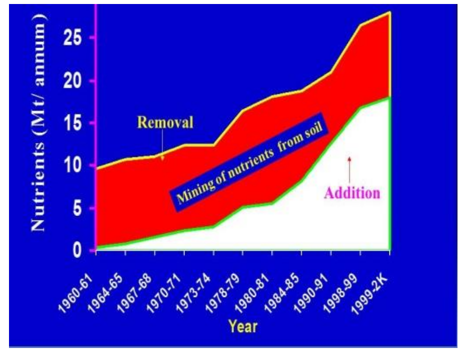


Fig 6. Status of mining of nutrients from soil

Depleting water resources

There is a lack of realization that water has an economic value in all its competing uses and should be recognized as an economic good and supported with sound planning for conservation and efficient allocation. Irrigation will remain the predominant end-user of available water resources.The gross irrigated area as well as groundwater irrigation coverage will increase by 2050 leading in to increased water demand by almost double over the same period(Saleth et al., 2013). The net sown area is decreasing day by day due to urbanization, industrialization and many other reasons. But, irrigation expansion is likely to continue and will remain a major contributor to growth in the gross irrigated and crop areas.

Degradation of natural resources

In the absence of adequate knowledge among farmers about techniques and benefits of recycling of farm resources, natural resources are degraded through unscientific farm practices causing potential threats for environments. 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 systems and irrigation. 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 bio- physic chemical properties of the soil, ensuring better soil environment for crop growth.

Climate change

Climate change and variability are posing the serious challenges influencing the performance of Indian agriculture. The fourth IPCC report clearly brought out the global and regional impacts of projected climate change on agriculture. India having diverse agro-climatic regions is more vulnerable in view of huge population dependant on agriculture and poor coping mechanism. There are evidences already of negative impacts on yield of wheat, rice and other crops in parts of India due to increased temperature, increased water stress and reduction in number of rainy days which in turn would result in greater instability in food production. Changing climate affects the small and marginal farmers the most because they can least afford irrigation.

Multiplicity of farming systems

Critical analysis of farming systems in India states that presence of > 38 type of systems and the systems varies with in the villages. 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 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 residue 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. The lack of proper and eco-friendly solid waste management technology and availability of residues affects the promotion eco-friendly green and organic farming packages.

Technology adoption gaps

Agricultural technology is never completely accepted by the farmers in all respects, as such there always appears to be a gap between the recommended technology by the scientists and its modified form at the farmer's level. The technological gap is thus the major problem in the efforts of increasing agricultural production in the country. A need of the day is to reduce the technological gap between the agricultural technology recommended by the scientists and its acceptance by the farmers on their field. 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. In fact Indian farms are endowed with diversified climates and natural resources but, there is a large gap exists at Indian farms in comparison to world's most productive farms in terms of average productivity of major components of farming systems. 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.

Lack of well-designed capacity building and HRD activities on farming systems

Strong capacity building and human resource development activities exist for mainstream and commodity based research. In India, farming system research is relatively new area and professional man power for research, education, extension and development is not sufficient to take up the issues concerned with farming systems in India.

OPERATING ENVIRONMENT

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 farm households. 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% 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 Gujarat 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 revealed that milch animals (cows and buffaloes), irrespective of breed & 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 was 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 intensification and diversification of enterprises in a farming system mode.

3.1 About ICAR-IIFSR

Based on a report submitted to Govt. of India by Dr A.B. Stewart of Macaulay Institute of Soil Research, Aberdeen (U.K.), during 1947, "Simple Fertilizer Trials on Cultivators' Fields" scheme was started by Agriculture Ministry during 1952-53 which led to popularization of fertilizer use and substantial increase in crop productivity. In 1956, "Model Agronomic Experiments' were added and a scheme of "All India Coordinated Agronomic Experiments Scheme" was started as an ICAR Project. During, 1968-69, scheme was reshaped and sanctioned as "All India Coordinated Agronomic Research Project (AICARP)" with two components viz.; 'Model Agronomic Experiments' and 'Simple Fertilizer Trials'. AICARP 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. In 1989, AICARP was upgraded into the "Project Directorate for Cropping Systems Research (PDCSR)" with the scheme of "All India Coordinated Research Project on Cropping Systems" at Modipuram (Meerut). The directorate was mandated to undertake and coordinate country-wide system-based basic and applied research in cropping systems perspective by adopting approach of 'On-Station (basic and applied) Research' at its headquarters as well as at main and sub centres of AICRP-CS, and 'On-Farm (farmers' participatory) Research' at on-farm research centres of AICRP-CS. New plan scheme of "Network Project on Organic Farming (NPOF)"with 13 co-operating centres was added to the PDCSR during 2003-04. The mandate of PDCSR was further broadened to encompass the whole gamut of farming systems during 2010. Accordingly, the PDCSR and AICRP-CS scheme were renamed as "Project Directorate for Farming Systems Research" and "AICRP on Integrated Farming Systems" respectively. On 27 November 2014, the Project Directorate was given the status of full-fledged Institute and renamed as "Indian Institute of Farming Systems Research" (IIFSR) with 4 divisions (Integrated Farming Systems Management, Cropping Systems & Resource Management, Organic Agriculture Systems and Transfer of Technology, Refinement & Human Resource Development). NPOF is further strengthened with addition of 7 centres. The AICRP on IFS (75 centres) and NPOF (20 centres) will also be integral part of the institute.

3.2 Mandate

- To undertake basic and strategic research in integrated farming system on production technologies for improving productivity and resource use efficiencies.
- To develop efficient, economically viable and environmentally sustainable integrated farming system models for different farming situations.
- To undertake on-farm testing, verification and refinement of system-based farm production technologies.
- To undertake human resource development and capacity building in integrated farming system.
- To act as a repository of information on all aspects of farming systems research and development.
- To coordinate and monitor integrated farming systems research in the country.

3.3 Mandate area

Farming systems research and extension including capacity building focussing on marginal and small farm holders in India

3.4 Objectives

- Development of on-station and on-farm (farmers' participatory) integrated farming system models for different farming situations
- Identify, evaluate and refine location-specific alternative production systems and evolve system-based production technologies.
- Standardize organic farming practices for crops, cropping and farming systems
- Capacity building through trainings and front line demonstrations in farming systems perspective

3.5 Significant achievements

The Institute, 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. The IIFSR with AICRP-IFS (75 centers) 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. The research efforts over last 2 decades have led to several significant findings. The summary of major achievements during cropping systems (1989-2010) as well as farming Systems (2011-14) approach is listed hereunder.

Cropping systems (1989-2010)

- Mapped the pre-dominant cropping systems in India
- Documented and demonstrated the efficient alternative cropping systems having potential productivity ranging from 16 to 35.2 t ha^{-1} $year^{-1}$ in 14 agro-climatic zones
- Documented on-farm response of pre-dominant crops and cropping systems to nutrients in 96 districts
- Standardized the component production practices for cropping systems involving pulses and oilseeds. Low cost technologies too.
- Sustaining cereal based cropping systems through INM using substitution approach (Long term)
- Standardized the research methodologies for Cropping Systems Research

Farming Systems (2011-14)

- Transformed the Cropping Systems Research to Farming Systems Research
- Established efficient on-station IFS models at 32 locations in 23 states for research, education and extension. Income levels: 3 models with > Rs 2.5 lakhs/ha/year & 13 models with Rs1.5 to 2.5 lakhs/year in the 2nd year of establishment itself.
- On-farm refinement of FS modules involving 1,116 farm households in 31 districts resulted in improvement of net income/year by 80%
- Package of practices for organic farming of 19 crops/systems have been developed and placed in public domain
- Developed bio-intensive complimentary cropping systems. The profitability of Rs 527/ha/day could be obtained by marginal farm holders to produce more with less.
- Developed partnership with 13 ICAR institutions, 9 AICRPs and 1 ZPD for Integrated Farming Systems Research

OPPORTUNITIES

- Increasing domestic and global demand for multi commodity quality products
- Tremendous scope for intensification and diversification of farming system components at small holder farms who will be constituting 95 % of total farms
- Identification of bankable farming system models for higher economic returns from agriculture
- Public-Private Partnership for developing farm equipment's to suit the small holder farming systems as farm and family size is expected to decrease while number operational holdings and farm wages are likely to increase.
- Opportunity to establish effective public-private-partnership farms and models
- Agro-eco tourism and green corridors with farming system models can of immense avenue for generating foreign exchange
- Opportunity to clean India for making green India through promotion of integrated farming systems and organic farming
- Integration of locally suitable components to enhance the productivity and profitability of the existing systems in the small holders.
- Scope for establishment of commercial business oriented farming system models for attracting rural youth towards farming
- Identification of climate resilient components of farming systems will help in sustaining the livelihood of small holders
- Employment opportunities for skilled manpower in the area of farming systems through commercial models
- Potential to create an capacity building platform based diversified datasets of models and modules established across the country

Goals and Targets

The 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.

- Characterization and constraint analysis of existing farming systems using the Information Technology tools such as remote sensing and Geo-referenced geographical information systems
- Development, standardization, on-farm evaluation and refinement of resource efficient and economically viable integrated farming system models for diverse farming situations with special reference to small and marginal farmers
- Cutting edge scientific techniques for vertical farming systems
- Development of innovative techniques and technologies for improved productivity in specialized farming systems
- Optimization of resource inflow and input-output relationships among different modules in integrated farming systems perspective.
- Integration of variable-rate-technology with sensor based input management options for enhanced input-use-efficiencies in cropping systems.
- Cluster based farming system models for small holders
- Identification of location specific bio-intensive, diversified complementary cropping systems for small and marginal farmers.
- Development of cost-effective resource conservation technologies for crop diversification and in-situ crop residue management.
- Development of cost-effective production technologies for organic production systems by understanding the scientific basis behind the traditional practices and blending them with scientific principles for improved yields with the clean India for green India concept.
- Information Technology enabled digital repository on farming systems for digital decision on components integration
- Development of efficient research tools/methodologies for farming systems research in context of small and marginal farmers of developing countries.
- Capacity building and human resource development in the area of Integrated Farming Systems Research, Extension, Education and Development
- Create opportunities for gainful employment in agriculture sector for rural youth and livelihood improvement for small farm holders.

Way Forward

6.1 Vision

Management of natural resources for holistic improvement of small and marginal farmers through Integrated Farming Systems

6.2 Mission

Improve food, nutrition, livelihood and financial security of small and marginal households through climate smart Integrated Farming Systems *(to make marginal and small households as bountiful)*

6.3 Thrust Areas

- Farming systems characterization, typology, modelling & expert systems using GPS, GIS, remote sensing and other applicable tools
- Development of district /village specific sustainable farming system models and modules including organic farming
- Vertical intensification of farming systems
- Climate smart self-sustainable farms and systems for small holders
- Digital repository and digital decision on farming systems
- Development of sensor based input management options for improving farming systems
- Clean India for Green India
- Capacity building and Human Resource Development for Integrated Farming Systems Research, Education and Extension

6.4 Strategies for Research

In the current economic situation, characterized by globalization of markets and soaring food prices, there is need to recognize, characterize and measure the small scale agriculture with the objective of not only exploiting their full potential. Due to low agricultural productivity, these small and marginal farmers as well as about 15 to 18% landless families living in rural areas are unable to generate remunerative employment and about 40% families are forced to live in poverty. With lack of food and income security, poor families are compelled to migrate to cities in distress, keeping their agricultural lands fallow, may become a major national challenge. Farming Systems Research offers the potential scope to solve the technology development and solve the problems. Research organizations in many countries are shifting towards farming system approach with heavy emphasis on participatory on-farm research.

6.4.1 Information technology enabled characterization of farming systems

Emphasis on development of system characterization software for existing situations with minimum data sets for its further application in devising suitable modules for integration into farming systems for sustainable productivity and profitability. Application of satellite based weather forecast for development of quality agro-advisory for further dissemination to farm level using mobile based apps to adapt precision techniques for higher returns through reduced cost of cultivation. Innovating application of information technology based tools viz., Remote controlled irrigation systems for precision application of irrigation water, infra-red based crop maturity detection tools, expert systems, Integration of variable-rate-technology with sensor based input management options for enhanced input-use-efficiencies in cropping systems and creation of user friendly database systems from farming systems perspective etc.

6.4.2 Future Family Farming

The women and men engaged in family farming produce 70% of world's food, and generate income for hundreds of millions of rural people, both within the family farms and in related enterprises. In India, contribution of small farmers to total farm output exceeds 50%, while they cultivate 44% of land. The holding sizes of marginal farms have decreased from the level of 0.40 ha in 1970-71 to 0.38 ha in 2010-11 and likely to reduce to the level of 0.32 ha with in this decade. By virtue of increased number of operational holdings (mainly due to fragmentation), their size is small but can be made bountiful by appropriate policy interventions. In India, it has been widely reported and accepted that farm size has inverse relationship with productivity and income. Marginal farmers are the ones who have lesser capital but higher use of labour and other family-owned inputs, and usually have a higher index of cropping intensity and diversification. Although, small holders have higher productivity compared to large size holdings, the main problem with small holders is low marketable surplus and profit despite the low expenditure on external labour costs. Family farming carries the potential to meet the diverse needs of household in an ecologically sustainable way. Developing climate smart family farms will be the futuristic plan for higher productivity and profitability with integration of smart components for smart families.

6.4.3. District/village specific sustainable integrated farming system models & modules

Multiplicity of farming systems existing in the country gives scope for developing district and village specific farming systems. Geo-referenced location specific integrated farming systems modules and models will hold key to make farming practice sustainable by small and marginal households in future scenario in combating the climate adversaries. This will augment productivity and profitability of small and marginal farmers providing them nutritional security apart from marketable surplus of products.

6.4.4 Farming systems diversification / intensification

Intensification and diversification of small holders will be key to achieve the desired profitability for youths. Scope exists to intensify and diversify with various components of farming systems in 59 % of small holders as they have only two or less components. 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.

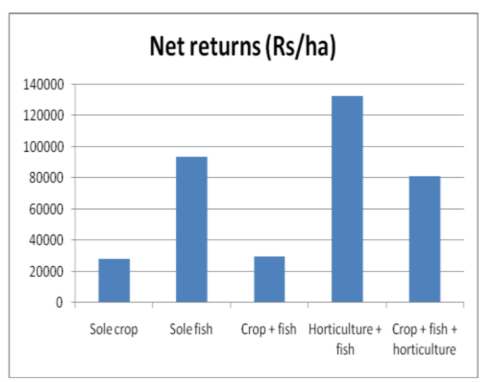


Fig 7. Net return (Rs./ha) from sole and various combinations of farm enterprises (Khan, 2010)

Similarly farmer perception based user friendly integration of enterprises such as broiler, poultry, fishery, floriculture, fruits etc are key in meeting the targets of livelihood, nutritional and profitability enhancement to these households besides environmental protection.

6.4.5 Vertical farming systems

With the ever increasing population coupled with degrading land resources, a larger part of the population is already having difficulty in securing quality food. It is necessary to think of innovative and creative ways to feed and nourish everyone. Vertical farming shall help in meeting the food & other demands of the rapidly growing urban population and can address the rising concern for environmental issues. Building low-cost vertical soilless system (hydroponics) for production of small vegetable and fruit crops can be viable options for small farmers. Vertical farming will facilitate organic farming with no use of pesticides, conservation of natural resources, and when applied in a holistic manner in combination with other technologies may address rising urban concerns for quality food. Poultry + Paddy + Fish in the same piece of land in different layer is the good example for the vertical farming system and this will facilitate to increase the per unit area profitability and reduce the labour requirement for the systems.

6.4.6 Specialized farming systems

The Institute would strive to harness power of science in enhancing farming system's productivity, profitability, resource use efficiency, cost-effectiveness, value addition and improving quality of food through blending of scientific and traditional knowledge. Specialized farming system components like protected agriculture, better management of dairy, poultry especially broiler in batches, high value vegetables in poly houses, floriculture in suitable areas, multi species multipurpose boundary plantations etc. needs to be promoted in small holder farms for enhanced profitability and produce more from less resources. A paradigm shift in farming systems research is the utmost need to accomplish the mission by integrating the modern tools and techniques of agriculture. Specialized farming systems also will facilitate sustainable use of natural renewable resources. Balancing economic, environmental, and social demands require a high degree of management skill and knowledge because every farm is a complex system of interacting components that exists in both natural and socio-economic environment.

Specialized farming of floriculture

6.4.7 Cluster and social farming

Organizing the small holders farm clusters for meeting the social, domestic and global goals will be critical. Some of the case studies are One Village One Product (OVOP) in Japan and Local Competitive Advantage (LOCA) in Sri Lanka. Farmer's clusters may be organised either in horizontal or vertical manner to cater to the needs to present and future farming systems. These clusters can comprise of contiguous group of minimum 10 or more villages where in multi-disciplinary interventions can be made to develop all the farms and clusters self-sustainable. Motivation of villagers to work in harmony to make efficient use of their resources for socio economic development, formation of farmer producer organizations with maximum participation of women for self-development and governance, value chain improvement through post-production processing and marketing facilities for agri and dairy producers, while generating employment for the landless are key in successful organization of small holder clusters.

6.4.8 Multiple uses of resources

Multiple uses 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 nutrient and energy based input-output relationships, rain water harvesting and recycling, and multiple uses of water for household. 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. The net water productivity in scientifically validated IFS model from 0.7ha, comprising of crop + livestock + horticulture + mushroom + fishery was higher (Rs.11.6 /m^3) over the existing farming system (Crop + livestock) i.e. Rs. 9.4/m^3. The water productivity increased 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. Also, the employment generation doubled. Integration of proper waste resource recycling 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.

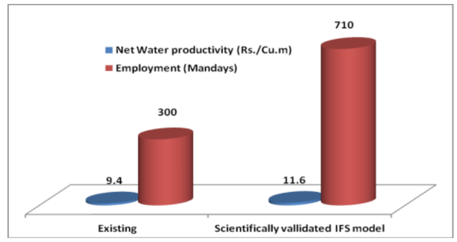


Fig 8 Net water productivity and employment between existing and scientifically validated IFS model

6.4.9 Organic farming systems

With the increasing purchasing power, the requirement for quality food which is free from chemical residues will continuously increase. Establishment of organic production systems which are socially, ecologically and economically sustainable is required. The spread of organic farming on 1-5 per cent area in the high productive zone and large spread in the northeastern states would help to strengthen the organic movement. 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. Organic farming will be incomplete without associated components of livestock such as dairy, poultry etc. Development of cluster based integrated organic food production systems will pave way for supply of producer & consumer friendly commodities with affordable prices. Carbon sequestration through organic farming involving all components including agro-forestry will be critical in achieving the desired results from organic farming systems.

6.4.10 Clean India for Green India

India’s per capita waste generation stands at 450 ± 75 g/day and it grows at the rate of 4 % /year in conservative locations and @ 5 %/year in fast growing areas. Waste disposal in India simply involves rounding up the waste from different parts of the city, and dumping everything in a landfill. Once a landfill is completely occupied, a new landfill is discovered in a different part of the city. The Energy Research Institute estimates that 1400 sq. km. of land would be required by 2047 for municipal waste disposal. Biodegradable wastes can be separated and subjected to composting by soil microorganisms which can be used for enhancing the fertility of soil which in turn will make India greener. The composts thus produced from bio-degradable wastes could be source of nutrients for organic growers. Through this multiple goals such as clean and hygienic city, reduction of greenhouse gases, 8 to 9 times saving of urban land, prevention of soil degradation from compost usage and employment potentials to unskilled workers can be achieved.

6.4.11 Climate smart farms and systems

Resilience starts with reducing vulnerabilities and farming system by nature having integration of components has the feature. However, building further resilience by way of incorporating the appropriate components is essential. The concepts of 4Rs (reduce, recycle, reuse and recovery) applied in farming systems are in favor of creation of better resilience to climatic adversities. Hence, climate smart farms and systems needs to be established through adaption of food production systems at the livelihood level and at the ecosystem. A reduction in greenhouse gas emissions and the agricultural carbon footprint is essential, which calls for changes of practices, including more resource efficiency, use of clean energy and carbon sequestration.

6.4.12 Conservation agriculture

Over exploitation of natural resources 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 offers scope for minimal environment deterioration. The concept involves minimum disturbance of soil and perfect land leveling to conserve both soil and water, besides saving labor and fuel. 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^{-1} 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. A vast potential exists 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*. Air pollution and loss of valuable macro and micro-nutrients during burning are two major adverse effects of this practice. Recycling of crop residues may form an important component of integrated nutrient management. It is possible to sustain system productivity and soil health on long-term basis, which may also help in increasing input use efficiencies. Scientific management of crop residues (stubbles of previous crop), on the other hand will, help replenish the soil's carbon content and promote activity of soil micro-organisms, land fertility and help save on fertilizers.

6.4.13 Precision farming for higher input use efficiency

Site specific crop management with precise uses of resources through spatial and temporal variations in soil-plant-atmosphere system using Precision Farming techniques will be the key to manage the future farms. This practice will comprise information acquisition related to variability in environmental and biophysical parameters, their interpretation for resource use, evaluation and control. Information technology tools like Global Positioning System (GPS), Geographical Information System (GIS) and Simulation Modeling for Decision Support System (DSS). Global Positioning System (GPS) and farming through information available from satellites will help improve resource use efficiency, economy and sustainable use of natural resources.

6.4.14 Integrative simulation modeling

Integrative (bio-physical or socio-economical) simulation modeling including artificial neural network (ANN) is a promising tool in farming systems research, which will help in unraveling the complex and dynamic interactions and feedbacks among bio-physical, socio-economic and institutional components across scales and levels and are a useful for taking decisions to foster sustainable farming systems. Participatory approach in integrated simulation modeling to address the problem of shrinking of resource availability and competition to access of resources and its market economy. The strength of integrated simulation models is that of providing a platform for the integration of research approaches, knowledge and data in the frame of interdisciplinary or trans-disciplinary processes. Under projected climate change scenario, there is a need to optimize the multiple input factors to achieve maximum benefit with sustainability, multi-criteria decision analysis with the integration of linear programming (LP) and simulation modeling should be taken up at different scales to address the input-output flow of resources.

6.4.15 Attracting and Retaining Youth in Agriculture (ARYA)

In the coming years, one of the biggest challenges for Indian agriculture would be retaining its youth in agriculture. Unless farming becomes both intellectually stimulating and economically rewarding, it will be difficult to attract or retain rural youth in farming (Swaminathan, 2001).The old Indian adage *"agriculture is the best whereas business is next to it"* is totally reversed in today's scenario. Empowering today's youth is our generation's greatest responsibility. Providing a platform to create professional and business oriented farming systems for youth will be very important. Further, the role of highly educated and skilled youth will be of highly useful in managing the knowledge intensive farming systems. Capacity building of youth population through advanced trainings will further empower them to go for creating input-output supply chains for primary and secondary agriculture. The only possibility of retaining youth in agriculture is through developing micro-business modules in farming systems as it offers scope for regular sustained income. The highly productive, economically profitable, environment friendly and sustainable successful models of farming systems can pave the way to attract the youths to work in rural areas even from urban areas having links to the rural system. This can reverse the process of moving rural youth to urban areas even from urban areas having links to the rural system. This can reverse the process of trans-migration and also may promote agro-eco tourism

6.4.16 FDI in agriculture/ Retail Market

Foreign Direct Investment (FDI) in agriculture, forestry and fishing has been less dynamic than FDI in other sectors. This perspective for 2050 raises the need of public and private investments sufficient to ensure adequate agricultural production potential, sustainable use of natural resources, infrastructure for markets, information and communication and research for technological breakthroughs for the future to help agriculture meet the challenges of climate change and growing energy scarcity. Unless investments are made in maintenance and sustenance of natural resources, the productive potential of land, water and genetic resources may continue to decline at alarming rates. Composition of investment on enhancing total factor productivity and profitability through exploration of market opportunities, enhancing technical skills will be required to achieve the production needed to meet future demand. Future focus on investment to give emphasis on all points in the value chain, from input supply, seed propagation, production on the farm, basic processing, trading and logistics, processing and retailing.

6.4.17 Empowerment of women through IFS

Women play a very important role in household management including agricultural operations. This is especially true for hilly and tribal areas. There is a vast scope to improve the household profitability by judiciously utilizing their time using innovative practices and ensuring multiple uses of various household resources. This is possible through women's empowerment through location specific trainings and critical need based. With the improvement in educational status in the years to come, the role of women in agriculture and management of household resources will be increasingly important. As such feminization of agriculture in the long run is expected and developing a women centric farming system models will be a real challenges as men are migrating to rural non-farm sectors.

6.5 Infrastructure requirement

Establishment of high-tech agronomy laboratories, better communication systems, futuristic IT tools and hi-tech farms are essential to meet the envisioned goals and targets in the Vision document. The facilities like hi-tech farms with fully automated operations of irrigation, recycling, harvesting and handling of harvested products are essential to develop the various farming system modules and models. Hi-tech labs for analyzing the residues in crop produces and evaluation of solid waste compost products are also essential. Other items like re-circulatory aquaculture systems, web enabled Information sensors, data loggers are also essential.

6.6 Capacity building/ HRD requirements

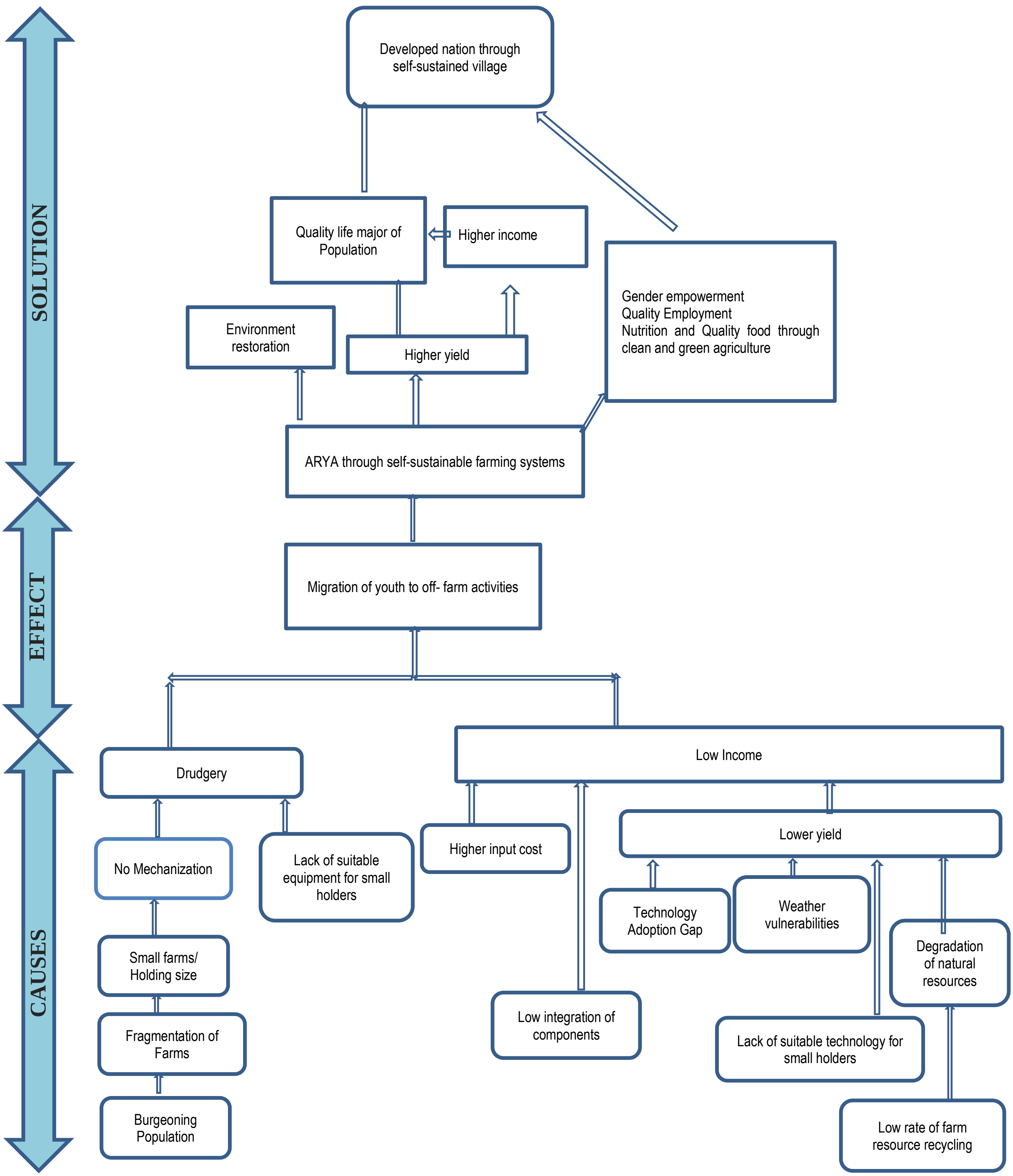
Current research practice has focused on specific components of technology, along commodity or disciplinary lines. In future, a more holistic approach is needed with interdisciplinary and usually multi-institutional studies of natural resource management, biological interactions of mixed crop, tree and animal production systems, including aquaculture in a farming systems context. In the changing scenario of globalization of education, future demands of agricultural research will be to facilitate and undertake human capacity building in the new areas of specialization such as IPRs, other WTO-related areas, techno-legal specialties etc., and the cutting edge technologies such as biosensors, genomics and biotechnology, alternative sources of energy, nanotechnology, etc. in addition to developing adequate skills in them for managing their research, by inculcating inter-disciplinary team spirit. Suitable training modules/ skill enhancement will be essential for agricultural research managers for strengthening their ability to recognize the challenges facing them and to adopt strategic planning as a tool for meeting the evolving challenges related to sustainable agriculture and self-reliance.

6.7 Strategic Frame Work

Goal	Approach	Performance Measure
Information technology enabled farming systems characterization	• Characterization and constraint analysis of existing farming systems • Development of digital expert and decision systems using IT tools • Creation of web enabled applications for various platforms such as mobiles, computers etc	• Improvement (%) in productivity and profitability of existing farming systems of small holders
Development and standardization of modules for self-sustainable farms and systems including specialized and cluster based farming systems	• Creation of vertical farming systems for better recycling and saving of resources in marginal and small holders • Modules of farming systems for meeting the 100 % requirement of nutrient, water, seeds, labour etc with in the farm • Models of specialized farming systems using cutting edge science and technology in identified areas • Cluster and social farming systems for	• Increase in profitability (%) over existing models • Saving in resources (%) • Reduction in market dependence (%) for inputs • Value of output generated from the cluster • Reduction in greenhouse gases (%) • Quantity of carbon

	holistic improvement of the society	sequestrated
Improved household food, nutritional and livelihood security of small and marginal farmers	• Adoption of Precision/ Hi-tech agriculture for higher productivity from small and marginal farms. • Development & dissemination of location specific On–Farm post-harvest agro processing and value addition techniques.	• Reduction in malnutrition (%) • Per cent improvement in dietary diversification index • Reduction in market dependence (%) for food commodities
Sustainable management of farm resources for increasing input use efficiency	• Development of cost-effective resource conservation technologies for crop diversification and in-situ crop residue management. • Optimization of resource inflow and input-output relationships among different modules in integrated farming systems perspective. • Development of cost-effective production technologies for organic production systems. • Use of sensor based input management options for enhanced input use efficiencies in cropping systems.	• Improvement in rate of recycling (%) • Per cent improvement in use efficiency of inputs • Reduction in cost (%)
Bio-degradable waste management for organic food production and farming systems	• Development of waste to wealth techniques involving microbial decomposition • Creation of organic farming system clusters • Reducing the dependence on chemicals including fertilizers and pesticides	• Number of microbial consortia developed • Reduction (%) in area required for land filling of wastes • Reduction in use of chemical fertilizers (%) • Improvement in soil health (%) • Amount of carbon sequestrated • Reduction (%) in greenhouse gases
Capacity building and human resource development for managing farming systems	• Course curriculum development on farming systems • Methodology/teaching facility for farming systems dissertations • International and national training programmers in farming systems for middle and senior level managers • In-field capacity building modules for farmers and development officials	• No. of courses developed • No. of dissertations in farming systems produced • No. of persons trained in farming systems

6.7 Cause-Effect-Solution tree



Interaction and Linkages

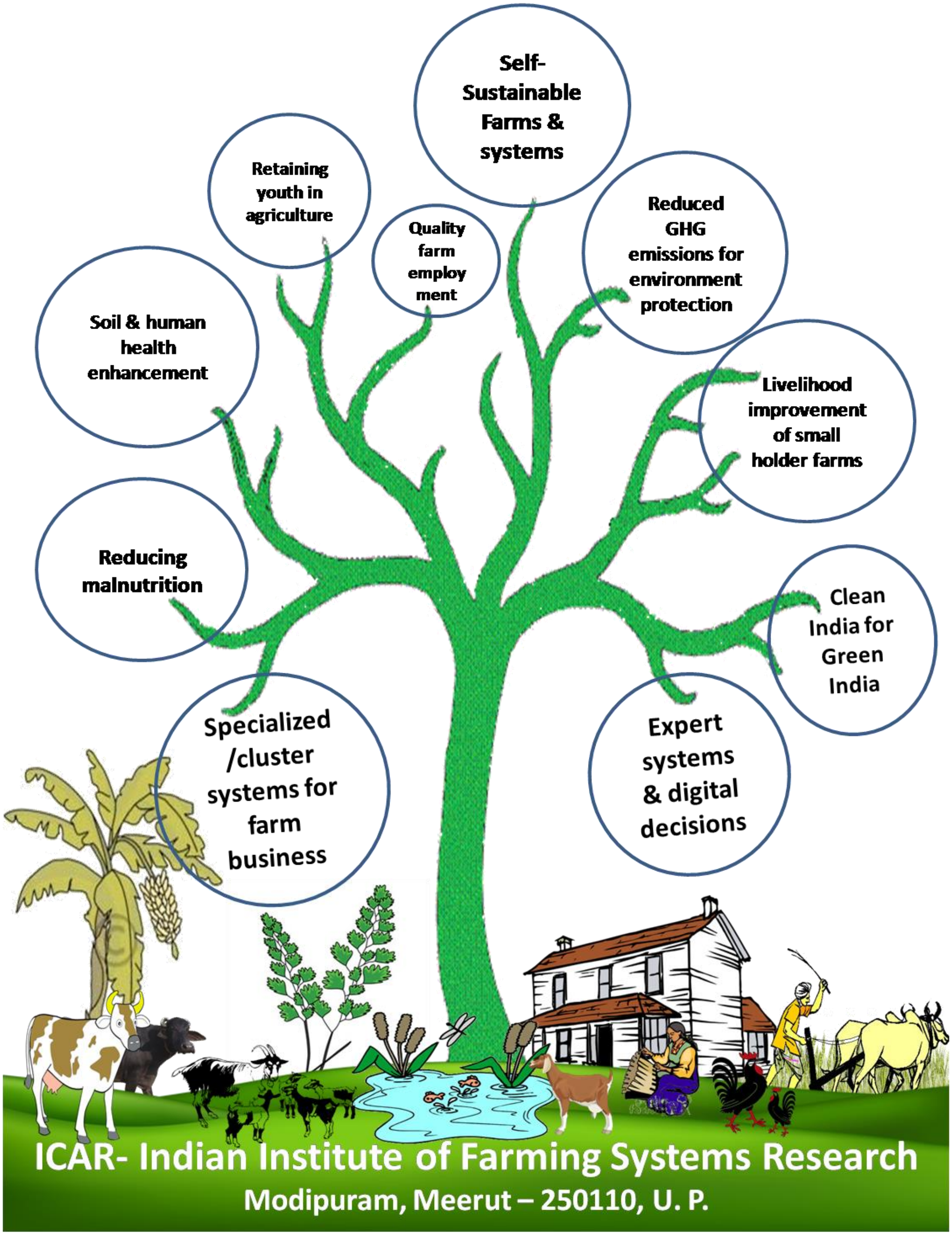
The Indian Institute of Farming Systems Research, Modipuram has collaborative research programme with ICAR institutes and State Agricultural Universities in all the agro-climatic regions through AICRP on Integrated Farming Systems and Network Projects. Besides this, the institute is also having the MoU with SAUs like IGKV, Raipur and SVPUAT, Modipuram for undertaking the research work by students. The institute also extends the consultancy services to Uttarakhand Organic Commodity Board and THDC Ltd for development of Integrated Organic Farming System models for hilly areas and farming system modules for Tehri district respectively. Quality production of breeder seed cane is also undertaken with the collaboration of UP council of sugarcane research. The institute is also having the collaboration with University of Nebraska, Lincoln and IPNI, South Asia

In the past, in order to strengthen the inter-institutional linkage for sharing of minds, manpower, materials and methods for Integrated Farming Systems Research, Statement of Understanding (SoU) has been signed with 18 sister institutions of ICAR, 9 AICRPs and 1 zonal project directorate. Looking in to the needs of farming systems in the years to come, agencies and specific area of collaboration required are given below.

Specific area of collaboration	**Agencies**
Farming Systems Characterization using Information technology tools	Space Application Centre, Ahmedabad National Centre for Agricultural Economics and Policy Research, New Delhi International Centre for Agricultural Research in Dry areas, Syria
Rainfed farming systems	International Crops Research Institute for Semi Arid Tropics, Hyderabad
Simulation modelling for farming systems	Indian Agricultural Research Institute, New Delhi University of Florida, USA Wageningen University, Netherlands International Maize and Wheat Improvement Centre (CIMMYT)
Organic farming	Ministry of Agriculture, Government of India Ministry of Water Resources, Government of India Ministry of Environment and Forests, Government of India
Conservation Agriculture	Borlaug Institute for South Asia, India
Development of digital tools for farming systems design and dissemination	Indian Agricultural Statistics Research Institute, New Delhi Indian Institute of Information Technology, Allahabad Indian Institute of Technology-Delhi, Roorkee

The partnerships based on critical need will be further strengthened with national and international institutions.

Expected Outcome



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