SOUVENIR

# CAU REGIONAL AGRI FAIR, 2017-18

November 5 - 7, 2017

**CENTRAL AGRICULTURAL UNIVERSITY**

Lamphelpat, Imphal - 795 004

Manipur, India

# SOUVENIR

## CAU Regional Agri - Fair 2017-18

November 05 - 07, 2017

Venue:
College of Fisheries, Lembucherra, Tripura

Organised by:
Central Agricultural University
Imphal, Manipur - 795004

# SOUVENIR

CAU REGIONAL AGRI-FAIR 2017-18
Central Agricultural University, Imphal - 795004, Manipur


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*The views expressed in the articles are the personal opinions of the contributors.*


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भारत सरकार
MINISTER OF AGRICULTURE
& FARMERS WELFARE
GOVERNMENT OF INDIA

04 OCT 2017

# MESSAGE

I am pleased to learn that the Central Agricultural University, Lamphelpat, Imphal is organizing CAU-Regional Agriculture Fair, 2017-18 on the theme "Integrated Farming for Doubling of Farm Income" at its campus, College of Fisheries, Agartala ,Tripura during November 5-7, 2017 and a souvenir is being brought out to mark the occasion. I hope that the three –day agriculture fair will provide the agricultural scientists and farming communities of the region a platform to exchange innovative ideas for better use of latest technologies and enhance agricultural production.

Integrated farming is the demand of the day to sustain the gross farm production. Adverse and unfortunate situations may cause huge loss if a farmer adopts single farming like crops, animals, fish, horticulture, etc. Due to uncertain climate change, such unlike situation may arise. Therefore, if a farmer is educated to adopt more than one farm business, he may be capable to cope such situation. Emphasis on adoption of integrated agro-climatic zone centric farming with suitable and sustainable technologies need to be given for diversification of agricultural activities.

It is my pleasure that CAU, Imphal is serving the farming community of the NE Region through different extension and research activities. CAU-Regional Agriculture Fair, 2017-18 is an important event in this regard and this event will encourage farmers and all stakeholders to work hard to achieve the target of doubling farm income.

I wish the CAU-Regional Agriculture Fair, 2017 a grand success.

(Radha Mohan Singh)

परशोत्तम रूपाला
PARSHOTTAM RUPALA

सत्यमेव जयते

कृषि एवं किसान कल्याण और
पंचायती राज राज्य मंत्री
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Minister of State For Agriculture &
Farmers Welfare and Panchayati Raj
Government of India

D.O. No. Message MoS(AC&FW)/PR/VIP/2016
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# MESSAGE

I am delighted to know that the Central Agricultural University, Imphal (Manipur) is organizing CAU -Regional Agriculture Fair, 2017-18 with the theme **"Integrated Farming for Doubling of Farm Income"** at its Campus, College of Fisheries, Agartala (Tripura) during November $5^{th}$ - $7^{th}$, 2017 and a Souvenir is being brought out on this auspicious occasion.

Integrated farming system improves income and provides household food consumption through provision of animal proteins, vegetables and fruits and increases food security in a holistic manner.

I convey my best wishes for the success of the CAU- Regional agriculture Fair 2017-18.

**(Parshottam Rupala)**

**Delhi Office :** Room No. 322, 'A' Wing, Krishi Bhawan, Dr. Rajendra Prasad Road, New Delhi-110001
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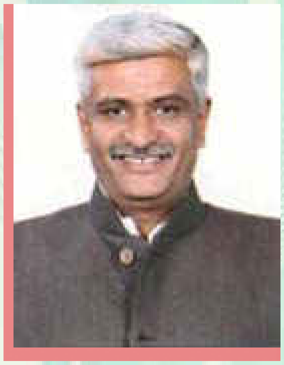
OCT 2017



# MESSAGE

It gives me immense pleasure to know that CAU-Regional Agriculture Fair, 1017-18 is being organized by Central Agricultural University in College of Fisheries, Agartala, Tripura during November 5-7, 2017 with a theme **"Integrated Farming for Doubling of Farm Income"**.

The small land holding with undulating hilly terrain is a challange to farmers for higher per unit area production from land and also from allied activities in N.E. States. N.E. States are potential for enhancing production of food crops like paddy, millets, pulses besides horticulture in given agro-climatic conditions. Government of India has taken several steps like insulating farmer against natural calamities, realization of remunerative prices using electronic platform of trading and reduction in cost of cultivation by using new technologies, to double the farmers' income by 2022. It seems very important to incorporate more than one farming operation on each and every farm as it makes available option to provide regular income and employment of small land holders.

I extend warm greetings to the organizers and participants of the fair and convey my wishes for the success of the event.

(Gajendra Singh Shekhawat)

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18th October, 2017

# MESSAGE

It is a great pleasure to learn that the Central Agricultural University, Imphal is organizing CAU Regional Agriculture Fair, 2017-18 on 5 - 7 November, 2017 at its campus, College of Fisheries, Lembucherra, tripura.

I convey my best wishes for grand success of the aforesaid programme.

**(Tathagata Roy)**

Imphal
October 10, 2017

**CHIEF MINISTER**
**MANIPUR**

# MESSAGE

It gives me immense pleasure to learn that the Central Agricultural university (CAU) is organising CAU - Regional Agricultural Fair, 2017-18 under the theme, **"Integrated Farming for Doubling of Farm Income"** at the campus of College of Fisheries, Lembucherra, Agartala, Tripura from November 5 to 7, 2017.

To meet the demand of the ever increasing population, the productivity in the agriculture sector needs to be raised. I hope that such Agricultural Fair will be very beneficial to the farmers to the extent that they could have the knowledge on Integrated farming, about the tools, technologies and new farming systems that enable them to increase the productivity. I believe that such Agri-Fairs would also go a long way in accomplishing Government's objective of doubling farmers' income by 2022.

I convey my warm greetings to the organisers and wish the Fair a grand success.

(N. Biren Singh)

Khagendra Jamatia

सत्यमेव जयते

MINISTER
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Home ( Fire Service) Departments
GOVERNMENT OF TRIPURA
Telephone No. - (0381) 241-3224 (O)
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No.F.1(2)/Min-Fish. Co-op & Home (F.S)/13/ Dated, 24th October, 2017.

# MESSAGE

I am very glad to learn that the Central Agricultural University, Imphal is organizing CAU-Regional Agriculture Fair, 2016-17 on the theme **"Integrated Farming for Doubling of Farm Income"** at its campus, College of Fisheries, Agartala (Tripura) during November 5 - 7, 2017 and a Souvenir is being brought out to commemorate the occasion. Organization of such events in this region will help to change the agricultural scenario including fishery sector and improve the living standard of the farmers.

I hope that during the CAU - Regional Agri Fair, 2017-18 farmers of the region will get the opportunity to be acquainted with the latest agricultural technologies and farm inputs as well as to interact with scientists of the University to have appropriate solutions for their farm related problems besides other activities. I would also take to opportunity to appeal to the diligent scientific community of the University to extend their helping hands to the farmers in imparting practical knowledge of integrated farming system whenever necessary to uplift the rural livelihood of the region and food security of rural people.

My warm greetings and felicitations are conveyed to the organizers and wish the CAU Agri Fair, 2017-18 a grand success.

(Khagendra Jamatia)
Minister

त्रिलोचन महापात्र, पीएच.डी.
सचिव एवं महानिदेशक
TRILOCHAN MOHAPATRA, Ph.D.
FNA, FNASc, FNAAS
SECRETARY & DIRECTOR GENERAL

सत्यमेव जयते

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# MESSAGE

I am happy to know that Central Agricultural University, Imphal is organizing CAU-Regional Agriculture Fair 2017-18 on the theme **"Integrated Farming for Doubling of Farm Income"** at College of Fisheries, Agartala, Tripura during 5 - 7 November, 2017, and to mark this occasion, a souvenir is being published to highlight the importance of integrated farming in enhancing farm income. This will help reduce unemployment in rural areas and also help retain rural youth in agriculture.

I wish the Agriculture Fair, a great success.

**(T. MOHAPATRA)**

Dated the 26th September, 2017
New Delhi

डॉ. अशोक कुमार सिंह
उप महानिदेशक (कृषि प्रसार)

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# MESSAGE

I am glad to learn that the Central Agricultural University, Imphal is organizing CAU-Regional Agriculture Fair, 2017 -18 on the theme **"Integrated Farming for Doubling of Farm Income"** at its campus, College of College of Fisheries, Agartala,Tripura during November 5 - 7, 2017 and a Souvenir is being brought out to commemorate the occasion.

The publication of Souvenir is a mirror to reflect the appropriate extension activities of agricultural and rural development in the N.E. Region. CAU-Regional Agriculture Fair 2017-18 will provide an opportunity to all the farmers and entrepreneurs to create awareness about the new research in different aspects of agriculture including integrated frming and this will help to enhance the farm income specially in the N.E. Region.

I convey my best wished to the organizers of the fair and all the members of the CAU, Imphal family for their sincere efforts for organizing such an important and beneficial fir in the interest of the N.E. farmers and the state of Tripura.

Dated 27.09.2017

**(A.K. Singh)**

**DR. K. M. BUJARBARUAH**
ARS, PhD, FNAAS, DSc(Hc)
VICE-CHANCELLOR

**ASSAM AGRICULTURAL UNIVERSITY**
JORHAT - 785 103
ASSAM (INDIA)

*(Recipient of Sardar Patel Outstanding Institution Award)*

# MESSAGE

I am very happy to know that the Central Agricultural University, Imphal, Manipur is organizing CAU- Regional Agriculture Fair, 2017-18 during November 5-7, 2017 on the theme "Integrated Farming for Doubling of Farm Income" at its campus, college of Fisheries, Agartala (Tripura) and a souvenir is being brought out to mark the auspicious occasion.

Integrated farming is the demand of the day to cope the challenges of drastic climate change, high cost of labour and other inputs. The present Central Government is very keen to transform the livelihood of the farmers and bring the same to the level of satisfaction, where all minimum amenities can be availed by them. The region being highest rainfall area, the fish farming with other farm operations may be a very good option to double the farmer's income.

I convey my blessing to the organizer of CAU-Regional Agriculture Fair, 2017-18 and all members of the CAU family for their whole hearted efforts in organizing such an important and beneficial event for the farmers of the N.E. Region in general and the State of Tripura in particular.

I wish the Fair a grand success

**(Kamal Malla Bujarbaruah)**

**Dr. M. Premjit Singh**
Vice-Chancellor

# CENTRAL AGRICULTURAL UNIVERSITY

# FOREWORD

It is my honour to present to everyone the 2017 edition of the annual CAU-Regional Agri Fair being held during November 5-7, 2017 at the College of Fisheries, Central Agricultural University, Agartala, Tripura. As the landscape of farming in the region is aiming to shift towards global standard practices extending and integrating resources available for efficient farming, I am sure this year's theme "Integrated Farming for Doubling of Farm Income", will resonate with the audience at the Fair.

It is human nature to evolve itself and change the way of living. Similarly, the ways we cultivate have also evolved over thousands of years of findings and better solutions. Integrated farming is not only about evolving our practices but also incorporating new tools made available to us by various fields such as science & technology and management to create a synergy.

Presently, the Union Government is emphasizing over doubling of farm income by 2022 which evokes all possible ways of integration of farming methods as well as subsidiary occupation(s) to utilize all available resources at maximum level. Since, whole NEH Region receives maximum rainfall and only one major cropping season i.e., *kharif* exists here, fish farming may be a best option for integrating farming operations. By adopting fish farming, regular and high income can be obtained.

While this Fair is a platform for us to showcase the works we do at CAU and connect various stakeholders in agriculture to each other, we look for strength and motivation through interactions with the farmers and feedback from them to guide in our endeavours to uplift the standards of farming of NE Region.

I would like to thank everyone participating in this CAU-Regional Agri Fair 2017 and contributing to its success.

**(M. Premjit Singh)**

# CONTENTS

# 1 ROLE OF INTEGRATED FARMING SYSTEM IN INCREASING FARMER'S INCOME AND EMPLOYMENT

***J.M. Laishram and L. Nabachandra Singh,***
*College of Agriculture,*
*Central Agricultural University, Imphal.*

Ensuring food, nutrition and livelihood security through agriculture without causing negative externalities on social, economic and environmental sustainability is a challenge to agriculture and rural development in developing nations. This has become even more important in the context of ever increasing pressure on natural resources and globalization of agri-food chains. In the face of encroachment of land for intensive agriculture, industrialization and urbanization in the first half of the 21st century, both economic and natural resource policy now need to be interlinked with smallholder agriculture. The proposition is to promote sustainable farming systems for smallholders – following agro-ecological principles as a poverty alleviation strategy. During the height of Green Revolution and even after its ill-effects started to prop up, the concept of integrated/bio-diverse/ agro-ecological farming received little attention worldwide, perhaps due to its presumed subsistence nature. In the early years of the new millennium, consensus started growing around the proposition that small family farms are going to play crucial role in shaping the future employment, energy demand and food sovereignty of the world. This is important, since the number of small and marginal farms is on the rise throughout the developing nations and many of them are leaving their ancestral vocations, since little incentive holds them back to farming. The situation becomes harsh in marginal and less integrated environments, where most of the poor people live. Future of agriculture and rural poverty alleviation depends on how we ensure food, nutrition and livelihood security through sustainable and integrated family farming, which is resilient to uncertainties of open markets and climatic variability. The challenge to increase food production is not only to feed consumers, but to maintain dietary balance also. In developing nations, with industrialization and commercialization of different production systems, people now have more expendable cash in hand to be spent on food posing challenge to the food production system aiming to meet socially acceptable and nutritionally appropriate demand for food.

Integrated Farming Systems (IFS) employ a unique resource management strategy to help achieving economic benefit and sustain agricultural production without undermining the resource base and environmental quality. Due to various reasons, such as decreasing farm income, reduced soil fertility, market demand, climatic variability, employing family labour etc., farmers of complex agro-ecosystems have developed some unique integrated farming systems, which are resilient to such multiple changes. Investing in such farming ensures that the growth in agriculture is inclusive, pro-poor, and environmentally sustainable and this can also be the most effective route to bring about economic growth and poverty reduction, with enhanced resilience of small farmers to disasters. This is particularly important since sustainable intensification of small farms is now considered to be of critical need for feeding the future generation. It is time to reckon these integrated systems as units of planning for effective natural resource management.

## Benefits of Integration in Farming System

Sustainable agriculture in developing countries emphasizes food security and sustainability of smallholder farmer livelihoods, as opposed to food safety and convenience for consumer livelihoods and environmental protection in developed countries. That is why the role of IFS must be appreciated within the context of smallholders of developing countries. Although there might be numerous multi functional benefits of IFS, I have taken up four among them as listed below:

## 1. Integrated farming system and farm income:

IFS is reported to fetch higher farm income and profitability than conventional farming in smallholder systems of developing world. By increasing the provision of animals and fish, IFS generates higher cash income. It is also reported to achieve low cost of production and thus increase farmer's net income without disturbing the productivity concern. Since it adds to the sustainability of the system (by ensuring local sourcing of agricultural inputs), the income from IFS is expected to be stable over years. Hence, IFS may break the subsistence blockade for many marginal farmers and help in maintaining investment in regional agriculture. The components in an IFS greatly determine the extent of farm income, its stability and equitable distribution across seasons. Crop-livestock-fish system or crop-livestock system is reported to give higher net return than crop-based systems alone.However, the amount of income is difficult to be interpreted due to the variation in space and time. Reports in Indian context in the last ten years suggest an income range of INR.55,000 per annum to INR.80000 per annum. Nevertheless, a sound meta-analysis would have given a better estimate of the gross return from IFS. Apart from increasing the farm production, IFS even out the risks and uncertainties of income from conventional cropping and reduces the time lag between investment and returns. Regular and evenly distributed income throughout the year render the farm resilient to uncertainties and reduces vulnerability against climatic and market variations.

## 2. Integrated farming system and food security

Among the major challenges the world faces today, the urgency of providing food security to the growing human population and slowing down the quick loss of irreplaceable biological diversity appear most prominent. IFS, often developed traditionally, maintain productivity of the farm, the availability of diverse food items throughout the year so that all members of the household are fed sustainably. Even if we measure food security by dietary diversity, apart from the predominant energy intake approach, IFS would provide better food diversity than conventional farming. In that sense, IFS addressed the issue of food security in a holistic manner.

IFS results in improved household food consumption, especially for the vulnerable family members through provisioning of animal proteins and vegetable/fruits. Although empirical account of food intake in IFS is not very common, it is reported to increase food security in wide contexts. Indirectly, improved income naturally contributes to higher food consumption and food security.

## 3. Integrated farming system, employment opportunity

Some authors have summarized the multifaceted benefits of IFS to include economic benefits in terms of increased food production, and social benefits in terms of provision of employment opportunities for excess labour force heading towards the urban areas. IFS is labour intensive, which creates on-farm employment and most of the labour required in the production process is contributed by the farmer and his family members. IFS is reported to generate more man-days in the farm itself than conventional farming, the figures although varying widely across systems. Where Behera et al. (1999) reported more than 450 man-days ha-1 year-1 in a pond-based integrated farming system, Ramrao et al. (2005) and Solaiappan et al. (2007)reported575,950 and 343 man-days ha-1 year-1 respectively in mixed integrated systems. Although, adjustment for inflation is required for comparing such reports, there is no systematic meta-analysis addressing this issue. Apart from generating man-days, IFS ensures that the employment is generated throughout the year, ensuring a steady sink for local labour force.

## 4. Integrated farming system and energy efficiency

In developing countries, major sources of farm energy expenditure are fertilizer, and farm machinery. Since integrated farms are relatively less mechanized and encourages the use of internal inputs, energy use is much lower in integrated farms compared to conventional farms. Integrated farms (a form of sustainable farming) are mostly found in smaller farms, which have higherenergy efficiency in general. Moreover, many of these integrated farms are subsistence and involve less mobility in and around the farm, thus saving human energy and energy associated with transportation of farm produce. Empirical evidences different parts of the globe suggest that integrated system is the most efficient in terms of energy efficiency (Bailey et al., 2003; Alluvione et al., 2011) and this input output ratio of energy varies greatly in different systems.

Deike et al. (2008) observed a ratio of 15-17 in European context, where Channabasavanna et al. (2010) reports a ratio of 6.40 in southern India.

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# 2 Integrated Organic Farming System for Doubling Farmers' Income in Sikkim

***R.k. Avasthe, Raghavendra Singh, S. Babu, B. Lepcha and A. Yadav***
*ICAR-National Organic Farming Research Institute, Tadong, Gangtok- 737102 (Sikkim)*

Sikkim a small hilly state in the Eastern Himalayas with almost no flat land, this entirely mountainous state has altitude range of 300-8598 m above mean sea level constitutes 0.22 percent of total geographical area with 0.05 percent population (6.11 lakh) of India. It has about 15.68 per cent of cultivable area out of the total geographical area of 7,09,600 ha. It is estimated that more than 80 per cent populace of the state is dependent on agriculture. Land distribution is skewed with 70% of small and marginal farmers (less than 2 ha) holding 28% of the operational area and 30% of other farmers (semi medium, medium and large) holding 72% of the operational area. Cultivators account for the greater majority of the people in the state and their percentage is 57.84 while agricultural labourers constitute only 7.81 per cent of the workers in the State. A family of 6-7 members requires at least 2 ha cultivable area in sloping hills to sustain their livelihood. Amongst the Himalayan States, Sikkim has the highest percentage of people living below the poverty line (36.55%) and highest percentage of undernourished population (57%). The sloping lands are three to four times less efficient than the plains in meeting the caloric and protein needs of their populations. They can sustain only 3-4 persons and 1 head of cattle/ha/year through crop. The mix type of agriculture is still practiced in the state at the subsistence level rather than commercial. Hence, Integrated Organic Farming System may be an option to fulfill the requirements of the farming community with better income and employment generation in the state.

## Integrated Organic Farming System (IOFS)

Integrated Organic Farming System (IOFS) is entire complex of development, management and allocation of resources as well as decisions and activities, within an operational farm unit, or combinations of units, results in agricultural production and processing and marketing of the products. Whereas organic farming is a production system, which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives. To the maximum extent feasible, organic farming system relies on crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mechanical cultivations, mineral bearing rocks and aspect of biological pest control to maintain soil productivity and to supply plant nutrients and to control insects, weeds and other pests.

Integrated Organic Farming System is a common sense whole farm management approach that combines the ecological care of a diverse and healthy environment with the economic demands of agriculture to ensure a continuing supply of wholesome, affordable food. It is a dynamic concept which must have the flexibility to be relevant on any farm, in any country, and it must always be receptive to change and technological advances. Above all, integrated farming system is a practical way forward for agriculture that will benefit all society, not just those who practice it.

Organic farming aims for human welfare without harming the environment and follows the principles of health, ecology, fairness and care for all including soil. The modern concept of organic farming combines the tradition, innovation and science. It has been reported that organic farming can minimize energy consumption by 30.7 per cent per unit of land by eliminating the energy required to manufacture synthetic fertilizers and pesticides and by using internal farm inputs, thus reducing fuel used for transportation. India can emerge as global leader with the presence of large number of organic producers (almost 7 lakh producers) and they need to be supported with technical knowledge and inputs, besides, marketing infrastructure. The research results available for little over a decade confirms the yield advantage in many crops such as basmati rice, maize, cotton, chickpea, soybean, groundnut etc.

### Objectives of IOFS

Farming system is a complex inter-related matrix of soils, plants, animals, implements, labour and capital, inter-dependent farming enterprises.

- To develop farm - household systems of rural communities on a sustainable basis
- To improve efficiency in farm production
- To raise farm and family income
- To increase welfare of farm families and satisfy basic needs

### Benefits of IOFS

- Stable income daily income other than income from cropping
- Minimization of risk due to subsidiary allocation to different enterprises in the event of unexpected crop failures
- Increasing employment opportunity
- Ensuring the higher productivity per unit area
- Augmented returns and recycling of organics in complementary form
- Easily adopted by marginal, small and resource poor farmers
- Overall upliftment of farm
- Better allocation as well as utilization of inputs within the farm.

### Why Organic farming in IFS?

Despite use of new and improved crop varieties and chemical fertilizers, crop yield began to slow down in the latter part of the 20th century. The world's annual cereal yield growth rate has declined from an average of 2.2 percent in the 1970s to 1.1 percent in the 1990s. Thus, nutrient management through organic farming helps stabilizing soil fertility via improving nitrogen fixation and reducing nutrient leaching. Recently, soil condition has also been affected by climate change and an increase in the prevalence of severe weather events. There is a need for innovative farming solutions to improve soil health so that food production resilience may be ensured. The following have been identified as the main threats to soils in the soil strategy.

- Soil organic matter decline reduces soil quality, affecting fertility, structure, water retention capacity, soil biodiversity and carbon storage.
- Soil erosion can be accelerated by soil cultivation, leading to the loss of soil due to the action of water, tillage or wind.
- Compaction by farm machinery leads to a decline in a soil's capacity to retain water and supply oxygen to roots. This can lead to soil erosion, increased water runoff and GHG emissions.
- Biodiversity decline (e.g. soil microbes and soil animals) is affected by all of the above and also climate change. Soil microbes benefit crop production because they decompose organic matter, release nutrients in a plant available form (e.g. nitrogen mineralization), stabilize soil structure and can control soil-borne pests and diseases.
- Soil contamination with chemicals or pests and pathogens, results when hazardous substances are either spilled or buried directly in the soil, or migrate to the soil from elsewhere.

### Components of IOFS

Integrated Organic Farming System is not exclusively based on short term economics but also considers ecological concepts. It utilizes appropriate technology and appropriate farming methods. The principles involved in this method are use and development of appropriate technology based up on the understanding of biological system, maintenance of soil fertility for optimum production by using renewable sources.

**Integrated organic farming system components:** The components of organic farming are

- Crops: Mono-cropping, mixed/ intercropping, multi-tier crops of cereals, legumes (pulses), oilseeds, forage etc.
- Livestock: Cow, goat, sheep, poultry, bees
- Agro-forestry: Timer, fuel, fodder and fruit trees

### How do farmers fertilize crops under IOFS?

- Organic farmers build healthy soils by nourishing the microbial inhabitants that release, transform, and transfer nutrients.

- Soil organic matter contributes to good soil structure and water-holding capacity.
- Organic farmers feed soil biota and build soil structure and enhance water-holding capacity.
- Organic farmers feed soil biota and build soil organic matter with cover crops, compost, and biologically based soil amendments.

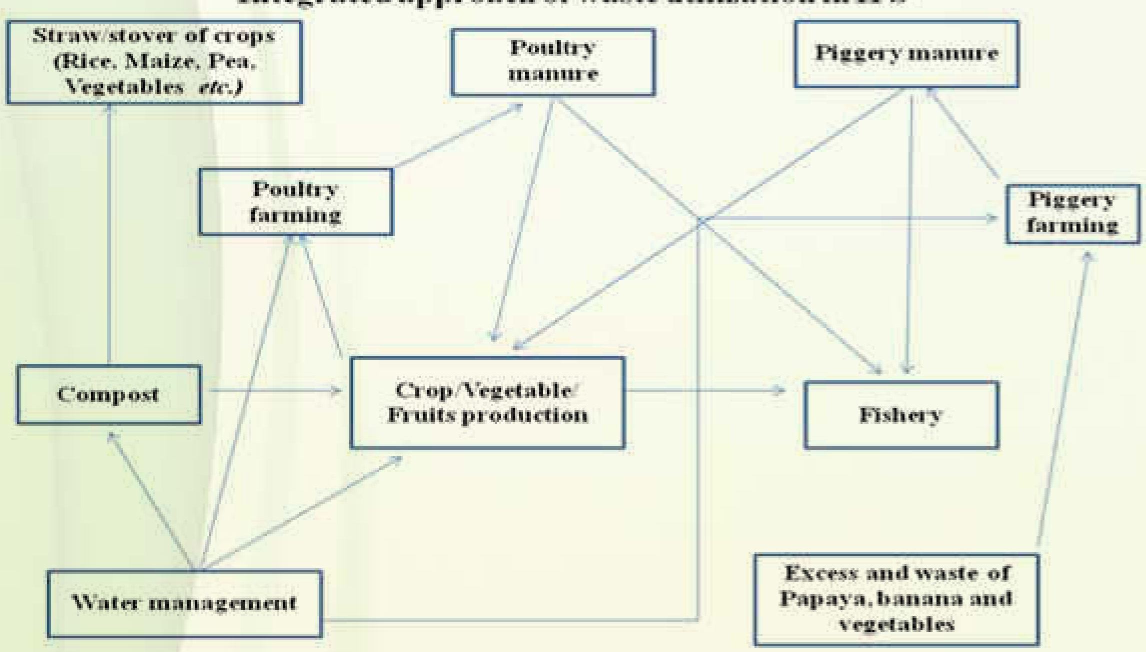
## How do they control pests, diseases and weeds in IOFS?

- The system produce healthy plants that are better able to resist disease and insect predation.
- Organic farmers' primary strategy in controlling pests and diseases is prevention through good plant nutrition and management.
- Organic farmers use cover crops and sophisticated crop rotations to change the field ecology, effectively disrupting habitat for weeds, insects, and disease organisms.
- Weeds are controlled through crop rotation, mechanical tillage, and hand-weeding, as well as through cover crops, mulches, flame weeding, and other management methods.
- Organic farmers rely on a diverse population of soil organisms, beneficial insects, and birds to keep pests in check.
- Growers implement a variety of strategies such as the use of insect predators, mating disruption, traps and barriers.

## Flow of crop and animal residue in IOFS

Integrated organic farming system works as system in which the byproduct of one component can be an input for the other components and vice-versa. After growing crops farmers get plenty of straw and stover which can be used for preparation of compost. It can also be used for feed materials to the livestock. Similarly, the composted material after decomposition is used for good quality manures as it contains essential nutrients that may supplement the requirements of crops and plants. In the same way, livestock and poultry wastes including the urine, dung and litter are used for preparation of manures and may be used for production of crops and orchards. The excess produce or waste materials obtained from horticulture is used as feed materials for livestock. Thus, IOFS is best suited for sustainable production and livelihood development in the NEH Region.

Integrated approach of waste utilization in IFS



## IOFS for marginal farmers for doubling income-a case study from East Sikkim

It is estimated that more than 70 per cent of rural population depends on agriculture and allied sectors for economic, food and nutritional security. The majority of the farmers of the East Sikkim district fall in small and marginal category. Nearly 27.1 per cent tribal population is living in the East Sikkim district. To improve the livelihood security of rural tribal population through Integrated Organic Farming System (IOFS) apparoch, a small tribal village Timpyem of 44 farming families with total population 161 persons (male: 54.03%, female: 45.96%) was identified for implementation which is located at 27o33'94" N Latitude and 88o60'29" E Longitude. The feasible technological interventions in Integrated Organic Farming System (IOFS) under Tribal Sub Plan were demonstrated in participatory mode by the ICAR-NOFRI and KVK-East Sikkim, Ranipool, East Sikkim during 2014-16 in order to enhance the cropping intensity, productivity and profitability of the villagers as well as of the state.

With the assistance of Tribal Sub-Plan, technological interventions were detailed by providing training, on field demonstrations and inputs support. Various inputs/interventions were provided under the project with the purpose of reorienting their traditional farming into integrated organic farming system (IOFS) to increase the farm income. Systematic study was done at one progressive tribal farmers in the village. An area of 0.3 ha was allocated to the rice-based cropping systems and 0.1 ha area to the maize based system. While fulfilling the vegetable requirements 0.05 ha area provided for the year round vegetable cultivation in low cost poly tunnel. 50 nos. of vanaraja chicks was given for backyard poultry. Livestock components (1+1) were their own under the IOFS model. The two years data on the all the compnents were analysed and found that the profitability of the system was Rs. 299/day with a B:C ratio of 2.03 (Table 1). The net energy output was 74.4× 103 MJ with 236 man day employment generated fron the 0.5 ha modal under IOFS (Singh et al., 2017).

**Table 1. Effect of different components of IOFS on economics**

| Components | Net area (ha) | Total cost (Rs./ unit) | Gross return(Rs/ unit) | Net return(Rs./ unit) | B:C ratio |
|---|---|---|---|---|---|
| Crops | 0.45 | 51800 | 137860 | 86060 | 2.66 |
| Livestock | 1+1 (Cattle) 50 nos. of Vanaraja | 57000 | 80300 | 23300 | 1.40 |
| **Total** | | **108800** | **218160** | **109360** | **2.03** |

### Conclusion

Integrated organic farming system is a holistic approach of agricultural development which involves crops, horticulture, forestry, livestock, poultry, and fisheries as essential components of the system in complementary manner especially in NE region. All the components are interlinked to each other the output of one component acts as an input of the other components for sustainable production system. Small and marginal holding with less dependency on external inputs especially in NE region by adopting the IFS produces sustained productivity for doubling farmers' income in the region.

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# 3 INTEGRATED FARMING SYSTEM - A HOLISTIC APPROACH TO DOUBLING FARMER'S INCOME BY 2022

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Agriculture is the backbone of our country. Crop production and animal husbandry is an important practice being carried out since time immemorial, but with the change in time, the practices have been changed keeping in view the local/regional and national demands.

Farming is a process of harnessing solar energy in the form of economic plant and animal products. System implies a set of inter related practices and processes organized into functional entity, i.e. an arrangement of components or parts that interact according to some process and transforms inputs into outputs.

Hon'ble Prime Minister of India, Sh. Narendra Modi has dreamt of doubling the income of every farmer in the country by year 2022 when the country will celebrate its 75th year of independence.

It's a challenging task, but we are resolute. We will accomplish this through time bound planning and execution. Eastern India, Assam and the northeast have a great role to play in bringing second green revolution in the Country.

Integrated farming is a whole farm management system which aims to deliver more sustainable agriculture. Integrated farming combines the best of modern tolls and technologies with traditional practices according to a given site and situation. In simple words it means using many ways of cultivation in a small available space or land.

## Goals of Integrated Farming System

### The four primary goals of Integrated Farming System are-

- Maximization of yield of all component enterprises to provide sound and stable income.
- Rejuvenation of system's productivity and achieve agro-ecological equilibrium.
- Avoid build up of diseases, insect pests and weed population through natural cropping system management and keep them at low level of intensity.
- Reducing the use of chemicals (fertilizers and pesticides) to provide chemical free healthy produce and environment to the society.

## Advantages of Integrated Farming System

1. Increased productivity through increased economic yield per unit area per time by virtue of intensification of crop and allied enterprises.
2. Improved profitability achieved mainly by way of reduced costs due to recycling of wastes of one enterprise as energy inputs for other systems.
3. Greater sustainability in production on farm due to integration of diverse enterprises of different economic importance. Recycling of wastes being in built in the system, this helps to reduce dependence on external high-energy inputs thus conserving natural and scarce resources.
4. Integration of different production systems provides an opportunity to solve malnutrition problem due to production of variety of food products.
5. The recycling of wastes for production helps to avoid piling of wastes and consequent pollution.
6. The farming system provides flow of

money to the farmer round the year by way of disposal of eggs, milk, edible mushroom, honey, silkworm cocoons etc. This will help resource poor farmer to get out from the clutches of moneylenders/ agencies.

7. Because of the linkage of dairy/ mushrooms/ sericulture/ fruit crops/ vegetable crops/ flower cultivation etc. cash available round the year could induce small and marginal farmers adopt new technologies such as fertilizer, pesticides etc.
8. Recycling of organic wastes reduces requirement of chemical fertilizer. Further, biogas production can meet household energy requirement. Thus, IFS, goes a long way in solving energy crises.
9. Fodder/ pasture/ tree species included in the system help to get more fodder and thus solve fodder crises to some extent.
10. Silvi component used in the system provides fuel and timber wood.
11. Inclusion of timber component in the farming system reduces pressure on forests.
12. Diverse components integrated can provide enough scope to employ farm labour round the year.
13. Integrated farming system forces the entrepreneur to know more things and hence improves the literacy level.
14. IFS provide opportunity for the growth of agri-oriented industries.
15. There is also advantage of increased input use efficiency.
16. Overall benefit of IFS is improved standard of living of the farmer's because of the products like edible mushroom, fruits, eggs, milk, honey, vegetables etc.

## Components in Integrated Farming Systems

- Agriculture + Fish farming.
- Horticulture + Duck rearing.
- Forestry + Pigeon rearing.
- Apiary + Mushroom cultivation.
- Sericulture + Azolla farming.
- Dairy + Kitchen gardening.
- Poultry + Fodder production.
- Goat rearing + Nursery.
- Sheep rearing + Seed Production.
- Piggery + Vermiculture.
- Rabbitory + Value addition.

## Elements of Integrated Farming Systems

Following elements may be included in IFS demonstrations depending upon the individual farmer's resources, interest and opportunities:

- Bio-fertilizers
- Bio-gas
- Bio-pesticides (Preparation of bio-control agents)
- Compost making (Vermicomposting)
- Farm ponds
- Green manuring
- Plant products as pesticides
- Rain water harvesting
- Solar energy
- Watershed

## Possible output of Integrated Farming Systems

Since Integrated Farming System (IFS) is an interrelated complex matrix of soil, water, plant, animal, environment and their interaction with each other enable the system more viable and profitable over the arable farming system. It leads to produce the quality food. To strengthen the food chain, it is essential to eliminate nutritional disorder which has been realized on account of appearing deficiency of mineral nutrients and vitamins in food being consumed. Horticultural and vegetable crops can provide 2-3 times more energy production than cereal crops on the same piece of land and will ensure the nutritional security on their inclusion in the existing system. Similarly inclusion of bee-keeping, fisheries, sericulture, mushroom cultivation on account of space conservative also give additional high energy food without affecting production of food grains. The integration of these enterprises will certainly help the production, consumption and decomposition in a realistic manner in an ecosystem.

## Present status of farming system research

The preliminary investigations clearly elucidated that integration of agricultural enterprises viz., crop, livestock; fishery, forestry etc. have great potential towards improvement in the agricultural economy. These enterprises not only supplement the income of the farmer by increasing the per unit productivity but also ensure the rational use of the resources and further create employment avenues. The following of suitable crop choice criteria having deep and shallow root system, inclusion of legume crop as catch, cover; fodder crops and adoption of bio-intensive cum alimentary cropping system along with other enterprise will certainly prove as a self sustained production system with least cost of production. The farming systems is governed by various forces viz., physical environment, socio economic conditions and political forces under various institutional and operational constraints and above all government favourable policies, which may keep the food security intact and livelihood fully protected.

For poor people, it starts small with ducks and chickens; then a few goats are kept for milk or fattening and to slaughter for a day of sacrifice; next a milch cow; then a bullock for ploughing in cooperation with another one buffalo family; then two bullocks. These can be used to plough the fields of others a very lucrative business in the planting season. In India, one would add a mulch buffalo at the apex of desirable animals on the farm. In the Vietnamese concept, the pigs will be the second step in the ladder. The concept means to start with small livestock and women and then the household will step by step get out of poverty. The poorest households kept only poultry and these households were those most dependent on common property resources for their living (e.g. use and sale of firewood from the forest). A similar stratification has been reported in several studies from Asia. Survey on farming systems in the country as a whole 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 bee keeping, sericulture, mushroom and fish cultivation was the most enterprising components of any of the farming systems prevalent in the country. The average yield gaps between 27 predominant and 37 diversified farming systems were examined across the agro-climatic zones through detailed survey on characterization of on farm farming systems.

## Productivity enhancement by Integrated Farming Systems

In view of serious limitations of horizontal expansion of land for agriculture, only alternative left is vertical expansion through various farm enterprises requiring less space and time but give high productivity and ensuring periodic income especially for the small and marginal farmers. The highlights about the research investigations carried out in India towards farming system outcome are discussed to conceptualize its significance towards farming community livelihood.

## Why Double Farmers' Income?

Ancient times approach for development of the agriculture sector in India has focused primarily on raising agricultural output and improving food security. The net result has been a 45 per cent increase in per person food production, which has made India not only food self sufficient at aggregate level, but also a net food exporting country.

The strategy did not clearly identify the need to raise farmer's income and did not mention any direct measure to promote farmers welfare. The net result has been that farmers income remained low, which is evident from the incidence of poverty among farm households.

Low level of absolute income as well as large and deteriorating disparity between income of a farmer and non agricultural worker constitute an important reason for the emergence of agrarian distress in the country during 1990s, which turned quite serious in some years. The country also witnessed a sharp increase in the number of farmers suicides during 1995 to 2004 losses from farming, shocks in farm income and low farm income are identified as the important factors for this. The low and highly fluctuating farm income is causing detrimental effect on the interest in farming and farm investments is also forcing more and more cultivators, particularly younger age group to leave farming. This can cause serious adverse effect on the future of agriculture in the country.

## The concept and time frame

Precision on the following points is important to assess the possibility of doubling the income of the farmers. The substantive points are:

- What is the period and targeted year for doubling the farm income;

- What is to be doubled, is it output, value added or income earned by farmers from agricultural activities;
- Whether nominal income is to be doubled or real income is to be doubled;
- Whether the targeted income includes only income derived from agricultural activities or would it also include income of farmers from other sources.

It is obvious that the targeted year to double the current income of the farmers or income for the agricultural year 2015-16 is by agricultural year 2022-23, which is seven years away from the base year 2015-16. Furthermore, if anything is to be doubled by the year 2022-23, it will require an annual growth rate of 10.4 per cent.

Another time, it is important to clarify what is sought to be doubled. It is the income of farmers or the output or the income of the sector or the value added or GDP of agriculture sector. If technology, input prices, wages and labour use could result in per unit cost savings then famer's income would rise at a much higher rate than the output. In nominal terms, the output became 2.65 times while farmer's income tripled in the seven years period. Therefore, doubling of farmers' income should not be viewed as same as doubling of farm output.

It is obvious that if inflation in agricultural prices is high, farmer's income in nominal terms will double in a much shorter period. In a situation where non agricultural prices do not rise or rise at a very small rate, the growth in farmer's income at real prices tends to be almost the same as in nominal prices. The government's target seems to be to double the income of farmers from farming in real terms.

## Sources of Growth in Farmer's Income

Doubling real income of farmers till 2022-23 over the base year of 2015-16, requires annual growth of 10.41 per cent in farmer's income. This implies that the ongoing and previously achieved rate of growth in farm income has to be sharply accelerated. Therefore, strong measures will be needed to harness all possible sources of growth in farmer's income within as well as outside agriculture sector.

The major sources of growth operating within agriculture sector are:

- Improvement in productivity;
- Resource use efficiency or saving in cost of production;
- Increase in cropping intensity;
- Diversification towards high value crops.

## The sources outside agriculture include

- Shifting cultivators from farm to nonfarm occupations and
- Improvement in terms of trade for farmers or real prices received by farmers.

## Strategy for Improving Farmer's Income

The sources of growth in output and income can be put in four categories.

- Development initiatives including infrastructure
- Technology
- Policies and
- Institutional mechanisms.

## Roadmap and Action Plan

The quantitative framework for doubling farmer's income has identified seven sources of growth. These are:

- Increase in productivity of crops.
- Increase in production of livestock.
- Improvement in efficiency of input use (cost saving).
- Increase in crop intensity.
- Diversification towards high value crops.
- Improved price realization by farmers.
- Shift of cultivators to nonfarm jobs.

## Conclusion

The low level of farmers' income and year to year fluctuations in it are a major source of agrarian distress. This distress is spreading and getting severe over time impacting almost half of the population of the country that is dependent on farming for livelihood. Persistent low level of farmer's income can also cause serious adverse effect on the future of agriculture in the country. To secure future of agriculture and to improve livelihood of half of India's population, adequate attention needs to be given to improve the welfare of farmers and raise agricultural income. Achieving this goal will reduce persistent disparity between farm and nonfarm income, alleviate agrarian distress, promote inclusive growth and infuse dynamism in the agriculture sector. Respectable income in farm sector will also attract youth towards farming profession and ease the pressure on nonfarm jobs, which are not growing as per the expectations.

Doubling farmers' income by 2022 is quite challenging but it is needed and is attainable. Three pronged strategy focused on (i) development initiatives (ii) technology and (iii) policy reforms in agriculture is needed to double farmer's income.

- The rates of increase in sources underlying growth in output need to be accelerated by 33 per cent to meet the goal.
- The country need to increase use of quality seed, fertilizer and power supply to agriculture by 12.8, 4.4 and 7.6 per cent every year.
- Area under irrigation has to be expanded by 1.78 million hectare and area under double cropping should be increased by 1.85 million hectare every year.
- Besides, area under fruits and vegetables is required to increase by 5 per cent each year.
- In the case of livestock, improvement in herd quality, better feed, increase in artificial insemination, reduction in calving interval and lowering age at first calving are the potential sources of growth.

Research institutes should come out with technological breakthroughs for shifting production frontiers and raising efficiency in use of inputs. Evidence is growing about scope of agronomic practices like precision farming to raise production and income of farmers substantially. Similarly, modern machinery such as laser land leveller, precision seeder and planter and practices like SRI (system of rice intensification), direct seeded rice, zero tillage, raised bed plantation and ridge plantation allow technically highly efficient farming. However, these technologies developed by the public sector have very poor marketability. They require strong extension for the adoption by farmers. R&D institutions should also include in their packages grassroots level innovations and traditional practices which are resilient, sustainable and income enhancing.

Indian Council of Agricultural Research, Central Agricultural Universities and State Agricultural Universities should develop models of farming system for different types of socio-economic and bio physical settings combining all their technologies in a package with focus on farm income. This would involve combining technology and best practices covering production, protection and post-harvest value addition for each sub systems with other sub systems like crop sequences, crop mix, livestock, horticulture, forestry etc. Such shift requires interdisciplinary approach to develop on knowledge of all disciplines.

About one third of the increase in farmers' income is easily attainable through better price realization, efficient post harvest management, competitive value chains and adoption of allied activities. This requires comprehensive reforms in market, land lease and rising of trees on private land. Agriculture has suffered due to absence of modern capital and modern knowledge. There is a need to liberalize agriculture to attract responsible private investments in production and market. Similarly, Farmer's Produce Organizations (FPOs) and Farmer's Produce Companies (FPCs) can play big role in promoting small farm business. Ensuring minimum support prices (MSP) alone for farm produce through competitive market or government intervention will result in sizeable increase in farmer's income in many states.

Most of the development initiatives and policies for agriculture are implemented by the States. States invest much more than the outlay by the Centre on many developmental activities, like irrigation. Progress of various reforms related to market and land lease are also State subjects. Therefore, it is essential to mobilize States and UTs to own and achieve the goal of doubling farmer's income. If concerted and well coordinated efforts are made by the Centre and all the States and UTs, the Country can achieve the goal of doubling farmer's income by the year 2022.

4

# Integrated Aquaculture: A Tool for Enhancing input use efficiency, Food Security and Poverty Alleviation for farming community of Arunachal Pradesh

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Aquaculture is the farming of plants and animals in an aquatic environment being practiced by the human civilization since last 4000 years in some regions of the world. The production of fish, crustaceans and shellfish through aquaculture activities has grown massively in the mid 1980s. Globally, aquaculture has become the fastest growing food production sector involving different fish and shellfish species. Aquaculture could increase the availability of low-cost fish in local markets bringing poor households above poverty threshold levels relatively quickly. It is estimated that aquaculture provides 43% of all the fish consumed by humans today. Production from aquaculture has increased in the developing world, which now accounts for more than 80 percent of global aquaculture production. This tremendous growth has provided numerous opportunities for greater food security, improved livelihoods and reduced poverty. The production process in aquaculture is determined by biological, technological, economic and environmental factors. A number of criteria can be used to classify an aquaculture system. From the economic point of view, the most significant criterion is its intensity, that is, its division into intensive, semi-intensive or extensive forms of culture. Measures of intensity include stocking density, production-by-area, feeding regimes and input costs, while the most interesting feature is the degree of control within the production process. Integrated aquaculture is described in the Aquaculture glossary of the Food and Agriculture Organization of the United Nations as: aquaculture system sharing resources, water, feeds, management, etc., with other activities; commonly agricultural, agro-industrial, infrastructural (wastewaters, power stations and so on). According to FAO integrated farming systems are described as: the use of output from one subsystem in an integrated farming system, which otherwise may have been wasted, as an input to another subsystem resulting in a greater efficiency of output of desired products from the land/water area under a farmer's control. Using inexpensive and simple techniques, aquaculture can supply more protein than normally produced through conventional agriculture such as diary, poultry, cattle rearing and even traditional fishing. This is more so, judging from high cost of inputs necessary for running of any of the farm of conventional agriculture.

Integrated aquaculture is a combination of aquatic organisms, such as fish, culture with other forms of agriculture such as piggery, duckery, cattle, poultry, crops plantation in such a way that either some of the by-products of this forms of agriculture that are considered as wastes can still be reused as direct/ indirect consumption by fish or the revenue from such agriculture can be used to run fish production successfully and as well increase the total profit of the producer. The goal of integrated aquaculture is embedded in its benefits such as: low operating and maintenance cost; multiple uses of land that would otherwise have been useless; increased revenue; saves feeding cost; efficient cash flow i.e. revenue from other agricultural practices can be readily available for use in enhancing fish production; continuous harvests of both plants and animal in the same piece of land which also ensures continuous cash flow and more profits; labour efficiency and effective monitoring since both fish and other plants/animals are within the same range. Risk management is another advantage and profitable aspect of farming multiple species: a diversified product portfolio will increase the resilience of the operation, for instance when facing changing prices for one of the farmed species or the accidental catastrophic destruction of another crop.

## Integrated Aquaculture as a Farming System

*Integrated Rice-Fish-Millet farming in Ziro*

In developing countries, population, income and urbanization all are increasing. As a consequence consumption of animal foods is also growing fast. By 2020 developing countries will be producing 60% of the world's meat and 52% of the world's milk. Aquatic food is an alternative animal protein source. It offers an excellent source of high quality and easily digestible protein. Aquaculture provides over 50% of total aquatic food production. Developing countries provide more than 90% of the global aquaculture production. Aquaculture can be integrated into many different farming systems via the use of multipurpose farm ponds and other water sources. Such farming systems are beneficial to the farmer for two main reasons:

i. Combining several production components decreases the risk element which agriculture entails. If one component fails, the other can provide the critical means for survival;

ii. The different components interact in a symbiotic and synergetic manner, enhancing overall production, optimizing resource use and thus providing for the subsistence needs of the household. Trees provide shade for crops and livestock while producing fruit; livestock manure is used as a fertilizer and crop by-products are fed to animals. The integrated fish farming system holds great promise and potential for augmenting production, betterment of rural economy and generation of employment.

## Benefits of adopting Integrated Farming System

1. Productivity enhancement/improvement of the system.
2. Net income/profit growth and fixed income.
3. Recycling of farm residues.
4. Increase in employment.
5. Balanced diet for farm family leading to nutritional security.
6. Pollution free environment.

There are varieties of integrated aquaculture practices, among them following are the suitable for prevalent situation of Arunachal Pradesh:

a. **Rice-Fish System:** Scientific rice-fish systems can ensure higher productivity, farm income and employment in these areas. The rice fields which retain water for a fairly long duration and free from flooding are generally suitable for rice-fish integration. Some modification of rice-fish plot is required to make the system more profitable. An approach was made by Krishi Vigyan Kendra East Siang to evaluate

*Rice-Fish Farming at East Siang*

the feasibility and economic viability of rice fish culture (RFC) by conducting trials in 8 different villages viz. Ngorlung, Niglok, Balek, Mirem, Sikatode, Ayeng, Rayang and Seren of East Siang district, Arunachal Pradesh during Kharif seasons of 2011 to 2014. In the multilocational trials on rizi-pisciculture survival rate of advanced fry was recorded between 44.5 % and 48.7 % with an average weight of 83 g to 91 g at the harvest. During the study period average total cost of cultivation of RFC and sole cropping of rice was calculated to be Rs 42,700 and Rs. 26,612 respectively. Average gross income and net income increased by Rs. 61,937 and Rs. 44,849 respectively by practicing RFC over the sole cropping of rice and it also raised the benefit-cost ratio of the system (2.61).

b. **Mushroom Cultivation in Conjunction with Aquaculture:** Mushrooms are fleshy fungi and are the most preferred food item. References to their consumption as food and even medicine are recorded

*Mushroom grower receiving Award*

in the classical religious writings (Vedas, Bible, etc). The first record of mushroom cultivation dates back during 1638-1715. Most early advances on the extensive mushroom cultivation were made particularly in different parts of Europe. Arunachallies preferred mushrooms in their diet they collect wild mushroom for the consumption purpose. But eating of wild mushroom sometimes leads to lethal effect to the consumer due to presences toxins in it. Being a source of most nutritious food scientific cultivation of the same may provide a good scope for possible job opportunities to many unemployed persons in the state. KVK East Siang along with AICRP on Mushroom at College of Horticulture and Forestry, CAU, Pasighat, Arunachal Pradesh is conducting capacity building programme of 01, 08 and 10 days for Farmers, Rural Youth and Extension Functionaries to scaling up area under mushroom cultivation in the district. Recently Mrs. O Sitang from Pasighat, Arunachal Pradesh has been awarded as best grower of mushroom in NEH region by DMR, Solan, Himachal Pradesh.

c. **Horticulture-Fish System:** The top, inner and outer dykes of ponds as well as adjoining areas can be best utilized for horticulture crops. These crops can easily be fertilized by the pond silt and fertile pond water during watering. The success of the system depends on the selection of crops. They should be of dwarf variety, less shady and evergreen. Seasonal highly remunerative dwarf variety of fruit bearing plants like mango,

*Integrated Horti-Fish Farming at Ruksin*

banana, papaya, coconut, lime etc can be grown around the pond. This will not obstruct the sunlight to the water bodies and also the pond will be free of dry leaves. Pineapple, ginger, turmeric, chilly can be grown as intercrops. Ponds dykes can also be used for growing vegetables solo as well as intercrops. During dry season, tomato, chilli, gourds, cucumber, melons, ladies finger etc can be cultivated while during wet season peas, beans, cabbage, cauliflower, carrot, beet, radish, turnip, spinach, ethic etc. can be raised. Flower bearing plants like tuberose, rose, jasmine, gladiolus, marigold, cassandea and chrysanthemum can also be cultivated on the pond dykes.

## Other aquaculture system suitable for the region includes:

a. **Duck-Fish integrated system:** Duck-fish integration is the most common integration in China, Hungary, Germany, Poland, Russia and some parts of India viz. West Bengal, Assam, Kerala, Tamil Nadu, Andhra Pradesh, Bihar, Orissa, Tripura and Karnataka. Most commonly used breed of Ducks for this system in India is the 'Indian runners'. It is highly profitable as it greatly

Duck-Fish Farming at Tabi village

enhances the animal protein production in terms of fish and duck per unit area. Ducks are known as living manuring machines. Besides manuring, ducks eradicate the unwanted insects, snails and their larvae which may be the vectors of fish pathogenic organisms and water-borne disease-causing organisms infecting human beings. Further, ducks also help in releasing nutrients from the soil of ponds, particularly when they agitate the shore areas of the pond. About 15-20 days old ducklings are generally selected for integration. It is better if the ducks are left in ponds only until they reach marketable size. The number of ducks may be between 240 to 300 birds per ha water area. For culturing fish with ducks, it is advisable to release fish fingerlings of more than 10 cm size; otherwise the ducks may feed on the fingerlings. As the nitrogen-rich duck manure enhances both phyto and zooplankton production, phytoplankton-feeding silver carp and zooplankton-feeding catla and common carp are ideal for duck-fish culture. The fish rearing period is generally kept as one year and under a stocking density of 10,000/ha, a fish production of 2,000-4,000 kg/ha/year can be obtained in duck-fish culture. In addition to this, eggs and duck-meat are also obtained in good quantity on an annual basis.

b. **Pig-Fish System:** China, Taiwan, Vietnam, Thailand, Malaysia and Hungary are the countries where pig-fish farming system is popular. The waste produced by 30-40 pigs is equivalent to 1.0 tone of ammonium sulphate. Exotic breeds such as White Yorkshire, Landrace and Hampshire are

Pig-Fish farming at Dipa village

reared in pig-sty near the fish pond. Depending on the size of the fish ponds and their manure requirements, such a system can either be built on the bund dividing two fish ponds or on the dry-side of the bund. Pig dung contains more than 70 per cent digestible feed for fish. The undigested solids present in the pig dung also serve as direct food source to tilapia and common carp. A density of 40 pigs has been found to be enough to fertilize a fish pond of one hectare area. Fish like grass carp, silver carp and common carp (1:2:1) are suitable for integration with pigs. Pigs attain slaughter maturity size (60-70 kg) within 6 months and give 6-12 piglets in every litter. Their age at first maturity ranges from 6-8 months. Fish attains marketable size in a year. Final harvesting is done after 12 months of rearing. It is seen that a fish production of 3,000 kg/ha could be achieved under a stocking density of 6,000 fish fingerlings/ha in a culture period of six months.

c. **Cattle-Fish System:** Manuring of fish pond by using cow dung is one of the common practice all-over the world. A healthy

Cattle unit at KVK East Siang

cow excretes over 4,000-5,000 kg dung, 3,500-4,000 lt urine on an annual basis.

Manuring with cow dung, which is rich in nutrients result in increase of natural food organism and bacteria in fishpond. A unit of 5-6 cows can provide adequate manure for 1.0 ha of pond. In addition to 9,000 kg of milk, about 3,000-4,000 kg fish/ha/year can also be harvested with such integration.

d. **Poultry-Fish System:** Poultry rearing for meat (broilers) or eggs (layers) can be integrated with fish culture to reduce costs of fertilizers and feeds in fish culture and maximize benefits. Poultry can be reared over or adjacent to the ponds and the poultry excreta recycled to fertilize

*Poultry-Fish farming at Vijoypur*

the fishponds. Poultry housing, when constructed above the water level using bamboo poles would fertilize fishponds directly. Birds are kept in confinement with no access to outside. Deep litter is well suited for this type of farming. About 6-8 cm thick layer prepared from chopped straw, dry leaves, saw dust or groundnut shell is sufficient. Poultry dung in the form of fully built up dip litter contains: 3% nitrogen, 2% phosphate and 2% potash, therefore it act as a good fertilizer which helps in producing fish feed i.e. phytoplankton & zooplankton in fish pond. So application of extra fertilizer to fish pond for raising fish is not needed. This cuts the cost of fish production by 60%. In one year 25-30 birds can produce 1.0 ton dip litter and based on that it is found that 500-600 birds are enough to fertilize 1.0 ha water spread area for good fish production. Daily at the rate of 50 kg per ha water spread area poultry dung is applied to the fish pond. When phytoplankton bloom is seen over the surface water of fish pond then application of poultry dung to the pond should immediately be suspended.

## Challenges and Future prospect of integrated farming system:

Most of the current integrated farms in Arunachal Pradesh are operated in the traditional way without proper planning, modern technology or modern farm management techniques and rely on personal experience. Marketing is therefore a recurrent problem except in years where demand is sufficient. Fish disease constitute a further major problem which the farmers cannot solve by themselves since they have inadequate experience and knowledge, and such knowledge is not as readily accessible as with other farm animals where feed manufacturers or veterinary supply companies offer services to assist farmers in many cases. A further problem for farmers is the shortage of credit and working capital, which forces them to sell their produce to middlemen, usually at unfavorable prices.

Main advantage of integrated farming is proper utilization of land resources and irrigation water as well as securing extra income and nutritional security. This system could be beneficial venture for optimum utilization of land and water resources especially for hilly terrain of Arunachal Pradesh. Moreover, it has the benefit of supplying rice as a source of carbohydrates and fish as a source of high quality protein. This aspect may be particularly relevant for the optimum resource utilization and providing nutrition security to tribal community of region. Adoption of this technique will open new avenues for self-employment, supplement the income of the farmers and enhance fish production in the region.

5

# INTEGRATION OF HORTICULTURAL CROPS IN INTEGRATED FARMING SYSTEM FOR INCREASING FARM INCOME IN ARUNACHAL PRADESH

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Arunachal Pradesh situated between latitude of 26$^0$ 30' to 29$^0$ 28' North and longitude of 91$^0$ 25' to 97$^0$ 24' East is the largest state area wise in North Eastern Region and blessed by nature with one of the richest flora and fauna on the earth. Due to its unique position in the Indian Sub-continent, the state has lot of climatic variations ranging from tropical to alpine. It has humid subtropical or nearly tropical plains which receives high rainfall, temperate climate as well as snow covered high mountains. In the mountains soils are fairly deep to very deep and well drained while alluvial in the plains, varying range of climate and soil condition, moderate temperature and plenty of rainfall are conducive for growing an array of horticultural crops. Harnessing these resources with proper location specific farming activities has comparative advantage in relation to the plains.

## Scope of Integration of Horticultural Crops in Farming System

In a hilly ecosystem with diverse climatic condition, there is tremendous scope for integration of horticultural crops in different farming system. An integrated system would ensure multiple production patterns in such a way as to maximize production of food, fodder and fuel. Agro forestry has been common in rural agro ecosystems in various agro climatic regions of India. These system aims at reducing the negative interaction and adding of positive interaction leading to high system efficiency with conserved land resources. Several crop combinations involving cereals, forest trees, horticultural crops, fodder trees, are practiced in agro-forestry, agro-horti, horti-silvi, agro-silvi-pastoral and horti-silvi-pastoral systems.

## Agro-horticultural system

This system is for those farmers who prefer mixed land use system. Agro-horticultural system is one of the important systems of where spaces between fruit crops are exploited for growing of cereals, pulses, vegetables, and forage crops to fed cattle etc. This system comprises agricultural land towards the foothills, horticulture in the mid portion of the hill scope and silvi pastoral land towards the top of the hill. Contour bunds, bench terraces, half moon terraces, grass water ways are some of the conservation measures require for treatment of land.

## Horti and Silvi Pastoral System

This system is an effective method to meet the multiple requirement of farming families. In this system, forests, horticultural crops, forage trees and pasture grasses are grown in the same piece of land. A large number of fruit crops, forest trees and pasture grasses are available which cause integrated in this system. However, care must be taken in selecting the plant so that crops should be adoptive to the region.

## Integration of horticultural crops in Arunachal Pradesh

A sense of permanent cultivation with integration of various horticultural crops are being built in Arunachal Pradesh with the changing demand in hilly ecosystem, Now, farmers are adopting horti-based farming system including various crops. Banana, pineapple and tapioca are being planted on the boundary of jhum field. Boundary crops check soil erosion and act as fencing. However, the success in the design of agro forestry systems lies handling interactions between components into the most advantageous forms. This is achieved through manipulation of biological and economic interactions through the proper choice of management practices are essential. It is worthwhile to examine the biological consequences of scheduling the operations of the highest availability, so as to reduce overall resource cost. The combined labour and capital cost per unit of production under a agro forestry system should be taken into consideration for this purpose. Other economic considerations are product diversification in a unit land to bring it to full potential, identify market demands and outlets for outputs, and optimize integrated land use capacity in both private and public land.

Such kind of horticulture based agroforestry system is also based on both biological and socioeconomic considerations. The biological aspect includes all the advantages of fruit and forest trees on the soil and environment, such as closed and efficient nutrient cycle, maintenance of organic matter, prevention of runoff. On the other hand the socio-economic factors that substantiate the potential value of this system are the mounting population pressure and lack of resources due to which the poor farmer are forced to utilize unproductive areas for food production and practice land management system that have disastrous consequences.

The system is considered to be an effective method to meet the multiple requirement of farming families by growing of fruit and vegetable crops, fast growing factor shrubs, trees in crops land and pastures, pastures under fruit and forest trees and vegetables as intercrops in tree plantations. If it is based on legumes, it rapidity builds up soil nitrogen and improved soil organic matter, soil structure and water infiltrations.

The horticulture-based agro-forestry system has the following advantages:

1. Horticulture based agro-forestry system has higher employment potential being more labour intensive, and provide a higher energy value per unit of cultivated area than cereals.
2. The system can help in the control of erosion of catchments areas which result in silting of the rivers.
3. Degraded land resource can be made productive by this system.
4. Intensification of monoculture of annual crops in rainfed areas accelerates run off and soil erosion and other degradation processing causing permanent damage to the ecosystem. Fruit trees, if suitably integrated with the farming system will conserve ecosystem and also provide nutrition fodder and fuel.
5. Drought hardly fruit tree component in a planting system provides insurance during drought years when annual crops fail or their production is highly impaired.

Based on the agro climatic condition of Arunachal Pradesh, the state has been divided into four horticultural zones as viz., Foot hills and valley (170-915 meters altitude), Mid hills (915-1803 m. altitude), High hills (above 1803 m. altitude), Rain shadow areas below 40 inches annual rainfall with wide range of chilling temperature.The major identified horticultural crops for the state are as follows :

## Fruits

Mandarin, Valencia has the unique potentialities in Arunachal Pradesh. It has already attained commercial importance. Pineapple and banana are some of the important fruit crop. Papaya, Jackfruit is extensively and traditionally grown at the low to foot hills of Arunachal Pradesh. Arunachal Pradesh has the potential of developing apple orchards in the rain shadow belts mainly in Kameng District where annual rainfall is around 900mm. Other temperate fruit crops like Kiwi, Persimmon have shown potential for large scale production. Besides Pear, Peach, Plum, Walnut are some of the potential temperate fruit crop in Arunachal Pradesh. Litchi is another potential crop in foothills.

## Vegetables

Most of the vegetables belonging to solanaceous, cucurbitaceous, Leguminous, cole crops, root crops, leaf vegetables are grown in Arunachal Pradesh. However, important vegetables grown in Arunachal Pradesh are brinjal, chilli, pumpkin, beans, leaf vegetables, colocasia, ash gourd etc. and wide range of Solanum species found in the state. A number of dioscoria species were also available. The state has a major share in production of ginger. There is wide scope for increasing the area under organic ginger and turmeric in the state.

## Floriculture crops

Floriculture industry has immense potential as it has an ideal climate and commands, the advantage of both tropical and temperate climatic conditions for growing variety of floricultural crops especially orchid round the year. There is need to create awareness amongst farmers educated unemployed youth and women to take up floriculture. Once the floriculture industry take root in the state there are other supportive and subsidiary industry like pottery, bamboo, cane, packaging material, transport etc. need to be strengthened providing employment to youths. Besides orchids, anthurium, gerbera is grown in some pockets in the state.

## Medicinal and Aromatic plants

Arunachal Pradesh is one of the important habitat for growing a lot of medicinal and aromatic plants. Medicinal plants constitute an important group among economic plants which are commonly used in treating and preventing specific ailments and diseases and generally considers to play a beneficial role in health care. Arunachal Pradesh with its rich diversified flora of medicinal plants capable of producing most of the important plants used in modern as well as traditional system of medicine. Pachouli, citronella and a number of native species available naturally for commercial exploitation.

## Conclusions

Integrated farming system with integration of horticultural crops can play a major role in the synthesis of sustainable farming systems for economic prosperity of farmers in Arunachal Pradesh. Considering agro-climatic condition, there is wide potentialities exists for achieving higher economic growth and creating job opportunities in this sector. Efforts should be made to formulate location specific programmes taking into account of agronomic, climatic, socio-economic practices as well as resource worthiness of the farmer in the state.

# 6 Climate Smart Agriculture-Saving Water and Energy through Micro-Irrigation

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Agriculture in India presently accounts for about 14% of the Gross Domestic Product (GDP) and 11% of total exports (Sharma, 2007; Ministry of Agriculture, 2013). Currently almost 46% of India's geographical area is under agriculture. A large percentage of this land falls in rain-fed regions generating 55% of the country's agricultural output, providing food to 40% of the nation's population (Planning Commission, 2012). More than 80% of the farmers are smallholder producers, with very poor capacity and resources to deal with the vagaries of weather and changes in climate. The food security of these people is always a challenge in front of India's developing economy. FAO defines food security as the state in which "all people at all times have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active, healthy life' (FAO, 2002). Agriculture must meet the needs of present and future generations for its products and services, while ensuring profitability, environmental health, and social and economic equity (FAO 2013).

It is a paradox in the world economy that producers are malnourished and undernourished whereas the urban rich with purchase power waste the food. The poor distribution of food and disparity in purchase power of the people from the development countries are also responsible to bracket the rural community and small holders as the most vulnerable community in the face of climate change. The heat of climate change has already been felt in the world agriculture. The uncertainty of the weather is looming large over world economy. The most vulnerable community is the small holders inhabiting in the rainfed agro-ecosystem. Hence, making the small holder community climate resilient and shock proof is the priority of the global scientific community.

As the world economy is growing particularly the developing countries, the demand for food and meat is increasing exponentially. The water footprint associated with them is also increasing in the same proportion. By 2050 world will add 2 billions more mouths to eat which will compete for the same water and air available today. This increase of population will be mainly in Asia and Africa which are also considered to be most vulnerable to the impact of climate change. IPCC in its 4th report (2007) indicated that the tropical and sub-tropical region will face reduced productivity and the temperate climate will experience with higher productivity with rise of global temperature.

## Effect of Climate Change on Water

Climate change has become inevitable component of nature. It is to considerable extent has been affected by human interventions that is not taken into account. The climate change scenario has triggered number of chain event such as increasing temperature, melting of ice and glacier, rise in sea level and variation in rainfall pattern. Likely impact of climate change will be enhanced annual variability leading intense floods and droughts. Due to simple reason of economic vulnerability of a country like India, where major area is under rainfed agriculture, is going to be affected more. Climate change is threatening the production stability and productivity. In many areas of the world, where productivity is already low, and the means to cope it is limited, climate change is expected to reduce productivity to even lower levels and makes production more erratic (Cline, 2007; Fisher et al. 2002; IPCC, 2007).

IPCC (2007), Ministry of Environment and Forest (2009) and Goswami et al. (2006) reported that Indian subcontinent is going to be affected largely due to change of rainfall (6-8% increase), higher temperature (2-4 0C), increased rain intensity (1-4 mm/d), decrease in rainy days (>15 days) and poor rainfall distribution. It was also predicted that crop yield might get reduced by 4.5-9% with the lowering of GDP by 1.5% (NICRA, 2007). Compounding to the problem of decreasing food production is associated reduction in water availability. As per data available the per capita water availability has reduced from 2309 m3 to 1902 m3 during 1991-2001. Further these are projected to reduce to 1401 and 1191 m3 by the year 2025 and 2050 (Kumar et al, 2005). As per the international norms the water availability at 1700 m3 is considered as water stressed and less than 1000 m3 is considered as water scarce.

These small holders in India are truly marginal in their endowment and vulnerable to the vagaries of the climate. These farmers are living on the edge with an uncertain climate. The small holders who find it difficult to adapt to the new paradigm will definitely be the first victims. They are vulnerable to any kind of shock which is not protected by traditional wisdom of their agricultural practices and knowledge. The present speed and intensity of the change of climate and the resultant volatility of the market, degraded natural resource base and food insecurity warrant shock proofing mechanisms in the agriculture which are suitable for small holder farms. Climate resilient agriculture is more important than the climate adaptive agriculture. In view of small holders needs, perhaps Low External Input Sustainable Agriculture (LEISA) technologies should be given more emphasis. Any water saving technology in the face of climate change has at least one solution to make the small holders resilient to vagaries.

All forms of life-human, animal and plants-relies on sufficient and dependable supply of water. In the past, the planning and distribution of water was dependant heavily on historical experiences as the climate had definite behaviour in the time lines. With the extra uncertainty introduced by the climate change scenario, they will be working with less predictable environment and will need to consider not only one outcome but a range of possible scenarios for which they will have to rank and compare the alternative in terms of risk and cost benefits (UNFCC, 2008).

## Climate Smart Agriculture

Climate-smart agriculture is a holistic concept. It unites numerous issues related to agricultural development and other global development objectives. It covers environmental issues, for example energy and water, as well as social issues, such as gender, and economic issues. Achieving the four dimensions of food security (availability and access to of food, utilization of food for adequate nutrition, and stability of food supply) needs to be the overall goal of food production and distributing systems in developing countries. Multiple components contribute to food security, and adapting food systems to climate change involves a diversity of approaches and resources (FAO, 2011c). Climate smart agriculture basically addresses the three issues: increase the sustainability of production, improves resilience of the production systems and reduces agricultural contribution to global warming. A cross-cutting development goal can be offered by the climate-smart agriculture. There are many opportunities for capturing synergies between the pillars of climate-smart agriculture, but also many situations where trade-offs are inevitable. However, climate smart agriculture needs to minimise the trade-offs and breaks the nexus among the production functions.

## Precision Farming

Precision farming is the title given to a method of crop and water management by which areas of land/crop within a field may be managed with different levels of inputs depending upon the yield potential of the crop in that particular area of land. It includes precision in use of quantity of inputs and timing of its application. The benefits of precision farming are tow folds:

i) The cost of production can be reduced
ii) The risk of environment pollution from the agro-chemicals applied at levels greater than those required by the crops can be reduced.

Precision farming is an integrated crop and water management system incorporating several technologies. The technological tools include: GPS, GIS, RS, Yield Monitoring and Variable Rate Technology.

National Research Council, Board on Agriculture Committee defined precision agriculture as “a management strategy that uses information technologies to bring data from multiple sources to bear on decisions associated with crop production” (NRC, 1997). The definition bring information technology to the centre stage of the precision farming but fails to express the premise of technological interventions needed to be integrated in precision farming. The term precision explains to the quality or state of being precise, where precise means minutely exact, a term synonymous with correct.

Precision agriculture is often put forward to integrate efficiency gains as an effective way of adapting to climate change, through dealing with mitigation (for example reduced GHG emissions and energy use arising from smaller applications and higher efficiency of nitrogen fertilizer use). However precision agriculture presumes energy sources on farm for machines and the availability of technological systems, such as GPS and GIS, which are supported by specialized agronomists and other farm advisers. Putting forward of the climate adaptive agriculture needs good ideas. Precision farming may be such a package which can be offered to the farmers and enable them to embrace it with the constraints and context of their world. In the context of small farmers' holdings, the application of GPS, GIS may not have much relevance. The automation of water application, use of decision support tools for variable rate application of water, fertilizers and pesticide may not find sufficient endowment with the farmers; however, variable rate application may be the pivotal philosophy of precision farming if it can be done based on location specific analysis of soils. Perhaps climate smart agriculture advocates the philosophy of exact application of water and nutrients based on the precise requirement of the plant at any particular location so that neither the crop suffers from shortage nor excess application leads to environmental pollution.

Crops do not require excess food. The nutritional requirement for any crop or variety is determined by the agronomist. A blanket application of such nutrition leads losses which can be minimised to the exact requirement through the package of precision farming. This may have short-term benefits in areas in which residual nitrates can be utilized by the crop and thereby prevented from leaching (Hergert et al., 1996). Reduction in pesticide inputs through variable rate applications can be particularly useful in patch spraying where significant portions of a field may not receive any pesticide treatment (Johnson et al., 1997). Reduction in irrigation water inputs in areas subject to leaching using variable rate irrigation. Minimizing or avoiding nutrient and pesticide additions where the potential for significant losses exist: This can be accomplished by varying nutrient or pesticide type, formulation, and rate according to soil conditions for erosion, leaching, runoff, and volatilization.

## Water and Energy Nexus

With growing population the demand for water and energy are set to increase dramatically due to increased incomes, changes in demographic patterns and changes in consumption pattern and lifestyles. This will lead to increasing stress on basic resources (i.e. water) for producing food and energy. The stress will endanger water, energy and food security, putting in jeopardy the development goals of improved human well being, economic development and poverty eradication (Kumar et al 2014). The improving efficiency is the demand of time to reduced the stress. As per various studies it has been reported that most of irrigation projects operate at efficiency less than 40 % on global and national level (Howell, 2001; Kusre et al., 2013). The low efficiency may be accounted for conveyance losses due to seepage, evaporation and non-beneficial use. The losses are also partly the result of poor on farm water management of water due to inadequate land preparation and lack of know-how of farmer in application of water, with consequent excess applications and deep percolation. According to a recent survey, 34 countries will face water scarcity by 2025 AD indicating that the per capita availability of fresh water supplies will be less than 1000 m3/person/year. The threshold renewable water availability on an annual per capita basis is about 1700 m3. A country, with a threshold value will suffer only occasional or local water problem. Below this threshold, countries begin to experience periodic or regular water stress. India (1400 m3/person/year) and China (1700 m3/person/year) will come into this category in the year 2025 AD. In India, it is estimated that the allocation of water for agriculture will be reduced to 71% from the present 85% in the next 15–20 years. (Sivanappan, 2014).

The competition between water and energy needs represents a critical business, security, and environmental issue, but has not yet received the attention that it merits. Energy production consumes significant amounts of water; providing water, in turn, consumes energy. In a world where water scarcity is a major and growing challenge, meeting future energy needs depends on water availability –and meeting water needs depends on wise energy policy decisions. Agriculture accounts for 70% of total global freshwater withdrawals, making it the largest user of water. Water is used for agricultural production, forestry and fishery, along the entire agri-food supply chain, and it is used to produce or transport energy in different forms (FAO 2011a). At the same time, the food production and supply chain consumes about 30% of total energy consumed globally (FAO 2011b). Similarly, growing bio-energy crops in an irrigated agriculture scheme may help improve energy supply and generate employment opportunities, but it may also result in increased competition for land and water resources with impacts on local food security.

Nexus interactions are complex and dynamic, and sectoral issues cannot be looked at in isolation from one another. Importantly, they exist within a wider context of transformational processes – or drivers of change-that need to be taken into account. The introduction of affordable groundwater pumps has transformed irrigated economies and now underpins the food security of countries, such as China, India and Pakistan.

In order to ensure the optimal management of trade-offs and the maximization of overall benefits, decision-making processes needs to be reflective and take into account the dynamic nature of complex systems. farmers' dependency on energy subsidies. At the same time, farmers are left with little choice but to pump water, as services by public irrigation agencies are often poor and unreliable.

## Saving Water and Energy through Micro-irrigation

It is important to break the nexus of water-energy-food somewhere for sustainability. No resource is unlimited and hence no plan of action can be based on infinite resources. Looking into the climate smart agriculture, which is based on the principle of sustainability with an aim of mitigation and adaptation of climate change, both conservation agriculture and micro irrigation can play a stellar role in saving water and energy. According to FAO conservation agriculture reduces water requirement of crops by about 30% lower energy needs by 70% and sequesters significant amount of carbon. On the other hand micro-irrigation, specially the small holders' low cost micro-irrigation gives a window to manoeuvre and break the nexus to an extent.

Water application through drip (or trickle), micro-sprinkler, micro-jet, bubbler, drip tapes, etc. are considered as micro-irrigation. Though there is no specific distinction to differentiate them from the conventional sprinkler irrigation, the discharge of any micro-irrigation can range from 2 lph to 200 lph, higher in case of micro-sprinklers. Micro-irrigation systems are also pressurised irrigation systems and need prime-mover to create pressure to convey and distribute the water. Drip irrigation generally works under a pressure head on 1 kg/cm2 or less which is equivalent to 10 m of water column.

Together China, India and Pakistan occupy about 70% irrigated area in the world whereas, only 30% area in the world is occupied by pressurised irrigation by these countries. Almost 60% of the rice grown area of these countries is irrigated where application of micro-irrigation is not possible. In spite of that China and India stand at 3rd and 4th position in the application of pressurised irrigation. India has only 0.59 Mha area under micro-irrigation out of 2.22 Mha of pressurised irrigation and 57 Mha of overall irrigated area (Kulkarni, et al., 2014). The statistics indicates that there is ample scope of increasing micro-irrigation area in India.

India has world's largest irrigated area and presently 57 million hectares (90 million ha harvested) are irrigated. About two-third of the area is irrigated by groundwater and one- third from surface water resources. The ultimate irrigation (harvested area) potential is estimated as 139 Mha without the 'River linking project' and 174 Mha upon its implementation. Present irrigation withdrawals are 534 km3 and are estimated to be 611 km3 in 2025 and 807 km3 by the year 2050 (Kulkarni, et al., 2014). In 1985 only 1000 ha were under drip/ micro irrigation, which rose to 35,000 ha in 1990, 152,930 ha in 1995, 350,850 ha in 2000, and about 500,000 ha by 2005. The Ministry of Agriculture has estimated an ultimate potential area (harvested) for micro and sprinkler irrigation as 27 million ha and 42.5 Mha, respectively. The Ministry has proposed to bring 17 million ha under pressurized irrigation in the country, comprising 12 Mha under micro irrigation and 5 Mha under sprinkler irrigation by the end of 11th Five Year Plan period (2007–2012). This is expected to result in an annual water savings of 58.6 billion cubic meters.

The beneficial impacts of drip and sprinkler irrigation in water-stressed regions have been widely studied in Israel, US and many other countries where commercial farmers have taken to it on a large scale. Even in India, several researchers have highlighted the benefits of the technology. The studies conducted by various institutions have revealed that the water saving in the MI method compared to surface irrigation is about 40–70% and increased yield up to 100% for some crops. In addition, the saline water can also be used in this system and the salt is accumulated only at the surface of the periphery of wetting zone and hence does not affect the crop growth. (Sivanappan, 2014). The yield of drip irrigated banana and grapes was estimated to be 52 and 23% higher compared to flood irrigation. Benefit-cost ratio of investment in micro-irrigation is estimated to be 13 without taking into account the value of water saved and 32 with water saving accounted for in the benefit-cost calculation. Net profit per hectare of micro-irrigation over conventional irrigation is `100,000 for grapes compared to `87,000 for banana crop. Unlike flood irrigation, drip irrigation works in undulating topography.

Farmers reported yield increases of roughly 50 to 100 % and decreases in water use of 40 to 80% compared to experiences with traditional surface irrigation systems. Table 2 shows the comparison of efficiency of various application methods. Micro irrigation system is very well suited for undulated terrain, shallow soils and water scarce areas. Saline/ brackish water can also be used to some extent, since water is applied daily, which keeps the salt stress at minimum and the salt will be pushed to the periphery of the moisture regime which is away from the root zone of the crop. Therefore, it does not affect the crop growth. The main advantages of micro irrigation as compared to gravity irrigation system are:

- Increased water use efficiency (90–95%);
- Higher yield (40–100%);
- Decreased tillage requirements;
- High quality products;
- Higher fertilizer use efficiency (30% saving in fertilizer);
- Less weed growth;
- All operations can be done at all times;
- Less labour requirements.

Besides these direct, private benefits to adopters several other benefits are enumerated as:

- It reduces soil erosion and nonpoint pollution because MI water percolates only to 45–60 cm;
- Fertilizers and pesticide residues do not mix with the water table;
- It ensures better and longer moisture retention in the root zone; and
- MI is a powerful instrument of drought proofing.

**Table 1: Water productivity gains from shifting to drip irrigation from surface irrigation (Sivanappan, 1994)**

| Crop | Change in Yield | Change in water use (%) | Change in water productivity |
|---|---|---|---|
| Banana | +52 | -45 | +173 |
| Cabbage | +2 | -60 | +150 |
| Cotton | +27 | -50 | +169 |
| Cotton | +25 | -60 | +255 |
| Grapes | +23 | -48 | +134 |
| Potato | +46 | -0 | +46 |
| Sugarcane | +20 | -30 | +70 |
| Sweet potato | +39 | -60 | +243 |
| Tomato | +50 | -39 | +14 |
| Tomato | +5 | -27 | +49 |

Table : 2 Comparison of efficiency of Drip and Sprinkler irrigation vis a vis surface irrigation system

| Sl No. | Irrigation efficiency | Methods of Irrigation | | |
|---|---|---|---|---|
| | | Surface | Sprinkler | Drip |
| 1. | Conveyance efficiency | 40-50 (canal)60-70 (well) | 100 | 100 |
| 2. | Application efficiency | 60-70 | 70-80 | 90 |
| 3. | Surface water moisture evaporation | 30-40 | 30-40 | 20-25 |
| | Overall efficiency | 30-35 | 50-60 | 80-90 |

**Source: Sivanappan (1998)**

In spite of all the advantages, micro-irrigation is spreading in India very slowly. It is primarily because of high capital cost, absent or inadequate subsidy, poor product quality and lack of awareness and knowledge of the farmer. IDE's MI program is a major breakthrough because it has down-sized, simplified and demystified the drip and sprinkler irrigation technology for targeting it to the ultra-poor.

The Low Head Small Holders'drip irrigation can be installed at low cost operates under low pressure and has the same technical advantages as conventional drip irrigation system. Commercially, now-a-days this kit is marketed for area from 25 m2 to 400 m2. An Israeli firm NETAFIM has developed gravity pressurized 'Family Drip Systems' which are marketed in China, India and Africa. As per the International Development Enterprise, India (IDEI), worldwide over 250,000 smallholders have adopted the low cost drip irrigation system covering about 50,000 ha. There are about 150 million rural poor families with smallholdings in India. During the last decade, over 100,000 smallholder farmers have adopted the low- cost drip systems. The IDEI envisages reaching 5 million farmers by 2020 in India.

Fertilization is an effective tool in precision farming. Application of required fertilizers to the crops through drip irrigation water is known as fertilization. It offers potential for more accurate and timely crop nutrition leading to increase in yield, quality of the products and early maturity of crops. In fertilization water and nutrients are applied in effective root zone simultaneously and ensures application uniformly. The draw backs in conventional method are volatilization, leaching and fixation get minimized. When using water soluble fertilizer with drip irrigation, it saves fertilizer dozes, time, labour, etc. It also minimizes soil deterioration. This results in substantial saving in quantity of fertilizers (30% to 50%). By combining liquid fertilizers with insecticides and herbicides, labour and machinery saving occur. It allows crops to be grown on marginal lands, such as sandy or rocky soils, where accurate control on water and fertilizers in the plant's root environment is critical. Since these fertilizers can be applied through drip irrigation through venturi or fertilizer tank or injection pump, the application becomes very simple and thus results in saving labour. Other benefits are:

- Higher water and fertilizer use efficiency and greater recovery of them and be achieved;
- Uniform nutrients application to all plants:
- Optimizing the nutritional balance by supplying nutrients directly into the root zone in readily available form;
- Better availability of nutrient especially P&K due to maintenance of proper moisture level;
- Improvement in Physico-chemical properties of soil.

Based on the study, it was found that the B.C. ratio for sugarcane with drip fertilization method was 2.66 compared to conventional (surface) method of 2.21. The water use efficiency was 180.85 kg/ha-mm with drip fertilization method compared to 59.53 kg/ha-mm for surface method (Sivanappan, 2014).

Small holders' drip irrigation systems do not need external energy. Keeping the water tank at 2 m height the system can be effectively run. A 200 litres tank can be easily filled manually. For bigger area, the pumping can also be done with the help of treadle pumps or other similar low head pumps.

Photo Voltaic Energy Pump of smaller capacity (up to 0.4 kW) can also be easily incorporated with such systems. Dependence on conventional energy source can be minimized in the irrigation process. Where ever possible wind energy operated pumps can also be used for filling up the water tank to run small holder drip irrigation systems. These small holders systems have gender benefits too. The women can operate the whole system without any effort. Technical knowhow is negligible. One should only examine the emitters' clogging time to time. The small holder family also owns the system psychologically.

## Conclusion

Climate Smart Agriculture has three pillars that are increasing the sustainability of production, improving resilience of the production systems and reducing agricultural contribution to global warming. Precision farming in the realm of climate smart agriculture has the objective to gain the sustainability by achieving the efficiencies of the inputs. Water and energy are two important inputs needed in the production process. Though in the context of small holders farms in India, other aspects of precision farming such as computer aided management, GIS and GPS may not find much relevance but the techniques like site specific nutrient management, variable rate technology, micro irrigation, etc. save both the materials and energy. The input like fresh water is going to be a scarce commodity on the other hand the demand for more food needs more water. The micro-irrigation techniques can reduce the trade-offs and reduce the extra pressure on energy and water. In the face of climate change, the precision irrigation, application fertilizers, use of photo voltaic pump will reduce tradeoffs between water and energy and will make the small holder much resilient to the vagaries of the climate.

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# 7 Rice Fish Rotation in Valley Districts of Manipur

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Manipur is located in the North Eastern Hill region of India that lies at an latitude of 23°83'N and 25°68'N and longitude of 93°03'E and 94°78'E having a total area of 22,347 square kilometers. It is a hill grit state where the hills constitute 92% area with various altitudes ranging from 2,000 to 3,000 meters above the mean sea level. Further, the state capital locates in the middle of the oval-shaped valley running from north to south encompassing approximate land area of 700 square miles (2,000 km2) surrounded by deep blue mountains on all sides at an elevation of 786 meters above the sea level.

The people of North-Eastern Hill Region depend on diverse agricultural practices ranging from a variety of shifting aquaculture systems, fallow systems, home gardens and sedentary systems, such as wet-rice cultivation. In North-Eastern Hill Region, the system of raising fish in the rice fields probably borne out from rice cultivation practice itself at water logged rice fields form natural habitat for wild fish and reportedly believed to have appeared first only as the simple capture device.

Manipur being a predominant agrarian state, the area of first crop/ pre-kharif/ spring rice (February- March to June-July) is decreasing due to many factors. The factors are non availability of suitable, preferred rice variety, lodging and sprouting of mature grains the existing rice variety during harvest due to rain, outyielding of only one proper main crop to the total of two crops i.e. first and second crops, meagre area of irrigated fields, expansion of Loktak and other major lakes due to Loktak Hydel Power Project, conversion of rice fields into fish ponds. Hence, the present study was carried out to improve or alter the existing practice of rice fish rotation of the farmers.

*A typical fish farm*

## METHODOLOGY

The study was carried out for three consecutive years in the valley districts of Manipur viz. Imphal East, Imphal West, Thoubal and Bishnupur districts. 20 numbers of fish farms with an area of 0.5 ha each were selected from the valley districts of Manipur. Study was conducted during the years 2014 to 2016 in the field of twenty farmers under refined System of Rice Intensification method (without ploughing, fertilizer or manure). After the harvest of fish in the month of February, rice nursery was raised. As the nursery was ready by 15-17 days (longer due to low temperature) the water from the farm is completely drained out and the soil bed is allowed to settle down. Plots were prepared and seedlings transplanted in the usual SRI manner. After the harvest of rice, fishes raised from the previous years in a separate nursery pond were stocked in the ratio of grass carp (500 nos.), silver carp (500 nos.), rohu (1000 nos.), mrigal (1000 nos.) and common carp (1000 nos.) during July month with the onset of monsoon. Rice variety: PAC 807 (A short duration hybrid of 120-125 days in spring) were used. Seed rate was 5Kg/ha and spacing was 25 x 25 cm. Beds/ plots were prepared on the naturally leveled pond beds. Transplanting of 15 days old seedling was done on the marks made by a roller marker as usual during March month (5th March). Weeding was done twice in the season firstly with a conoweeder followed by a hand weeding.

*Pond bed after harvesting fish*

*Pond bed after transplantation of rice*

*Transplanting of rice in SRI method*

*A view of transplanted rice*

*Rice in tillering stage*

*Rice at maturity*

## ADVANTAGES

The average Benefit Cost ratios for rice and fish are 2.51 and 2.60 respectively. This practice enabled the farmer to earn an average annual gross income of Rs. 3,48,850/ha giving rise to a B: C of 2.56. First crop/ pre-kharif/ spring rice (February, March – June, July) is dying down in Manipur due to many factors such as non-availability of suitable variety, susceptibility to lodging and sprouting because of rain during harvest, meager irrigated area, submergence of shallow lake areas due to Loktak Hydel Power Project, etc. One major factor for the main low land rice is low yield of first crop and the second one is due to improper land preparation due to lack of time. In fact, one proper crop of rice out yields the total of first and second crops which is very much disappointment of the farmer. Nowadays, shallow lake areas that were once good paddy fields have been conditionally converted into fish farms. In these fish farms, farmers are trying to harvest at least one crop of short duration rice. An improvement for the existing production system in these areas was expected to revive the ever decreasing trend of first crop. Fish production is approximately twice as high in rotational rice-fish farming systems. So, fish farming in the rice fields is officially promotes in National Aquaculture Development Plan in China. It is envisaged that a substantial amount of rice can be produced through integrated rice and fish culture system. In India, rice-fish farming is considered particularly suitable for the less productive rainfed areas. Successive government in the state are also focusing on sustainable rural development, food security, and poverty alleviation, rice-fish farming systems received a great deal of attention in the recent past. In some rice-fish culture systems, instead of concurrent rice-fish culture, rice plantation and fish culture are conducted alternately in the same field. Rice plantation and fish culture may be conducted alternately by crop or annually. Compared with concurrent rice-fish culture systems, rice and fish do not have a close symbiotic relationship in alternate farming systems. However, alternative rice plantation and fish culture are beneficial to each other in many aspects. Alternative rice-fish culture is relatively easy and does not require extensive earthwork to modify the structure of the field.

**Table 1. Benefit Cost ratios of Rice**

| Year | 2014 | 2015 | 2016 |
|---|---|---|---|
| Yield (MT/ha) | 9.42 | 9.58 | 9.62 |
| Gross return (Rs) | 65940 | 77325 | 87925 |
| Cost of cultivation (Rs) | 26530 | 30930 | 35170 |
| Net return (Rs) | 39410 | 46395 | 52755 |
| B:C | 2.49 | 2.50 | 2.56 |

**Average B: C = 2.51**

**Table 2. Benefit Cost ratios of fish**

| Year | 2014 | 2015 | 2016 |
|---|---|---|---|
| Yield ( Kg/ha) | 2438.8 | 2470.75 | 2436.42 |
| Gross return (Rs) | 275607 | 306715 | 332023.5 |
| Cost of production (Rs) | 104250 | 11574.5 | 131750 |
| Net return (Rs) | 171357 | 295140.5 | 200273.5 |
| B:C | 2.64 | 2.65 | 2.52 |

**Average B: C = 2.60**

**Pooled B: C for rice and fish = 2.56**

## CONCLUSION

From this study, we can draw a conclusion that in the shallow lake areas of Manipur where paddy fields have been converted into fish farms thereby reducing the area of rice fields, farmers can profitably take up the practice of rice fish rotation and as a result standard of living of these farmers can be improved as well as area of pre-kharif rice can be increased in Manipur.

# 8 Duck Farming for Rural Development

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More than 80 % of global poultry production is found in traditional family-based production systems which contribute up to 90 % of total poultry products in many countries. Family poultry system provides a renewable asset, a ready source of cash, quality nutrients in the human diet used to meet important social and cultural needs and obligations. Village ducks are active in pest control, weed control and also provide manure. Family based poultry / duck systems as an affective entry point for poverty alleviation programme is gaining widespread acceptance.

As per the statistical report available at the Basic Animal Husbandry Statistics, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture and Farmers Welfare, Government of India, the pattern of growth of duck population in North Eastern Region (NER) of India during 2007 to 2014 shows that the population of duck in Assam were highest amongst the NER states (8,439 and 7,311 thousand ducks respectively) followed by Tripura (756 and 743 thousand ducks respectively) and the population of ducks was lowest in Sikkim (1 thousand ducks in both the years). The duck population of NER was about one third (36 to 38 %) of national figure.

India is having tremendous potentiality in diversified agricultural practices as Indian agriculture is the backbone of its stable economy. Poultry is an important branch of animal husbandry practices which not only provide nutritional security to vast population, but contributes significantly to national GDP. Among various species of poultry, duck stands second to chicken in terms of production potentialities and farmer's acceptability. The coastal states of India have large number of water bodies either used for aquaculture or remain fallow. These water bodies are the rich

sources of duck feed which can be utilized for better economic return through integrated duck-fish farming. Duck based integrated farming with rice and fish has practiced effectively in Asian countries since centuries ago. Duck is a water fowl and water bodies are its natural habitat. Ducks can be reared in confinement by providing commercial feed , however, for small and marginal farmers it may not be always economically sustainable. Rearing ducks in village ponds with extensive management or with semi-intensive management is a viable and profitable practice for rural farmers.

## ADVANTAGES OF DUCK FRAMING

Ducks rank next to chicken for meat and egg production. Duck can be raised in both commercial and small scale meat or egg production purpose or in backyard with other birds or animals. Important advantages of duck farming are as follows:

Ducks need simple, less expensive and non-elaborate housing facilities.

Compared with chicken, ducks have comparatively shorter brooding period and ducklings grow faster.

Ducks are highly resistant to the common avian diseases.

Ducks have the natural tendency of foraging on aquatic weeds, algae, green legumes, fungi, earthworms, maggots, snails, various types of insects etc. and hence are economical to be raised as compared to chicken.

Six to ten ducks per 0.405 hectors of water surface can be used to free the water bodies from mosquito pupae and larvae.

Ducks lay well even in second year and hence longer profitable life compared with chicken.

The mortality rate of the ducks is less than chicken and usually ducks live longer than chicken.

Ducks can be trained to go to ponds and come back in the evening of their own.

## DUCK BREEDS /VARIETIES

- Khaki Campbell : Egg type, brown coloured small sized duck breed ( male 2.2 to 2.4 kgs and female 2 to 2.2 kgs kg ) with laying capacity of more than 300 eggs per bird. Egg size varies from 65 to 75 gms.
- White Pekin : Meat type, white coloured large sized fast growing duck. At 42 days of age, it attains about 2.2 to 2.5 kgs of body weight with a feed conversion ratio of 1: 2.3 to 2.7 kgs.
- Muscovy : Large bird ( male 4.5 to 6.4 kgs and female 2.2 to 3.1 kgs ) wild type , poor layer with black and white plumage, require less water. Produce quality meat and highly resistant to diseases.
- Crossed native ducks : They are produced by crossing between Khaki Campbell and indigenous ducks. They have multi-coloured plumage, medium in size, good layers ( 240 to 280 eggs ), hardy, good foragers and best suited for Indian coastal eco-system.

## RURAL DUCK PRODUCTION

Different forms of rural duck production are extensive, semi - intensive, or intensive. In extensive system the ducks are able acquire feed by scavenging from natural resources and there is minimal necessity to provide commercial feeds. A low cost duck house is required for night shelter along with brooding facilities.

***Duck house*** : Low cost duck house with floor space area of 2 - 2.5 ft$^2$ per bird may be constructed near the pond or any water body. For cross – ventilation at least two windows covered with wire nets should be there in opposite direction of the house.

***Brooding of ducklings*** : The floor of the brooding room should be covered with rice husk, wood shaving as litter material or with gunny bags which are to be changed for drying in every alternate day during brooding period. Feed and drinking water should be available to the ducklings under the brooder or hen. The duckings are easily chilled when they become wet while still in the down stage and hence the care should be taken that the ducklings should not enter into the waterer. Pans or troughs with water guards are satisfactory. Place waterers over low, wire – covered frames to help reduce wet litter problems. The waterers should be wide and deep enough for a bird to deep its bill and head. An electric bulb (200 watt) with reflector hanging at least 2 feet height from the floor may be provided so that the ducklings feel comfortable. Brooding period for all the breeds normally takes about 2 – 3 weeks. After brooding period, the ducklings are allowed to enter the pond. Care should be taken to prevent casualty or mortality due to predators.

***Growing of ducklings*** : After finishing brooding period, the ducklings can be exposed to the open space around the home and kitchen wastes are offered as feed. Chick mash can be given for another week as supplementary feed till the ducklings are able to collect their feed requirement from outside. Supplementary feeds like broken rice or wheat and other kitchen wastes may be provided for better growth during the period.

***Sex determination*** : At about four months female ducks sounds more as compared to male ducks. Tail feathers are prominently elevated in male ducks. Sometimes a ring like colouration in the neck is found in the male ducks specially in Khaki Campbell and Crossbred Native ducks. Drakes are comparatively heavier than female ducks.

***Laying period*** : Khaki Campbell and Crossbred native ducks lay egg at around 20 weeks of age. They usually lay eggs during the late night to early morning. During laying period provision of about 50-60 gms duck feed per bird per day may be helpful for better productivity. During afternoon hours broken rice, rice bran, little salt, calcium powder may be offered to female ducks for better egg production. Ponds provide supplementary food to the ducks. The averaged sized eggs weigh about 60 gms.

***Health management*** : Compared with chickens, ducks are less susceptible to diseases. Duck plague ( also known as Duck viral enteritis ) is a deathly disease of ducks reaching about 80-90 % mortality in flocks of all ages. Symptoms of individual birds include loss of appetite, decrease egg production, nasal discharge, increased thirst, diarrhea, ataxia, tremors and drooped – wing appearance. Swollen and protruding penis in males may also be observed. Vaccination with duck plague vaccine can protect the birds from Duck plague. The birds are vaccinated three times at 2nd week, 10th week and at 24th weeks of age. Thereafter the birds are to be vaccinated every 6 months. Ducks are very susceptible to alfatoxin content of the feed and shows paralytic symptoms with poor health conditions. Ducklings are more susceptible.

## DUCK BASED INTEGRATED FARMING

The integration of rice and duck farming was practiced in some East Asian countries, particularly Japan, Korea, Vietnam, China and Indonesia. The system was adopted by the farmers of these countries as one of the means of organic farming where weeds and insects could be effectively controlled by the ducks.

Integrating duck in rice farming have been proven to increase 20% higher yield with about 50% higher net return. Not only rice production but also subsidiary products like meat and eggs can be used in the same cultivation area. Through control of weeds and insects ducks reduces labour inputs. Not only economic benefits, rice and duck integrated farming is specially environmental friendly. The application of synthetic fertilizers and pesticides can be reduced thereby improving soil quality and pest control. In times of calamities this technology provide higher food security to small farming households and on long term basis the contribution to reduce the emission of the greenhouse gas methane emission, ultimately contributing to alleviate global warming. Hence, integration of duck in lowland rice production is recommended as climate adaptation and mitigation option.

Duck – fish integrated farming is a common type of integrated farming between fish culture and duck farming. The mutual need of fish and duck for water in addition to other considerations and benefits is the basis for this integration. The duck – fish production system can generate a much higher income than traditional agricultural activities, such as , sole fish farming or poultry farming. Duck-fish production will face stronger pressure from other business in competition for resources in peri-urban areas.

## DUCK PRODUCTION OF SMALL SCALE FARMERS

In developing Asian countries small scale duck production substantially contributes to household food security, helps diversify incomes, and serves as a renewable asset in many rural households. Poor access to appropriate technologies and information as well as lack of market and support services are the problems for small – scale duck production. If these problems are minimized, there will be improved productivity, increase income and sustainable duck production systems.

Ducks are well resistant to a variety of poultry diseases and ducks easily adapt to various adverse environments. Ducks require less manpower for their management and they can grow well with locally available feeds. Even women and aged people can manage ducks with less equipped facilities.

In order to make small scale duck production sustainable the use of better breeds and management of health and local feed resources along with introduction of appropriate new technologies must be encouraged. There is a great potential for duck farming as a commercial entity for small – scale farmers, with the right programme and policy support from the government and private enterprises. To support more intensive farming system modern technologies are required to support more intensive farming system in order to be attractive to farmers. For sustainability and competiveness of small scale duck production, development of commercial strains, feeding strategy, and institutional innovations must be intensified, and regulations and standards must be implemented.

Availability of quality ducklings, high cost of feed inputs, threat of avian flu, and shrinking of agricultural lands are the problems of the farmers which need immediate attention from the government and the private sectors. Organization of farmers into self help groups, and cooperatives to facilitate efficient management, technology diffusion, supply management, and improved production and market are the development strategies to improve small - scale duck production.

## OPPORTUNITIES

**Potential for high growth and opportunity for increased income :** Indigenous duck breeds are used in traditional duck rearing method and no supplementary feed is provided leaving the ducks to fend by scavenging in the areas surrounding the farm houses. High yielding breeds of ducks fed with balanced feed will lay about 220 to 300 eggs per year and this will increase the income of the duck producers.

**Demand-Supply gap :** Rural poultry accounts for 70 % of Indian population. Per capita consumption of rural people is 15 eggs and 0.15 kg poultry meat which are far behind from the ICMR recommendation of 180 eggs and 11 kg of meat. To ensure the availability of egg and poultry / duck meat for the rural masses revival of rural poultry / duck production utilizing modern scientific approach is highly essential.

**Easy to enter the business :** It is easy to start the business of duck rearing with a small investment at the household level with 5 to 10 ducks. The required inputs which include ducklings or hatching eggs, a hen for hatching and a small cage or box for keeping the ducks are available locally at a minimal cost.

**Gender issues :** In the backyard duck farming system, women have the biggest role in taking care of the ducks, sometimes with the involvement of children. In case of commercial duck farming, men are more involved as the nature of farming requires the farmers to stay and move outside their house.

## CONSTRAINTS

Some of the constraints faced by the duck farmers in the growth of farming enterprises include the following :

**High interest rates of microcredit providers / local money lenders :** Despite the abundant natural feed and scavenging farming system, capital investment is required to purchase ducklings, pullets or laying ducks, drugs, vaccines etc. Capital is also required for hatching purposes to produce ducklings. Local money lenders lend money for short time at a very higher interest rate.

**Duck Healthcare :** Due to farmer's lack of knowledge of management, prevention and control of duck diseases there may be disease outbreak and high mortality rates and thus lowering household income. Unavailability of required vaccines at proper / right time may result in difficulty in control of duck diseases.

**Lack of knowledge of duck farming :** Duck farmers do not have proper knowledge of the requirement of balanced diet for ducks which would increase the productivity of their flock.

**Lack of communication :** Lack of proper communication in north eastern region of India hinders the development of duck farming due to problems in transportation of feed, ducklings, medicines, vaccines etc.

**Non availability of ducklings :** It is a problem to get improved duck varieties in north eastern region and farmers are dependent in indigenous type of ducks.

## SUGGESTIONS

Value chain development ( Forward and Backward Linkage) for duck farming could be an effective way of supporting pro poor development. Backward linkages support includes supply of ducklings and pullet ducks, feed supply, vaccine supply and technical or duck health care services. Forward linkages support includes the marketing of farm products like eggs and live birds for meat purposes. Elimination of middlemen's role in the local market will result in a positive impact on duck farming value chain.

Availability of duck vaccines should be regular and in time. Private agencies and Government organizations should coordinate for regular availability of duck vaccines in the larger interest of the poor farmers.

Providing training and awareness programme regarding duck farming will help to increase the productivity of the ducks and thereby the profit of the farmers.

Research and identification of various varieties of snails and large scale multiplication of useful varieties will help in supplementing protein source to the ducks.

Duckweed (*Wolfia arriza*) culture : In areas where there is problem of animal and protein sources, duckweed will be very helpful. It contains 15-45 % protein and can represent an important alternative source of protein in poultry / duck feeds where soybean or fishmeal is unavailable.

Systematic research on indigenous / desi ducks and to develop suitable crosses with exotic varieties which are well adapted to the local climatic conditions.

## CONCLUSION

Encouragement of duck farming in rural areas will help in bridging the gap of demand and supply of poultry meat and eggs. This can also results in an improvement of livelihoods, employment generation and ensure food security. Integrated duck based farming will help in organic food production.

# 9 Role of Garo Women in Integrated Farming System for Doubling the Farm Income

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The issue of doubling farm income and its modality to achieve the target have become a challenging issue for the agriculturists in the country. It becomes more pertinent in respect to North-eastern region of the country due to its present subsistent nature of farming. It provides an ample scope to double the farm income by raising the farm productivity and adoption of some of the farm income enhancement measures; probably under the broad umbrella of Integrated Farming System (IFS). But, the blanket application of IFS and its different modules for the north-eastern region will not serve the purpose due to unique nature of agricultural system in the region and the state of Meghalaya is also no exception.

Integrated farming is a commonly and broadly used word to explain a more integrated approach to farming as compared to existing monoculture approaches. It refers to agricultural systems that integrate livestock and crop production. Integrated Farming System (IFS) has revolutionised conventional farming of livestock, aquaculture, horticulture, agro-industry and allied activities. It could be crop-fish integration, livestock-fish integration or combination of crop, livestock, fish and other enterprises.

The integrated farming system approach introduces a change in the farming techniques for maximum production in the cropping pattern and takes care of optimal utilization of resources. The farm wastes are better recycled for productive purposes in the integrated system. A judicious mix of agricultural enterprises like dairy, poultry, piggery, fishery, sericulture etc. suited to the given agro-climatic conditions and socio-economic status of the farmers would bring prosperity in the farming. An integrated farming system allows us to use some of the advantages of nature, and ecology, as opposed to relying on chemistry to solve all our production issues.

The research studies in Integrated Faming System envisaged the following advantages;

- Integration of allied activities will result in the availability of nutritious food enriched with protein, carbohydrates, fat, minerals and vitamins
- Integrated farming will help in environmental protection through effective recycling of waste from animal activities like piggery, poultry etc.
- IFS provide an opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises.
- Provides flow of money to the farmers round the year.
- Combining crop with livestock enterprises would increase the labour requirement significantly and would help in reducing the problems of underemployment to a great extent.
- IFS provide enough scope to employ family labour round the year.
- Animals play a multiple role in the functioning of the farm it can be converted into prompt cash in times of need.
- Helps in the sustainability of small holder family farming production system.
- Besides sustainability it also provides food security to the farmers.
- Animals play key and multiple roles in the functioning of the farm, and not only because

they provide livestock products (meat, milk, eggs etc.) or can be converted into prompt cash in times of need. Animals transform plant energy into useful work animal power is used for ploughing, transport and in activities such as milling, logging, road construction, marketing and water lifting for irrigation.

The state of Meghalaya has predominantly an agrarian economy with a significant commercial forest product based industry. The people of Meghalaya believe in traditional agricultural system. The traditional agricultural systems help in improving soil fertility through decomposition of plant material left on soil. Meghalaya is a predominantly agrarian state where about 80% of its population depends on agriculture for livelihood. Rice is the main food grain crop, complemented by other like maize, wheat and a minority share of pulses. Oil-seed crops like rape and mustard are also grown. Fibre crops like cotton, jute and mesta are the traditional cash crops. The climate of Meghalaya also permits a large variety of horticultural crops including spices, mushrooms, fruits, vegetables, flowers and medicinal plants. Spices include ginger, black pepper, the notoriously hot chilli variety *Bhut Jolokia* along with other chilli varieties, bay leaf and the acclaimed *Lakadong* variety of turmeric. Sub-tropical fruits include banana, pineapple, jack-fruit, guava, citrus fruits, and papaya. Other fruits grown in Khasi Hills are peaches, plums, strawberry and pears. Some of the plantation crops like cashew nut, areca nut, rubber, tea are other major crops grown.

The service sector is made up of real estate and insurance companies. Meghalaya's gross state domestic product for 2012 was estimated at Rs.16,173 crore in current prices. The state is geologically rich in minerals, but it has no significant industries. The state has about 1,170 km of national highways. It is also a major logistical centre for trade with Bangladesh. (Statistical Handbook, Govt of Meghalaya, 2012)

## FARMING SYSTEM IN MEGHALAYA

The ethnic communities of Meghalaya follow two major types of agricultural practices such as shifting cultivation or slash and burn agriculture and terrace cultivation. In the lower elevation and plain areas, settled cultivation is also in practice. Shifting cultivation is practiced in and around forests, and terrace cropping is practiced in valleys and foothills, and inside plantation forests.

These traditional systems of cultivation practices are well adapted to the environmental conditions and the traditional knowledge of indigenous communities growing cereals and other agricultural crops have enabled them to maintain an ecological balance. Enormous increases in human population have led to massive coverage of land under shifting cultivation is a matter of concern on sustainable development point of view. Besides shifting cultivation and terrace farming, there are some other potential indigenous farming systems in northeast India developed by the tribal farmers using their ingenuity and skill. These techniques and systems have a sustainable agriculture base and are practiced since centuries in some isolated pockets of Meghalaya and other north-eastern states. These farming systems make use of locally available resources and there is need of an in-depth study to know the secrets of their success.

## INTEGRATED FARMING SYSTEM IN MEGHALAYA

Though various crops are being commercially and scientifically cultivated in various pockets of Meghalaya, IFS is being encouraged to be taken up by the farmers as this system will bring better productivity as well as sustainability. IFS generate employment for the household members as combining crops with livestock enterprises would increase the labour requirement significantly which will help in reducing the problems of under employment to a great extent and lead to increase in farm income. This provides enough scope to employ female labours round the year. In addition to employment it also provides flow of money to the famers round the year. Since Meghalaya has a hilly topography selected integrated farming system suitable particularly for the region can be adopted. The following integrated farming systems suitable particularly for the region are;

Integrated Fish cum Pig Farming

Pig husbandry Practices

Integrated Fish cum Duck Farming

Duck rearing

Integrated Chicken –Fish Farming

Integrated Fish Farming cum Cattle Farming

Integrated Fish Farming cum Rabbit Fanning

Integrated Fish Farming cum Agriculture-

i) Fish farming –cum- Horticulture farming

ii) Fish farming –cum-Vegetable farming

But, the present approaches of implementing and popularizing of Integrated Farming System and less importance in gender sensitization restricts its growth and prosperity. Thus, it is high time to address the issue of gender role in Integrated Farming System as involvement and importance of women in farming is well acknowledged by the researchers and agriculturist throughout the globe. Agriculture is the backbone of the Indian economy. Women play a vital role in building this economy. Their activities typically include producing agricultural crops, rearing animals; processing and preparing of food. The role of Garo women in farm activities should also be put under scanner and their contribution in farming also be explored.

## ROLE OF GARO WOMEN IN AGRICULTURE, ANIMAL HUSBANDRY AND FISHERY

The role of Garo women in farm activities are pointed out in the following heads;

### AGRICULTURE

1. They do weeding, transplanting and harvesting of paddy.
2. They use to collect roots, tubers, edible plants, fire wood from the forest etc.
3. Storing of the seeds.
4. In the paddy fields women generally take part in sowing seeds, uprooting seedling from seed beds and transplanting.
5. Fertilize application can be done by women.
6. Plant protection.
7. Threshing and post harvest practices

### ANIMAL HUSBANDRY

Women play an important role in animal husbandry activities as

1. Manager
2. Decision makers
3. Skill workers
4. They help in farm operation by taking their animals for grazing.
5. Look after the sale of milk.
6. Helps in collecting feeds.

### FISHERIES

The women plays important role in fishery activities

1. The task of looking after pond and preparing fish feed can be done by women.
2. The women perform preparatory work, fish processing and trade.
3. Women dry and make smoked fish and sell this in basket which they carry on their heads from village to village.
4. They are involved in net mending and preparation.
5. Sorting of fish.

## PROSPECTS FOR INVOLVEMENT OF GARO WOMEN IN INTEGRATED FARMING SYSTEM

- Women can play a significant role in IFS as they are involved in applying manure in the field and to feed the domestic animals. The work will be easier for them and they can utilize the one resource for other.
- Under the **Integrated Fish-cum-Pig Farming** the pig dung acts as excellent pond fertilizer and raises the biological productivity of the pond and consequently increases fish production. In Garo Hills, women do all most all the work in pig rearing but usually they do not know that piggery enhance fish production as well as their income. Fish and pork are the basic food requirements in kitchen. By doing this integrated farming they can reduce their family budget also. Some of the fishes feed directly on the pig excrete which contains 70 per cent digestible food for the fish which will give additional benefit. The pond water is used for cleaning the pigsties and for bathing the pigs. Here, the women can play an important role.
- Cleaning of the pigsties is generally done by the female members of the households. This generates employment for the female family labours._The uses of animal excrete as manure considerably reduces the cost of production and also eliminates the middle man interference in most inputs used.
- **Integrated Fish cum Duck Farming** is advantageous in many ways. The rural women in Garo Hills are habituated in duck rearing and manage most of the work related with it. The

Duck fertilizes the pond by their droppings and the droppings provide supplementary fish feed. Ducks get most of their total feed requirements from the pond in the form of aquatic weeds, insects, larvae, earthworms etc. The animal droppings or excrete acts as excellent fertilizers for the ponds which results in complete saving on pond fertilizers. It is a labour- saving method which gives advantage for family labours particularly the females to get employment round the year. Employment generation will improve the socio-economic status of the farmers and would bring prosperity in farming.

Thus, the issue of doubling the farm income in sustainable manner can be addressed through Integrated Farming System approach. But, neglecting the involvement and active participation of rural women in IFS will not result its output in its full potential. Moreover, it may restricts the income opportunities of family farming through Integrated Farming System approach and in the process, the mission of doubling the farm income will be at stake.

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# 10 Role of Livestock Sector in Augmenting Farmers Income in North-Eastern Hill Region

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Livestock production is important for the majority of farmers in developing countries especially for small farmers in more marginalized conditions where land cannot be used for other purposes. Livestock production and agriculture are intrinsically linked, each being dependent on the other, and both crucial for overall food security. Livestock sector is an important subsector of the agriculture of Indian economy. It forms an important livelihood activity for most of the farmers, supporting agriculture in the form of critical inputs, contributing to the health and nutrition of the household, supplementing incomes, offering employment opportunities, and finally being a dependable "bank on hooves" in times of need. It acts as a supplementary and complementary enterprise. According to NSS 68th Round (July 2011-June 2012) survey on Employment and Unemployment, 16.44 million workers as per usual status (Principal status plus subsidiaries status) were engaged in the activities of farming of animals, mixed farming, fishing and aquaculture.

The Northeast Hill (NEH) region of India is endowed with natural resources. A sizable section of the population in the region lives in economic and cultural isolation, and the poverty incidence among different states varies from state to state. Nearly 80 per cent of the population lives in the rural areas and the food insecurity is acute in the rural areas of the region. Agriculture is mostly traditional and productivity is low. About 95 per cent of the population is non-vegetarian and livestock rearing is an important enterprise embedded in the culture of the region. Livestock production is an integral part of crop farming and contributes substantially to household nutritional security and poverty alleviation through increased household incomes. Development of this sector will result in more balanced development of the rural economy and improvement in the economic status of poor people associated with livestock. The main agricultural activity of farmers in Northeast India is the mixed crop-livestock system characterized with low inputs and outputs. Livestock is an important component of mixed farming system due to preference of meat in the diets of people in the region. All the North-eastern states are highly dependent on imports to meet their demand for eggs, fish, meat and milk. There is an increasing demand for livestock products in the region. The Northeastern Council estimates that the Northeast region of India is deficient by nearly 50 percent in milk and 87 percent in eggs. It also projects that the requirements of these items will rise to 2.5 percent annually by 2020 (NE Vision-2020, GOI).This suggests that livestock rearing has been largely untapped and has the potential to improve the livelihoods among poor farmers in the region. India's latent power house, the NEH region is expected to position itself as the back office for the remaining states, however, the topography issues such as

- Hilly terrain and porous border
- Bad communications such as road and rail links
- Weak ICT infrastructure

## Livestock population

India has vast resource of livestock and poultry, which play a vital role in improving the socio-economic conditions of rural masses. There are about 300 million bovines, 65.07 million sheep, 135.2 million goats and about 10.3million pigs as per 19th Livestock Census in the country. The share of Gross Value Added of livestock sector to the Agriculture Sector (Crops, Forestry, Livestock and Fishing) has increased from 21.8% in 2011-12 to 25.7% in 2015-16 at Constant prices. At Current prices, the share has increased from 21.8% in 2011-12 to 25.8 % in 2015-16. Livestock in NEH region comprises of cattle (2982400), buffalo (138630), pig (2318320), goat (1689610), sheep (55340), Mithun (297290), Yak (18100) and poultry (16318300). Cattle accounts for about 7 % of the total cattle of the country while the share of pig is 40% to the total pigs. The state-wise livestock population has been shown in the Table-I. This region doesn't have any economically viable breeds of livestock except the indigenous bullock on which most of the agricultural operation depend. The indigenous cows are of low reproductive and productive quality. This region also has the largest number of non-descript animals in the country.

**Table 1: Total Number of Livestock and Poultry—20012—State-Wise (in Thousands)**

| States | Cattle | Buffalos | Sheep | Goats | Pigs | Horse & ponies | Yak | Mithun | Total Live-stock | Total Poultry |
|---|---|---|---|---|---|---|---|---|---|---|
| Arunachal Pradesh | 463.76 | 5.97 | 13.55 | 305.54 | 356.35 | 4.03 | 14.06 | 249 | 1412.67 | 2244.23 |
| Manipur | 263.84 | 66.37 | 11.46 | 65.16 | 277.22 | 1.1 | 0 | 10.13 | 695.77 | 2499.52 |
| Meghalaya | 896 | 22.06 | 20.1 | 473.07 | 543.38 | 2.31 | 0 | 0 | 1957.63 | 3400.03 |
| Mizoram | 34.57 | 5.17 0.65 | 0.65 | 22.21 | 245.24 | 0.72 | 0 | 3.29 | 311.86 | 1271.35 |
| Nagaland | 234.97 | 32.72 | 3.84 | 99.35 | 503.69 | 0.47 | 0 | 34.87 | 911.16 | 2178.47 |
| Sikkim | 140.47 | 0.7 | 2.63 | 113.36 | 29.91 | 511 | 4.04 | 0 | 802.12 | 451.97 |
| Tripura | 948.79 | 10.81 | 3.11 | 610.92 | 362.53 | 0.01 | 0 | 0 | 1936.18 | 4272.73 |
| Total NE | 2982.4 | 138.63 | 55.34 | 1689.61 | 2318.32 | 519.64 | 18.1 | 297.29 | 8027.39 | 16318.3 |
| All India | 190904.11 | 1108702.12 | 65069.19 | 135173.09 | 10293.70 | 624.73 | 76.66 | 298.26 | 512057.30 | 729209.32 |

*(Source : BAHS, 2017, DAHDF,MOA,GOI )*

## Livestock products:

The total milk production in NEH region was 532.93 tons during 2016-17 which accounted for only about 0.33 percent of total milk production of the country. The estimated total production of eggs in this region was 5719.28 lac numbers (2016-17) which accounts for only about 0.65% of total egg production of the country. The total meat production in the in NEH region was 179.19 thousand tones which is 2.43% of total meat production of the country. The per capita availability of milk and egg is far below than the recommended level suggested by ICMR (except Sikkim). This scenario remains stagnant for last five years.

**Table 2: Estimates of Milk, Egg and Meat Production - 2016-17- State Wise**

| Sl. No. | States | Milk (,000 tones) | Egg (lac nos.) | Meat (,000 tones) |
|---|---|---|---|---|
| 1 | Arunachal Pradesh | 52.53 | 495.21 | 20.47 |
| 3 | Manipur | 78.97 | 992.00 | 27.47 |
| 4 | Meghalaya | 83.96 | 1063.90 | 41.00 |
| 5 | Mizoram | 24.16 | 408.07 | 14.79 |
| 6 | Nagaland | 79.37 | 397.35 | 31.37 |
| 7 | Sikkim | 54.35 | 68.49 | 4.40 |
| 8 | Tripura | 159.59 | 2294.26 | 39.69 |
| 9 | NE India | 532.93 | 5719.28 | 179.19 |
| 10 | All India | 163693.67 | 881385.77 | 7385.61 |

*(Source : BAHS, 2017, DAHDF,MOA,GOI)*

**Table 3: Per capita availability of Milk and Egg-2013-14-State-wise**

| Sl. No. | States | Milk(Gm./Day) | Egg (no./year) |
|---|---|---|---|
| 1 | Arunachal Pradesh | 109 | 38 |
| 3 | Manipur | 75 | 34 |
| 4 | Meghalaya | 83 | 38 |
| 5 | Mizoram | 62 | 38 |
| 6 | Nagaland | 91 | 17 |
| 7 | Sikkim | 228 | 11 |
| 8 | Tripura | 114 | 60 |
| 10 | All India | 352 | 69 |

*(Source : BAHS, 2017, DAHDF,MOA,GOI)*

## Role of Livestock in enhancing Farmers Income and Poverty Alleviation

Approximately one –quarter of the global poor, of whom 2.8 billion live on less that US$2 per day, are livestock keepers. Livestock are one of the few means available to the poor for generating capital assets. Studies revealed that the poor the household, the greater the economic and social importance of livestock. The potential of livestock to reduce poverty is enormous. Roles of livestock keeping revolve around storing wealth, contributing to food and nutritional security, providing draught power, transport and manure, and serving traditional social functions. Livestock production provides a constant flow of income and reduces the vulnerability of agricultural production (Holmann et al., 2005). The contribution of livestock to the wider rural economy remains under-appreciated by all players in development, except farmers. This leads to the current absurd under-investment in the livestock sector as a whole, yet, for example, in India the dairy sector alone is the most valuable part of the whole agricultural sector, creating more value than all rice production.

Increasing income in urban areas is driving the demand for animal products, opening up new opportunities for poor farmers to make money. Even small improvements to feeding and healthcare in traditional low-input systems when combined with a market focus can make this happen. Ruminants have an amazing ability to convert crop residues and other unused vegetation into high value products. This can help poor families get out of poverty. There is also a growing body of evidence that the consumption of even small quantities of animal products – meat and milk being the most obvious – has a huge benefit on a child's development.

Although agriculture is the prime source of livelihood for a majority of rural population in the North-Eastern region (NER) of India, dependence on livestock as an alternative source of income is significant (Kumar, et al., 2007). About 82 per cent of the small holder s in NER rear livestock to supplement their livelihood. Landless comprise 19 per cent of the rural households in NER and are the most deprived group. Their share in total population of different livestock species ranged between 0 and 3 per cent. Small landholders (< 2ha) are a big deal in the NER with a share of 76 per cent in rural households. They possess nearly half of the arable land, about 88-90 per cent of all the livestock species. It implies that there are more income and employment opportunities for smallholders in the livestock production than in land-intensive crop production (Kumar, et al., 2007).

Apart from the importance of animal production to national economy, livestock play an important role in contributing to rural livelihood, employment and poverty relief. In mixed and integrated farming systems livestock contribute to both intensification and diversification of income. The majority of the NEH region poor is dependent on such systems. Livestock are capital assets for the rural poor. As a capital livestock yields returns in the form of meat, milk, egg, wool or hides/skins and indirectly through manure or draught power used in raising income from crops. Investment in livestock has very low transaction costs, once the first breeding female has been acquired, and mated, since flock or herd growth follows from reproduction. If an emergency arises, the animals may be sold to raise the needed money that act as a "Bank".

## Strategy for Development:

**a. Action Plan for Improvement of Genetic Resources:** The region requires one comprehensive breeding policy and its strict compliance. Effective artificial insemination services must be introduced at village level. Community rearing or rearing by experienced farmers of certified bull for natural breeding in remote areas. Unauthorized slaughtering / smuggling of productive animals through the international as well as inter-state borders must be prevented.

**b. Improvement of Indigenous species:** There is need of qualitative improvement of all indigenous species of livestock.

**c. Health Care:** The vaccine production facility in the region should be upgraded with PPP mode to ensure availability of biological throughout the region. As the region is geo-strategically placed and shares international borders, the infrastructure for disease surveillance should be strengthened.

**d. Feed & Fodder:** There is acute shortage of feeds and fodder in this region. Steps like fodder tree plantation under social forestry & steps for rejuvenation of other CPR, PPP mode for utilization of existing government fodder farms and available departmental land for commercial cultivation, market of fodder, formation of SHG for utilization of waste land, forest land in fringe areas, dry fodder treatments and silage production, ensuring supply of low cost motorized chaff cutter and other implements needed for efficient use of crop residues and supported as small scale industry, production and pre- flood storage of balanced feed block and supply of such feed block to flood affected areas both during and after the flood should be taken.

**e. Marketing:** To ensure good remuneration for the farmers, a sound marketing structure is very important. To strengthen the marketing of livestock and livestock products SHG or such groups for procurement and distribution should be formed. Application of IT based tools for milk weighing, testing and payment to producers at par with milk quality in the line of NDDB may be introduced. Strict laws should be enacted to prevent adulteration. Photo identity card to milk vendor should be introduced to help civil society organizations to ensure traceability in case of adulteration.

**f. Extension Strategy:** Extension efforts are required for ensuring improvement and continuation of livestock farming. One ideal farm with locally available resources should be established to train the farmers in each block. Attitudinal transformation amongst society in general and the younger generation of farming communities in particular for ensuring smooth succession of family business related to livestock sector. Community knowledge on livestock practices/ methods should be scientifically explored, documented and disseminated in local languages. Sustainable livestock farming, appropriate management of common property resources should be undertaken at village level. The region is infamous for lack of entrepreneurship. Entrepreneurship Development Programme (EDP) should be organized in collaboration with reputed national institutes for educated unemployed youth. The cooperative sector of the region is very weak and has little or no presence. Strategy should be taken for development of cooperative system so that the farmers could reap the benefits of "single window" system for their economic needs.

**g. Establishment of livestock product processing unit:** Livestock product processing unit like milk, meat, egg and there by-products for value addition should be established.

**h. Credit Inflow:** Farmers access to financial institution is very low and emphasis should be put to ensure more credit inflow at lower interest rate.

**i. Strengthening of ICT especially mobile phone technology:** Mobile communication technologies have become gradually more important in many parts of the world, especially in improving the delivery of information about agriculture (Munyua *et al,* 2008). These communication devices present several advantages such as portability, wide range of coverage and instantaneous two-way communications. Moreover, the availability of state-of-art technologies, which are now integrated into mobile phones, has further improved communication. Built-in global positioning systems (GPS), high-resolution digital cameras and short-length video recorders are exemplary embedded technologies. These advances facilitate the use of mobile phones for sending and receiving voice, text, image and video information (Munyua *et al,* 2008). Mangstl (2008) found that mobile telephony is regarded as the most successful ICT tool used in attempts to develop the global agricultural sector. It eliminate the time and distance barrier that get in the way of knowing the latest information on any particular livestock problem from any part of the world and can discuss with the best scientist / experts in the field. The whole region is mountainous and there less physical communication facilities. Reaching one village to another village takes time and money. Due to shortage of extension personnel in the state line departments Krishi Vigyan Kendras (KVKs), Agriculture Universities, it is not reaching the farming community personally. Therefore there is need to use the Information and Communication Technology (ICT) especially mobile technology to transfer livestock technologies quickly to the farmers. This also facilitates in brining the farmers and the subject matter specialists together in sharing the knowledge which was not possible in traditional extension service. Use of ICT's as an extension tool in knowledge management can exhibit multifaceted dimensions and multifarious roles for technology access.

Role of College of Veterinary Sciences and Animal Husbandry, Central Agricultural University, Selesih, Aizawl in augmenting the Farmers Income

The College has a well-planned program for Research, extension education and transfer of technologies related to animal health, production and value addition to the end users.

**Farmer's Associations/Clubs:** Farmers clubs, breeder clubs, Rural Poultry Resource Centres are opened by the College in the villages and regular monthly meetings and seminars for members of these associations are held.

**Village adoption**: The College has adopted 14 villages to enhance piggery production and 10 villages for backyard poultry production through societal development programme of Department of Biotechnology, GOI, New Delhi. Interventions resulted in improved productivity, reproductive fitness and reduced mortality/morbidity of the livestock and poultry. The College is implementing *Mera Goan Mera Gaurav* in 48 villages of the three districts of Mizoram. The Tribal Sub plan-Project of the College adopted 50 villages to develop socio-economic status of the people through livestock and poultry farming.

**Training/Vocational Trainings:** Trainings/ Workshops/vocational trainings of varying durations areorganized for professionals and livestock owners besides conducting seminars for dairy, piggery, goat, and poultry and quail farmers.

**Field outreach activities:** Various extension activities viz. Animal Health Camps, Free vaccination programme, Expert Lectures/Technical guidance/ Field days, Farmers Advisory Service, exhibitions, Dog shows and TV/Radio talks are regularly organized.

**Publications:** The College is regularly publishing Package of Practices for piggery, dairy poultry, goatery etc.

**Distance Education Certificate Course:** The College is offering distance education certificate program for piggery farmers in Mizo, Khasi, Manipuri and Adi languages for the farmers of NEH region from the year 2013-14. The course is of three months duration and certificates are given after successful completion of the course and 650 farmers have been awarded certificates after successful completion of the course.

**Societal Development Programmes**: The College is implanting Societal Development Projects on Backyard Poultry Farming and Piggery for rural women and farmers funded by Department of Biotechnology, Government of India. Through these novel projects models on Backyard poultry and Piggery are development so that it can be replicated in other parts of the NEH region by the line departments. It is estimated that a Backyard Poultry unit of 25 birds (20 female and 5 male) can generate income to the tune of Rs. 50,000/-, a one Sow unit can generate about Rs.45,000/ and with one Boar a farmer can earn up to Rs.20,000/-.

**Research and Development:** The College is actively engaged in location specific research and development in veterinary and animal husbandry sector. Till date the college has successfully Completed 52Intramural Research Projects, 07 Externally Funded Research Projects, 13 Intramural Research Projects and 15Externally Funded Research Project are going on.

**Krishi Vigyan Kendra (Farm Science Centre)** : To strengthen the extension activities, the Ministry of Agriculture, Government of India, New Delhi had sanctioned a Krishi Vigyan Kendra (Farm Science Centre) for Aizawl District (Mizoram) during the X-Five Year Plan at the College of Veterinary Sciences & Animal Husbandry, Selesih, Aizawl under the Central Agricultural University, Imphal. The Krishi Vigyan Kendra, that became functional during the financial year 2005-06, is a district level Institution committed to technology assessment, refinement and dissemination. The Krishi Vigyan Kendra, Aizawl is working under the administrative control of the College of Veterinary Sciences & AH, CAU, Selesih, Aizawl (Mizoram). The Centre is providing on-campus and off-campus training to farmers of Aizawl District on different aspects of Crop Husbandry, Animal Husbandry, Plant Protection, Organic Farming, Fish Farming, Integrated/Composite Farming system etc. On-farm demonstrations and training to Extension Workers of the Line Departments are other notable activities of the Centre.

**Agricultural Technology Information Centre (ATIC):** The College is having one ATIC located in the Extension Education Complex building along with the KVK. The centre provides need based information to the farmers on various aspects of farming.

## Conclusion

Livestock production is important for the majority of farmers in NEH region of the country especially for small farmers where land cannot be used for other purposes. Livestock production and agriculture are intrinsically linked, each being dependent on the other, and both crucial for overall food and nutritional security. Though the region is bestowed with natural resources, it is lagging behind in every aspect. A holistic approach is the need of the hour to develop this dwindling sector. The development of the livestock sector will help in augmenting the farmers' income thereby reducing poverty.

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# 11 Dairy as an Option towards Enhancing Farmers' Income in NE Hills: A Case Study of Meghalaya

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It has been a dream for every farmer in India to double their farm incomes. The time has gone when increasing output and food security were the only goals in agriculture. Increasing productivity does not always result in increasing their farm income, so strategies that explicitly identify the need of the farmers have to be found out. Years have passed; many governments have come and gone promising a bright future for the Indian farmers and still Indian farming community remains in distress condition. But time has come to rejoice as the prayers of millions of farmers have been answered when Prime Minister Narendra Modi said "I wish to double the income of farmers by 2022 when India will celebrate 75 years of its independence" while addressing farmers rally at Bareilly on 28 February 2016 (The Hindu, 2016). In this regard NITI Aayog also prepared a policy paper and suggested ways to achieve doubling farm income by 2022. A number of seminars, conferences, workshop, training programme etc. are being conducted by different government organizations to put light in this direction. The central idea behind this is to promote farmers' welfare, reduce agrarian distress and bring parity between income of farmers and those working in non-agricultural sector. The goal of doubling farmer's income has been labelled impossible and inevitable by some experts (The Economic Times, 2016). Now the challenge here is how to addresses this goal.

## How to address the goal of doubling farmers' income in North East Region (NER)?

Coming to NER, it looks more impossible to achieve such goal of increasing farmers' income within such short time period because the NER of India faces its own intrinsic limitations by default being a hill region. These includes geographical constraints, meagre use of fertilizers as the region is organic by default, lack of infrastructure, lack of marketing facility, lack of farm mechanization, etc. In such conditions an alternative to increasing farmers' income may require a different approach other than what is applicable in mainland India. So in this paper we will try to seek an answer to this. The focus is that it is the profit within a short run that matters in the end and not the income alone when the costs of inputs are increasing. Hence, a case of Meghalaya as a representative of North Eastern Hills (NEH) is taken in this study.

Meghalaya is one of the seven states of the North East Hill (NEH) region and is primarily an agrarian state. Though agriculture contributes a major share to the total state domestic product, livestock sector also plays no less role in increasing the income of the farmers as meat is preferably consumed by the people of the state in their daily diets. The consumption of milk is very low in this region yet the demand for milk is expected to increase due to increasing per capita income and changes in life style (Feroze *et al.,* 2011). So, enhancement of dairy sector may be of prime importance to meet the increasing demand for milk. About 30 % of the landless and 48% of marginal households keep livestock in the North Eastern Hill (NEH) region (NSSO, 2003). Livestock sector can also generate alternate livelihood to the marginal section of the society (Feroze *et al.,* 2011) and help in reducing poverty at household level (Rathod and Datta, 2013) through marketing of milk. The growth in both agriculture and livestock sector has varied widely across states within the NEH region. However, the inter-state growth in the livestock sector has been more equitable than the crop sector (Kumar *et al.*, 2007). This led to the question whether the farmers should go for crop cultivation or livestock rearing. The challenge for the farmers is to choose the best alternative of all the available alternatives that can enhance their incomes to double or at least near to double.

The study is based on reviews of earlier findings of research conducted in the School of Social Sciences (SSS), College of Post-Graduate Studies (CPGS), Umiam, Meghalaya. The finding of this study will help enable to address some of the challenges regarding enhancing of farmers' income to double or near to double.

## Status of Agriculture in Meghalaya

The total geographical area of this region is 18,375 thousand ha, which accounts for 5.50 per cent of total geographical area of India during 2012-13. The net sown area is 28569 ha in Meghalaya and 57226 ha are sown more than once (Table 1). Agricultural performance in the region remains sluggish on account of a number of factors. The status of agriculture in Meghalaya, alike other NEH states, is far behind than the plain lands of India but the government is trying to give a push to this sector through adoption of different strategies. The region is striving hard to attain food self-sufficiency and food security. Agriculture contributes 16.42 per cent to Meghalaya's Gross State Domestic Product (GSDP) at 2004-05 prices as in 2013-14 (Planning Commission, 2014) and provides employment to more than 65 per cent of the total workforce of the state. Agriculture in this region is subsistence in nature where livestock has its own role in the mixed farming system. Rice is the primary cereal crop of covering about 90% of the area under cultivation. The three districts in Garo hills are the major rice growing districts (Table 2). Maize, tomato, cabbage, pineapple, betel nut, areca nut etc. are the other major crops. Arecanut, maize and cashew nut are widely cultivated crops in West Garo hills district.

### Table 1. Meghalaya land use classification (2013-14)

| Districts | Area under Forest | Land not available for Cultivation | Other Un-Cultivated land excluding Fallow land | Fallow Land | Net Area Sown | Total | Area Sown more than once | Gross Cropped Area |
|---|---|---|---|---|---|---|---|---|
| Jaintia Hills | 154025 | 32706 | 131132 | 27357 | 36127 | 381347 | 417 | 36544 |
| East Khasi Hills | 106986 | 53655 | 65555 | 10755 | 37846 | 274797 | 11105 | 48951 |
| West Khasi Hills | 206513 | 75078 | 145161 | 66684 | 31238 | 524674 | 6854 | 38092 |
| Ri-Bhoi | 87089 | 33061 | 86946 | 15045 | 22299 | 244440 | 2925 | 25224 |
| East Garo Hills | 124535 | 11304 | 62146 | 25152 | 37053 | 260190 | 5294 | 42347 |
| West Garo Hills | 164766 | 22064 | 38896 | 45952 | 95647 | 367325 | 25357 | 121004 |
| South Garo Hills | 102283 | 11173 | 25398 | 24386 | 25647 | 1888689 | 5274 | 30723 |
| Total | 946197 | 239041 | 555234 | 215331 | 285659 | 2241462 | 57226 | 342885 |

(Source: Directorate of Economics & Statistics, Meghalaya, 2016)

### Table 2 Districts wise area under major crops cultivated in Meghalaya (ha)

| Crops | Ri-Bhoi | West Khasi Hills | East Khasi Hills | Jaintia Hills | East Garo Hills | West Garo Hills | South Garo Hills | Total |
|---|---|---|---|---|---|---|---|---|
| Rice | 9616 | 5843 | 7845 | 12165 | 17796 | 48229 | 8526 | 110020 |
| Maize | 1585 | 2093 | 4441 | 3203 | 1086 | 4628 | 1001 | 18037 |
| Pineapple | 3869 | 935 | 771 | 83 | 1369 | 3391 | 1174 | 11592 |
| Tea | 1525 | 98 | - | - | 99 | 723 | 16 | 2461 |
| Cashew nut | - | - | - | - | 332 | 5275 | 4135 | 9742 |
| Areca nut | 176 | 5061 | 1376 | 1912 | 2306 | 6098 | 369 | 17298 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Turmeric | 164 | 125 | 110 | 1553 | 135 | 534 | 108 | 2729 |
| Tomato | 186 | 608 | 46 | 900 | 158 | 213 | 84 | 1295 |
| Cabbage | 55 | 1051 | 101 | 126 | 199 | 249 | 81 | 1862 |
| Betel leaf | - | - | - | - | - | - | - | - |

(Source: Project report on cost of cultivation of ten major crops in Meghalaya, 2016)

Meghalaya is home for 1.96 m livestock which is 7.36 per cent of the total livestock of NE region and 3.57 m poultry which is 7.81 per cent of the total poultry population of the region (Livestock Census, 2012). Bovine population constitutes 49 per cent of total livestock population of Meghalaya. Pig and goat are the other major animals reared in Meghalaya with a share of 27 per cent and 21 per cent in the total livestock population of the state. Total bovine population of Meghalaya is 0.92 m which is 6.47 per cent of the total bovine population of NE region. About 59 per cent of the total cattle of the state are found in three districts of West Garo Hills (WGH), South West Garo Hills and East Khasi Hills (EKH) (Table 3). Meghalaya has second highest indigenous cows after Assam in NE region. Only three per cent of the cattle population is crossbred (CB) in the state in comparison to NE average of eight per cent. Buffalo population in Meghalaya is minimal with only two per cent of the NE buffalo population. Maximum of the buffaloes are reared in West Khasi Hills, South West Garo Hills and Ri-Bhoi districts.

**Table 3. District wise bovine population in Meghalaya**

| Sl. No. | District | Cattle | | Total Cattle | Buffalo | Total Bovine |
|---|---|---|---|---|---|---|
| | | Crossbred | Indigenous | | | |
| 1 | East Khasi Hills | 12807 | 69410 | 82217 | 1756 | 83973 |
| 2 | Ri-Bhoi | 9295 | 27614 | 36909 | 5043 | 41952 |
| 3 | West Khasi Hills | 498 | 95150 | 95648 | 5849 | 101497 |
| 4 | South West Khasi Hills | 331 | 25652 | 25983 | 202 | 26185 |
| 5 | East Jaintia Hills | 622 | 62981 | 63603 | 927 | 64530 |
| 6 | West Jaintia Hills | 663 | 33610 | 34273 | 1692 | 35965 |
| 7 | East Garo Hills | 196 | 66400 | 66596 | 8 | 66604 |
| 8 | North Garo Hills | 241 | 76379 | 76620 | 18 | 76638 |
| 9 | West Garo Hills | 1631 | 239283 | 240914 | 4233 | 245147 |
| 10 | South West Garo Hills | 134 | 113390 | 113524 | 5164 | 118688 |
| 11 | South Garo Hills | 40 | 69426 | 69466 | 2 | 69468 |
| | Meghalaya | 26458 | 879295 | 905753 | 24894 | 930647 |

(Source: Livestock Census, 2012)

**Table 4. District wise milk production in Meghalaya in 2011-12 ('000 tonnes)**

| Sl. No. | Districts | Cow | | | Buffalo | Total milk production |
|---|---|---|---|---|---|---|
| | | Indigenous | Crossbred | Total | | |
| 1 | East Khasi Hills | 1.33 | 19.94 | 21.27 | - | 21.38 |
| 2 | Ri-Bhoi | 3.07 | 20.65 | 23.72 | 0.46 | 24.18 |
| 3 | West Khasi Hills | 5.17 | 1.01 | 6.18 | 0.27 | 6.28 |
| 4 | Jaintia Hills | 4.21 | 2.63 | 6.84 | 0.20 | 7.02 |
| 5 | East Garo Hills | 6.06 | 0.12 | 6.18 | 0.18 | 6.16 |
| 6 | West Garo Hills | 9.18 | 3.68 | 12.86 | 0.88 | 13.57 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 7 | South Garo Hills | 1.33 | 0.10 | 1.43 | 0.01 | 1.40 |
| | Meghalaya | 30.35 | 48.13 | 78.48 | 2.00 | 80.48 |

(Source: GoM, 2014)

The total milk production of Meghalaya is 82.16 thousand tonnes in 2013-14 which is 6.60 per cent of the total milk production in NE states. Cow milk constitutes about 97.5 per cent of the total milk produced in the state (Table 4). Within the total cow milk CB contributed 61.95 per cent. About 74 per cent of the total cow milk is produced in the three districts of Ri-Bhoi, East Khasi Hills (EKH) and West Garo Hills (WGH) of Meghalaya. Milk production has increased from 63.80 thousand tonnes in TE ending 2001-02 to 80.77 thousand tonnes in 2013-14 which is an increase of 26.60 per cent. The per capita milk availability is 83 g/day during 2007-08 which is lower than the NE average of 94g/day and much lower than the Indian Council of Medical Research (ICMR) recommendation level of milk consumption of 220 g/day for a person. The average productivity of CB cattle in milk in Meghalaya is 7.33 kg/day/animal but the local cows and buffalo are low yielder *i.e.*, 0.34 and 0.96 kg/day/animal, respectively.

How profitable are the enterprises?

**Table 5. Returns from the major crops in Meghalaya (₹/ha)**

| Crops | District | | Net Returns | BC ratio |
|---|---|---|---|---|
| Rice | East Garo Hills | | 6408 | 1.10 |
| | West Garo Hills | | 8549 | 1.12 |
| | Ri-Bhoi | Transplanted rice | 6507 | 1.11 |
| | | Direct seeded rice | 19790 | 1.28 |
| | | *Jhum* | 36342 | 1.68 |
| Maize | West Garo Hills | | 10941 | 1.32 |
| | West Khasi Hills | | 11787 | 1.36 |
| Tomato | West Jaintia Hills | | 196712 | 1.86 |
| | East Khasi Hills | | 92833 | 1.46 |
| Cabbage | East Khasi Hills | | 98626 | 1.53 |
| | West Garo Hills | | 120134 | 1.79 |
| Turmeric | West Jaintia Hills | | 61896 | 1.39 |
| | South West Garo Hills | | 88975 | 1.78 |

(Source: Project report on cost of cultivation of ten major crops in Meghalaya, 2016 and Intra-Mural research project report on economics of rice cultivation and estimation of producer surplus of rice in Ri-Bhoi district of Meghalaya, 2014)

Return from the major crops cultivated in Meghalaya is presented in the Table 5 and Table 6. For rice crop, the net return is found to be highest in case of *jhum* cultivation (₹36342/ha) and the benefit cost ratio over total cost is about 1.68 which implies that the *jhum* rice, which is organic by practise, cultivation is an economically beneficial venture for the farmers of Ri-Bhoi district because of lower cost of cultivation as seed and labour are the only input costs. But the debate among the scientific and political community is on whether to continue *jhum* or not as it is believed that the soil quality is deteriorating due to reduced *jhum* cycle.

Further, among the major crops, the net return of tomato is found to be highest (₹196712) followed by cabbage (₹120134) and turmeric (₹88975) while the BC ratio was estimated 1.86 for tomato, 1.79 for cabbage and 1.78 for turmeric respectively. From the returns analysis, it is clear that crops like tomato, cabbage and turmeric is profitable among all the other crops but their net cultivated area is very small. Even though rice crop occupies the highest net cultivated area, it is estimated to have the lowest net return and BC ratio among all the crops.

## Table 6. Returns from major orchard crops (₹/ha)

| Crops | | Till 3rd year | 4th year | 5th year | 6th year | 7th year | 8th year | 9th year | 10th year | 11th year | 12th year |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tea | Net return | -62432 | -75848 | -56238 | -10908 | 42598 | 105761 | - | - | - | - |
| | BC ratio | 0.05 | 0.47 | 0.71 | 0.96 | 1.14 | 1.30 | - | - | - | - |
| Pineap-ple | Net return | -87042 | 52434 | - | - | - | - | - | - | - | - |
| | BC ratio | 0.17 | 1.27 | | | | | | | | |
| Betel leaf | Net return | -60321 | 90663 | 217692 | 356179 | - | - | - | - | - | - |
| | BC ratio | 0.38 | 1.27 | 1.56 | 1.79 | | | | | | |
| Cashew nut | Net return | -83712 | | -76178 | -57162 | -22573 | 29743 | 97751 | 180065 | - | - |
| | BC ratio | - | | 0.24 | 0.51 | 0.83 | 1.19 | 1.56 | 1.92 | | |
| Areca nut | Net return | -242486 | | | | -263254 | -255455 | -159767 | -17058 | 178808 | 453689 |
| | BC ratio | - | | | | 0.06 | 0.21 | 0.57 | 0.96 | 1.38 | 1.68 |

(Source: Project report on cost of cultivation of ten major crops in Meghalaya, 2016)

Return from the major orchard crops cultivated in Meghalaya is presented in Table 6. The BC ratio of cashew nut is found to be highest (1.92), followed by betel leaf (1.79) and areca nut (1.79). Even though the returns from these crops are high, it takes a long time to realise return from them. For instance the net return from cashew nut becomes positive ( ₹29743) from 8th years onwards. So, cashew nut is profitable from eighth year and afterwards it more or less benefit up to certain period of the crop life span. In order to realise return in the short run, it will be advisable to cultivate pineapple crop as it gives return sooner compared to other crops even though the BC ratio is the lowest. Thus, this all highlights the limitation of crop sectors in doubling the farm income in short run in the hill states.

## Table 7 Season wise returns from dairy

| Animal | Returns | Districts | | | | | |
|---|---|---|---|---|---|---|---|
| | | East Khasi Hills | | | Ri-Bhoi | | |
| | | Summer | Rainy | Winter | Summer | Rainy | Winter |
| Local cow | Net return (₹/animal/day) | -36.19 | -3.14 | -42.32 | -22.19 | -36.77 | -30.41 |
| | Net return per litre (`/L) | -30.16 | -2.05 | -42.75 | -21.34 | -7.72 | -23.22 |
| CB cow | Net return (₹/animal/day) | 155.08 | 166.91 | 146.42 | 150.37 | 124.54 | 150.73 |
| | Net return per litre (₹/L) | 16.93 | 18.18 | 18.16 | 17.18 | 18.22 | 17.24 |

(Source: Research project report on cost and returns in milk production: Developing standardised methodology and estimates for various production systems, 2015)

The return structures from dairy for local and crossbred cows are given in Table 7. The net return per local animal per day was estimated to be negative in all the seasons due to low productivity of the local animals which makes the enterprise non-profitable across season and districts. Unlike the local animal the net return from CB animals is found to be high. The net return per CB animal per day was estimated to be 18.22 in Ri-Bhoi and 18.18 in East Khasi Hills in rainy season which is the highest in both the districts throughout the whole season. This higher net return may be due to high price realization for milk and high productivity of CB animals. In addition to this, the gestation period to realise net positive return from dairy is least among all the enterprises and the return is regular. The two bright spots in dairy are high productivity of CB cows and high price realized from sale of milk by the farmers. Though the underdeveloped dairy production environment of Meghalaya is characterised on the basis of poor resource endowments, yet viability of milk marketing is not so poor.

## Final words

The agro-climatic condition in Meghalaya is favourable for the cultivation of different crops namely rice, maize, tomato, cabbage, turmeric, tea, pineapple, beetle leaf, cashew nut and areca nut. Though rice occupies the lion share of cultivable land in the state, but it does not have the potential to double the farmers' income. Comparatively vegetable cultivation in the state is profitable. The orchard crops which generate high income have long gestation periods. The local animals are reared mainly for meat purpose and it is subsidiary in nature while the CB animals yield very high returns and profitable in short as well as long run. Thus, rearing of CB animals for dairy purpose can be an option for the farmers of Meghalaya to enhance their income compared to cultivation of conventional crops. This will help in increasing the income, may or may not always be double in magnitude, but it at faster pace so as to meet the goal.

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# 12 Fish farming for doubling farmers' income and enhancing climate resilience

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The **North East region** of India comprises of eight states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Mizoram, Sikkim and Tripura. Seventy percent of the population of the region are dependent on agriculture and allied activities for livelihood. However, the region continues to be a net importer of all major food commodities including food grains, dairy, eggs, meat and fish for its own consumption. Poor returns from the agricultural sector leads to a clearly visible hesitation to pursue basic agriculture. Though at present India is mostly self-sufficient in food production, this will not be enough to feed the burgeoning population in the near future.Undoubtedly,achieving this through horizontal expansion of agriculture will lead to a big threatto climate and biodiversity. Notably, climate change is affecting both food driven human activities such as agriculture, animal husbandry and aquaculture as well as the natural ecosystem and associated livelihoods in an ever increasing manner (Figure 1). Doubling the income of farmers' community is not just a big dream in the prevailing situation, but the need of the hour for sustainability. Hence, it is high time to revitalize the whole agriculture system in order to increase vertical productivity, farmers' income and toattract people towards climate resilient smartfarming systems to have sustainable growth.Majority of the people of North East India are fish eaters, and they depend on fish for protein. However, the bulk of fish for consumption are brought to the region from other states and neighboring countries, draining out the money from the region. Role of fisheries and aquaculture in the prevailing situation is very important and provide an excellent opportunity for doubling the farmers' incomes and employment while putting the least pressure on climate and biodiversity.Changing climate results in erratic rain patternsresulting in drought, flood, and complete failure of crop and outbreak of several diseases. Significant technologies to combat this are evident in agriculture such as development of crop varieties resistant to drought, diseases, saline stress etc. and water use efficient irrigation mechanisms such as dip and micro irrigation.

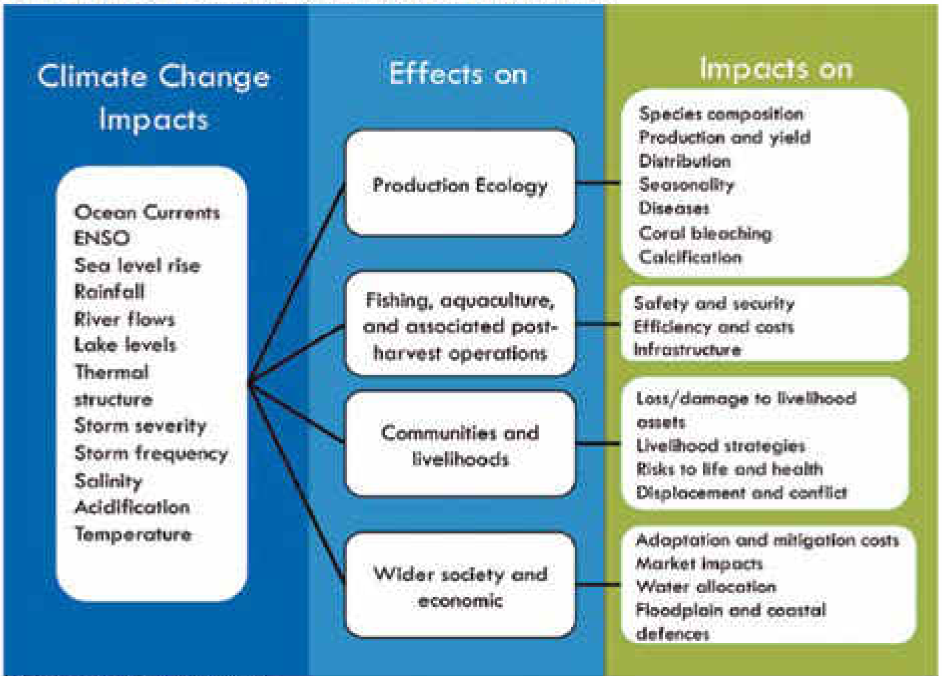
## Impact of climate change on fisheries:

Climate change affects fisheries via altering feeding & breeding behavior, migration route and prey-predator relationships, resulting in decreased growth, high mortality, reproduction failure, and disease outbreak (Fig 1).

The FAO has outlined a number of adaptation strategies to changing climate,thatresonates with most fisheries and aquaculture contexts:

- Reduce external stressors on natural systems
- Identify and protect valuable areas
- Investments in safer harbours and landings
- Promote disaster risk management
- Mainstreaming
- Capacity building
- Recognition of opportunities
- Learning from the past

Climate change impact pathways in fisheries and aquaculture




*Source:* From Badjeck *et al.* (2010).

- Link local, national and regional policies and programmes
- Spatial planning
- Monitoring
- Policy and management considerations

Specific approaches for enforcing these strategies in individual socio-economic settings vary. Considering the specific characteristics of the North-Eastern region of India, a few approaches for climate resilient sustainable aquaculture and doubling the farmer's income are discussed below.

## Introduction of airbreathing fish for climate resilient aquaculture

One of the best climate change combat strategies for aquaculture in the North-East region would be species diversification, using climate resilient species which can tolerate wide range of climate stressors. Air breathing capacity would be a key feature to look out for species in this scenario. Some of the promising species for this purpose are tilapia, Pangasius, Magur, Singhi, Murrel and Common carp. Interestingly these species havea good market demand and fetch a high price in the north-east states. Moreover,the scope of their culture is very high in comparison to conventional carp culture in the prevailing small backyard pond system.

## Pond for aquaculture vis-à-vis ground water recharge

The North-eastern states receivean average of2067.8 mm rainfall in a year extending from April to late October (Jain et al., 2013)which is much high in comparison to the national average 1190 mm (Rainfall Statistics India, 2015). A considerable part of the region has a hilly terrain with undulating land pattern and/or hills with high percentage of sand (≈40 %) in soil. Which is not quite conducive for agriculture, this topography can effectively be utilized for aquaculture purpose. Creation of ponds at the hills footwill ensure water availability for more than six months during the rainy period and will be suitable for aquaculture purposes. This will be a productive way of utilizing barren lands of the region.Though the rainfall in the region is very high, it is not being utilized to its full potential. Since much of the water drains away due to the hilly terrain without percolating the soil. Creation of ponds at the foot hills willnot only help in recharging the ground water (Sharda et al., 2006), but also support and expand the area under the irrigated agriculture.In north-east agriculture is mostly rain-fed and land area under irrigated agriculture is only about 11% in the region on contrary to national average of 36%.In dry season, the pond can be used for organic agricultural purposes as the soil will have high moisture content to support vegetation.

## Pond for aquaculture vis-à-vis for solar energy empowered micro-irrigation based agriculture

Though the region receive good rainfall during rainy season, agriculture still face scarcity of water, due to high seepage rate and scarcity of systematic irrigation system. Problem also get aggravated due to unreached and/or interrupted power supply, mechanization and agricultural manpower. Creation of pond primarily for the aquaculture activities can be used for micro-irrigation for horticultural crop such as cabbage, tomato, onion, cauliflower, papaya, and floriculture etc. The micro-irrigation technique due to high efficiency, reduces the water requirement by about 50% and increase the production by 25-80% depending upon crop. Introduction of solar energy derived water pump in micro-irrigation will augment farmers' income & nutritional intake,environmental sustainability through clean energy, and reduce dependency on conventional electricity for irrigation and input cost (Burney et al., 2010).

## Introduction of alternate species in aquaculture for more income and conservation

Like other parts of the country, carp such as rohu, catla, mrigal, silver carp, common carp, grass carp dominates the culture system of north-eastern states also, mostly because of high growth rate and available technology for seed production to grow-out for these species. Interestingly, people of the region exhibit equally high preference forlocally available species likepabda, reba, bata, pengba, tengra, singhi, magur. Some species likepabda in Tripura and pengba in Manipurbear thetag of delicacy and are highly prized in the respective states. This also invitesa problem of overexploitation from the wild (Sarkar et al., 2010; Singh et al., 2013). To fill the gap between demand and supply, to increase the income of the farmers and as well as to reduce the pressure on wild stock, alternative and best strategy would be to bring the species in culture system (Mijkherjee et al., 2002). Hence, there is an immediate need to promote the culture of these highly priced fish such as pabda, pengba, chitala, mystus, king fish, magur, murrel, bual etc. and provide training to the farmers. The breeding technology and culture practice have been developed for some of the species such as pengba&pabda by the College of Fisheries, Tripura.

Further, carp such rohu, catla, mrigal, silver carp, common carp, grass carp requires larger pond for faster growth. However, north-eastern states of India are dominated by small and marginal farmers owning backyard ponds of an average size of around 0.17–0.5 hectares (Singh 2007, 2008).Alternative species such as pabda, pengba, maguretc perform very well in small pond and give better returns.

## Molluscan farming a lucrative venture

Several speciesof mollusca such as apple snail (Pomace sp.), freshwater mussel (*LamellidensSp., Parreysia Sp.)*are found in different drainage systems of the region. They are often collected from natural sources such as river bed, rice field etc. by the local people for own consumption. Molluscs have high nutritional value, due to the presence of minerals, protein and lipid and enjoy very high market price and export potential.Extending technology for seed production and culture to the farmers of the north-east will add new avenue of culture and improve the livelihood and income of farmers of the region. This will reduce the pressure of over exploitation from wild leading to loss of biodiversity and ecological balance.

## Seed certification

Farmers of north-eastern states also face challenge for quality and quantity of seed. Hatchery produced seed often do not perform well due to inbreeding and negative selection. Though seed certification is already in place and is mandatory in agriculture and animal husbandry to assure the quality of seed for production traits, it is still in process of conceptualization in the case of aquaculture. It would be surprising to note here that, collection of brood stock directly from river has been taken as assurance of quality of seed produced from there, without proper evaluation of production traits.Seed certification will enable further popularization of improved varieties such as theJayanti rohu of ICAR-CIFA that exhibits 17% higher growth (Mahapatra et al., 2006). Several fish species tilapia, scampi, etc. exhibits sexually dimorphic growth pattern where mono sex culture is more profitable than the mixed culture. Technology having combination of "direct sex reversal using hormone and sex chromosome based species specific breeding plan" already been developed long back to produce monosex population carp, tilapia and scampi, which do not have ill effects on the consumer or environment, can be utilized to increase fish production in the region.In this regard, Rajiv Gandhi Center for Aquaculture (RCGA), Tamil Nadu has taken a lead role in to developing monosex population and providing training to government official and entrepreneurs.

## Cage aquaculture

Reservoirs and dams have become an integral part of the developing society to supply water for house-hold, agriculture, and industries. This has created an opportunity for cage aquaculture. Cage aquaculture using planktivorous fish can be introduced in the reservoir (Das et al., 2009). With initial funding supports for inputs for cage culture, productivity can be increased in the long term.

## Integrated/mixed farming for maximizing nutrient utilization

Farmers of the region have small land holdings and low capital capacity for inputs. Hence, scope for large scale commercial farming as followed in the main land may fair poorly. In this scenario, to maximize the output, integrated farming would be the best approach where several forms of integration is possible like rice cum fish farming, fish cum duck farming, fish cum pig farming, fish cum cattle farming, fish cum horticulture etc. Some of these are being followed alreadyand can be boosted further (Munilkumar&Nandeesha 2007). Integrated farming has the advantage of reducing the input cost (up to 50%) by recycling the nutrients, maximizing the output per unit area. Additionally, it also reduce the risk associated with agriculture; in case of failure of one component, returns remain viable from other components. In rice cum fish culture, rice productivity is enhanced by15%, input cost reduces for labour cost towards weeding, supplemental feeding of fish, and fertilizer. Ponds having wider dyke (>4 m) can be used for growing vegetable such as cabbage, cauliflower, potato, spinach etc. and which trash leaves can be used as feed for herbivores fish species like grass carp.

## Development of entrepreneur

Several technique has been developed in aquaculture. However, it is very much apparent that adaptation rate is poor in the region. Possibly less attention has been paid to the extension works. Skill development/vocational training programme on different aspects of aquaculture such as culture, seed production, processing & value addition, feed preparation, marketing and self-help group (SHG) formation, preparation of gear and craft etc to farmers of north-eastern states willenhance self-sufficiency in fish production, improvement of livelihoods, and generation of employment leading to overall economic upliftingof the peoples of the region.

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# 13 Trapping Solar Energy: Technology for Improving Farmers' Income

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The agriculture sector is the single largest employer in the world, sustaining the livelihood of 40% of the population, many of whom live in poverty (United Nations, 2015). Increasing productivity in the agriculture sector is widely recognised as one of the most effective ways to fight poverty and stimulate socio-economic development. In fact, for every 10% increase in farm yield, there has been an estimated 7% reduction in poverty in Africa and more than 5% in Asia (United Nations Environment Programme (UNEP, 2012).

Irrigation is among the measures that can improve yields, reduce vulnerability to changing rainfall patterns, and enable multiple cropping practices (Food and Agriculture Organization (FAO, 2011). Although, expanding land area under irrigation nevertheless represents a marginal share of total cultivated area, especially in India. According to the World Bank, only about 35% of total agricultural land in India was reliably irrigated in 2010(IWMI, 2010).The North-East India has very less irrigated agricultural land except Assam, where it is about 17%. The major cause for less irrigated area is hilly terrain and scattered agricultural lands. The possibility of expanding irrigated area seems to be less. The humid environment of North-East India has also an uneven distribution of rainfall causing water scarcity to the crops during winter. Arunachal Pradesh receives an average annual rainfall of 4500mm. In spite of this the period from October to March is severely dry and the crops face water stress as shown in the figure (1). This may be one of the reason of less productivity as well as low cropping intensity in the region. The soil is sandy, porous, and gravelly and has low water holding capacity as shown in the figure (2). Affordable, reliable and environmentally sustainable energy is a vital input for delivering irrigation services.

An integrated solar pumping for irrigation withrainwater harvesting has been tested at the College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh. It was found most suitable sustainable in providing irrigation to the horticultural crops during winter season with frequent interrupted electricity supply. Thus saving the money spent on diesel and petrol.

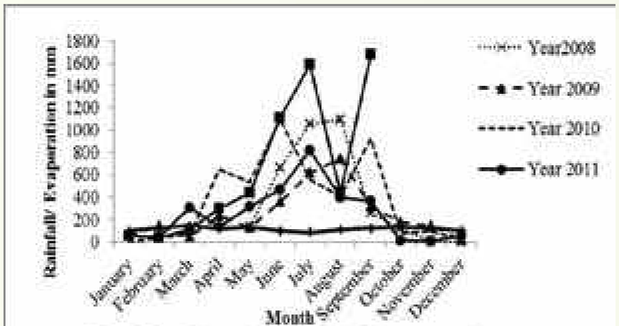


**Fig. 1. Monthly variation of rainfall vs evaporation showing the dry months at Pasighat, Arunachal Pradesh**

**Fig. 2. Sandy, porous and gravelly soil**

## Rainwater harvesting

Rainwater harvesting is the process to capture and store rainfall for its efficient utilization and conservation to control its runoff, evaporation and seepage. Some of the benefits of rainwater harvesting are:

- It increases water availability;
- It protects crops from changing rainfall patterns;
- It checks the declining water table;
- It is environmentally friendly;
- It improves the quality of groundwater through dilution, mainly of fluoride, nitrate, and salinity; and
- It prevents soil erosion and flooding, especially in the urban areas.

Rainwater harvesting is in reality extending gift of monsoon based on the principle "Catch the water where it falls". The harvested water in ponds can be utilized to provide life saving irrigation to the crops during water stress period.

## Technology towards conserving water

Rainwater can be harvested in a dugout-cum-embankment pond at the mid or lower reaches of the hill slope for multiple uses including drinking water supply, recycling in winter season for crop production and fish production. The soil in the entire region except at few places, have low water holding capacity and seepage losses are very high. In the hill slopes or in valleys the pond construction needs some measure to prevent the seepage of stored water. Silpaulin lined small tanks can be constructed in the terraces. Low cost and durable technology is available for preventing the seepage. The pond or the tank can be lined by 200-400 micron UV stabilised silpaulin film. Desired size of silpaulin film can be procured from the supplier by giving the total surface area of the tank to be lined.

The pond is constructed at the suitable location. The excavated soil is kept as embankment surrounding the tank. As the exposed soil of the tank is embedded with stones, about 2" of stone free soil is spread over the surface for cushioning. A trench of at least 1' × 1' is made surrounding the upper surface of the tank. Then the silpaulin film is unfolded at the centre of the tank and gradually stretched towards the sides. Care should be taken during unfolding of the silpaulin film that should not get damaged. The size of the silpaulin film should be decided in such a way that one fold of the silpaulin film should be provided at the centre and sides for future expansion under pressure of stored water as shown in figure (3). At last the remaining portion of the film in inserted in the trenches and soil is covered over this with subsequent compaction. If the size of the silpaulin film is found to be large than the required size, the extra part of the film can be inserted inside the silpaulin film as double layer, to give to the surrounding sides of the tank. The periphery of the tank is used for walking during pisciculture and recreation. The water harvesting pond should be enclosed by fencing to prevent the film from physical damage.

Based on the experience obtained from the construction of large size water harvesting ponds in the gravelly and porous soil of Aruanchal Pradesh, it is observed that the pond was made full of water by the month July. The area receives an annual average rainfall of 4500mm. Catchment area is not needed for runoff collection for the storage. This reduces the cost of water harvesting system. The harvested water can be utilized to irrigate vegetable crops like potato, cabbage, cowpea and fruit crops like oil palm and litchi, etc. through micro-irrigation.

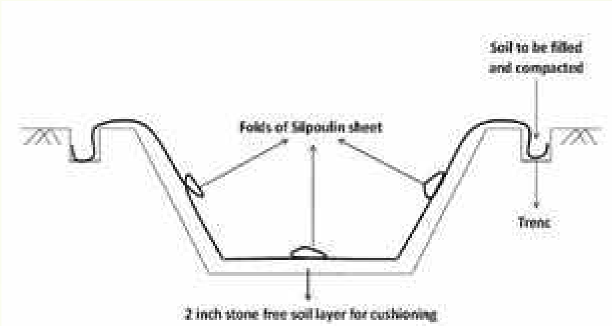


Fig.3. Layout of Silpaulin lined Water Harvesting Pond

## Economics of Silpaulin lined WHP

Small size WHP is very easy to construct and also costs very minimal. Large size WHP needs excavation by using machines, which costs more. However, onetime cost is involved in excavation of pond and the cost of silpaulin film and labour cost in finishing work. In the subsequent years no cost is involved. The average life of silpaulin is 6 to 7 years. Hence, the cost per litre of water in silpaulin lined WHP is less than 50 paise. The harvested water may be utilized for irrigation and fish culture.

## Solar Pumping system

Photovoltaic (PV) water pumping systems may be the most cost-effective water pumping option in the plain and hilly areas of North-East India.Most parts of the regionhas poor electricity availability and poor road connectivity. However, the state has plenty sunlight availability during winter season, which can be tapped by solar system. Simple PV power systems run pumps directly when the sun is shining, so it worksmost efficiently during winter &summer months when water is needed most. Further proper sized and well installed PV water pumps are very reliable and require little maintenance. The list of currently available solar pumping systems in India is given in table (1).

### Table 1.Available Solar Pump Specification

| Surface Pump | | |
|---|---|---|
| **Pump size** | **0.1hp** | **0.5hp** |
| Max. Vertical Lift (m) | 30 | 40 |
| Max. flow rate (lph) | 500 | 25000 |
| Solar PV Input range (Wp) | 80 | 500 |
| Solar DC Voltage Range | 16 | 34 |
| Approx. Cost in Rupees (excluding GST & transport) | 16000/- | 47000-54000/- |
| Submersible Pump | | |
| **Pump size** | **3hp** | **10hp** |
| Max. Vertical Lift (m) | 10-70 | 50 |
| Max. flow rate (lpd) | 300000-45000 | 171000 |
| Solar PV Input range (Wp) | 3000 | 9000 |
| Approx. Cost in Rupees (excluding GST & transport) | 2.8lakhs* | 10lakhs* |
| *Govt. Subsidy is available | | |

The stored water in the above water harvesting pond can be used for irrigatinghorticultural plants during winter by solar operated drip irrigation. Floating platform based solar submersible pump is suitable for silpaulin lined WHP. The harvested water is pumped and utilized to irrigate horticultural crops through micro irrigation as shown in figure (4).During experimentyields of vegetable crops obtained are given in table (2) using available solar pumping systems including solar module and pump and accessories is given. This will be helpful for the farmers to opt for the solar pumping system depending on their needs.

### Economics of Solar Pumping System

Comparison of solar irrigation solutions, depends on a number of factors, like (i) initial capital costs (type and size of system, cost of shipping and installation); (ii) recurring costs (e.g. costs relating to operation and maintenance, labour and fuel); (iii) ensuing economic benefits (e.g. fuel savings, yield increases); and (iv) current energy expenditure.

A number of studies have assessed the economics of solar irrigation solutions. The results are limited due to differing contexts, methodologies and cost assumptions. However, there is emerging consensus that solar-based irrigation offers substantial economic benefits. In India, several studies point to the competitiveness of solar solutions compared to diesel under many conditions (Agrawal and Jain, 2015; KPMG and Shakti Foundation, 2014; GIZ, 2013; Self Employed Women's Association (SEWA) and Natural Resources Defense Council (NRDC), 2015; Prayas, 2015).

### Crop Production

At CHF, PasighatVegetable cowpea variety (*Vignaunguiculata*) Khasi kanchanwas grown through gravity fed low cost drip technology. It was irrigated through the solar pumping system, which pumps the harvested water from the silpaulin lined rainwater harvesting pond. The crop was sown in paired rows at spacing of 30 × 15 cm with 1-2 seeds per hole, respectively during November. Pod yield at the rate of 75kg/ ha was obtained as shown in figure (4).

Further an experiment on varietal trail was conducted on potato by using sprinkler irrigation. The water was pumped from the solar pumping system, which pumps the harvested water from the silpaulin lined rainwater harvesting pond. The potato crop was sown at spacing of 60cm × 20cm. The details of the yield obtained are given in table (2).

### Table 2.Varietal Evaluation Trial on Potato (2016-17)

| Sl. No. | Name of the Variety | Total tuber yield (kg/ha) | Marketable tuber yield (kg/ha) | Tuber dry matter (%) |
|---|---|---|---|---|
| 1. | Kufri Jyoti | 31.75 | 30.63 | 18.98 |
| 2. | KufriHimalini | 26.5 | 25.63 | 20.55 |
| 3. | KufriShailja | 27.5 | 26.38 | 21.03 |
| 4. | KufriGarima | 27.5 | 26.63 | 19.85 |
| 5. | KufriPushkar | 33.75 | 32.5 | 21.75 |

| | | | | |
|---|---|---|---|---|
| 6. | KufriLalima | 34.25 | 33.13 | 20.63 |
| 7. | KufriKhyati | 22 | 21.13 | 24.18 |
| 8. | KufriAshoka | 24.5 | 23.63 | 24.1 |

Cabbage variety BC-76 was cultivated through gravity fed low cost drip technology. It was also irrigated through solar pumping system, which pumps the harvested water from the silpaulin lined rainwater harvesting pond.A yield of 1.2q was obtained from a plot of 144sqm as shown in figure (4).

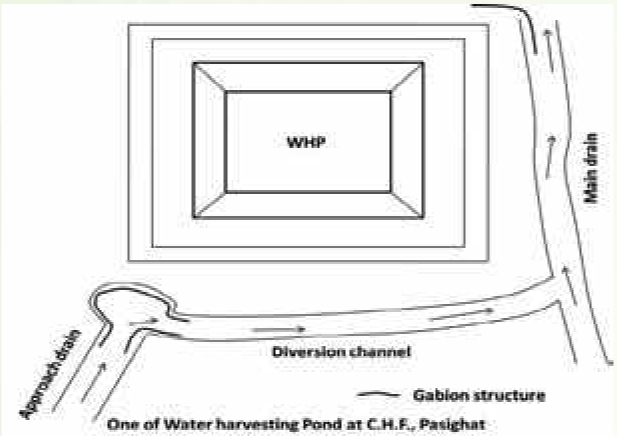


Fig. 4. Sketch of layout of WHP

Fig. 5. Unfolding of Silpaulin film

Fig. 6. Spreading of Silpaulin film


Fig. 7. Harvesting of in-situ rain water in the water harvesting pond

Fig. 8. Harvesting of in-situ rain water in the water harvesting pond

Fig. 9. SPV Module

Fig. 10. Submersible Pump in Floating Platform

Fig. 11. Solar based low cost drip irrigation Cowpea

Fig. 12. Solar operated Sprinkler Irrigation in Potato

Fig. 13. Solar operated Low cost drip irrigated cabbage

**Photographs of Integrated use of Rainwater harvesting and Solar Pumping Technology**

## Conclusion

Parts of North-East India have good number of sunny days during winter. In these areas the integrated solar pumping for irrigation with rain water harvesting is a sustainable technology for the farmers to grow winter crops and irrigate fruit crops in hill slopes. This will increase their farm yield and it emerging as a major breakthrough in conserving the precious water and saving the energy.

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# 14 Issues and strategies for Agriculture in hill ecosystems of North East India with particular reference to doubling farm income

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Agriculture in the N.E. Hilly Region is mostly rainfed, subsistence type and suffers from a number of constraints. By and large, the region is characterized by fragility, inaccessibility and marginality. Floods, soil erosion, landslides etc. are common to the region causing huge loss to the agriculture and economy due to its undulating topography, geo-physical settings with faulty land use systems. The farmers of the region are mostly small and marginal with small land holdings, low investment and low risk bearing capacity. Over 75% of the people of the region are directly dependent on agriculture for their livelihood, food and nutritional security. Therefore, improvement of agriculture has a direct and significant effect on the economy of the people of the region. Climate change and climatic variability is now a widely debated topic, globally. The impact of climate change on agriculture is being witnessed in different countries of the world including India. Rising temperatures and occurrence of extreme events, such as high intensity rainfall, frequent droughts and floods, variation in rainfall pattern are well witnessed in NEH Region also. Climatic aberrations will seriously affect the poorest section of the society who heavily relied on climate-sensitive sectors such as rainfed agriculture and fisheries (Samra *et al*., 2004; Prasad and Rana, 2006). Reduction in crop, livestock, and fishery productivity due to climate change /climatic variability is well predicted and there are variable perceptions about the intensity and consequences of climate change. The climate variability and low availability of resources and mitigation strategies with the farmers make the challenges further complex in North Eastern hill agriculture. The annual mean maximum temperature in the region is rising at the rate of + 1.11 $^{0}$C per decade (Singh and Ngachan, 2012). The annual mean temperature is also increasing at a rate of 0.04 $^{0}$C per decade in the region (Das, 2009). The decreasing trend of rainfall and number of rainy days has also been reported by (Saikia *et al*. 2012).

Slash and burn agriculture (*Jhum*) is still practised in almost all the hill states, except Sikkim on steep slopes, with reduced cycle of 2-3 years as against 10-15 years in the past. About 0.88 m ha area is still under shifting cultivation in the NE region. Huge amount of biomass (about 10 t/ha) burnt annually in *Jhuming* that leads to release of considerable amount of $CO_2$. The region, once endowed with rich genetic diversity of flora and fauna, has been denuded due to human activities and adoption of unscientific and unsustainable land use system. With rapid increase in human and livestock population and the rising demand of food, feed, fuel, fodder, fibre, timber and the other developmental activities, the farmers have been forced to exploit forestland and water resources in complete defiance of the inherent potential. This has resulted in progressive decrease in forest cover, loss of biodiversity, serious soil erosion leading to depletion of plant nutrients, water, gradual degradation and decline in land productivity and drying up of perennial steams as well as causing serious ecological imbalances. Gradual degradation of these resources is of prime concern and calls for location-specific measure to conserve, utilise and manage these resources for optimising production on sustained basis without adversely affecting its quality.

Climate variability and climate change are a reality now. An understanding of the impacts and vulnerably of hill agriculture sector and comprehensive understanding of adaptation options is essential. A multi-pronged strategy of using indigenous coping mechanism, wider adaptation of the existing climate counter acting technologies and concerted research and development efforts for evolving new location specific technologies are needed for adaption and mitigation. Judicious nutrient management, increased use of organic manure and biomass recycling etc. will lead to increase the SOC pool. Some of the options for agriculture in hill ecosystems for doubling farm income are –

## Integrated Farming Systems

The majority of the farmers of the country are small and marginal. In order to achieve food and livelihood security, as well as for enhancing income, the adoption of Intensive integrated farming Systems is one of the welcomed approaches. Integrated Farming System (IFS) is based on the concept that "there is no waste", and "waste is only a misplace resource which can become a valuable material for another product. IFS has been considered as a very effective mechanism to tackle the menace of climate change as it accommodates different farming components, like crop-animal-fish-horti-MPT etc. suitably, use of natural resources can be done more judiciously, promotes internal flow of bio-resources to maintain soil health, promotes conservation and recycling of rain water, generate employment opportunities and there by promotes food and nutritional security.

## Organic farming

The region is by default organic. There is enough potentiality for promotion of organic farming at least in high value crops which will definitely lead to enhance farmer,s income as the products are likely to get premium price if appropriate strategy/ arrangement can be made for certification and export. For this, emphasis needs to be made on provisioning organic inputs including nutrients, seeds/planting material as well as plant protection inputs. Rajkhowa and Kumar (2013) reported that the huge potentiality of biomass recycling for improvement of soil health in the region. Increased emphasis needs to be given for production and use of vermicompost in the region in view of huge biomass availability. Efficient conversion of different plant biomass utilizing earthworms and cellulose decomposing microbes was also reported by Mahanta *et. al.*,(2014). The use of biofertilizers is still minimal in hilly and mountainous regions and requires to be promoted by producing effective strains with enhanced shelf life. A variety of biofertilizers that could be popularized are nitrogen fixers (Rhizobium, Azotobacter, Azospirillum), phosphate solubilizing bacteria (PSB), blue-green algae, mycorrhizae and plant growth promoting rhizobacteria (PGPR).

## Water harvesting and its efficient use

Water is a vital component of agricultural production and is essential to increase both quantity and quality of produce. Agriculture is the major user of water in most countries and currently this sector faces the enormous challenge of producing almost 50 % more food by 2030 and doubling almost 50 % more by 2050. Although the NER is endowed with high average annual rainfall (2500 mm), but analysis of long term weather data shows reduction in total rainfall as well number of rainy days. In view of limited access to irrigation, small farmers need to develop water conservation in-situ or ex-situ, rain water harvesting systems to maximize on-farm water management. Creating awareness among the people about environmental and anthropogenic facts behind floods, droughts, scarcity of water and sustainable development of water resources of the region by involving the people and utilizing indigenous knowledge and technology at the same time seems to be urgent need. There is also urgent need to promote micro irrigation for efficient use of harvested water which will ensure higher water productivity.

In –situ moisture conservation through utilizing crop residues /weed biomass etc. as mulch along with conservation tillage holds promise for crop intensification and enhanced water use efficiency. Successful cultivation of toria, lentil, pea, buckwheat etc. in rice fallows was demonstrated in the farmer's field. Intercropping of groundnut, soybean etc. in maize along with conservation tillage in the terrace land situation resulted in enhanced productivity, higher water use efficiency, higher soil C build up and better moisture conservation. A good crop of toria could be harvested utilizing the residual moisture.

## Conservation Agriculture

Conservation agriculture with adoption of resource conservation technologies with no or minimum tillage, residue management, appropriate crop rotations, large scale production and use of organic manures, water harvesting and its efficient utilization etc. has the potential to enhance the use efficiency of natural resources such as water, air, fossil fuel and soil etc. Conservation Agriculture (CA) aims to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. It contributes to environmental conservation as well as to enhanced and sustained agricultural production. It can also be referred to as resource-efficient /resource effective agriculture. Results of the study various study conducted in the ICAR research complex for NEH Region revealed that in rice and maize based cropping systems, practice of minimum or no tillage along with residue management resulted in enhanced crop productivity, carbon build up in soil, resource conservation as well as helped in timely establishment of crops. The successful zero/ no till cultivation of toria, pea, lentil etc. in the states like Manipur, Meghalaya in rice fallow are evidences of the potentiality of crop diversification and enhanced resource use efficiency.

## Protected cultivation

It is now well accepted that the protected cultivation of crops is not only a climate counteracting technology but also associated with higher profit and enabling round the year cultivation of crops. Enhanced resource use efficiencies, minimizing pest and disease attack etc. are also some added advantages of this technology. Promotion of such technology particularly for cultivation of high value fruits and vegetables including flowers will surely give better dividend to the farming community

## Availability of seed/planting material

The region is seriously constraint in regards to seed and quality planting material. There is need for serious effort to produce/provisioning production and supply of quality seed and planting material. Seed production in participatory mode may be one of the welcomed approaches for meeting the requirement. Moreover, Govt. seed farms are to be strengthened and revamp if needed to produce quality seed in a big way. Appropriate policy as well as active involvement will go a long way for making the availability of quality seed/planting material.

## Post harvest management and marketing

Although the region is surplus in production of fruits and vegetables, however, the major portion of the production is lost due to lack of post harvest storage and processing. Most of the fruits are sold at distress market without any post harvest management. There is ample scope to enhance farmers income provided there is serious effort on PHM. There is urgent need for development of infrastructure in relation to storage, processing and value addition of such products. Further, massive capacity and skill development programme with required support from financial institutions will play a direct role on attracting rural youth to agriculture and allied activities (both on farm and off farm). Appropriate market infrastructure development and providing real time market information to the farming community will also definitely play a major role in enhancing farmer,s income.

## Farm mechanization

Farm mechanization is important to reduce drudgery, ensuring timely agricultural operations as well as for enhancing resource use efficiency. It will also help in attracting and retaining youths in agriculture and lead to enhance income. Making availability of suitable tools and implements for different field and post harvest operations is very much important which in turn will definitely enhanced the ultimate farm income. In this context, formation of custom hiring centres in different villages needs to be developed.a

Such technologies can improve the sustainability of agriculture by conserving the resource base with higher input use efficiency and also mitigating GHGs emissions. Development of climate resilient crop varieties, modifying sowing/ planting dates, crop diversification, adoption of location specific integrated farming system, promotion of organic production system in potential area and crops, micro irrigation integrated pest management, crop insurance, increase nutrient use efficiency, agro-forestry intervention. improved weather –based agro-advisory, protected cultivation, intercropping/mixed cropping, use of renewable source of energy, creation of seed bank, custom hiring centre, use of indigenous technical knowledge, adoption of technology that reduces GHGs emissions like SRI, direct seeding, agro-forestry, increased use of non renewable source of energy in agriculture etc. are some of the adaptation strategies for agriculture under climate change scenario. Skill development and capacity development among farming community are also important not only to improve work efficiency but also for enhance economic activity and adaptation to climatic variability.

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# 15 Role of farmmechanization in doubling the farmers' income in North Eastern Hill Region

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The production and productivity of crops cannot be enhanced with primitive and traditional operations/tools. Hence, there is need to strengthen mechanization to stabilize farm economy. Increased use of purchased inputs in agriculture necessitates rise in its use efficiency, which is possible though appropriate mechanization.. The rising labour wages and maintenance cost of bullocks also necessitate farm mechanization. Although, the reason to support farm mechanization in Sikkim can be numerous, the timeliness of operations assumes greater significance due to rainfed agriculture. To ensure timeliness of various operations, it is quite inevitable to use such mechanical equipment which have higher output capacity and cut down the number of operations performed. This will increase the cropping intensity. However, keeping the socio-economic and topographic factors in mind, selective mechanization is needed in Sikkim. Some of the concerns related to farm mechanization in Sikkim and suggestions to improve it are given below. While switching over from mono or double cropping or triple or multiple cropping, the design of local farm tools have to be improved for efficient use. Emphasis has to be given on design and development of manually operated tools suitable for mid hills; Feasibility study of new implements and machinery developed for similar conditions elsewhere can be taken up in Sikkim;

The results of the so many studies confirm that in those States where agricultural mechanization has made good progress. The average farm power availability in India has increased from about 0.30 kW/ha in 1960-61 to about 2.02 kW/ha in 2013-14. While in 1960-61 about 92.30% farm power was coming from animate sources, in 2013-14 the contribution of animate sources of power reduced to about 11.80% and that of mechanical and electrical sources of power increased from 7.70% in 1960-61 to about 88.20% in 2013-14. Productivity and unit power availability is associated linearly.

Farm Mechanization in India has been a story of tractorisation. Time has come for promotion of efficient equipment and tools and small engine driven equipment to address small farm requirements adequately.

## 2. Benefits of Mechanization

(1) Increasedproduction due to timeliness

(2) Increased input efficiency and human productivity

(3) Mechanization increases the productivity of agricultural inputs

(4) Mechanization results in lower cost of work

(5) Brings in improvements in agricultural technique

(7) Mechanization modifies social structure in rural areas

(8) It leads to commercial agriculture and enhanced cropping intensity

(9) Problem of labour shortage could be addressed by mechanization

(10) It releases manpower for non-agricultural purposes

(11) Climate change mitigation up to some extend particularly timely harvesting and threshing

## 3. Impact of Agricultural Mechanization on Production, Productivity, Cropping Intensity Income Generation and Employment of Labour

Agricultural mechanization implies the use of various power sources and improved farm tools and equipment, with a view to reduce the drudgery of the human beings and draught animals, enhance the cropping intensity, precision and timelines of efficiency of utilization of various crop inputs and reduce the losses at different stages of crop production. The end objective of farm mechanization is to enhance the overall productivity and production with the lowest cost of production. According to NCAER (1980) survey covering 815 farming households in 85 villages, the increase was 72 per cent in the case of sorghum, and 7 per cent in the case of cotton as compared to traditional bullock farms. ITES, Madras (1975) found that the productivity increase on tractor owning and hiring farms ranged between 4.1 and 54.8%. The estimated contributions from farm mechanization may be summarized as;

- Savings in seeds: 15-20%;
- Savings in fertilizers: 15-20%;
- Increase in cropping intensity: 5-20%;
- Savings in time: 20-30%; and
- Reduction in manual labour: 20-30%;
- Overall increase in farm productivity 10-15 %
- Reduction in cost of cultivation by up to 25% and
- Increase in production by 20%

## 4. Important arguments against mechanization

- Small sized farms
- Displacement/unemploymentof agricultural workers
- Need of cattle/draught animal in integrated farming system
- Technically underprivilegedand ill-informed farmers
- Lack of appropriate technologies
- Availability of improved tools, equipment and machinery
- Shortage of spare parts and service facilities in the vicinity

## 5. Constraints of mechanization in NEH Region

- Very little cultivable flat lands
- Most of the cultivation done in either sloping fields or in narrow terraces
- Terraces are narrow often with average width of about a meter and with vertical interval above 1.0 m
- Terraces are not uniform in width and tapering at both sides hence small machinery is needed.
- Large land holders do not necessarily go for cultivation. They lease their land to tenants
- Low investing capacity of small farmers
- Farming done at subsistence level
- Tilling, intercultural & sowing equipment are specific to type of land and those designed for plain lands does not necessarily suit hill agriculture
- Modifications needed before these machinery designed for the plains can be replicated in the hills

## 6. Opportunities

6.1 Sub-Mission on Agricultural Mechanization (SMAM) is being implemented by Ministry of Agriculture and Farmer's Welfare from 2014-15 under the National Mission onAgricultural Extension and Technology with following components. It includes;

- Promotion and Strengthening of Agricultural Mechanization through Training, Testing and Demonstration
- Demonstration, Training and Distribution of Post Harvest Technology and Management (PHTM)
- Financial Assistance for Procurement of Agriculture Machinery and Equipment
- Establishment of Farm Machinery Banks for Custom Hiring
- Establishment of Hi-Tech, High Productive Equipment Hub for Custom Hiring
- Promotion of Farm Mechanization in Selected Villages

6.2 Existence of CAU/ICAR/SAUs and other developmental agencies in the region to provide the technological and financial support

6.3 Adequate funding for research/ development and extension

6.4 The mechanization in the region is almost non-existence. It provides opportunity for development of innovative/ appropriate technologies.

## 7. Some Suggestions

There are practical difficulties in the way of introduction of the machines on the farms. Some of these can be removed.

- The Government should provide credit facilities to those farmers who are willing to purchase the machinery individually
- Joint farming societies may be developed to serve as machinery cooperatives in the different States.
- Machine Stations may be developed in different parts to give the tractors and servicing facilities to the cultivators on subsidized rates.
- Cheaper types of small machines suitable for Indian conditions should be evolved. These would help the labourer to perform his task more efficiently rather than displace him.
- Develop local manufacturers by vocational training so that improved tools and equipment is available in the vicinity.

## 8. Package of implement/technologies identified for small farm mechanization of Rice cultivation

| Sl. No. | Agricultural operations | Gap | Improved implement/tools/technology identified |
|---|---|---|---|
| **Rice Cultivation (*Kharif season*)** | | | |
| 1 | **Land preparation/reclamation** | | |
| | (a) Land cleaning | Manual scythe is presently used by the farmers | Knapsack type brush cutter<br>Work rate: 5.0 h/ha |
| | (b) Primary tillage | Country plough | Wing plough<br>Work rate: 50 h/ha |
| | (c) Secondary tillage | Wooden hoe (Dante) | Light weight power tiller<br>Work rate: 30 h/ha<br>Improved peg planker cum leveler<br>Work rate: 20 h/ha |
| | (d) Manure application | Manual spreading | Manual granular fertilizer applicator (organic fertilizer only) |
| | (e) Puddling | Wooden hoe (Dante) | Light weight power tiller<br>Work rate: 50 h/ha |
| 2 | **Sowing/planting** | | |
| | (a) Transplanting | Manual transplanting<br>Work rate: 125 h/ha | Wash root type transplanter<br>Work rate: 20 h/ha |
| | (b) Direct seeding | Not practiced | Two row sprouted rice seeder<br>Work rate: 16 h/ha |
| 3 | **Intercultural operation** | | |
| | (a) Weeding | Manual hoe | Conoweeder<br>Work rate: 12 h/ha |
| | (b) Fertilizer application | Not applied | Manual granular fertilizer applicator (organic fertilizer only) |
| 4 | **Harvesting** | | |
| | | Manual with the help of serrated sickle | Knapsack type paddy harvester |
| 5 | **Threshing and cleaning** | | |
| | (a) Threshing | Manual (beating on wooden plank | Pedal operated wire loop type paddy thresher |

| | | | |
|---|---|---|---|
| | (b) Cleaning | Manual with the help of natural wind | Hand operated cleaner cum grader<br>Work rate: |

## 9. Some of the tools/equipment developed/modified/adopted by CAEPHT

Animal drawn improved helical blade puddler

Animal drawn single row zero till drill

Animal drawn two row multicrop seed drill

Improved large cardamom harvesting knife

Light weight self propelled zero till planter

Rotary tiller for light weight power tiller

Peg type planker

Two row sprouted rice seeder

Wash root type rice transplanter

Conoweeder

Wing plough

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