Compendium

Model Training
on
"Recent Advances in Natural Resource Management for Doubling Farmers Income under Changing Climate Scenario"

Sponsored by:

Directorate of Extension
Ministry of Agriculture & Farmers Welfare
Govt. of India

Organized by:

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Model Training Course
On

RECENT ADVANCES IN NATURAL RESOURCE MANAGEMENT FOR DOUBLING FARMERS INCOME UNDER CHANGING CLIMATE SCENARIO

28th August to 4th September, 2018

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Foreward

Climate change affect the health, growth and productivity of crops, livestock, fish, forest and pasture in different ways. It also, has an impact on the incidence of pests and diseases, biodiversity and ecosystems. Frequent changes in weather parameters, more importantly temperature and precipitation would not only threaten food production but also access, stability and utilization of food resources. Adaptation to climate change will need to focus on strengthening measures, such as early warning systems; systems to identify climate change "hot spots" and disaster risk management; and evolving sustainable and ecol-friendly farming practices. Other equally important measures call for significantly increase in rural investments to reduce the long-term effects of short-term climate variability on food security, through provision of crop and livestock insurance and incentives that encourage farmers to adopt farm and social forestry, conserve resource and better agricultural and land use practices.

Agriculture development in India needs to focus on reducing greenhouse gas emissions through measures, such as significant reduction of deforestation; improving forest conservation and management; effective control of wildfires; promotion of agro-forestry for food or energy; soil carbon sequestration; restoring land through controlled grazing; improving nutrition for ruminant livestock; efficient management of livestock waste (through biogas recovery); and developing strategies that conserve soil and water resources by improving their quality, availability and efficiency of use.

Our institute is regularly organizing training as well as awareness programs for the farmers, educated unemployed youths, NGO's, self-help groups (SHGs) for sustainable animal husbandry. In continuation, we are organizing this training programme on '***Recent Advances in Natural Resource Management for Doubling Farmers' Income under Changing Climate Scenario'*** sponsored by Directorate of Extension Ministry of Agriculture & Farmers Welfare, Govt. of India. The aim of this training is to disseminate knowledge about the adverse effect of climate change on Indian agriculture and how to mitigate the effect of climate change in order to improve livelihood of the farmers. This training programme will upgrade the knowledge and skills to professionals involved in scientific, clinical and extension activities related to agriculture and allied sector.

(Abhijit Mitra)

Preface

Agriculture is an important economic activity, providing livelihood to millions of farmers and other workers in the country. Performance of the agricultural sector is crucial, considering its role in income generation, poverty reduction as well as in ensuring food security to ever growing population of the country which is projected to reach 1.5 billion by 2030. Today the challenge before agriculture is not just about producing enough food to meet the growing demand of the population but sustainability of the system. Climate change is one of the key factor influencing the performance of agriculture given that majority of the cultivated land in the country is under rain fed condition. Changing temperature and rainfall pattern have a drastic effect on agriculture production, affecting the livelihood of millions of people depending directly or indirectly on agriculture. Climatic variability increases production risk and deters adaptation of improved technology. It is high time to emphasize on the adaptation and mitigation strategies among farming communities in order to combat the deleterious effect of climate change.

Every effort has been made to include various information related to research initiatives taken up to address climatic change effect on agriculture as well as to address the field level challenges in terms of lack of awareness among the farmers and barriers to adoption of suitable technology for mitigating and adapting to changing climate are major concern. All our valuable contributors were encouraged to provide suitable and fundamental information to the trainees for improvement of knowledge, practical implementation of different technologies in their field conditions to enhance the livelihood of the farmers under changing climate scenario.

We acknowledge our contributors of this book who are working with the ultimate objective of improving the livelihood through natural resource management for sustainable development in the North Eastern region. We wish to extend our sincere thanks to Directorate of Extension, Ministry of Agriculture & Farmers Welfare, Govt. of India for the financial support. The organizing committee is highly thankful to the Director, ICAR NRC on Mithun, Medziphema Nagaland for his valuable advice and guidance.

Date: 28th August 2018 **Editors**

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SCOPE OF LIVESTOCK DEVELOPMENT THROUGH NATURAL RESOURCE MANAGEMENT FOR DOUBLING THE FARMERS INCOME

M. H. Khan and Ekonthung Ezung
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Livestock Sector: National Perspective

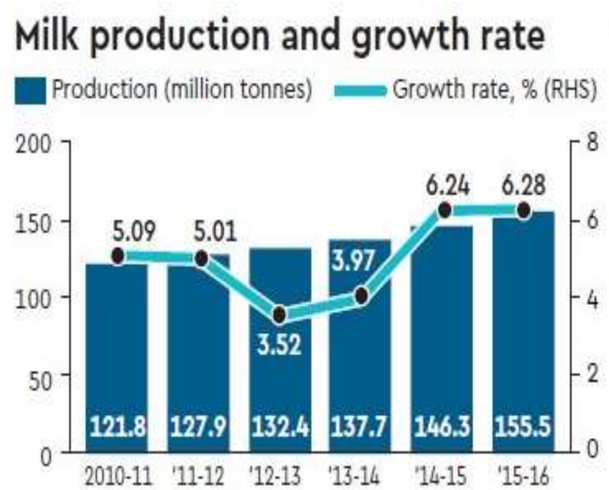
By setting the target of doubling farmer's income by the year 2022, the Prime Minister has clearly signaled a transition in agri-food policy with an excessive emphasis on food grain production towards improving welfare of the farming community. Given the continued excessive employment pressure, proliferation of small landholdings and growing agrarian crisis, this move is indeed an important change in the policy landscape. Doubling farmer's income, however, requires identification of high-income generating activities, and the necessary policy support to harness their true potential. Animal husbandry is such an activity that provides livelihood support to two-thirds of the rural households, especially the landless and marginal farmers who control 70-75% of livestock populations. Animals generate a regular stream of outputs that can be consumed by the owning-households and/or sold for cash to meet their daily consumption needs. These can be raised with a small initial capital and, being reproducible assets, can be multiplied to generate income. Animal husbandry is also labor-intensive and has the potential to absorb surplus labour. With such characteristics, the growth in livestock production would be more pro-poor than growth in crop production.

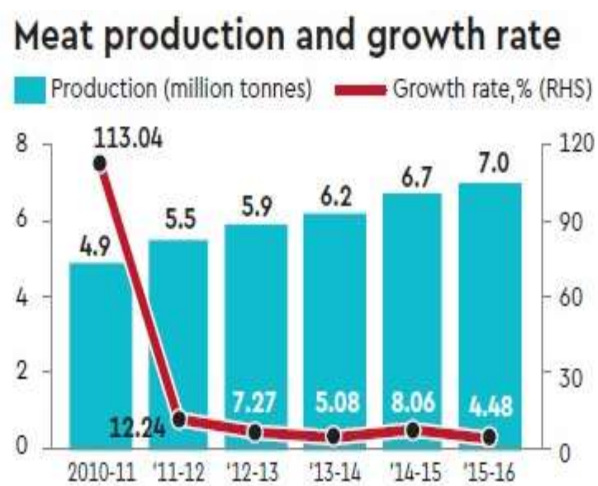
Between 2005-06 and 2014-15, the livestock sector experienced a robust growth of close to 5% accounting for 29% of gross value of output of agricultural sector and 40% of overall agricultural growth. Milk is the largest agricultural commodity in quantity terms, and its value now equals to that of cereals. Consumption of livestock products is more responsive to income changes; and sustained economic growth and fast-growing urban population have been fuelling rapid growth in the demand for livestock products. The rapidly expanding global market for livestock products is also creating immense scope for exports. It is worth noting that India has emerged as one of the largest exporters of bovine meat in recent years. The expanding market for livestock products offers significant opportunities for enhancing rural incomes. Nevertheless, livestock production might face a confluence of challenges that need to be overcome to keep the growth momentum underway. Livestock productivity is low because of excessive number of animals in relation to the available resources. Raising productivity requires optimization of population and augmentation of feed resources. Despite an improvement in availability of feed resources, the country remains deficit in dry fodder by 10%, in green fodder by 35% and in concentrate feed by 33%. The key options to augment feed resources include (i) better utilization of crop residues such as paddy straw, (ii) promotion of cultivation of high-yielding fodder crops, and (iii) discouraging Exports of nutrient-rich oilseed cakes.

India has 48 million male cattle and buffaloes for draught purposes. Utility of these animals has diminished because of increasing mechanization of agriculture and decreasing farm size. While slaughtering of unproductive buffaloes is allowed, cattle slaughter is banned in most Indian states. A long-term solution is to optimize population via sexed semen technology that allows birth of off-springs of desired sex.

Even though there has been a considerable improvement in animal health infrastructure and manpower yet diseases like foot and mouth disease, peste des petits ruminants (PPR) and influenza occur frequently and restrict realization of the production potential. Food safety is also becoming an important concern. This calls fora paradigm shift in animal health policy from curative to preventive management and improvement in delivery of livestock services.

Fostering rapid growth in livestock sector needs sturdy financial support. Livestock's share in total agricultural credit has rarely exceeded 5%. Financial institutions treat credit to livestock sector as investment credit that attracts a higher interest rate and is often advanced against collateral. The cost of raising a milch animal is about 75% of the variable cost of cultivation paddy or wheat in a hectare. This compels for provision of short-term credit for animal husbandry. Institutional mechanisms to protect animals against risk are also not strong and require significant improvement. In the past five years, only 5.3 million animals, mostly high-producing cattle and buffalo, have been insured.





Markets for live animals and their products are unorganized, except for a few pockets of modernized markets in some western and southern states. Marketing and transaction costs associated with their sale in informal markets are high. Cooperatives in dairying and contract farming in poultry have proven to be quite successful in linking farmers to markets and such initiatives need to be replicated on a wider scale. Lastly, livestock sector has remained under-invested. It receives a meagre 5% of the total public investment in agriculture. The urgency now is to allocate more resources for livestock development, targeting livestock services, markets and value chains, feed and fodder resources, and R&D to harness the pro-poor growth potential of this vital component of our rural economy.

Livestock Scenario in North East Region

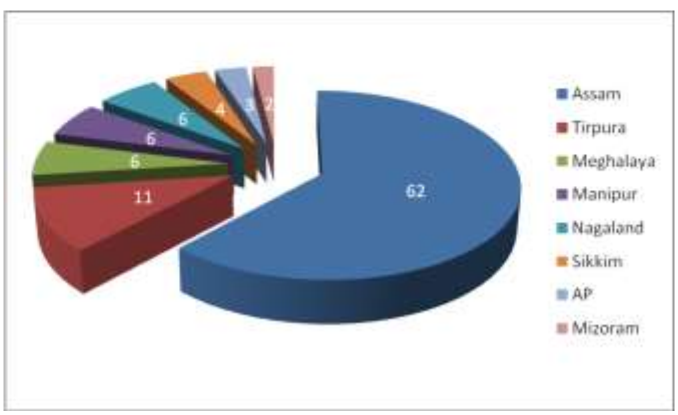
The seven states of North East India along with Sikkim, namely Arunachal Pradesh, Assam, Meghalaya, Manipur, Mizoram, Nagaland and Tripura cover 255.79 lakh hectares, constituting 7.92% of total land area of the country. The region has diverse hill ecosystems covering more than two-third of total geographical area. Agriculture is the major economic activity, followed by animal husbandry. The region has 3.73% of the total population of the country and contributes 2.6% to the Net Domestic Product with the total forest cover of more than 66.1% against the national average of 21.1%.

Animal Husbandry Sector Scenario Livestock production in the North East is pre-dominantly the endeavor of small holders, as almost 90% of the rural household rear livestock of one species or the other. Though there is vast potential for growth in this sector, the region has not achieved self sufficiency level in its production.

Milk production: Milk production is secondary to agricultural operations in the region. There are hardly any commercial livestock farms in the rural areas although in the periphery of cities and towns, a few commercial dairy farms exist. However, due to the favorable climatic conditions for setting up of dairy farms and processing units, many cooperatives and private players want to widen their presence in the region. As a step towards this, they need to shape alliances with local players for procuring milk and selling their branded products.

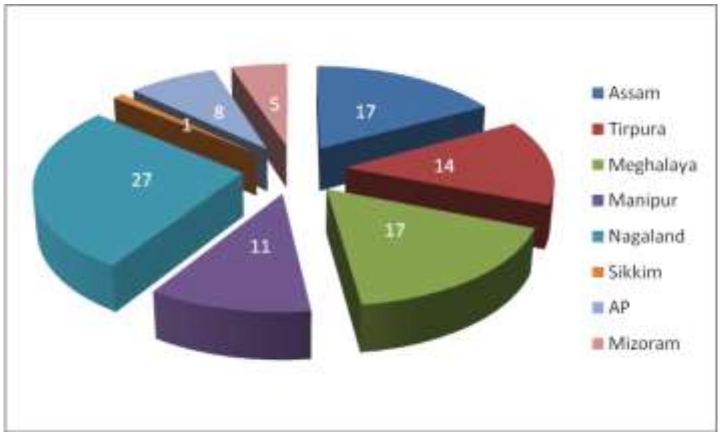
Meat Production: The main agricultural activity of farmers in Northeast India is the mixed crop-livestock system with livestock as an important component, due to preference of meat in the diet of people in the region. The area is also subsequently known as meat consuming zone of India. There exist no social taboos in taking any type of meat but the most preferred one is pork, followed by beef, chicken and others. Assam, Nagaland and Meghalaya are the major pig rearing states. Approximately, 28% of the total pig population of India is found in the region. Piggery is a promising venture in the region due to high demand for pork among the tribal people of the region.

Milk Production in the north east region of India (2014-15)



Source: Department of Animal Husbandry, Dairying and Fisheries

Meat Production in the north east region of India (2014-15)



Source: Department of Animal Husbandry, Dairying and Fisheries

Egg Production: Egg production in the northeast region is largely governed by the backyard poultry farming, which usually comprises rearing indigenous birds with low production performances. The potentiality of indigenous bird in terms of egg production is only 70-80 per year. Backyard poultry is advantageous as it provides supplementary income in shortest possible time with minimum capital investment and simple operation, while ensuring availability of eggs even in remote areas. Moreover, with this practice the egg production can be increased so as to achieve self sufficiency in eggs for local demand.

Scope of Livestock based Integrated Farming for livelihood Improvement in NER

Agriculture, horticulture and animal husbandry forms the mainstay of food production in the hilly states of India. A majority of the population lives in rural areas and depends for their livelihood on agriculture and allied enterprises. There is a tremendous pressure to set up the food production for the people of the hill states. However, the area available for cultivation is less owing to the rugged terrain and undulating topography; and there is least scope for horizontal expansion to increase the production. This calls for planned utilization of the agricultural land and water resources with an integrated approach to produce diverse food in large quantities from a unit area. Fishery can play an important role in the economic development of the farming communities. The composite fish culture comprising of both Indian major craps and exotic craps would be a viable proposition and can be practiced in different elevations with suitable modifications in species combination and ratio. However, in a rural set up, fish culture becomes more economical when integrated with other agricultural and allied enterprises. In integrated livestock-fish farming, fish derives benefit from livestock dung and manures and at the same time, the livestock derives from the aquaculture ponds, thus resulting in the overall development.

Integrated farming systems are probably as old as farming itself if the broader definition of integrated farming is taken into consideration. Integration occurs when outputs (Usually by- products) of one production system are used as inputs by another, within the farm unit. Livestock-crop systems (in which crop residues are consumed by livestock and manure is recycled to fertilized the soil) are widespread and is rather well documented. Livestock-fish systems, although their main feature is also by-product recycling, however, did not develop at the same pace in other Asian countries except China, and until recently, were poorly understood. In many developed countries, intensive Livestock production is now considered as a source of the pollution of the environment due to the release of organic matter into the rivers. Intensive farming of Pigs and poultry produce large number of manure and animal urine which must now be treated in order to prevent serious environmental problems. The most prevalent methods of manure disposal is its use as fertilizer on land, but excessive use of fertilizers will lead to eutrophication of inland and coastal waters. There is a possibility of recycling organic wastes, manures and farm effluents in fish ponds. The end product is an improved production of animal protein, particularly needed in developing countries like India.

The aim of integrated farming is the recycling of animal wastes (faeces, urine and spoiled feeds) to serve as fertilizers, and sometimes as food for fish cultured in ponds, enclosures and cages. According to Pillay (1990), the basic principles involved in integrated farming are the utilization of the synergetic effects of inter-related farm activities, and the conservation, including the full utilization, of farm wastes, and 'waste is only a misplaced resource which can become a valuable materials for another product' (FAO, 1977).

1. Integrated Farming of Fish Livestock

Integrated farming of fish and livestock is consisting of the culture of fish (or shrimp) associated with the husbandry of domesticated animals such as cattle, pigs, ducks, chicken, etc. Integrated farming is traditional in Asia, especially in china and is now applied in Europe and, on a small scale, in Africa and some Latin American countries. The highest productions obtained so far in integrated fish farming are with pigs, ducks and chicken (*Edwards et al., 1986*). In some countries, fish farmers also integrate geese, rabbits, goats, ship, cattle and the water buffalo with fish culture, on a smaller scale. The main fish species stocked in animal-fish pond systems, either in mono or polyculture are the common carp and some exotic varieties. Indigenous species such as Catla (*Catlacatla*), the surface feeder; Rohu (*Labiorohita*), the column feeder; Mrigal (*Cirrhinusmrigala*) and Kalabasu (*Labiocalabasu*), the bottom feeder have been recommended with exotic varieties such as Grass carp (*Ctenopharyngodonidella*), Silver carp (*Hypophthalmichthysmolotrix*) and Common crap (*Cyprinuscarpio*), hybrid of Tilapia, Grey mullet and Eels are also raised mainly in Polyculture. Stocking densities and species composition varies considerably from system to system and sometimes from country to country depending upon several factors. The organic rich livestock wastes are utilized as a substitute of fish feed and pond fertilizers, which can replace about 60% of the input cost in aqua farming. There may be various combinations of Integration such as fish-cum-pig, fish-cum-poultry, fish-cum-duck, fish-cum-cattle, etc. The animal housing unit in the system is constructed over pond surface, on pond embankments or vicinity of the pond so that the farm yard waste is available in close proximity.

1.1 Pig-fish integrated system

This method is a classical Chinese integrated fish farming system widely practiced in its original geographical area. This system was well established by immigrant Chinese in several south-east Asian countries (such as Thailand, Malaysia and Singapore and later also in other parts of Asia India, Nepal and Bhutan). In this system, pigs are reared in pens or sites built on the banks of the fish ponds (waste are washed out into the pond) or constructed over the ponds on piles or wooden stilts and have a lattice type of floor (allowing wastes to fall directly into the pond) Generally small pig sites are constructed over the fish ponds and bigger ones on the dykes. Pig manure reaches the pond directly or after being collected and fermented in suitable pits. Fresh Pig manure is regarded as highly efficient for pond fertilization and fish can utilize directly the feed spilled by the pigs.

The number of pig ha^{-1} of pond varies from 40 to 300 depending upon the pig size and water quality of the pond. However, the number of piglets generally recommended is 100 ha^{-1} (or 1 Piglet 100 m^{-2} of pond) while adult pigs may range between 30-40 numbers. Piglets are weaned at two months age (average weight 12-13 Kg) and are ready for fattening. They reach 70-85 Kg after 6-7 months. Exotic pig breeds like Hampshire and their crosses are usually preferred for integrated farming system as compared to the local pig breeds since they are highly prolific, having high feed conversion efficiency, large body size and faster growth rate. During the period of one year, two crops of pigs can be raised.

Fish culture is generally practiced at least for 12 months in the integrated pig-fish system. In this period, generally, Catla attains a weight of 800gm to 1 Kg, Rohu 600-800gm, Mrigal 400-600gm, Silver carp 1-1.2Kg, Grass carp 1-1.5 Kg and common carp 800-1Kg. Total fish production may range between 2.5-3 t ha^{-1}.

1.2. Poultry-fish integrated system

Theoretically, this is the best possible integration system in which poultry are raised on the pond surface, drop their nutrient-rich manure feed in the pond; the fish gather protein- rich natural feed from the pond eco-system or may consume directly the feed spilled by the ducks. In many countries of South-east Asia, egg laying duck breeds are raised rather than the white peking type meat duck to scavenge on rice stubbles without formulated feeds. In most of the cases, it proves to be uneconomical to keep the duck confined to the pond and feed them with complete feeds. The market demand (especially that of the local rural markets) is very limited for the peking type meat ducks in most of the developing countries. Substituting the duck with geese in the integrated system hasproven successful both technically and economically in some countries (China, Hongkong, Taiwan, Philippines), although this change does not resolve the general problem of having a narrow market niche for the product. Moreover, geese are usually more susceptible to diseases than ducks.

Raising egg laying hen or broiler chicken in poultry houses built above the fish ponds or on the dykes is not a traditional method of integration, but it becoming popular in countries where formulated poultry feeds are manufactured locally and are available at reasonable prices, e.g. Thailand, India, Malaysia and the Philippines. This type of integration occurs both in large commercial ventures and small farms usually close to urban markets.

1.3. **Duck-cum-fish farming**

The combination of duck and fish farming is considered as a means of reducing the cost of feed for ducks, and a convenient and inexpensive way of fertilizing ponds for the production of fish (Pillay, 1990). In this integrated system, ponds provide living and foraging areas for the ducks and fish. Ducks are reared in shelters built on the banks of the ponds or constructed over the ponds on stilts, or sometimes built on floating platforms. Fish-cum-duck integration is most popular in developing countries but it is not much popular in north-eastern states of India. Among various breeds of duck, Khaki Campbell is recommended for fish-cum-duck integration. Fish pond being a semi closed biological system with several aquatic animals and plants provide an excellent disease free environment for the ducks. The ducks should be kept away from the dykes of the ponds since they search for insect, frogs and snails, damaging the earthen walls with their peaks and provoking erosion and the collapse of the dykes. Fencing inside the pond is therefore recommended. Ducks are known to eliminate almost all the snails in ponds in depth of up to 30-40 cm, thus controlling the immediate host of Schistosomiasis (parasitic infection by a trematode worm acquired from infected water). There are different duck strains. Peking ducks are used in central Europe, China, Philippines, Africa and Latin America. The Khaki Campbell strain is raised in Thailand and the Mule duck in Taiwan. Muscuovy ducks are sometimes used in Africa. Each strain has different fattening periods, and a marketable size of 2-2.8 kg is obtained within 7-9 weeks depending on the strain, the size at stocking and feeding.

Ducks are reared at different densities depending on the climatic conditions, method of rearing (extensive or intensive), water quality and other factors. About 300 ducks are enough to fertilize a pond of 1 ha. Demonstration trails conducted in India is polyculture of Indian and common carps (at a stocking density of 6,340 fingerlings ha $^{-1}$) raised with ducks (100 ha $^{-1}$) have yielded 4,323, kg of fish ha^{-1} year $^{-1}$, 250 kg of ducks (live weight) and 1,835 eggs (*Jhingran and Sharma, 1980*).

1.4. **Chicken-cum-fish farming**

The droppings of the birds in this system are utilized to fertilize the pond. Poultry litter recycled in to fish pond produces 4,500-5,000 kg fish ha^{-1}. Broiler production provides good and immediate return to the farmers. The Poultry letter is applied to the pond in daily doses at the rate of 40-45 ka ha^{-1}. The application of the litter maybe deferred during the days when algal blooms appear in the ponds. One adult chicken produces about 25 kg of compost poultry manure year^{-1}. 500-600 birds would provide sufficient manure for fertilization of 1 ha of fish pond.

The fowls of Rhode Island Red or other improved birds (Vanaraja) are suitable for integrated chicken-fish culture. About 8weeks old birds can be kept in poultry house after proper vaccination and other prophylactic measure. Each poultry house must be provided with some nest boxes for egg laying. Egg production starts after 22 weeks and it becomes regular till 18 months of age. After 18 months egg production starts declining. Therefore, it is recommended to replace the old stock with fresh one. Fish culture is generally practiced at least for 12 months in the integrated chicken-fish system. In this period, generally, Catla attains a weight of 800gm to 1 kg, Grass carp 1-1.5kg and common carp 800gm-1kg. Total fish production may range between 2.3-2.8t ha -1. Approximately, 100,000 eggs and 1,250 kg of live birds can be expected from 500-600 birds.

1.5. **Ruminant –fish integrated system**

Large ruminant (cattle and buffalo) are integral part of Asian farms and will remain so in the foreseeable future despite some advances in farm mechanization. However, there are significant obstacles in this respect to integrate them with fish production. First of all, most of these animals are allowed to graze rather than kept and feed in feedlots, their manure is scattered all over the farm and/or the pasture. They may be padlocked at night, but the manure collected in the enclosure is traditionally used to fertilize crops by small farmers. The manure of ruminants contains fewer nutrients than that of poultry and pig, especially when it is collected from the fields after being dried and/or leached out. For these reason there are very few integrated ruminant-fish systems in the region, although cattle and buffalo dung is widely used to fertilize nursery fish ponds.

In some countries, integrated goat-fish systems were also tested with encouraging results, e.g. in India, Indonesia and the Philippines. However, these systems are not expected to make significant impact in the region.

2. Rational of Fish-Livestock integration

The rationale behind integrating, fish with livestock is the large amount of nutrients (N-P-K) present in the feed that is recovered in the manure, with possible proportions of 72-79% nitrogen, 61-87% phosphorus and 82-92% potassium. These act as fertilizers in fish ponds to produce plankton which comprise high–protein natural feed for certain species of fish. Nitrogen and phosphorus are the nutrients are most likely to be limiting for plankton growth in the pond but fish yield is probably more directly correlated to manure nitrogen content (*Edwards, 1991*) since nitrogen is more volatile than phosphorus. Based on the nitrogen content of different manures (2.6% in laying duck, 1.9% in pig, 2.2% in dairy cow and 1.1% in buffalo), it is possible to estimate the stocking density of different livestock species. Comparative effectiveness of the manure on the development of organisms in the feed web and promotion of biological activity in fish ponds are: duck manure> pig manure>raw chicken manure> cattle manure>

sheep manure. Manure may contain upto 25% crude protein, but more than half of this is usually non-protein nitrogen, e.g. uric acid, which is not assimilated by fish. Therefore, manure itself is a poor feed for fish. Manure also contains less energy than conventional pelleted feeds. Though many species of fish consume manure directly, it is a low quality feed-stuff compared to conventional pelleted feed and natural plankton.

Another advantage of manure utilization in fish ponds is that since carbon forms about 50% of the biomass of plankton, the high organic content of the manure is an important source of carbon which is released by bacterial respiration. However, depending on the productivity and the quality of water and soil, the effectiveness of livestock manure (enriched with cellulose-rich organic matter) in acting as nutrient sources for fish growth and in raising fish yield varies.

Two possibilities have been observed by *Schroeder et al.., (1990)*

a. Application of manure would improve fish yields only under conditions of water and soil which are poor in essential nutrient minerals, e.g. carbonates or organic matter, or pond water of a low pH, or fish ponds receiving very ‘soft’ waters deficient in minerals, or ponds with a low primary production.

b. Application of manure may be ineffective in raising fish yields above the rates achieved by daily applications of mineral (N-P-K) fertilizers under conditions when the fish pond is receiving daily applications of mineral of fertilizers, or where fish ponds are highly productive with very fertile soil naturally enriched with nutrient minerals and carbonates, or fish ponds with nutrient-rich waters resulting in a high concentrations of algal-based waste organic matter.

3. Principles of Fish Production in Integrated Farming Systems

Principles pertaining to technology of livestock-fish farming are as follows:

i) Fish Production in integrated systems is more complex than the conventional separate aquaculture system, requiring more knowledge and better management practices.
ii) Integrated farming system may vary in the degree of intensification of the livestock and fish sub-systems varying from extensive, semi-intensive to intensive sub- systems.
iii) Extensive sub-systems utilize natural feed produced without fertilizers; semi-intensive sub-systems require fertilizers to produce natural feed and/or supplementary feed but with a significant component diet supplied by natural feed; and in intensive sub-systems all the nutritional requirements are provided by artificial feed given to fish with natural feed contributing little or no nutrition.
iv) Fish cultured in an integrated farming system benefits from a significant amount of the nutrition derived from

natural feed, which develops in the pond due to the fertilization by organic manures. This suggests the important role of surface algal based feed web which cultivates in fish biomass.

v) The largest contribution of the manure to fish nutrition, therefore, appears to be due to its fertilizing effect in the pond. Bacteria, breaking down the organic matter in the manure, release nutrients which lead to the production of phytoplankton and zooplankton.

vi) In a manure-fed fish pond, fish nutrition may also be derived from direct consumption of the manure. However a detritus feed web has a secondary role in fish biomass production, as compared with the algal-based feed-web.

vii) The direct nutritional value of manure for fish is by its content of spilled animal feed. A large production of the nutrients in livestock feed are not assimilated, but are voided in the excreta, particularly in the pig excreta.

viii) Over-fertilization with manure may lead to poor water quality if fish pond, particularly leading to depletion of dissolved oxygen resulting in increased fish mortality.

ix) Management of water quality is needed to overcome fish mortality due to oxygen depletion and extreme fluctuation of dissolved oxygen levels. The strategy is to promote a growing biomass of phytoplankton which will generate sufficient oxygen to maintain relatively high dissolved oxygen. It is essential to maintain a positive net photosynthesis.

x) Criteria for selection of fish species for stoking into manure fed fish ponds should be based on the ability of fish species to (a) filter and feed plankton (bacteria, phytoplankton and zooplankton), and (b) to tolerate low levels of dissolved oxygen (<2 mg 1^{-1} minimum as defined by 'Criteria for the Protection of Aquatic Life').

xi) Determination and recommendation of the optimal stocking density of fish consider differences in local circumstances such as the fish species, manure type and inputs to the pond, addition of other off-farm feed, and water quality of the pond.

xii) Ways to intensify fish production from integrated farming systems involve management inputs to stock a higher initial fish biomass, followed by harvesting the fish intermediately when the growth curve of stocked fish starts to slow down.

xiii) There is a need for a more complex marketing system to handle the inputs and products from two sub-systems as opposed to a single sub-system.

xiv) Integrated farming on the one hand enables the distribution of risk (both biological and economic), since two sub-systems are involved as opposed to one in a single-commodity farming system; on the other hand, the failure of one sub-system can adversely affect the other.

4. Conclusion

Using integrated livestock-fish systems to resolve the environmentally safe manure disposal to feed lot type animal husbandry farms will certainly gain momentum in India with the proliferation of such ventures. It is likely that fish farming combined with animal husbandry can be developed on large-scale in India, where small-scale rural fish farming already exists.

The integrated farming systems are potentially important in raising the income level as well as the standard of living of small-scale farmers. Most of the farmers are lacking technical knowledge which must be remedied by realistic technical assistance. Small farmers will need further support in extension services, credit and marketing in developing socially and economically sound integrated livestock-fish systems in carefully selected areas (usually close to urban areas). More commercial types of integrated fish farming system will certainly keep expanding through the efforts of the Indian Council of Agricultural Research, State Governments, NGOs and private sectors by providing technical and financial support to the small farmers in adopting and operating such systems.

5. Reference

Edwards, P., 1991 Integrated fish farming. INFOFISH International 5, 45-52.

Edwards, P., Kaewpaiton, K., McCoy, E.W., Chantachaeng, c., 1986. Pilot small-scale crop/livestock/fish integrated farm. AIT Research Report- 184, AIT, Bangkok, Thailand, 133.

FAO, 1977. China: recycling of organic wastes in agricultural. FAO Soil Bulletin-40, Rome, 2-4.

Jhingran, V.G., Sharma, B.K., 1980. Integrated Livetock-fish farming in India. In: Pullin, R.S.V., Shehadeh, Z.H. (Eds), Integrated Agriculture Aquaculture Farming Systems, ICLARM Conference Proceedings 4, 225-238.

Pilly, T.V.P., 1990. Aquaculture: Principles and Practices. Fishing News Books, London, 52.

Schroeder, G.L., Wohlfarth, G., Alkon, A., Halevy, A., Krueger, H., 1990. The dominance of algal based food webs in fish ponds receiving chemical fertilizers plus organic manures. Aquaculture 86, 219-229.

MANAGEMENT OF AGRO FORESTRY FOR INCREASING INCOME OF THE FARMER

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Introduction

Air, water and land are basic resources for biological systems. Among these, the land is the most important basic resource for several biological production systems. The land and its soil profile support the plants and other living organisms. The land provides a medium and stores nutrients and water for the growth of plants and animals. Production of food grains, vegetables, fruits, firewood, spices, fodder, timber and other crops largely depends on the land area, type of soil, availability of water, technology and several other physical and socio-economic factors. The soil, which is the uppermost layer of earth crust, is important for plant growth and production of several kinds of goods, e.g., agricultural, horticultural, forestry, etc.

India has 1 percent forest area of the world that is supporting about 16 and 18 percent of global human and livestock population, respectively. According to National Forest Policy, 1998, the total forest area of the country was 75.18 million ha which about 22.8 percent of the total geographical area was. It is now estimated through land sat imagery that the forest cover is only 19.5 %. The average loss of forest land is nearly 0.15 million ha / yr and such degradation is alarming. This is mainly due to heavy pressure of increasing human population on land, growing demand of timber, fuel wood, fodder, grazing, encroachment, shifting cultivation, urbanization, industrialization and improper land management.

Though the total land area of the country is 329 ha, all of it is not productive. There are several factors which limit the productivity of the land. Some of the important factors include: water stress, physiography, soil erosion, land degradation, floods, etc.

The rural population is heavily dependent on forests mainly for timber, fuel wood, fodder and minor forest produce. The forests remain under the tremendous pressure of the increasing population to meet their requirements.

Agro forestry

Fig: Forest cover

AGRO FORESTRY:

Agro forestry means practice of agriculture and forestry on the same piece of land. Agro forestry is not a new system or concept, but the term is definitely new. People raised together trees, crops and animals traditionally on the same farm. This practice of mixed farming developed over centuries for meeting most of the requirements of a family. The crops provided food grains for livelihood. They also gave fodder. The trees gave wood for construction of houses and also yielded firewood. The animals provided milk and meat. They also pulled the plough and the carts. The farming system yielded almost everything which people needed. Nair (1979) defines agro forestry as a land use system that integrates trees, crops and animals in a way that is scientifically sound, ecologically desirable, practically feasible and socially acceptable to the farmers.

King and Chandler (1978) defines " Agro forestry is sustainable land management system which increases the overall yield of the land, combines the production of crops (including tree crops) and forest plants and/or animals simultaneously or sequentially, on the same unit of land and applies management practices that are compatible with the cultural practices of the local population.

ADVANTAGES OF AGRO FORESTRY:

Agro forestry systems have several advantages. Some of these advantages are as under:

1. Maximize production
2. Supplement food and fodder
3. Meet diverse needs of the people
4. Improve soil
5. Utilize wastelands and degraded lands
6. Provide employment opportunities
7. Increase farm income
8. Minimize adverse effect of climatic factors
9. Aid industrial growth
10. Improve environment

Fig: Agro forestry Farming

MANAGEMENT OF AGRO FORESTRY:

Indian agriculture is a small-scale undertaking and the profits are low. The family is the owner and also the worker. Except in some agro forestry systems, there is no clear distinction between the labourer and the manager. The products are primarily directed towards sustaining the family. The farmers are poor and do not have purchasing capacity. Most of the farm operations are performed manually. Only about 30 percent land has irrigation facility and the remaining suffers the vagaries of nature.

Several agro forestry systems have been practiced in India through the ages. Some of these systems were considerably modified. However, most recently trees have found a place because they yield a variety of products and give handsome revenue. Though the policy and general purpose of agro forestry systems continue to be maximization of production of agricultural commodities, some minor deviation are often observed wherein emphasis is given to maximizing total production and net returns. The planning, organization and control of different management practices depend upon the agro forestry systems. The technology also varies greatly with the system.

The management of agro forestry is possible only if we know the different agro forestry systems. The management of agro forestry for increasing the income of the farmer can be achieved by understanding the different agro forestry system and utilizing the different components at the right place at the right time. Some of the agro forestry systems for increasing the income of the farmer are as follows:

1. Improved fallow (in shifting cultivation area):

Fallow are cropland left without crops for a period ranging from one season to several years. The objective of improved fallow species in shifting cultivation is to recover depleted soil nutrients. Once the soil has recovered crops are reintroduced for one more seasons. The main features of the improved fallow system are that trees and shrubs are not grown with crops on the same land. Improved fallow can be established in a variety of ways and at various stages of fallow methods. Direct seedling of clean filled harvest plots and selective cutting of bush followed by enrichment of planting with tall plants. Introduction of leguminous plants like *Leucaena leucocephala, Gliricidia maculata, Alnus sp., Acacia sp., Albizia sp,Sesbania sp.,Erythrina sp., Flemengia sp., Mimosa sp. etc.* to maintain or restore soil fertility and reduce erosion. Some plants can be introduced primarily for their economic value.

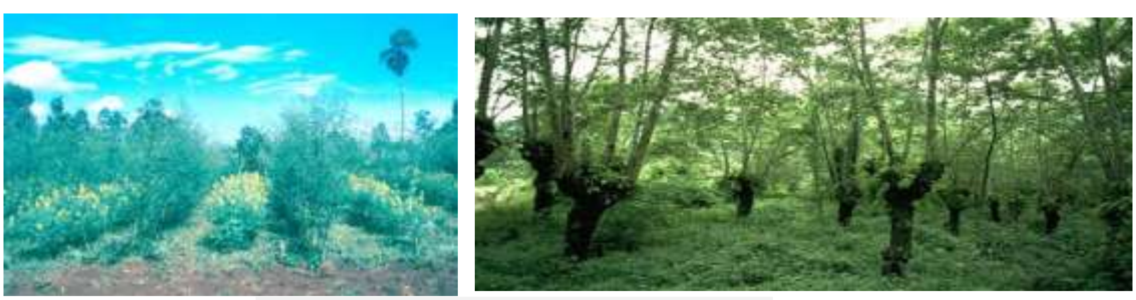

Fig: Improved fallow

2. **The Taungya system:**

It is a form of agro forestry system in which short term crops are grown in the early years of the plantation of a woody perennials species in order to utilize the land, control weeds, reduce establishment costs, generate early income and stimulate the development of the woody perennials species.

Taungya is Burmas ward meaning hill cultivation, it was introduced into-India by Dr. Brandis in 1890 and the first Taungya plantation was raised in 1896 in north Bengal. It is practiced in Kerala, West Bangal, U.P., and to lesser extent in Tamil Nadu, A. P. Orissa and the north eastern hill regions this is a modified term of shifting cultivation in which labour is permitted to raise crop in an area but only side by side with the forest species planted by them. The practices consist of land preparation, tree planting, growing agricultural crop for 1 to 3 years until shade becomes the dense and then moving on to repeat the cycle in a different area. There are three types of Taungya.

a) Departmental Taungya:

Under this, agricultural crops and plantation are raised by the forest department. By employing daily paid labours. The main aim of raising agricultural crops along with the plantation is to keep along with the land free of unwanted vegetation.

b) Leased Taungya:

The forest land is given on lease to the person who affects the highest money for raising Agrilural crop for a specialized number of years and ensure care of tree plantation.

c) Village Taungya:

This is the most successful of all the three Taungya systems. Under this the people who have settled down in a village inside the forest for this purpose raise crops. Usually each family has about 0.8 to1.7 ha of land has raise trees and cultivate crops for 3 to 5 years.

3. Tree gardens:

The term 'tree gardening' is used here to denote multiple-storeyed agro forestry systems where a mixture of several fruit and other trees are cultivated, sometimes with inclusion of annual crops. It is a type of agro forestry system where fruit trees are grown along with trees yielding timber, firewood, fodder etc. Tree gardening or the cultivation of a wide variety of crops in a multiple-storied agro forestry system is an indigenous practice on private lands. The system is described according to their management characteristics, past development as well as possibilities and constraints for further development. The tree gardens are characterized by a large variety of mostly multipurpose plants in various vegetation layers, which provide for a good utilization of environmental factors like water, nutrients and sunlight. This variety ensures a varied production of different materials throughout the year.

Fig: Taungya system

Fig: Tree gardens

4. Multipurpose trees and shrubs on farm lands:

Multipurpose trees (MPTs) and shrubs are woody (or firewood) trees that are deliberately grown and managed for more than one substantial contribution such as products or service functions to the land-use systems in which they are grown. They may supply food, wood, firewood, forage and nitrogen to the soil providing habitat, shade or soil improvement. In most cases multipurpose trees and shrubs have a primary role such as being part of a living fence, a windbreak, or used in an ally cropping system. In addition to this they will have one or more secondary roles, most often serving to supply a family with food, firewood, and forage. Several forms of plantations, e.g. single row or multiple rows on fields on one side or all sides of these multipurpose trees can be grown in this system. In some areas, trees were grown on farmlands to protect the site, for conservation of soil and moisture and to avoid damage by wind, frost, etc. People also grow trees of some species, e.g, *Morus spp., Terminalia spp*., so that they could practice sericulture.

5. **Alley cropping:**

Alley Cropping is planting rows of trees at wide spacings with a companion crop grown in the alleyways between the rows. Alley cropping can diversify farm income, improve crop production and provide protection and conservation benefits to crops. Common examples of alley cropping plantings include wheat, corn, soybeans or hay planted in between rows of black walnut or pecan trees. Non-traditional or value added crops may also be incorporated for extra income, including sunflowers or medicinal herbs planted in between rows of nut trees alternated with nursery stock trees. Fine hardwoods like walnut, oak, ash, and pecan are favored tree species in alley cropping systems and can potentially provide high value lumber or veneer logs while income is derived from a companion crop planted in the alleyways. If the land slopes, farmers should plant the hedgerows along the contour, that is, the trees in each hedgerow should be planted at the same level of slope. When planted as hedgerows between rows of agricultural crops, some tree species reduce soil erosion. When planted on slopes, alley crops slow down runoff rainwater and trap sediment, which can form natural terraces after several years. Farmers should prune hedgerows regularly to prevent them from competing with nearby crops for sunlight and water. When pruned regularly, hedgerows can provide a reliable source of animal fodder and fuel. If planted in double lines rather than single lines, hedgerows can produce almost twice as much foliage and wood, without greatly increasing the competition with nearby crops for water, nutrients, and sunlight.

Fig: Multipurpose trees on farm lands

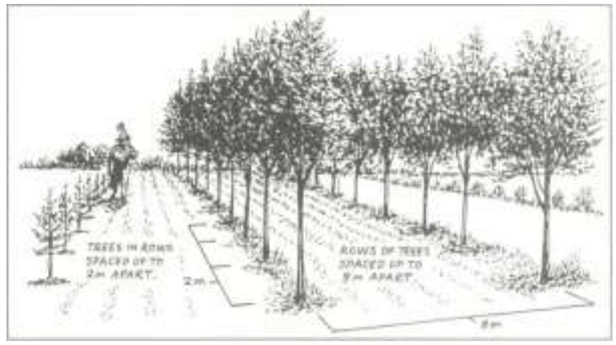

Fig: Alley cropping

6. Tree crops with plantation crops:

Plantation crops have an important place in the country's economy. Although these crops occupy only a small area, their production plays an important role in the country's export. Important plantation and garden crops include, tea, coffee, cocoa, rubber, coconut, areca nut etc. Tea is grown mainly in Assam, West Bengal, Tamil Nadu, Kerala and Karnataka. Tea (*Camellia sinensis*) is a shade-loving plant and thrives well in humid climate. It does not grow well in poor soils and exposed to the full sunlight. Several tree species are grown in lines to provide necessary shade in a tea plantation. Leguminous trees such as *Albizia chinensis, Acacia spp., Dalbergia serica, Derris robusta*, etc are grown as shade trees in northeast India. The quality and the quantity of shade determines the tea leaf production. It is now concluded that medium to light shade gives a better yield of leaves than no or heavy shade. Leguminous trees benefit the tea crops by providing light shade and adding nitrogen. About 90 kg/ha per year of nitrogen is added in the soil with planting if *Albizia chinensis*. Tea is mycorrhizal plant and light intensity also affects the mycorrhizal formation.

Coffee is cultivated in the hilly tracts of the western and eastern ghats in the states of karnataka, Tamil Nadu, Kerala and Andhra Pradesh. *Coffea arabica* and *Coffea robusta* are two important species of coffee extensively planted. It thrives well in warm and humid climate. It cannot withstand frost and extreme heat. Shade protects the plants from extremes of temperature and rainfall. Trees also protect the coffee plants from hailstorms, check soil erosion and add leaf litter in the soil.

Trees are grown in young plantations to cover the ground between the rows and to keep down the weed growth. They also provide shade and green manure to young plants. The plantation crops can be introduced in natural forests by clearing the ground vegetation and leaving some trees for shade. Valuable tree species are also planted with rubber, cocoa and other plantation crops.

ree crops with plantation crops

7. Homestead plantations:

It is almost a common practice to plant trees around habitations, courtyards, wells, threshing yards , in the fields and several agricultural crops, vegetables, spices and other crops are grown under them. in every region of the country. The trees are planted for fruits, wood, seeds, flowers, shade, etc. The species planted depends on climate, soil and preference of the farmer. In rural areas, fruit and commercial trees predominate. However, multipurpose trees such as *Acacia nilotica, Azadirachta indica*, etc. are of common occurrence in most regions of the country. There is a multilayered cropping system in homestead plantations. Bigger trees occupy the top layer, small trees and shrubs yielding fruits and other useful products occupy the middle layers and shade tolerating vegetables, and spices are found in the ground layer. A large variety of climbing and twining plants yielding vegetables and spices are commonly grown in homestead plantation or home gardens. Most home gardens also support a variety of animals. Some trees produce fodder. The waste materials from crops and homes are used as fodder and feed for animals and birds. The homestead plantations usually occupy a small area close to houses, wells etc. The cropping intensity is considerably high. The home gardens involve a higher degree of labour input compared to monocropping.

8. **Shelterbelts and wind breaks:**

A shelterbelt is defined as a belt of trees and shrub maintained for the purpose of shelter from wind, sun, snowdrift, etc. shelterbelts are generally more extensive than windbreaks and covers areas larger than a single farm and sometimes a whole region on a planned pattern. Shelterbelts are also sometimes called protection belts. A windbreak is a narrow shelterbelt or other obstacle maintained against the wind. It is also called a windbelt and wind breakage, i.e., breaking the force of wind by trees or branches. A windbreak means any barrier erected to break down or slow down the effects of wind. Multirow windbreaks are often called shelterbelts. The purpose of windbreak and shelterbelt is to provide protection from the wind.

Shelterbelts and wind breaks consist of group of trees and shrubs maintained in such a way that that they work as a protective mechanism against wind, sun, snow etc. Various parts of the tree, e.g., crown, leaves, stem and roots supported by other vegetative forms, e.g., shrubs, herbs, etc, play a significant role in making this protective mechanism efficient. The height of the trees in windbreaks and shelterbelts is important as it decides the area of protection. The crown and the leaves effectively retard wind action. In India, shelterbelts and wind breaks are required mainly for protection against wind and sun.

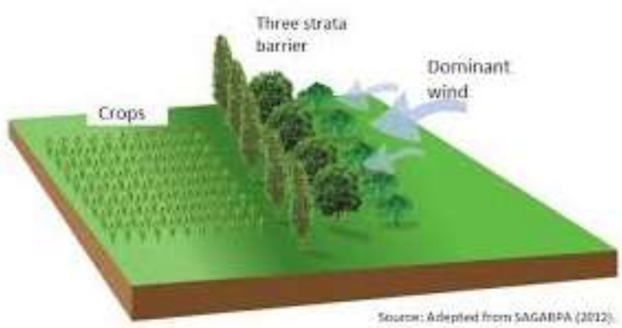

Fig: Shelterbelts and wind breaks

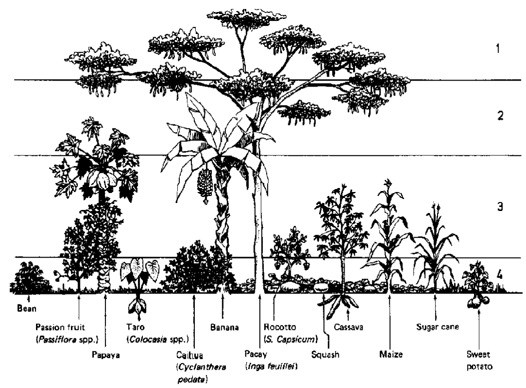

Fig: Homestead plantations

9. **Living fence of fodder trees:**

On small crop land, you can plant trees such as *Leucaena* or *Gliricidia* to serve as live fences that separate your land from other land, and protect it from animals. Plant the fence from stem cuttings (*Gliricidia*) or seeds (*Leucaena*) placed very close to each other (about 50 cm). Live fences are often combined with trees for the production of wood. Either some stems of the fence species can be allowed to grow large, e.g. cypress, or trees of another species can be planted in the fence and allowed to grow well protected by the fence. Several multipurpose trees and shrubs are planted on the boundary of the fields as hedgerows

10. **Trees and shrubs in pasture:**

Trees and shrubs can be an important component of good pastures when chosen carefully and with consideration of what will work in a specific area. Adding trees and shrubs in and around pastures can be beneficial for a number of reasons; it not only plays a major role in the hydration of the land and the control of erosion, but it can also provide shade, shelter and fodder. The roots of trees and shrubs will further stabilize soil, reduce erosion and maintain water clarity, absorbing excess nutrients like nitrates from livestock manure. The benefits include shelter from cold winter and dry summer winds, reduced exposure to sun further decreasing stress to your livestock and providing a more comfortable living environment. The leaf litter provided by trees and shrubs as they drop their leaves each fall, improves the soil fertility of your pasture, resulting in improved nutrient uptake by your livestock. The nutritive value of trees and shrubs forage is determined by its ability to provide the nutrient required by an animal to balance requirements. Tree and shrub forage have been primarily used as feed for ruminants (cattle, goats, sheep), although there are some reports of their inclusion in the diet of non-ruminants (poultry and pigs).

Conclusion:

The management of agro forestry for increasing the income of the farmer depends on the knowledge of different agro forestry system. If we understand the concept of different agro forestry system and if we choose the component according to the need of the locality, then there will be income generation from all the systems. The only disadvantage with agro forestry is that it is time taking process, but once you establish any agro forestry system the income will increase. Just by managing the different agro forestry system the income of the farmers will be increased.

SOIL AND WATER CONSERVATION TECHNIQUES FOR DOUBLING FARMERS' INCOME

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Introduction

The policy of "***doubling the farmers' income by the year 2022***" (laid out by Prime Minister of India, Shri. Narendra Modi on August 15, 2017) *i.e.* by the next five years, when India celebrates its 75th Independence day, is not an impossible, but rather, a challenge to the scientific personnel involve for the betterment of the farming community. Doubling the income of farmers by 2022 over the base year of 2015-16, requires an annual growth of 10.41% in farmer's income. This indicates that the previously achieved growth rate in farm income has to be sharply accelerated, which requires a strong measures to speed up growth in agricultural sector. The concept of doubling the farmers' income comes with the wake of increasing rate of farmers' suicide due to the two consecutive years of drought 2014-15 and 2015-16, followed by the fall in the prices of commodities in 2016-17. With 6th largest economy and the second most populated country (1.25 billion) in the world, 80% of Indian masses rely on agriculture for their livelihood. But, agriculture in India faced many uncertainties ranging from rainfall, insect, pest attack to market prices, with small and scattered land holdings and large variations in terms of climate, soil, topography *etc*. among different regions within a country. This creates difficulty in raising the livelihood standard and income level of farmers, as the measures taken up to improve their livelihood have to suitable considering differences in each region. Therefore, strong measures will be needed to harness all possible sources of growth in farmers' income within as well as outside agriculture sector.

Under this policy several schemes have been launched, and the schemes which come under the soil and water conservation related programmes are:

1) **Soil Health Card (SHC) scheme** launched in February, 2015, by which the farmers can know the major and minor nutrients available in their soils which will ensure judicious use of fertilizers and reduce cost of inputs and improve soil fertility.
2) **Neem Coated Urea** fertilizer is being promoted to regulate use of urea, enhance its availability to the crop and reduce cost of fertilizer application. The entire quantity of domestically manufactured and imported urea is now neem coated.
3) **Paramparagat Krishi Vikas Yojana (PKVY)** is being implemented with a view to promote organic farming in the country. This will improve soil health and organic matter content and increase net income of the farmer so as to realise premium prices.
4) **Pradhan Mantri Krishi Sinchai Yojana (PMKSY)** with the slogan **"More crop per drop"** and **"Har khet ko pani"** (water for every farm), is being implemented to expand cultivated area with assured irrigation, reduce

wastage of water and improve water use efficiency.

Under these schemes and programmes, several techniques and methods are involved for soil and water conservation and resource management, in turn maintaining the soil fertility and increase crop production resulting in the enhance level of farmers' income.

Soil and water conservation techniques

Soil and water are the foundation for any agriculture system. Good soil with adequate soil moisture produces the good crops and bad soil with no moisture produces the ill crops. So, conservation of soil and water resources is the most important characteristic features of sustainable agricultural development. Here soil conservation signifies the reduction in the soil erosion, maintaining the soil physical structure as well as organic matter content in the soil, restoration of degraded lands, thus maintaining the soil fertility and reducing the soil nutrient loss. Water conservation on the other hand indicates, conservation of natural water resources, harvesting of waters and storage through farm ponds, rainwater harvestings and utilization of these water resources efficiently and reducing the wastage of water. The resource conservation techniques will be discussed under the schemes launched in the following sections.

1) **Soil Health Card (SHC):** Soil health and quality is the basis for the good production of any crop. For creating this card a soil samples collected from the farmers' field have to be analysed for number of soil parameters both macro and micro nutrients in the soil chemical laboratory. These parameters are soil pH, electrical conductivity (EC), soil organic carbon (SOC), available nitrogen (N), phosphorus (P), potassium (K), sulphur (S) and micronutrients like zinc (Zn), boron (B), manganese (Mn), iron (Fe), copper (Cu) *etc*. After analysis of these nutrient contents in the soil

Fig.1. Soil Health card sample (*Source: http://www.soilhealth.dac.gov.in*)

samples of farmers' field, each nutrient is rate as low ↔ medium ↔ high based on the critical level of the nutrient content in soil (Fig. 1). Based on the level of nutrient content in the soil, after soil test, recommendations are given for addition of lime in case of acid soil, gypsum for alkaline soil and manures and fertilizers to the nutrient deficient soils.

This soil test will help the farmers to know the fertility status of his land holdings and help him in efficient utilization and addition of the fertilizers as required for the each crop based on the soil test results. This will prohibit the excess application of fertilizers, which does not increase the crop production, instead loss through leaching and deep percolations, often leading to the environmental pollutions. This efficient utilization of the fertilizers and manures will reduced the input cost of the farmers at the same time increase in production of crops with optimum dose of fertilizers, thus maintaining the soil health and sustainability.

2) **Urea management:** Urea fertilizer is used as a source of nitrogen (46%) to the crops. Although it is quick released fertilizer, this has many disadvantages. It is readily soluble in water and leaches easily along with the irrigation water. If applied on top of soil in hot sunny days, volatilization occurs in the form of gaseous ammonia. On the other hand, denitrification occurs under submerged condition and it can lead to 87% loss of added nitrogen. The excess amount of nitrogenous fertilizers pollution leading to eutrophication or algal blooms. So in order to overcome these problems the slow released nitrogenous fertilizers were introduced *e.g.* coated urea, urea mud balls *etc*. or nitrification inhibitors *e.g.* N-serve, DCD *etc*. Neem coated urea (Fig.2) as encouraged by the Govt. (since July, 2004) through subsidies for doubling of farmers income, are those coated urea with the neem seed oil. This urea is highly accepted by the farmers. The coating of neem over urea leads to more gradual release, helping plants gain or uptake of more nutrients and resulting in higher yields and lower underground water contamination due to leaching of urea.

Fig. 2. Neem coated urea
(Source: https://www.pinterest.se/pin/307159637068719936)

There are various other techniques of application of urea in order to reduce the losses and increased its efficiency and these are as follows-

i) Instead of broadcasting, urea should be well incorporated to the soil.
ii) Split application of urea should be adopted.
iii) Foliar application in lower doses also beneficial.
iv) Slow released nitrogenous fertilizers or sparingly soluble N fertilizer should be used.

v) Nitrate fertilizers should be avoided in alkaline soils.

3) **Organic agriculture:** Organic agriculture is growing of crops without the use of chemical fertilizers and pesticides and use of other synthetic substances. It relies on use of organic products like manures, compost, green manures, biofertilizers *etc*. for the management of soil health. This system encouraged the inclusion of leguminous crops in crop rotation and intercropping systems and mixed cropping systems and reduced tillage are followed. For management of disease and pest, biopesticides and biological control agents are used. Following the organic agriculture system has following advantages:

a) ***Soil health and sustainability*****:** Healthy soil has the teeming millions of microorganism performing various functions *viz*. nutrient cycling system, decomposition or breaks down of organic matter etc. maintaining the ecological balance as well as enriching and maintaining the fertility status of soil to sustain the crop production system. When the unbalanced dose of chemical fertilizers or pesticides is applied, the cycle is broken down and ecological balance is disturbed. Since, natural materials (e.g. compost, vermicompost, manures, biofertilizers etc. (Fig. 3, 4 and 5) are used instead of synthetic chemicals (e.g. fertilizers and pesticides), with organic agriculture system the soil health can be maintained as well as maintaining the nutrition and health of the people.

Fig. 3. Vermicompost (Source: http://pakagrifarming.blogspot.com/2013/08)

Fig. 4. Biofertilizer (Source: https://www.indiamart.com)

Fig. 5. Green manuring (Source: http://abcofagri.com/green-manuring)

b) ***Reduction in input cost*****:** Since organic agriculture system avoids the used of synthetic expensive chemical fertilizers and pesticides. The system also encouraged the used of reduced tillage practices limiting the use of heavy machinery and the energy consumption for operating those instruments. All these practices in organic agriculture system highly reduce the input cost of crop production system and save the part of the farmers' income comparing to that of the intensive agriculture system.

c) ***Premium prices*****:** The crops produced under this system are safe and healthy without any chemical residue in it. So, once the certification process is completed, the crops can fetch the premium prices, ultimately leading to the doubling of the farmers' income.

4) **Conservation and efficient use of water:** Water is one of the precious unrenewable resources gifted by nature, and a source of life on mother earth. Without water, plants cannot survive. So, its conservation, economic utilization and encouraging of recycling of waters is essential for the sustainability of water resources.

In agriculture, **water conservation** can be carried out through-

i) ***Farm ponds*:** Normally three types of farm ponds (Fig. 6) *viz*. excavated (dugout), embankment type and dugout-cum-embankment type (combination) are constructed for collection of excess runoff. Embankment type and dugout-cum-embankment types of ponds are feasible in hilly and undulating topography. Embankment type of ponds are created by constructing a small length of dam across a water course whereas dugout-cum-embankment type of pond can be created by excavating a site surrounded by hillocks from two or three sides and making the embankment from excavated soil on remaining sides. In flat areas these two types of ponds are not feasible. In such areas, dugout ponds are constructed.

The farm ponds help storing of stream water as well as rainwater for irrigation purpose or for other domestic purposes for off season use. The initial cost of establishment may be high if constructed with reinforced concrete, but plastic film lining (Fig. 7) can also be used which is cheaper and durable.

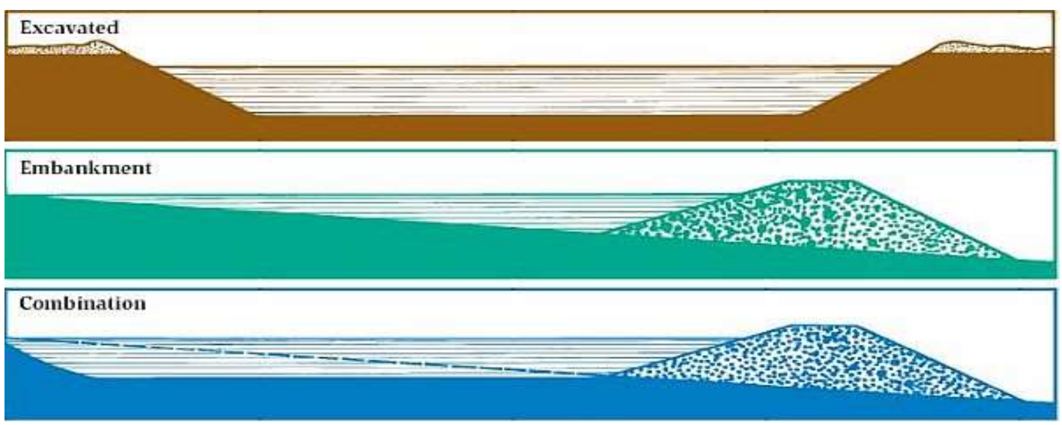

Fig 6. Types of farm ponds: Excavated type (dugout), Embankment type and Dugout-cum-embankment type (combination).

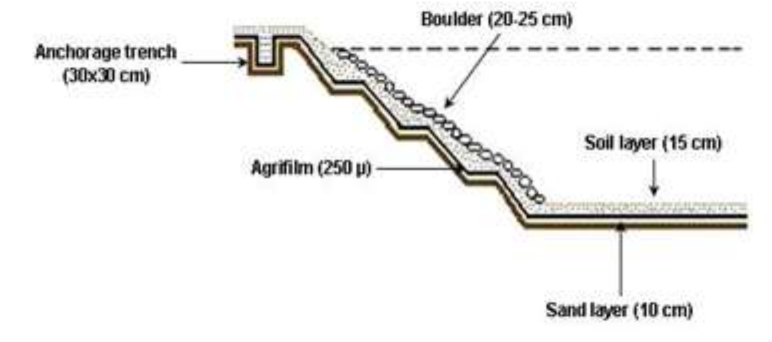

Fig 7. Schematic diagram of LDPE lined farm pond

ii) ***Rainwater harvesting*****:** Rainwater is the easiest and cheapest source of water which can be utilize both for the agriculture and domestic water consumption. It can be collected in farm ponds that run off the catchment areas or rooftop water harvesting can be carried out by connecting PVC pipes to the storage tanks.

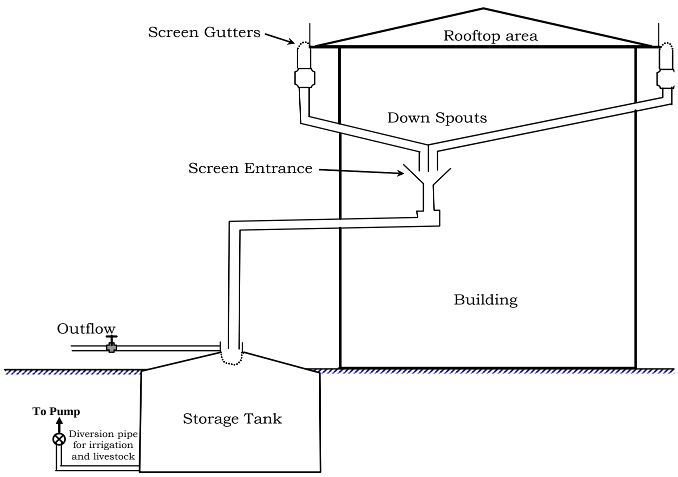

Fig. 8 Schematic diagram of a typical rooftop rainwater harvesting structure (Sahoo and Bhatt, 2013)

Another way of saving the water resources is by in situ conservation. This can be carried out by practicing the **mulching** which reduces the water loss through evaporation. There are different types of mulching viz. plastic mulching, straw mulching, stone mulching *etc*.

Efficient water utilization in agriculture: Huge amount of water is wasted with improper irrigation practices through runoff, leaching, seepage *etc*. leading to loss of large amount of resources with fewer turnovers. In addition, the crops also require only a certain amount of water at regular interval, and the excess amount available to them is wasted through deep percolation. So, efficient water utilization in agriculture system is very important, in order to save the resources and conserved the available water for the post monsoon. Water can be irrigated to crops efficiency by two methods-

a) **Drip irrigation:** Drip irrigation is an irrigation system in which water is dripped directly to the root zone of plants. The water is slowly delivered to the crop root zone by eliminating runoff, evaporation, and drift. It has several advantages viz. minimum loss of soil nutrients, high efficiency of fertilizers, weeds growth are reduced, no erosion and better crop production. The efficiency of irrigation is 80-90%.

b) **Sprinker irrigation:** The efficiency of sprinkler irrigation systems are 60-70% and more efficient than the surface irrigation systems (30%). This type of irrigation system also helps in leaching excess salts from the soil.

Conclusion: When you value the resources available with you and use efficiently the earnings get doubled. So, judicious utilization of available resources in agriculture is very important in doubling the farmers' income. The above mentioned are some of the promising techniques of soil and water conservation for doubling of farmers' income. These technologies are not new in agriculture but the lack of awareness and the communication gap between the experts and the farmers, fail to deliver these products. Sometimes, the fault lies with the farmers in adopting these technologies as they fail to understand the importance and its benefit in the long run.

Reference

Ashoori D, Bagheri A, Allahyari MS and Al-Rimawi AS (2016) An examination of soil and water conservation practices in the paddy fields of Guilan province, Iran. Annals of the Brazilian Academy of Sciences 88(2): 959-971.

https://www.quora.com/Is-it-possible-to-double-farmers-income-by-2022

Reddy KS, Kumar M, Rao KV, Maruthi V, Reddy BMK, Umesh B, Ganesh Babu R, Srinivasa Reddy K, Vijayalakshmi and Venkateswarlu B (2012). Farm Ponds: A Climate Resilient Technology for Rainfed Agriculture; Planning, Design and Construction. Central Research Institute for Dryland Agriculture, Santoshnagar, Saidabad, Hyderabad-500059, Andhra Pradesh, India. 60p

Sahoo B, and Bhatt BP (2013). Multiple Water Use System for Sustainable Agriculture in the North-Eastern Hilly Regions of India, Chapter-9, In: Water Management in the Hill Regions–Evidences from Field Studies, Palanisami K, Sharda VN and Singh DV (eds), International Water Management Institute (IWMI)-Tata Water Policy Research Program, Bloomsbury Publishing India Pvt. Ltd., New Delhi, ISBN: 978-93-82563-49-5, pp. 126-159.

CLIMATE CHANGE IMPACT ON LIVESTOCK AND NATURAL RESOURCE MANAGEMENT

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Introduction:

Climate change is already affecting livestock and natural resources. The distributions of plant and animal species will continue to change as rising temperatures alter ecosystems and amplify existing environmental concerns. Nature has given every living creature's ability to adapt to the given environment up to some extent. However, if the changes continue it lead to stress – climatic stress and less adaptable species may even disappear from their current habitats. Climatic stress may be defined as the negative impact of climatic factors on the living organisms in a specific environment. Climate is generally defined as a long term average of various meteorological variables. Climate is a combination of several elements such as environmental temperature, humidity, precipitation, air movement, solar radiation, atmospheric pressure and ionization. Among these temperature, humidity, precipitation and solar radiation are most important and have greater impact on livestock as well as natural resources. Climatic stress affects livestock in two ways, first by the direct influence on animals and secondly by the indirect on the animals environment and vegetation.

Impacts of climate change on livestock:

Climatic stress affects growth, production and reproduction of animals worldwide directly and indirectly.

A. Direct effects of climatic stress on animals

The major components of climate affect an animal's performance directly through neuro-endocrine system influencing the equilibrium or homeostasis of the body including body heat balance, thermoregulation, chemical balance of water, electrolyte, and circulatory balance of cardio-vascular activity.

1. Effect of high temperature

For animals, the most stressful of all the climatic stressors is heat. As environmental temperature increases, thermoregulatory responses may be noted down as sign of heat stress such as; restlessness, crowding under shade or at water tanks, panting, increased salivation, increased respiration rate, initial increase in heart rate and later on reduced heart rate, lethargy, decreased activity, increased maintenance energy requirement by 20-30%, decrease in the intake energy available for productive functions, decrease in dry matter intake by 10 to 20%, decrease in milk production from 10 to 25%, decrease in reproductive performance in terms of decreased estrus period length, conception rate, growth, size and development of ovarian follicles, increased risk of early embryonic deaths, decreased fetal growth and calf size. The optimal environmental temperature for lactation is dependent on the species, breed and degree of tolerance to heat .For example the milk yield declines in Holstein cattle at 21^0C, in Brown Swiss and Jerseys at about 24 -27^0C. Conception rate declined from 61 to 45% when rectal temperature increased by 1°C.

Despite wide fluctuations in environmental temperature, animals are normally capable of maintaining a relatively constant body temperature (i.e. between 38.4 and 39.0°C), which is essential to preserve the multitude of biochemical reactions and physiological processes that occur with normal metabolism. When environmental temperatures move out of the thermo-neutral zone or comfort zone animals begin to experience either heat stress or cold stress. Comfort zone for HF is 5-21^{0}C. Jersey and Brown Swiss is 5-24^{0}C (Johnson, 1965), crossbred cow of India is 15-25 ^{0}C, and Indian buffalo is 13-24^{0}C. Thermo-neutral zone depends on the age, breed, feed intake, diet composition, previous state of temperature acclimatization, production, housing and stall conditions, tissue (fat, skin) insulation and external (coat) insulation, and the behavior of the animal. Black cattle absorb twice as much heat from the sun as white cattie. Further, the ratio of surface area to body mass decreases as overall size increases. Therefore, large cattle, such as adult cows, are at a disadvantage in losing excess body heat compared to calves; they are also at greater risk of becoming overheated. The primary obstacle to evaporative cooling is high relative humidity, which in some environments may be exacerbated by limited air movement. In dairy cattle, milk production is seriously affected once the Temperature-humidity index (THI) rises above 78. THI could be used as an indicator of thermal climatic conditions. THI values of 70 or less are considered comfortable, 75 – 78 stressful, values greater than 78 cause extreme stress.

2. Effect of solar radiation on animals

Increased solar radiation increase the heat load on animals consequently reduces feed intake and it affects various performance like growth, production and reproduction of animals. It may directly affect skin causing sunburns, skin cancer and other photosensitive disorders.

3. The effects of low temperature/cold stress

Factors that create stress during the winter months are cold, wind, snow, rain and mud. Hypothermia occurs when the body temperature drops well below normal. As hypothermia progresses, metabolic and physiological processes slow down, and blood is diverted from the extremities to protect the vital organs. Teats, ears and testes are prone to frostbite. In extremes, respiration and heart rate drop, animals lose consciousness and die. Average daily gain in winter is 10-26% lower than during summer since winter feed intake is the same or slightly greater than in the summer. The milk yield of all mammalian species undergoes seasonal variations. In cattle, the yield is less affected within the temperature range of 5^0 to 21^{0}C. At temperature lower than 5^0 C, the yield decreases slowly. The optimal environmental temperature for lactation is dependent on the species, breed and degree of tolerance to cold. The minimal critical temperature for Jersey cattle is 2^{0}C; whereas Holsteins are not greatly affected at even -13^{0}C.

4. Effect of high humidity

High absolute humidity depresses evaporative heat loss greatly and thus adds to the heat load of the animal. In combination with high temperature and high humidity causes depression in feed intake and consequent reduction in production by animals. However, humidity does not have undesirable effect on the performance of dairy animals at low ambient temperature because they do not have to depend on evaporative channel for heat dissipation under such conditions. It has been suggested that 13-16^{0}C temperature and 70-85% RH as the optimum combination for milk production.

5. Effect of length of day light on livestock

Photoperiod not only affects the breeding performance and calving patterns but also the feeding and grazing period of the animals. Sheep and goat is short day breeder while horse is considered as long day breeder. In case of poultry day length markedly affects egg production. Photoperiodic effect on estrous cyclicity is observed in both cattle and buffalo. Probably, declining day length and cooler ambient temperature favors cyclicity.

B. Indirect effect of climatic stress on animals

Apart from effect of climatic stress directly on animals, it has effect on vegetation on which they live. The quantity and quality of feed and fodder availability and distribution of resources over time period are determined by climate of the region.

Management strategies for amelioration of climatic stress on animals

1. Management of animals against climatic stressors by shelter

Trees are an excellent natural source of shade. A large, leafy, non-deciduous tree is effective blocker of solar radiation and the evaporation of moisture from leaf surface cools the surrounding air. The provision of properly constructed shade is essential in tropical regions. It was estimated that total heat load could be reduced from 30 to 50% with a well-designed shade (Bond and Kelly, 1955). Ideally, shelters should have high insulating properties and should be extensive enough to eliminate much of the radiation from the sky. In tropical area loose housing system is recommended. Major design parameters for permanent shade structures include: 1) orientation, 2) floor space, 3) height, 4) ventilation, 5) roof construction, 6) feeding and water facilities, and 7) waste management system. Asbestos cement, galvanized iron or aluminium are less satisfactory but are usually the most commonly available shelter materials. The shelter materials should have a low radiation coefficient. Their defects may be offset to a certain extent by making their surfaces reflecting (with silver or white paint), and by constructing the shelters properly. Thatch from palm leaf, straw or grass is a very satisfactory material. The preferred orientation of a shade structure depends upon whether or not cows are confined to the structure. However, for environments that are particularly hot and humid, floor space equivalent to 60-65 square feet per cow is recommended. Space requirements are essentially doubled in hot and humid climates to provide additional open area for improved air movement. Natural air movement under a shade structure is affected by it's height and width, the slope of the roof, and the presence of, or size of, the ridge opening. As a general rule shelter should be at least 3 meters height. Air movement may occur naturally as breezes through the open sides of structures or by the concept of thermal buoyancy in which air warmed by the presence of animals and radiation through the roof creates air flow toward the ridge opening. Wood makes the most comfortable roofs being good insulator, but is liable to fire risk. The slope of a roof is expressed as its pitch angle of slope with the horizontal. The pitch should be 35^0 for thatched roof, 25^0 to 30^0 for a tiled roof and 12^0 to 18^0 for sheet roof. The slope is generally kept steeper in heavy rainfall areas. The pitch should not exceed 45^0 at any rate. Therefore, one should keep in mind the above mentioned points at the time of construction of shelter for animals.

Cooling in hot and humid climates emphasizes shade, wetting the skin, and moving air to enhance the cow's major mechanism for the dissipation of heat. Air temperature of micro-environment can be lowered by air conditioning or refrigeration but the expenses of such types of air cooling make these impractical. Evaporative cooling systems have improved the environment for lactating dairy cows in arid climates. These systems use high pressure, fine mist, and large volumes of air to evaporate moisture and cool the air surrounding the cow. Sprinkling uses large water droplet size to wet the hair coat to the skin. Cooling is accomplished as water evaporates from the hair and skin. Upper body sprinkling followed by forced-air ventilation reduces body temperature; increase feed intake and milk yield. When cows were sprayed for 1.5 min of every 15 min of operation, 11.6% improvement in milk yield was observed. Exit lane sprayers are designed to automatically spray water onto the cows as they pass. The evaporative cooling pad (corrugated cardboard or similar material) and a fan system which uses the energy of air to evaporate water is a more economically feasible method to cool the micro-environment. High pressure foggers disperse a very fine droplet of water which quickly evaporates, cooling the surrounding air and raising the relative humidity. The typical design incorporates a ring of fogger nozzles attached to the exhaust side of the fan. As fog droplets are emitted they are immediately dispersed into the fan's air stream where they soon evaporate. Animals are cooled as the cooled air is blown over their body. Zone cooled cows (cooled air blown over the head and neck) averaged 19% greater milk yield than controls. A mist droplet is larger than a fog droplet but cools air by the same principle. These systems do not work well in windy conditions or in combination with fans in humid environments, where mist droplets are too large to fully evaporate before setting to the ground. The consequence is wet bedding and feed. Fine mist injection apparatus is recent design of micro-environment evaporative cooling systems. This apparatus injects water under high pressure into a stream of air blown downward from above. Coolers are positioned in the roof of the shade structures or cowsheds and air is pulled through the cooler at very high rates. This system is effective in arid climates.

2. Feeding management

Feeding of animals in cooler hour like in morning and evening should be promoted. Feeding strategy like providing green fodder, mixing of dry fodder with green fodder, grazing during morning and evening hours etc is very useful to overcome from heat stress. In summer soak the concentrate in equal amount water for 20-30 minutes. This helps in better utilization of nutrients and reduces dustiness in concentrates. It has been reported that sprinkling water on buffaloes or making them wallow in clean water helps to improve fertility in summer months. Conserve surplus green as silage and hay so that they can be used during scarcity period of green fodders for cheap milk production. Management of the dietary electrolyte balance is based on adding essential body salts and electrolytes to the drinking water and feed. Care should be taken to supplement extra minerals as there will be a reduction of minerals available to the animals due to low dry matter intake. Water requirements parallel the increase in ambient temperature, and water intake may increase as much as 50% during periods of heat stress. Animals need ample access to fresh, clean, cool and good quality drinking water to allow for increased intakes in order to compensate for increased losses from sweating and increased respiration rates.

Management of animals against cold stress

Most of the animals tend to be tolerant to cold and less affected compared to heat stress. For livestock cold should be considered as a regional problem particularly in Indian context. Management of animals from cold one should protect animals from the wind. Wind markedly reduces the effective temperature, increasing cold stress on animals. Use ample amount of good, dry bedding. Providing adequate dry bedding makes a significant difference in the ability of cattle to withstand cold stress. Keep cows clean and dry. Wet coats greatly reduce insulating properties and make cows more susceptible to cold stress. Mud-caked coats also reduce the insulating properties of the hair. Provide additional feed. Feed more hay and grain. If wet feeds are fed, make sure they are not frozen. Cows in the last trimester require additional grain feeding during periods when the effective temperature falls below the lower critical level. Frozen troughs and excessively cold water seriously limit water intake.

Future prospects

Substantial efforts are needed to identify specific genes associated with tolerance and sensitivity to climatic stress. Furthermore, available quantitative relationships allowing the assessment of penalties to livestock production, reproduction, health and efficiency resulting from adverse climates are few and need to be standardized as per agroclimate based livestock husbandry. Livestock environmental research has been largely comparative in nature (e.g., comparing shade with no shade for animals at a given location), which does not provide a generally applicable relationship for the prediction of performance in other climates. Although the development of new or refined models is a slow and tedious process, there is a strong case for further research under controlled environments to develop and refine such models which will help for rational decisions in housing and managing our livestock. In the development of these models, particular care must be taken to recognize the compensatory abilities of livestock so that the extent to which trade-offs can be accomplished between management and housing can be evaluated. Interactions between intensity and duration of stress caused by weather and nutrition, and the subsequent adaptation to or recovery from stress, should be delineated. The occurrence of compensatory growth following cold weather has not been established, although such recovery is likely. Research on the compensatory ability phenomenon of growing animals should be in the context of general systems theory, as the final body size and weight of animals subjected to various stressors during growth appear to be an excellent illustration of the principle of "equifinality". Adaptation of animals to stressing environments should be studied further as stress can lead to desirable effects through adaptation. Other gaps exist in current knowledge, particularly with respect to the adverse effects of cold weather, including effects on feed energy utilization, and the effects of climate combined with the effects of nutrition, insects, parasites, disease vectors, transport and handling and other factors that influence livestock performance. Response functions for reproductive performance and efficiency of livestock are almost nonexistent. Field research is needed to determine the technical feasibility of practices developed from laboratory studies or tests that involved limited numbers of animals. The presence of site related anomalies can be observed and investigated. Laboratory and field experiments must be coordinated to validate laboratory results and to avoid restricted geographic applicability of field results. Animals of high genetic potential are needed for all studies so that housing or management practices can be assessed realistically.

Impact of climate change on Natural resources:

Freshwater:

The impacts of climate change on hydrologic conditions and freshwater resources will vary depending on the location and the time of year. The most significant impacts on freshwater resources will come from changes in the quantity, timing, and type of precipitation – some areas may experience an increase in winter precipitation and a decrease in summer precipitation while others may experience less precipitation year-round. Flood and drought risk may increase in many areas. Other climate-related drivers, such as increased temperatures, will also affect freshwater resources. Key impacts include: ***Changes in precipitation patterns***: Changes in the quantity, timing, and type of precipitation will affect surface and groundwater hydrology with corresponding impacts on water quantity and quality.

Rising temperatures: Rising temperatures are accelerating the rate at which snowpack, ice and permafrost are melting, which can contribute to temporary increases in river flows and flooding, followed by decreases in river flows. Rising temperatures will also cause greater water loss through evapotranspiration and will have a direct effect on water quality and the health of aquatic ecosystems (e.g., when water is too warm it cannot it cannot hold enough oxygen for aquatic organisms to survive). ***Extreme weather events and floods:*** The number and intensity of heavy precipitation• events will most likely increase, affecting hydrologic conditions and water quality (e.g., through increased flooding, erosion and runoff).

Sea level rise: Sea level rise will contribute to coastal flooding and salt-water intrusion into coastal aquifers and surface waters.

Water scarcity and drought: Increased temperatures and decreases in rainfall and snowpack will contribute to water scarcity and drought in some regions, particularly arid regions like the Southwest.

Changes in groundwater supply: The aforementioned impacts on precipitation and hydrology will affect the rate of aquifer recharge – some areas may experience more rapid recharge, but areas that are already water-stressed will likely experience a decline in the rate of aquifer recharge. Groundwater availability will also likely be affected by increases in withdrawals in these areas (correlated with increased water demand and decreased availability of surface water).

These impacts have implications for water supply, water quality, flood management, and aquatic ecosystem health. For example, reductions in river flow affect water quality (e.g., through increased concentrations of pollutants) as well as aquatic ecosystem health. Flooding also damages habitats and impairs water quality. Adaptation measures to help mitigate these impacts include:

Wetlands:

Wetlands are recognized as a critically important natural resource due to the ecosystem services they provide, and are subject to special protections under both international law52 and domestic law.53 Wetlands are particularly sensitive to changes in hydrological conditions which will occur as a result of altered precipitation patterns and sea level rise. Key impacts include:

Changes in precipitation: Changes in precipitation and hydrologic conditions can fundamentally alter wetland dynamics. Some wetlands may diminish or disappear due to reduced inflow.

Rising temperatures: Rising temperatures will increase evapo-transpiration, causing greater water loss from wetlands, and directly affect water quality and ecosystem dynamics.

Sedimentation and water quality: Increased erosion and runoff from storms and higher volume precipitation will likely result in addition pollution entering wetland ecosystems, which will further impair the functioning of these systems.

Sea level rise: Wetlands are situated in coastal areas will also be affected by sea level rise, which can submerge these areas or otherwise result in modifications to hydrologic conditions (e.g., through salt water intrusion).

Shifts in species composition, range and abundance: Changing conditions with wetlands will alter the composition, range and abundance of wetland species. Wetlands contain a high percentage of rare plant and animal species, many of which are highly sensitive to change and geographically isolated and thus vulnerable to the effects of climate change.58

These changes may impair the ability of wetlands to deliver ecosystem services, such as water filtration and storm buffering. Adaptation measures for wetlands include:

Restoring wetlands and mitigating other disturbances: Activities aimed at restoring impaired wetlands and mitigating other disturbances (such as invasive species) can be implemented to improve the resilience of these ecosystems to change and to enhance their ability to provide critical ecosystem services.

Inflow and outflow management: Measures to manage inflows: limiting upstream withdrawals, channeling water into the wetland, constructing water storage systems so that water can be released when needed, treating inflows to remove pollution, diverting sediment to nourish wetlands that are subsiding, and limiting outflows to reduce drainage from the wetland.

Maintain connectivity: The concern authority can maintain wetland connectivity by preventing fragmentation and protecting wetland habitat corridors.

Wetland buffers: The authority should create wetland buffers zones to moderate the effects of storm water runoff, prevent erosion, reduce sediment and nutrient input, and filter pollution. Such buffers also provide habitat for wetland-associated species.

Forests:

- There may be more insect and disease outbreaks
- Increased tree stress may affect forest growth
- Drier forests will lead to more intense and frequent forest fires
- Local tree species will be less suited to local conditions. Climate conditions may change faster than local trees can migrate, which may case cause them to die off in some areas
- Healthy forests store carbon; damaged and unhealthy forests will be less effective at this
- Healthy forests can withstand – and reduce – the impacts of climate change

Therefore, we can say that managing livestock and natural resources against climatic stress is really a challenge. Management strategies should aimed at alleviating rather than eliminating climatic challenges on animals.

References

Beede DK, et al, 1987. Integration of cooling methods for environmental management systems in hot humid environments. Proceedings of the 24th Annual Florida Dairy Production Conference, p. 68-93.

Bucklin RA, et al, 1991. Methods to relieve heat stress for dairy cows in hot, humid climates. Applied Engineering in Agriculture, 7(2):241-247,.

Chen, 2000. Characteristic change of several forest landscapes between 1896 and 1986 in Heilongjiang province, Acta Batanica Sinica, 49 (2) (2000), pp. 979-984

Grime, J. P. 1997. "Biodiversity and Ecosystem Function: the Debate Deepens," Science vol. 277, (29 August), pp. 1260-1261

Hafez E.S.E., 2000. Reproduction in Farm animals. 7th Edition. Lippincott Williams & Wilkins (Publishers). Philadelphia.

IPCC. 1995. "Climate Change 1995: Second Assessment Report of the Intergovernmental Panel on Climate Change" (IPCC).

Li, W.H, Min, Q.W and Zhang, Q. 2010. Interaction relation between forest and global climate change**.** Journal of Northwest Forestry University (in Chinese), 25 (4) (2010), pp. 23-28

Sedjo, R. A. and A. Solomon. 1989. "Climate and Forests," Chapter 8 in Greenhouse Warming: Abatement and Adaptation, Norman J. Rosenberg, William E. Easterling III, Pierre R. Crosson, and Joel Darmstadter (eds.), Washington, DC: Resources for the Future.

Wei, S.-J, Sun, L and Wei, S.-W. 2013. Effects of climate changes on forest disasters and the preventive measures**.** Journal of Catastrophology (in Chinese), 28 (1) (2013), pp. 36-38

INCOME GENERATION THROUGH HORTICULTURE BASED FARMING SYSTEM WITH SPECIAL REFERENCE TO NORTHEAST INDIA

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Introduction

Indian Horticulture sector contributes 30% share of total value of output in agriculture sector making very significant contribution to the Indian economy. Apart from ensuring nutritional security of the nation, it provides employment opportunities, diversification in farm activities, and enhanced income to farmers. India is currently producing about 307.2 million tonnes of horticulture produce(2017-18 2nd est) which has surpassed the food grain production which is 279.5 million tonnes (2017-18 3rd Est). India has emerged as world leader in the production of a variety of fruits like mango and banana and is the second largest producer of fruits and vegetables. Besides, India has maintained its dominance in the production of spices, coconut and cashewnut. Among the new crops, kiwi, gherkins, kinnow, date palm and oil palm have been successfully introduced for commercial cultivation in the country. Launch of National Horticulture Mission has spurred the production and productivity of horticultural crops. Productivity of horticultural crops has increased by about 34% between 2004-05 and 2017-18(2nd Adv Est). Increase in demand for horticultural produce due to greater health awareness, rising income, export demands and increasing population poses the challenge for further increasing the production and productivity of horticultural crops. However, the issue of climate change has thrown up greater uncertainties and risks, further imposing constraints on production systems.

Horticulture plays a pivotal role in expanding the economic growth of the country in general and NE India in particular. The horticulture scenario in Northeast India is rapidly changing in the last few years with an increase in seasonal vegetable crops and booming floriculture industry. There is a wide scope for income as well as employment generation through commercial cultivation of different horticultural crops or as integrated based with other components. The North Eastern region is considered to be the richest reservoir of genetic variability of a large number of horticultural crops. It may be mentioned that in hilly areas, particularly horticultural crop cultivation as an alternative to jhum practice is gaining importance due higher income generation and environmental protection. In NEH region, farming being the main stay of the people and development of horticulture will markedly improve the economy of the people. With the exception of tea plantations and, to a certain extent, mandarin, assam lemon, banana, pineapple, coconut and arecanut plantations, most of the horticultural crops in the region are largely grown mixed in homestead gardens. Establishment of orchards and planting of plantation crops on hill slopes will prevent soil erosion which could be an alternative to the shifting cultivation and a source of income generation.

Horticulture based farming system

Integrated farming system (IFS) is an innovative and unique approach to promote efficient land use and animal management techniques based on biophysical resources, particularly of small and marginal farmers. Horticulture based integrated farming system is one of the rising agriculture systems for the northeastern region. The practice of this type of farming system has been continued in this region in a traditional way from time immemorial. The basic principles of the farming system are productive recycling of farm wastes. Different subsystems work together in integrated farming system resulting in a greater total productivity than the sum of their individual production. It is focused round a few selected inter dependant, interrelated and often interlinking production system based on a few crops, animals and related activities.

Horticulture Based Farming System includes suitable combination of horticultural crops with different agricultural crops, multipurpose trees and shrubs, livestock, beekeeping, vermicompost besides integrated agro-aquaculture (IAA). There is immense scope for the integration of fisheries and livestock under IAA. Further, the development of horticultural land use system with mixed horticultural crops including fruits, vegetables, root crops, spices and ornamentals grown under optimum management conditions can be more remunerative on long term basis with least gestation cycle. While utilizing the steep slopes, bunds, half moon terraces and grassed waterways are major soil and water conservation measures required for proper land development. However, vegetable crop cultivation should invariably be done on bench terraces prepared on mild slopes.

Potential areas for self employment

Crops	Cultivar	Duration	Cost: benefit ratio	Employment (mandays/ha/crop/season)
Pineapple	Kew, Queen	14-16 months	1: 3.87	137
Banana	Barjahaji, Jahaji, Malbhog	12-14 months	1: 4.45	180
Orange	Khasi mandarin	After 5 years	1: 5.71	242
Assam Lemon	Assam lemon	After 3 years	1: 2.31	108
Ginger	Nadia	9 months	1: 4.00	700
Turmeric	Megha turmeric-1	9-10 months	1: 4.00	700
Tomato	Megha tomato-3, hybrids	4-5 months	1: 2.25	250
Spine gourd	Local	3-4 months		175

There are certain horticultural land use systems to be taken into consideration for integration of subsystems into a sustainable farming system.

- **Selection of crops**: Suitability of crops depends on varied altitude, soil and climatic condition/ local preferences and marketability. i) High hills: 900-2000m above MSL (apple, peach, pear, plum, apricot, potato, cabbage, cauliflower, radish, beans, etc.) ii) Mid hills: Below 500 m (citrus, banana, pineapple, passion fruit, papaya, guava, ginger, turmeric, chilli, brinjal, tomato, bean, sweet potato, tapioca, colocasia, etc.) iii) Foot hills: Bordering areas of hills (jackfruit, areca nut, black pepper etc.). Vast areas of the hills are suitable for cultivation of tropical, sub-tropical and temperate fruits viz. tropical: Cashew nut, banana, papaya; sub-tropical: Pineapple, citrus, passion fruit, guava, banana, gooseberry, etc.; temperate: Apple, Peach, pear and plum; spices: Chilli, turmeric, ginger, garlic ; Vegetables: Tomato, chilli, brinjal, potato, radish, pea, colocasia, okra, pumpkin, bottle gourd, cucumber, carrot, cabbage, cauliflower, knol-khol, French bean, winged bean, dolichos bean; Tuber crops: Tapioca, sweet potato and Tree vegetables: Tree bean, tree tomato and drum stick

- **Crop planning and production technology**: The lower one-third area should be terraced and utilized for growing vegetable/spices or tuber crops. While planning crops, it should be necessary to keep in mind the requirement of farmers. Two crops round the year can be grown even under rainfed conditions. High yielding varieties of crops should be introduced. Usually the terrace risers have to be protected by growing some fodder grasses, so that apart from protecting the risers from erosion, it provides a subsidiary source of income to the farmers. The mid one-third area should be utilized for fruit crops and the remaining upper one-third under the forests (fodder or fuel trees). The plants should be planted in half moon terraces.
- **Horticultural land use (with fruit crops only)**: The land use under pure horticultural system also has high potential in the region. In case more area (jhum land) is available in the selected site and the owners are interested for growing of fruit trees collectively as cooperative farming type in order to bring their large area under horticulture then pure orcharding can be done and land use pattern may be developed accordingly, keeping in view the soil and water conservation aspects. This system of cultivating the land will be highly profitable in long run and area will be developed as a fruit growing belt.
- **Mixed horticultural land use**: If the farmer is interested to grow only different horticultural crops in the land available with him the whole jhum land may be divided in the following pattern for developing mixed horticultural land use. Two third areas from top towards lower hillside to be converted into contour and 3-4 fruit blocks can be developed e.g. banana, orange, lemon, and papaya blocks. The lower 3/4 contour to be utilized for the cultivation of rhizomatous crops. After that 3-4 terraces may be completely utilized for the pure vegetable cultivation. The contour bunds can be utilized for the planting of pineapple. The water and soil management practices are to be followed in a systematic manner so that the soil loss can be checked to a considerable stage. The following practices (management) are to be adopted while considering this land use. The legume vegetables should be considered for the cultivation as intercrop so that soil fertility may be restored.
- **Agri- horticulture**: In this system the 2/3 area (upper side) is covered under horticultural crops for which half moon terraces and contour bunds are prepared on the hill slope and 1/3 area towards down side is used for the cultivation of cereals, oil crops etc. on the bench terraces. In this land use pattern, the following crops may be grown after the land preparation. 1) Fruit trees in half-moon terraces (Triangular system of

planting) on contour. 2) On the contour bunds the pineapple in two rows should be planted at closer distance, which helps in soil erosion from contour area. 3) The interspaces in the contour are utilized for the cultivation of the vegetables. The leguminous vegetables like bean, cowpea, guar, pea and good cover crop like rice bean should be cultivated. 4) Ginger and turmeric can be grown in the interspace area in the contours.

- **Agri-horti-silvi -pastoral (model land use):** In this system the middle 1/3 area of the hills is taken for the cultivation of horticultural crops and upper 1/3 area and lower 1/3 area are being cultivated for establishment of economic forest plant plantation with fodder and cereals, millets etc. respectively. The middle portion is converted under contours and the fruit plants are planted in half moon terraces on the contours. The contour bund is utilized for pineapple planting. The two or three separate blocks of each fruit crop may be made so that cultural operations may become easier. The vegetables, root crops, rhizomatous crops etc. are cultivated in the interspaces of the contour. The lower one or two contours may be used for pure vegetable cultivation.
- **Horti-silvi-pastoral system**: The horti-silvi-pastoral system has great potential to provide a sustainable land use system, which would maintain an acceptable level of production of fruits, vegetables, fuel wood, timber, fodder etc. and at the same time, conserve the basic resources (mainly soil) on which production depends. This system was found economically viable and socially acceptable alternative to jhuming in this region.
- **Multi – tier horticultural system**: 1. Horti-horti multi-tier system: areca nut + black pepper +ginger/ turmeric/ pineapple/ Assam lemon; Cucurbits e g. bitter gourd on bower system+ ginger /turmeric below 2. Silvi-horti-three tier system: Muti pupose trees (MPT) + black pepper + ginger/turmeric/pineapple 3. Silvi-horti-two tier system (Tree bean and pineapple or subabool and pineapple) a) Alder based farming system of Nagaland (alder and vegetables like potato, cole crops or alder and cereals like maize, rice etc.) b) Alder based large cardamom system of Sikkim c) MPT + Assam lemon
- **Multi-tier system for plantation crop**: Tea plantations in the North East region play major role in the economy and employment generation. It has been established that tea and coffee plantations require sparse shade and Albizia, Dalbergia, Acacia have been used as the major tree species for the purpose which in general formed a two-tier system of silvi-horticulture. Black pepper has been introduced in some of the plantations for making the system more profitable.

For two - tier system:

Tree spp. (Albizia) + tea or coffee plantation

Tree spp. (Dalbergia) + tea or coffee plantation

Tree spp. (Acacia) + tea or coffee plantation

For three - tier system:

Tree spp. (Albizia) + black pepper + tea or coffee plantation

Tree spp. (Dalbergia) + black pepper + tea or coffee plantation

Tree spp. (Acacia) + black pepper + tea or coffee plantation

Horticultural nursery- an option for entrepreneurship development in the integrated farm

Nursery is consequently the basic need of the hour. Majority of the farmers in North east India procure seeds or saplings from local markets for development and cultivation of various horticultural crops, but the authenticity or quality of the plating materials is uncertain. There is a huge scope of including a nursery with protected structures, mechanized facilities and modern nursery techniques (root trainer, plastic protrays, rooting medium, potting mixture, water retaining colloids etc.) for mass production of genetically pure and quality planting material of horticultural crops (fruits, vegetables, spices, flowers ornamentals etc) with scientific method of propagation. Vegetative propagation or micro-propagation is used in such nurseries to ensure uniform genetic material to overcome the limitations like poor control over climatic factors, low germination percentage, poor crop stand in the field condition, longer duration, insects-pests and disease problems, high cost and labour requirement etc. It will open gates for export opportunity and employment generation as well.

Avenues through processing of the horticultural produce

Post harvest management and processing of the produce at on-farm level can fetch premium price to the growers. Banana, orange, pineapple, passion fruit, tomato, turmeric and ginger are the most important commercial horticultural crops of the region. Location- specific processing units may be established for preparation of semi-processed products like tomato puree, banana pulp and orange & pineapple juice and concentrates. The existing processing units of the region may also be modernized and utilized for manufacturing the processed and semi processed products. Processed products like squash, RTS beverages, jam, jelly, tooty fruity, fruit bar, pickles etc may be prepared from the locally available fruits and vegetables to cater the need for local consumption. For instance, a benefit cost ratio of 1: 1.43 and 1:1.28 can be obtained from Naga King chilli pickles and sauces respectively, which has a good potential for income enhancement for the growers in the region.

Conclusion:

Sustainable horticultural systems can be achieved by appropriate planning and by building on the best management practices employed by modern horticultural enterprises to achieve a holistic approach to their farming system. The issues for a sustainable horticultural system are to protect and enhance the existing vegetation for greater biodiversity and security of the rural environment at large and judicious use of the natural resources available to ensure higher productivity and profitability by producing the range of premium products required by the market place. Income enhancement through diversification of the crops can be a major game changer. Diversification towards high value crops is required to improve both income and resource use efficiency. Similarly, diversification towards livestock, poultry and non-farm activities is considered ideal, especially for small holders who do not possess adequate land to generate enough income for the family and thus ensuring food and nutritional security.

SCOPE OF LIVESTOCK PRODUCTS FOR INCOME GENERATION

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Livestock sector plays an important role in Indian economy and provides livelihood to two-third of rural community. Livestock and poultry including cattle, water buffalo, sheep, goat, pig and chicken are primarily reared for meat, milk, egg and draught purpose and for fertilizers. Mithun is reared for meat and draught purpose in the north eastern hilly regions of India and few other species like yak, camel, and rabbit, duck, emu and Japanese quail are also reared in some parts of the country as a source of their livelihood. India has around 42 breeds of sheep, 26 goat breeds, 13 buffalo breeds, 40 cattle breeds, 6 pig breeds and 17 chicken breeds registered with Indian Council of Agricultural Research- National Bureau of Animal Genetic Resources (ICAR-NBAGR) and has 56.41% of the world's buffaloes which ranks first in buffalo population and stands second in cattle and goat and fourth largest sheep population in the world. Looking into North East the economy of the people largely depends upon the income generated from livestock and crop production. Mithun with a population of 34,871 next to Arunachal Pradesh contributing to 11.69% and has a growth rate (19th Livestock census) of 12.98%.Mithun which is reared as a meat animal, the only species which is found in the North East has a huge potential for income generation of the farmers. Population of different livestock in NER is given in table 1

Table 1: Livestock population in north eastern region (in 000s)

States	Cattle	Buffalo	Sheep	goat	Pig	Poultry
Arunachal Pradesh	464	06	14	306	356	2244
Assam	10308	435	518	6169	1636	27216
Manipur	264	66	11	65	277	2500
Meghalaya	896	22	20	473	543	3400
Mizoram	35	05	01	22	245	1271
Nagaland	235	33	04	99	504	2178
Sikkim	140	01	03	113	30	452
Tripura	949	11	03	611	363	4273
N E Region	13291	579	574	7858	3954	43534
% N.E contribution	6.96	0.53	0.88	5.81	38.41	5.97
India	190904	108702	108702	135173	10294	729209

Table 2: Meat production and consumption pattern of meat in North East, India

States	Population (In lakh) 2011 census	Meat Production ('000 Tonnes)	Per capita consumption (Kg/annum)	Deficit/surplus (Kg/caput/annum)
Arunachal Pradesh	13.82	20.47	14.81	2.41
Assam	311.69	46.86	1.50	-10.90
Manipur	27.21	27.47	10.09	-2.30
Meghalaya	29.64	41.00	13.83	1.43
Mizoram	10.91	14.79	13.55	1.16
Nagaland	19.80	31.37	15.84	3.44
Sikkim	6.07	4.40	7.25	-5.15
Tripura	36.74	39.69	10.80	-1.60
N E Region	455.88	226.05	4.96	-7.44
India	12101	7385.61	6.10	-6.30

Source: 19th Livestock Census, Dept. of Animal Husbandry, Ministry of Agriculture, GOI, 2013-2014, BAHS, 2017.Deficit calculated on the basis of difference between availability of meat and minimum requirement as recommended by ICMR (+) indicates higher consumption than the recommended one.

However at present our livestock production system is by "mass but not by quality and yield". Hence we need to adopt value chain approach and quality production system are required to ensure Food safety, Environmental responsibility, Animal health and welfare, Social responsibility and Traceability (FEAST) in order to compete with the global market and most of all in order to have a profitable venture in the long run.

There are two scopes in livestock meat industry:

1. Meat production including poultry
2. Animal slaughtering, processing, value addition and by-products utilization.

The first major segment deals with meat animals and poultry with inputs from animal genetics, animal nutrition, animal health and animal production management disciplines. The primary objective of this segment is production of meat animals and poultry at optimum slaughter age and slaughter weight to yield quality meat with maximum return to the farmer. The second major segment deals with slaughter of meat animals and poultry for harvesting of meat and edible offal pertaining to post harvest handling of products and its by-products utilization and marketing of these products. The primary objective of this segment is to supply clean and safe meat to consumers.

There is a huge potential for income generation opportunities in the meat sector, some of the few points are:

1. There is liberalized global market for export.
2. Increasing awareness for wholesome food leads to increased demand for hygienically processed and packed meat and meat products.
3. Increased income, purchasing power of young population and changing consumption patterns.
4. Entry of private entrepreneurs for establishing processed meat industry
5. Increased employment opportunities in the meat and allied sector.

Livestock contributes nearly 12% to rural household income. The global market for processed meats is estimated to be USD 362 billion in 2012 and is projected to reach USD 799 billion by 2018 with a compound annual growth rate of 14.3%. Maximum growth of this sector is expected in China, India, Japan and New Zealand. Because of huge anticipated growth, leading manufacturers are focusing on expansion of their respective meat processing business across India to broaden their production line. However, the lack of awareness about the processing equipment's and availability of trained manpower in India are the main obstacles in the growth of meat processing market. At present further processing and value addition of meat in India remains less than 2.0 % except in poultry where approx. 7.2% of meat are processed. Compared to broiler industry which is growing at a rate of 12-15% per annum, ready to eat meat products segment is growing more than 20% in India. Ready to eat meat sector is growing at consumer affluence. Large meat processing companies have entered into India catering to the demands of certain percentage of population. KFC currently operates 625 stores in the country and is aiming to open 1000 stores in 100 cities. Venky's Xprs has opened its outlets in Pune, Mumbai and Hyderabad and is planning to expand. Godrej Tyson has created the infrastructure to market poultry products in most of the Western and Southern cities in India. But such initiatives in large animal is almost absent. The evolution of modern retail outlets with better packaging, labelling, chilling and cold chain facilities will hopefully address the drawbacks of the existing situation.

Meat production and consumption in North Eastern Region:

The consumption of meat is relatively higher in this region because of social and religious acceptance. Coupled with the traditional meat-eating habit, increasing per capita income, urbanization and changes in life-style, the region is deficit in production of livestock products. Analysis of data in respect of annual meat production in NER (Table 2), it is observed that Nagaland is the top meat producer, while looking into the per capita consumption, Nagaland topped the list with (15.84 kg/annum). Few states even consume higher quantity of meat than the one (34g/caput/day) recommended by ICMR.

Opportunities for value addition for income generation in NER:

As seen in Table 1 NER holds less than 1 % of the national buffalo and sheep population, about 6 % of national cattle, goat and poultry population and 38% of the total pig population and mithun is found only in North eastern region of India where it occupies special status in the ethnic tribal population and is considered as a delicacy where it is reared as meat animal and is highly among the tribal people of North Eastern India. There is a wide gap between the requirement and availability of meat in India and North East in particular as the majority of the population in the region is non-vegetarian wherein meat is used as a main source of animal protein about 18% out of the total food expenditure is used in meat.Entrepreneur's must focus on this gap and invest in establishment of organized farms and meat processing plants for exploiting the business potential.

Technologies for production of different value added meat products:

Value added products are further processed products which increase convenience to the consumers. Primary processing of meat includes tenderization, grinding, flaking, freezing and packaging whereas further processing includes drying, curing, smoking, margination, emulsifying, cooking etc. The purpose of further processing of meat is to produce value added meat products and provide variety to consumers. It also serves for longer shelf life, transport and eases of distribution to larger population and is an avenue for promoting entrepreneur venture and employment generation. Value added products can be broadly classified based on processing, variety/convenience and functions and are briefly discussed as follows:

1. Comminuted/emulsion based products: Comminution is a process by which particle size of meat is reduced. The degree os particle size reduction differs greatly between various processed products. Meat emulsion is prepared by mixing of meat with other non-meat ingredients and thereafter chopping to prepare a uniform batter. Commonly used ingredients for production of emulsion are deboned meat, salt, sodium nitrite, sodium tripolyphosphate, extender (flours, soyabean etc), seasonings (spices), binders (boiled potato etc.) and water. Common steps involved in the preparation of emulsion based meat products are: mincing of meat, chopping of the minced meat with other ingredients in the bowl chopper, moulding of the emulsion as per the product requirement and cooking. Some of the emulsion based meat products commonly prepared are burger patties, nuggets, slices, sausage, balls etc.

2. Enrobed meat products: Enrobing is a technique for coating the meat products with edible materials to improve their cooking yield and provide better protection against oxidative and microbial deterioration. Enrobing helps in acceptability, imparting desirable crispiness and increase in the pleasure of eating with attractive colour and appearance and the products is more juicer.

3. Cured and smoked meat products: Curing is one of the oldest method of preservation technique. It is the

addition of salt, sugar and nitrate/nitrite to meat for the purpose of preservation, flavour enhancement or colour development. In applied concentrations most curing agents are bacteriostatic, fungi static and most detrimental to gram negative organisms. There are different methods of curing: Dry curing (ingredients will be rubbed on the meat), pickle curing (ingredients will be dissolved in water and applied either by immersion or injection methods). Curing and smoking contributes attractive colour, unique flavour and extending the shelf life of meat products.

4. Traditional meat products: Traditional meat products are the products which have evolve over generations and have unique sensory attributes which are specialty products traditional to their region. These products rely mainly on the ingredients available locally and hence will be typical to certain areas. The products are often linked to cultural identity. Some of the traditional meat products in North east are:

Table 3. Traditional meat products of North East

Name of product	Origin	Type and description of product
Adin	Arunachal Pradesh	Smoked dried meat with fermented bamboo shoot
Ekung esoadin	Arunachal Pradesh	Meat cooked with fermented bamboo shoot
Esosoki or Esohoki	Arunachal Pradesh	Meat cooked with rice powder
Sokisowad	Arunachal Pradesh	Boiled mixer of meat offals such as stomach, liver, intestine etc
Sa bai	Mizoram	Fresh/dried smoked meat mixed with rice, vegetables and cooking soda
Vawksa Salubawl	Mizoram	Edible meat, offals of pig steam cooked and mixed along with spices and condiments and sesame seed
Sawchhiar	Mizoram	Local sticky rice mixed with chopped meat fried with oil and some local spices
Saum	Mizoram	Fermented pork fat
Savunbawl	Mizoram	Pork skin (rind) after singeing is mixed with little amount of water, salt, cooking soda and salt and cooked in low flame.
Momo	All the states of North eastern region	Dough, rolled into small balls filled with pre fried minced meat with spices, steam cooked
Mhodi	Nagaland	Meat and other organs cooked by boiling or frying with oil mixed with local spices and cooked.
Galho	Nagaland	Meat fresh/dried smoked meat boiled with rice, local vegetables

Tsütüotei	Nagaland	Fermented cucumber leaf mixed with meat, offals with fermented bamboo shoot and local spices, cooked by either frying with oil or by adding water.
Anishi	Nagaland (Ao)	Meat mixed with yum leave (local vegetables)
Oso rütsü	Nagaland (Lotha)	Meat fresh/dried either boiled or fried with fermented bamboo shoot
Mangsu curry	Nagaland (Sumi)	Meat fresh or smoked dried cooked with fermented soya bean either by boiling or as a curry by adding local spices
Dohkhleik	Meghalaya	Edible offals such as Brain and the head meat of pig are mixed with spices and condiments and are fried in oil
Dohjem	Meghalaya	Small pieces of pork meat and fats along with intestines, liver, heart, spleen is cooked with black sesame
Tungrymbai	Meghalaya	Meat usually pork when cooked with fermented soyabean
Jadoh	Meghalaya	Khasi fried rice, cooked with black sesame/ along with local spices and condiments and pork fats.
Putharao	Meghalaya	It is like roti made by steaming powdered rice after moulding into roti shape
Doh klong	Meghalaya	Pork is cut into small pieces and adding local spices which are fried in oil
Doh kpu	Meghalaya	Pork minced mixed with onion, garlic, green chillies moulded into a ball fried in oil
Doh snam (Meghalaya) *Sathithun (Mizoram)*	Meghalaya Mizoram	Intestine cleaned filled with blood ginger, garlic and onion steam cooked commonly known as blood sausage
Asan adin	Assam	Pork is boiled and smoke-dried.
Eg-adin banum/ Khaophram (Roasted)	Assam	Pork pieces mild cooked- marinated with local spices condiments-woven in bamboo sticks-roasted over fire
Eg-adin Luktir	Assam	Dried pork mince mixed with dried bamboo soot, dried chilly and local herbs and spices
Cheu	Assam	Semi-Boiled pork pieces smeared with turmeric, red chilli and salt woven in bamboo sticks & roasted over fire (Charcoal)

Honohein	Assam	Dried pork used for curry preparation
Noau soum	Assam	Boiled rice smeared over the boiled pork pieces filled tightly in bamboo cans and sealed-fermentation occurs within few days and acts as preservative
Saphak	Assam	Boiled fats of pork-kept in air tight bottle
Sathu	Assam	Pieces of pork fat-half boiled –kept inside the sathu (Water gourd) -kept near the fire for 4-5 days
Ashi kioki	Assam	sliced dried pork, fermented bamboo shoot /soybean
Gahori Achar	Most of the tribes in Assam	It is a pork pickle marinated with oil, vinegar and other locally available spices.
Eg-adin banum/ Khaophram (Roasted)	Assam	Pork pieces mild cooked- marinated with local spices condiments-woven in bamboo sticks-roasted over fire
Eg-adin Luktir	Assam	Dried pork mince mixed with dried bamboo soot, dried chilly and local herbs and spices
Cheu	Deuri	Semi-Boiled pork pieces smeared with turmeric, red chilli and salt woven in bamboo sticks & roasted over fire (Charcoal)
Honohein	Dimasa,Karbi	Dried pork used for curry preparation
Noau soum	Dimasa, Karbi	Boiled rice smeared over the boiled pork pieces filled tightly in bamboo cans, sealed-fermentation
Saphak	Assam	Boiled fats of pork-kept in air tight bottle
Ashi kioki	Kukki Naga	Sliced dried pork fermented bamboo shoot /soybean
Gahori Achar	Assam	Pork pickle made -

In addition to providing variety to consumer, these traditional meat products create strong cultural identity as they are associated with traditional norms and beliefs. They enrich diets through diverse flavours, aromas and texture. Traditional meat products also contribute towards household food security and household processing. They also have potential to create employment opportunities and income generation for the rural and urban folks, thus creates small and medium scale entrepreneurship.

Conclusion:

Effective interventions like reducing mortality rate, minimizing the post-harvest losses, linking small producers to market, increased value addition and further processing, exploiting natural organic, minimally processed, fresh and locally grown sentiments will augments the farmers income. India is bestowed with several indigenous meat products, thereby providing enough opportunities and scope to expand their market beyond the geographical limit. Process optimization, large scale production, safety management and better packaging will further boost their demand and sustainability. Large scale production, safety management and better packaging will further boost their acceptability. Processed meat sector development is an important feature of organized meat sector with many benefits such as value addition, convenience, improved economics, increased demand, employment generation and entrepreneurship development. Efforts must be made to understand various functional attributes of these products and various scientific interventions should be adopted to enhance their quality as well as extend their shelf life without affecting their originality. As traditional food products are made mostly with local raw ingredients, they contribute to the development and sustainability of the rural areas. Large scale production and aggressive marketing efforts utilizing the advantage of logistic network will ensure their availability throughout the year and also increase their market potential. To achieve this entrepreneur must first understand the science behind meat production and processing. Effective blending of scientific knowledge with understanding of market dynamics and business principles can help in creating business ventures in meat processing sectors

Reference:

19th Livestock census (2012) Ministry Of Agriculture Department Of Animal Husbandry,Dairying And Fisheries Krishi Bhawan, New Delh

Naveena, B.M., Rituparna Banerjee, Muthukumar, M and Girish, P.S. (2018). Opportunities for doubling farmer's income in livestock value chain. In: Innovations in Livestock Sector for doubling farmers income: Strategies and opportunities in meat value chain. From 25th July to 14th August,2018, pp 1-8.

Girish, P.S. and Kumari, A (2018). Opportunities for meat processing and value addition in NEH states: Enterpreneurial avanues. In: Innovations in Livestock Sector for doubling farmers income: Strategies and opportunities in meat value chain. From 25th july to 14th August,2018, pp 155-162.

U.K Pal, L. Lalchamliani, P.K Mandal and S. Kasthuri (2017). Traditional meat products/preparations of Bengal and North Eastern India-Present Status and Future Prospects In: Climate change and Sustainable food production. Pp 265-278. ISSBN 978-93-86724-13-7.

MANAGING CLIMATE CHANGE IMPACTS ON SOIL AND WATER RESOURCES IN NORTH EASTERN REGION

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Climate change and its impact on water resources and agriculture are major global concerns of this century. The rising temperature has alarming influence on the hydrologic cycle and water resources (Huntington 2006; Oki and Kanae 2006). Human interventions in the Energy–Land–Water–Climate (ELWC) nexus are severely affecting earth's ecosystems including its land and water resources (Vitousek et al. 1997; Doll and Bunn 2014).

According to the fifth assessment report of IPCC (AR 5), renewable water resources are reported to decrease in some region and increase in other and in other increase, though with large uncertainty in many places. In general water resources may decrease in many mid-latitude and dry subtropical regions, and increase at high latitudes and in many humid mid-latitude regions (Jiménez Cisneros et al. 2014). Though there could be short term shortages even in the areas where increases are projected, due to more variable stream flow and seasonal reductions of water supply because of diminishing snow and ice caps. Climate change has altered observed stream flow seasonality in regions receiving snowfall. Except in very cold regions, Global warming has reduced the spring maximum snow depth and advanced the spring maximum of snowmelt discharge; has resulted in smaller snowmelt floods and increased winter flows, and reduced summer low flows (Jiménez Cisneros et al. 2014).

It has been reported that the all India mean temperature has increased by 0.5–0.7 0C in the last century though the change in seasonal and regional distributions are not homogeneous (Kothawale and Rupa Kumar 2005; Solomon et al. 2007; Jain and Kumar 2012; Stocker et al. 2013; Jayaraman and Murari 2014). Increasing temperature is expected to increase the evapotranspiration, it has been observed that the reduced soil moisture availability and changes in climatic variables such as wind speed, solar radiation, relative humidity seems to have compensated the effects of temperature increases on ET and resulted in decline of evapotranspiration in several paers of India (Jung et al. 2010; Jhajharia et al. 2012, 2014, Patle et al 2013, Chattopadhyay and Hulme , 1997, Bandyopadhyay et al., 2009). This has been happening due to reduction in wind speed and increase in RH and cloud cover. Chattopadhyay and Hulme (1997) reported that the relative humidity more critical than temperature in tropical surface water balance. In absence recorded long term stream flow data of Indian river basins, limited studies on the impact of climate change on the observed runoff in the Indian river basins are available for India (Madhusoodhanan et al, 2016).

Impact of climate change on water resources and agriculture in NE Region

North-Eastern Hill region is characterizes by humid sub-tropical climate with hot, humid summers and very high rainfall. North-Eastern Hill region is least developed area of India. Lower income, poor infrastructure, lack of basic amenities, difficult terrain, poverty, minimal access to technology had been the major hurdle in the development of developed this region. Realizing this Government is giving special attention to this region. Despite the fact that the region receives very high rainfall, access to water for domestic and irrigation has been the major concern.

With the global warming and climate change, the region is expected to suffer more. Indian Network for Climate Change Assessment (INCCA) in its report "Climate Change and India: A 4×4 Assessment" has reported that temperature in the North-Eastern region may rise in the region may rise by 1.8°C to 2.1°C. This may lead to increased evapotranspiration (INCCA, 2010). However, increased CO_2 concentration in the atmosphere may enhance the photosynthesis and reduced stomatal opening resulting lesser loss of water on the form of transpiration. This may compensate the increase in evapotranspiration due to rise in temperature.

Despite of the fact that mountainous and hilly regions are major sources of water supply for rest of the regions in non rain months, access to water for domestic, agricultural and other uses is becoming increasingly difficult. Mountains contribute disproportionately high runoff, provide a favourable temporal redistribution of winter precipitation to spring and summer runoff and reduce the variability of flows in the adjacent lowlands (Viviroli et al., 2003; Viviroli and Weingartner, 2004). Climate change has diverse impact on water resources of hilly and mountainous regions. Climate change has intensified the hydrologic cycle. Due to this hydrology of hilly and mountainous regions is changing at a faster rate. Unpredictable and erratic high intensity short duration rainfall, drying up of springs and streams in summer due to receding glaciers, warmer and humid climate, higher evaporation, changes in soil moisture and overland flow pattern are the major concerns in hilly regions.

Land and water resource management technologies for managing the climate change impacts in North Eastern Region

Major portion of the North Eastern Region has hilly and mountainous terrain. The region is facing challenges from a growing population, increasing human interventions, rapid urbanisation, rapid changes in land use, deforestation, mining, burning of the vegetation to increase the area under agriculture, growing tourism industry and other economic activities.

The major sources of water in hilly and mountainous areas are rainfall and snow. Though the major part of the rainfall flows away as surface runoff, a considerable portion is stored in the soil profile and is released in the later part of the year as base flow and spring water. Water from base flow and springs can be stored in small tanks or can be used directly through the network of pipes. Glacial melt is an equally important source of water in the mountainous region. Melted water flows down slope through the cervices, cracks and pipes which dominant sub-surface features of the mountainous region.

Managing land and water resources in hilly and mountainous area is difficult due to undulating terrain; small and scattered landholdings, steep slopes, lesser soil depth, high infiltration, poor water holding capacity of soil, poor irrigation infrastructure and preferential subsurface flow. These restrict the use of modern technology and inputs. Besides precipitation, other hydrological processes such as canopy interception, stream flow, through fall, surface retention, surface detention, infiltration and lateral seepage, overland flow, channel or stream flow, interflow/base flow, and evapotranspiration play significant role in seasonal and annual variations in water availability in the hilly and mountainous regions. These get pronounced during monsoon. Impacts of hydrologic processes become hazardous in hilly region during monsoon on steep and erosion prone slopes subjected to unsuitable land uses. This causes not only the degradation in uplands but also siltation and floods in valleys and plains.

Strategies required to develop land and water resource have to different from the plain. Besides precipitation, hilly and mountainous regions are the major source of water for plain. If these regions are not managed properly, economy of the plains may also be adversely affected due to siltation of reservoirs, reduced sub-subrface/base floe, reduced water supply to rivers.

The main sources of water in hilly areas are rainfall and snow. Though the major part of the rainfall flows away as surface runoff, a considerable portion is stored in the soil profile and is released in the later part of the year as base flow and spring water. Water from base flow and springs can be stored in small tanks or can be used directly through the network of pipes. Glacial melt is an equally important source of water in the mountainous region. Melted water flows down slope through the cervices, cracks and pipes which dominant sub-surface features of the mountainous region. Major sources of water and the mode of its utilization in the hilly regions are described below.

Key to manage the land and water resources in hills lies in managing the followings

Base Flow harvesting: base flow is a predominant phenomenon and a source of water in hill. Base flow is the stream flow coming from ground water seepage into a stream shown. Though the river or stream carries water for few months in a year, base flow occurs throughout the year, making it a potential fresh water source. This subsurface flow can be utilized through sub-surface dykes.

 The original site selected for Gauging Station	 ari Ka Khad – The main Channel of the Watershed
 Work in progress for construction of the channel for installation of HL Flume	 The Hl Flume, Stilling Well and Housing for Stage Level Recorder

Large streams: Large streams are a predominant source of water in the hills. Large streams are natural watercourses containing water for at least part of the year and depending on the local resources, ingenuity, and skills, diverse practices of cultivation and water management have been developed by the local people. These need further improvement.

Springs: Springs normally occur in the mountainous regions where the water table reaches the surface and are an important source of water in the villages particularly in hilly areas. Spring water can be utilized through tanks.

 Spring water harvesting through concrete lined tanks in Moolbury Watershed of Himachal pradesh	 Source of water for Moolbury Village

Soil erosion: Due to inappropriate land uses and fragile ecosystem, hilly region are more erosion pron. Soil conservation measures such as bench terraces, contour trenching and graded bunds can be used for controlling soil erosion.

Modern methods of irrigation: Modern methods of irrigation such as drip and sprinkler for efficient utilization of water resources should be promoted in these areas.

Integrated agro-forestry based farming system: Integrated farming system considering the local requirement and resource availability would be better option. This should consider the improvemt in local technology rather than the complete replacement.

Technologies for managing soil and water resources in North Eastern Region

Soil and water conservation technologies	Purpose	Design Criteria	Requirement
Bench Terraces	To control soil erosion and to maintain soil fertility. Terracing is the most common response. Terracing has various advantages and has contributed considerably to soil conservation on sloping agricultural lands. The advantages of terracing include easier tillage and substantial	For designing bench terraces the specifications regarding vertical interval, length, inward grade, longitudinal grade etc. are to be determined. Condition of soil depth, slope, rainfall, farming practices have a direct bearing on terrace design. The design of bench terraces	To find the vertical interval factors needed are percentage of land slope, soil depth, depth of cutting and width of terrace. To estimate the peak rate of runoff, rainfall intensity, length, average width of terrace and permissible

	reduction in soil erosion.	consists of the following: - Terrace spacing - Terrace grade length - Terrace cross section	velocity of flow for different soils is required.
Contour Trenching	Contour trenches are used both on hill slopes as well as on degraded and barren wastelands for soil and moisture conservation and afforestation purposes. The trenches break the slope and reduce the velocity of surface runoff. It can be used in all slopes irrespective of rainfall conditions (i.e., in both high and low rainfall conditions), varying soil types and depths. Trenches can be continuous or interrupted. The interrupted one can be in series or staggered, continuous one is used for moisture conservation in low rainfall areas and require careful layout. Intermittent trenches are adopted in high rainfall areas	Trenches are not more than 15m long and are generally staggered. The cross section rarely exceeds 0.3m 8 0.3m, the objective being merely to fix sufficient moisture in the soil to enable the berms to be revegetated. Contour trenches are excavate at suitable intervals depending upon the slope of the land.	The size of the trench depends upon the soil's depth. Cross section and land slope are required to design the trenches The trench may be of 30 cm base and 30 cm top width and square in cross section or it can be trapezoidal with side slopes 1:1. Based on the quantum of rainfall to be retained, it is possible to calculate the size and number of trenches.
Check dams	A check dam is generally constructed on small streams and long gullies formed by the erosive activity of water. The various types of check dams are brush wood dam, loose rock dam and woven wire dam. It cuts off the runoff velocity and reduces erosive activity. The water	Ideally a check dam is located in a narrow stream with high banks. While constructing a series of check dams on along stream course, the spacing between two check dams should be beyond their water spread. The height of the check dam should be such that even during the highest flood, water does not	

	stored improves soil moisture of the adjoining areas and allows percolation to recharge the aquifers	spill over the banks.	
Graded bunds	Bunds are small earthen barriers provided in agricultural lands with slopes ranging from 1 to 6 percent. They control the effective length of slope and thereby reduce the gain in velocity of runoff flow to avoid gully formations.	The design of graded bunds involves determination of the spacing between the bunds, the grade and cross section of the channel. .	To determine the spacing either horizontal or vertical interval is required. Soil, climate(rainfall), slope of the land and type/extent of vegetation cover on land are some of the required factors.
Contour Stone wall	It is constructed with stones across the hill slopes thereby intercepting the surface runoff. These terraces help in retarding the soil loss and conserving soil moisture.	Spacing of such stonewalls are not rigid. Spacing ranging from 10 m to 30 m can be adopted depending upon slope of the terrain.	For the construction, a shallow trench has to be dug and the stones collected and packed directly on to the foundation and in the super structure to form the terrace. The stones should be properly interlocked The soil excavated to form the foundation for the terrace is used for forming a small bund on the upstream side of the terrace. Terrace is stabilised by planting suitable vegetation on the bund.

Gully Plugs	They are earthen embankments usually constructed for blocking the active and erosion prone gullies for their stabilisation. a) Brushwood dams b) Loose rock dams c) Woven wire dams	There are no standard principles of the design of these structures. These are to be designed and constructed based on the needs and availability of materials in a given situation. The overall height of temporary check dams use for this purpose should not be more than 75 cms; an effective height of about 30 cms is satisfactory.	Locally available vegetative cutting are used in their construction. In the woven dam a wire mesh is used to hold the stone in place. All the check dams involving stones are to be adopted in areas where stones are available easily and in plenty. The rock fill dam and the woven wire dam are more lasting than the loose rock dam.
Irrigation Tanks	The main function of this storage structure is irrigating crops. Earthen bunds are reinforced with masonry to collect and store rainwater for irrigation. The cost of this tank (dam) depends upon the size, location and site condition. It costs about US$ 1 500 - 2 500 to irrigate 1 ha of land. Water from the tanks is normally used to grow paddy crop	The capacity of the tank has to be calculated on the basis of the rainfall and catchment area of the tank. Select the site for the tank or check dam. From the Topo sheet or village map, find out the correct catchment area of the watershed at that location. Take the cross sections and longitudinal section of the stream or gully where the tank or dam is constructed. Based on the levels taken, prepare 50 cm contour for	The location should be such that it should receive water from a large catchment area. Cooperation and coordination of the farmers and the community is essential to use the water. The location should be such that it will be a narrow point with high ground and wide-open space in front of the tank location so that a large quantity can be stored with minimum cost.

		sufficient area to decide the water spread area and the capacity of the tank based on the yield of the watershed.	
Percolation Ponds	A percolation pond, like an irrigation tank, has a structure to impound rainwater flowing through a watershed, and a waste weir to dispose of the surplus flow in excess of the storage capacity of the lake created. The storage capacity of percolation pond is around 30 to 60 million litres.	The section of the bund is similar to that of an irrigation tank, except that the cut-off trench is taken to a depth equal to half the height of the bund. The purpose of the cut-off in the case of the percolation tank is just to prevent erosion of the downstream slope of the bund due to piping. The cut-off should be shallow enough to permit the percolating water to pass downstream into the aquifer. The percolation tank bund has a hearting and a casing, and is provided with stone pitching on the upstream face and turfing on the downstream slope.	A masonry waste weir is also necessary to pass surplus water. Drains are provided under the bund to lead water percolating into the bund safely downstream.
Sub-Surface Dams	Groundwater dams are structures that intercept or obstruct the natural flow of groundwater and provide storage for water underground. They have been used in several parts of the world, notably India, Africa and Brazil. Their use is in areas where flows of groundwater vary considerably during the course of the year, from very high flows following rain to negligible flows during the dry season. The basic principle of the groundwater dam is that instead of storing the water in surface reservoirs, water is stored underground. The main advantages of water storage in groundwater dams is that evaporation losses are much less for water-stored underground.	There are two main types of groundwater dam: the sub-surface dam and the sand storage dam. A sub-surface dam intercepts or obstructs the flow of an aquifer and reduces the variation of the level of the groundwater table upstream of the dam. It is built entirely under the ground The sand storage dam is constructed above ground. Sand and soil particles transported during periods of high flow are allowed to deposit behind the dam, and water is stored in these	The best sites for construction of groundwater dams are where the soil consists of sands and gravel, with rock or a permeable layer at a depth of a few meters. Ideally the dam should be built where rainwater from a large catchment area flows through a narrow passage. Various materials may be used for the construction of groundwater dams. Materials should be waterproof, and the dam should be strong enough to withstand the imposed soil and water loads. Dams may vary from 2 to 10 meters high. Materials include compacted clay, concrete, stones and clay, masonry

	Further, risk of contamination of the stored water from the surface is reduced because as parasites cannot breed in underground water. The problem of submergence of land which is normally associated with surface dams is not present with sub-surface dams.	soil deposits When constructing a sub-surface dam in a riverbed, one can increase the storage volume by letting the dam wall rise over the surface, thus causing additional accumulation of sediments. Similarly, when a sand-storage dam is constructed it is necessary to excavate a trench in the sand bed in order to reach bedrock, which can be used to create a sub-surface dam too. Groundwater dams are built across streams or valleys. A trench is dug across the valley or stream, reaching to the bedrock or other stable layer like clay. An impervious wall is constructed in the trench, which is then refilled with the excavated material.. The reservoir is recharged during the monsoon period and the stored water can be used during the dry season. Excess water flows over the top of the dam to replenish aquifers downstream. Water may be obtained from the underground reservoir either from a well upstream of the dam or from a pipe, passing through the dam, and leading to a collection. point downstream Groundwater dams cannot be a universally applicable as these require specific conditions for functioning.	wall or plastic sheets.

References

Bandyopadhyay A, Bhadra A, Raghuwanshi N S and Singh R.(2009). Temporal trends in estimates of reference evapotranspiration over India. Journal of Hydrology Engineering 4 (5): 508–515.

Chattopadhyay, N., and M. Hulme (1997). Evaporation and potential evapotranspiration in India under conditions of recent and future climate change. Agricultural and Forest Meteorology 87: 55–73. doi:10.1016/S0168-1923(97)00006-3.

Doll, P. and S.E. Bunn. (2014). The impact of climate change on freshwater ecosystems due to altered river flow regimes. In Climate change 2014: Impacts, adaptation, and vulnerability.

Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, ed. C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea

Howells, M., S. Hermann, M. Welsch, M. Bazilian, R. Segerstro¨m, T. Alfstad, D. Gielen, H. Rogner, et al. (2013). Integrated analysis of climate change, land-use, energy and water strategies. Nature Climate Change 3: 621–626.

Huntington, T.G. (2006). Evidence for intensification of the global water cycle: Review and synthesis. Journal of Hydrology 319: 83–95.

Oki, T., and S. Kanae. 2006. Global hydrological cycles and world water resources. Science 313: 1068–1072.

INCCA, (2010) Climate Change and India: A 4 X4 Assessment A Sectoral and Regional Analysis For 2030 S. Ministry of Environment and Forest, Government of India.

Jain, S.K., and V. Kumar (2012) Trend analysis of rainfall and temperature data for India. Current Science 102: 37–49.

Jhajharia, D., Y. Dinpashoh, E. Kahya, V.P. Singh, and A. Fakheri- Fard (2012) Trends in reference evapotranspiration in the humid region of northeast India. Hydrological Processes 26: 421–435.

Jayaraman, T., and K. Murari (2014) Climate change and agriculture: Current and future trends, and implications for India. Review of Agrarian Studies 4: 1–49.

Jiménez Cisneros, B.E., T. Oki, N.W. Arnell, G. Benito, J.G. Cogley, P. Döll, T. Jiang, and S.S. Mwakalila, (2014) Freshwater resources. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral

Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 229-269.

Jung, M., M. Reichstein, P. Ciais, S.I. Seneviratne, J. Sheffield, M.L. Goulden, G. Bonan, A. Cescatti (2010) Recent decline in the global land evapotranspiration trend due to limited moisture supply. Nature 467: 951–954.

Kothawale, D.R., and K. Rupa Kumar (2005) On the recent changes in surface temperature trends over India. Geophysical Research Letters 32: doi:10.1029/2005GL023528.

Madhusoodhanan, C. G. K. G. Sreeja, T. I. Eldho (2016) Climate change impact assessments on the water resources of India under extensive human interventions. Ambio, 45:725–741 DOI 10.1007/s13280-016-0784-7

Patle, G. T., D K Singh, A Sarangi, Anil Rai, Manoj Khanna and R N Sahoo (2013) Temporal variability of climatic parameters and potential evapotranspiration. Indian Journal of Agricultural Sciences 83 (5): 518–524.

Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.M.H.L. Tignor, and H.L. Miller (2007) The physical science basis: Contribution of working group I to the fourth assessment report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Stocker, T.F., D. Qin, G.K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, et al. 2013. Climate change (2013) The physical science basis. Contribution of working group

I to the fifth assessment report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press.

Vitousek, P.M., H.A. Mooney, J. Lubchenco, and J.M. Melillo. (1997). Human domination of Earth's ecosystems. Science 277: 494–499.

Viviroli, D., Weingartner, R., and Messerli, B. (2003) Assessing the hydrological significance of the world's mountains, Mt. Res. Dev. 23, 32–40, 2003.

Viviroli, D. and Weingartner, R. (2004) The hydrological significance of mountains – from regional to global scale, Hydrol. Earth Syst. Sci., 8, 1016–1029, doi:10.5194/hess-8-1017-2004.

ROUTINE FARM OPERATION AND MANAGEMENT PRACTICES FOR ENHANCING LIVESTOCK PRODUCTIVITY

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Purpose

1. To get the farm jobs completed on time and properly.
2. To utilize labor efficiently.
3. To provide better regular care to animals.
4. To get higher returns through efficient management practices.

Description:

Routine means a prescribe and detailed course of action to be followed regularly. Establishing routines in our activities improves our efficiency. Taking into account the prevailing practices in animal production in commercial farm, the following routine may be adopted to improve the performance of livestock; although the routines to be followed may vary with the objectives and agro climatic locations. Schedule of Day to day operation on your farm should be prepared as per convenient of the locality.

Common Management Practices

Colostrum Feeding (The first milk secreted after parturition). It contains large amount of Gama globulins which are anti-bodies produced by the cow against antigens encounter during her life including those against many disease producing organisms. Colostrums is highly fortified source of nutrient having 7 times the protein and twice the total solids of normal milk, thus it gives an early boost in portion and solid intake. It contain higher amount of minerals and vitamin A which are essential to combat disease. Ingestion of these through colostrums substantially increases the calf's survivability. Absorption of these antibodies provides the calf with an umbrella of passive immunity. Colostrums give a laxative effect which is helpful in expulsion of muconium (first faeces). It will be highly useful to feed colostrum in the first 15-30 minutes followed by a second dose in approximately 10-12 hours.

First ½ hour to 12 hours of life, calf should be given with colostrum of its 5-8 % of body weight. Then 2nd and 3rd day, it should be of 10% of its body weight. The excess colostrums can be stored by refrigeration and can be used to other calves or orphan calves.

Composition of Colostrum

Constituents	Colostrums of cow milk	Colostrums of buffalo milk	Normal Milk
Total solids	28.30	31.0	12.86
Ash	1.58	0.9	0.72
Fat	0.15-1.2	4.0	4.0
Lactose	2.5	2.2	4.8
Casein	4.76	7.7	2.8
Albumin	1.5	3.6	0.54
Globulin	15.06	12.5	-
Total protein	21.32	23.8	3.34

Weaning

Now a days, early weaning is recommended for better management and economic return.

Under early weaning system, weaned calves housed separately and scientific feeding schedule and manage mental practices followed.

In this method, the cow is not allowed to suckle by its calf after colostrum feeding.

Instead, the cow is completely milked out and required quantities of whole milk or skim milk are fed to the calf.

Weaned calves should be trained to drink milk from pails / nipple pail so that feeding management is easier.

Weaned calves should be weighed every week and the quantity of milk to be fed is calculated accordingly.

Identification for farm animals

Identification of animals is must, as a requirement in the daily management, to spot and identify a particular animal in a herd/group/flock.

Reasons

For registration and recording of the parentage in breeding programme / birth for individual feeding of animals during milking,during sale, for participation of animals in the rally, show and exhibition. For treating the animal, heat detection etc.

Methods of Identification

Neck chain/Neck rope

Ankle band

Brisket tag

Tail tag

Chalk/grease marker

Black/light colored paints

Pictures/sketches

Photographs

Ear tattooing

Ear Notching

Branding

Ear tagging

1.Ear tatooing

It is one of the permanent methods of identification system.

Instruments Required

Tattooing forceps, tattoo no/letters

Tattooing ink/paste

Procedure

The required dies (Numbers and letters) assembled in the tattooing forceps.

Locate the area in the ear to be tattooed. (above the cartilage equidistance between tip and cartilage of the ear).

Clean the area with alcohol.

Position the equipment. Check the Number / letter in a piece of paper before applying in the ear.

Then squeeze the forceps for puncturing properly.

Rub the tattoo ink / paste on the punctured area.

2.Ear tagging

Most popular method of identification system.

Equipments Required

Tagging forceps & tags

Procedure

Select the tag type (Single piece / Double piece).

Use the contrasting ink and style based on the skin colour of the animal.

Invert the ear tag into the appropriate applicator.

Locate the area in the ear for tagging) (half the way between base and tip of the ear).

Puncture the ear with applicator if the tags are non-piercing type.

Apply the ear tag by puncturing the ear with the applicator.

3.Branding

Hot Iron branding: A good hot iron branding should be visible and recognizable since it destroys hair follicles located under several layers of the skin and leaved a permanent bald scar on the skin of the animal.

Required

Branding irons / Electric branders made up of iron or steel, squeeze chute / Trevice (for restraining)

Procedure

Assemble and keep the equipment ready

Heat the branding iron

Before branding, restrain the animal

Check the temperature of branding iron. It should be grey ashes.

Then press the iron and shake the handle against the skin for fixing the iron properly.

Time of application usually 3-5 sec.

The brand marks should be big enough to read identify at a distance and each letter separated 2.5cm to prevent sloughing of the skin.

Apply an antiseptic for healing of wound.

Freeze branding

Application of cold iron to the skin of the animal causes destruction of melanocytes and white hairs grows on the branded area.

Procedure

Assemble the necessary cold branders / iron.

Cool the branding irons in the liquid nitrogen or dry ice

Before application, restrain the animal

Clip the area of the branding site, clean and apply alcohol to the clipped area

Apply the cold branders to the clipped area and apply equal pressure by pressing iron properly and evenly on the skin.

Time of application 30 sec to 1 min.

4.Ear notching

Commonly used in pigs and in beef cattle.

Notching means making a ‘V’ shaped notches at specific areas of the ear with the help of a sharp scissors or pincers.

For e.g. a notch in lower right ear is no.1. and notch in lower left ear is No.3.

Castration

Making the animal unable to reproduce is generally known as castration.

In India and other South-East Asian countries bullocks are extensively used for agricultural operations.

Buffalo is particularly valued as a draught animal in rice growing areas.

Male cattle and buffaloes meant for work should be castrated.

Purpose

To render the animal docile

To induce faster gain in body weight and to improve the quality of meat.

To control indiscriminate breeding.

To prevent certain genital diseases.

Castration also results in lean and slender neck which facilitates the correct fitness of yoke especially in work cattle.

Precaution

Castration should be performed during cold season and strictly avoid rainy season for fear of fly problems.

Castrated animals should be rested for few days in clean and comfortable pens.

Optimum Age

Young animals: within 3 months (Surgical method and elastrator)

Adult animal: within one year of age (Closed method – Burdizzo castrators)

Methods

1. Burdizzo method

It is also known as bloodless castration. The Burdizzo castrator is used to crush the spermatic cord and thus stopping the blood to the testes.

This results in atrophy of the testes and stoppage of spermatozoa production.

After casting, secure the animal. Move the spermatic cord to the side of the scrotum and then clamp the Burdizzo at about 3-5 cm above the testicles and it is held for a few seconds.

Then repeat this operation on the same cord at a location about 1cm below the first one. This method is safe, quick and less chance of getting infection.

2.Open or surgical method

Scrotum is opened and testicles are removed, aseptically and the wound is treated with antiseptics.

In young bulls the cord may be cut as savagely off but in the case of mature bulls the cord should be twisted before severing it.

3. Rubber ring or elastrator method

A strong and tight rubber ring placed around the cord at an early age of calf.

This creates constant pressure and the testicles are atrophied and absorbed and the ring drops down.

Elastrator rings are very painful to the animal and so it is not usually recommended. Optimum age: below 3 months.

Disbudding

Disbudding means arresting the horn growth at an early age, when the horn root is in the bud stage.

Horn serves no useful purpose.

Purpose

Dehorned animals need less space in the sheds.

Cattle with horns inflict bruises on each other that may result in heavy economic losses.

Horned animals are a danger to the operator.

Dehorned animals can be handled more easily.

Prevents the occurrence of horn cancer.

Optimum Age 15 to 20 days.

Methods

1. Hot iron method

A specially designed electric dehorner is used for this purpose. This is bloodless method it may be used at any season.

The rod heated with electricity has an automatic control that maintain the temperature at about 10000 F, applying it to the horn bud for l0 seconds is sufficient to destroy the horn tissue.

2. Elastrator

A specially made thick rubber ring applied to the base of the horn.

The rubber band shuts off circulation and the horn gradually comes off. Small buds drop off in 3 to 6 weeks and large horns may take even 2 months.

It is a painful method and this method is used on cattle when the horn length is about 5-10 cm.

3. Chemical method

Caustic potash or caustic soda is the common chemical used for dehorning. These are available in the form of paste or solution.

Clip the hair around the horn buds and surrounding area, a ring of Vaseline to protect the eyes against chemicals.

Rub the chemical over the buds until bleeding occurs.

4. Dehorning saw or clippers

When older cattle are to be dehorned a specially designed clippers or saw are used.

A considerable amount of bleeding may follow the operations.

To prevent the bleeding the main horn artery should be tied off with a cotton or silk thread.

This may be done by sliding a sewing needle under the artery to pull the thread in place before tying.

It is necessary when sawing or clipping the horns, to take about half an inch of skin in order to get at the horn roots. Normal udder should have four severely placed teats of uniform size. But animals with one and even two extra teats are also seen. Such extra teats may be blind or leaky.

It should be removed before the calf attains 6 months of age.

After controlling the calf, the region is thoroughly cleaned and disinfected with Tincture iodine and mark extra teats before removal. These teats are clipped off with scissors.

Some more tincture is applied after finishing the process. In the older heifer, suture is put in order to arrest bleeding.

Ageing of animals is important for the following reasons,

To issue soundness certificate

To select and purchase livestock

To know the breeding status of the animal

To estimate the value of the animal

The age of an animal can be estimated from

The date of birth available in registers or by

Dentition

Horn rings

Number of young one produced by the animal.

Cattle - Dentition

Temporary dentition: 0/4 0/0 3/3 0/0

Permanent dentition: 0/4 0/0 3/3 3/3

At birth: Calves are usually found to have their 8 incisors and 3 pre molars of the temporary dentition easily palpable below the gums.

At 1 month: 8 temporary incisors have their crowns free from the gums and the teeth are quite prominent and well defined. The three temporary molars are well up and wearing.

At 6 months: The teeth are well placed in the jaw and are no longer overlapping.

At 1 year: The most marked change between this time and 6 months of age is the wear of the temporary incisors.

At 2 years: The first pair of permanent central incisors replace the corresponding temporaries and the first and second molars push out the temporaries and cut through the gums.

At 2 1/2 - 3 years: The second pair of permanent medial incisors replace the corresponding temporaries.

At 3 - 3 1/2 years: The third pair of permanent lateral incisors replace the corresponding temporaries.

At 4 years: The last pair of permanent corner incisors replace the corresponding temporaries.

At 4-5 years: The teeth are slightly worn along their cutting edges, and they occupy a less crowded position.

At about 6 years: The surface of wear has reached practically half-way across the upper surface of the teeth, and a portion of the root is exposed.

At 10 years: The greater parts of the crowns have worn from the teeth and only a little cup-shaped piece of enamel remains.

At about 12 to 14 years: Only the stumps of the teeth remain.

In horned breeds of cattle a rough estimate of age can usually be made by counting the number of rings round the bases of the horns. The first ring appears at about 2 years and thereafter one ring is added annually.

Type of teeth	**Age of eruption**
1st pair central incisors	2-2 ½ years
2nd pair central incisors	3 years
3rd pair central incisors	4 years
4th pair central incisors	4 ½ years
Type of teeth	Age of eruption
1st pair molars	2 years
2nd pair molars	2 ½ years
3rd pair molars	3 years
4th pair molars	3 ½ years
5th pair molars	4 years
6th pair molars	4½ years

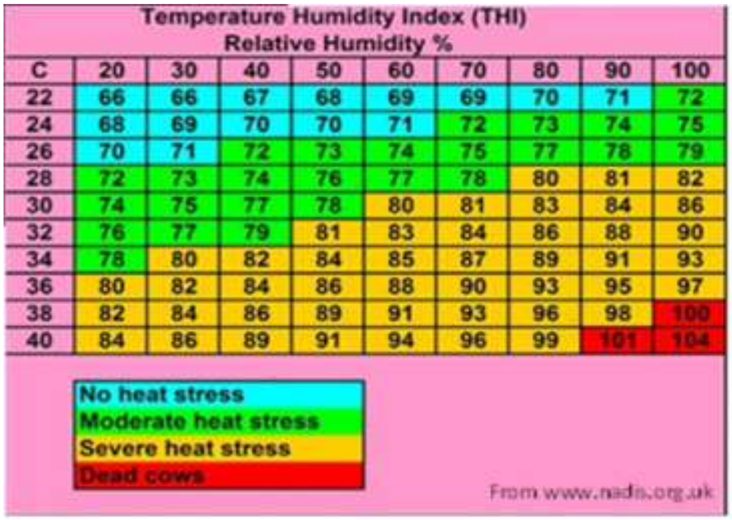
Full mouth in country breed - 4 1/2 years.

Management of heat stress in the farm.

Climatic change is the big problem in recent time. Climate changes affect a range of factors associated with production, reproduction, work capacity and adaptability of the animals. Global climate change is expected to alter temperature, precipitation, atmospheric carbon dioxide Animal husbandry sector depends upon the climatic conditions where it mainly affected by the temperature and humidity. Environmental stress reduces the productivity and health of livestock resulting in significant economic losses. Climate changes, could impact the economic viability of livestock production systems worldwide.Heat stress affects animals performance and productivity of dairy animals in all phasesof production. Heat stress has a direct effect on oestrus behavior in dairy animals. They display the most remarkable sexual activities in morning and midnight but the lowest activity was reported at noon time during high ambient temperature. The outcomes include decreased growth, reduced reproduction, increased susceptibility to diseases, and ultimately delayed initiation of lactation. Productive and reproductive success in livestock is essential for the economic livelihood of producers. Housing, feeding, management improved cooling system and many other new technologies are available through which climatic impacts on livestock can be reduced.

Temperature Humidity Index(THI).

Heat stress is associated with THI as the primary environment factor that produce heat stress are temperature and humidity. Body temperatures beyond 45–47°C are lethal in most of the animals. Exposure of animals to the hot conditions evokes a series of changes in the biological functions that include depression in feed intake, efficiency and utilization, disturbances in metabolism of water, protein, energy and mineral balances, enzymatic



Temperature Humidity Index (THI)

C	Relative Humidity %								
	20	30	40	50	60	70	80	90	100
22	66	66	67	68	69	69	70	71	72
24	68	69	70	70	71	72	73	74	75
26	70	71	72	73	74	75	77	78	79
28	72	73	74	76	77	78	80	81	82
30	74	75	77	78	80	81	83	84	86
32	76	77	79	81	83	84	86	88	90
34	78	80	82	84	85	87	89	91	93
36	80	82	84	86	88	90	93	95	97
38	82	84	86	89	91	93	96	98	100
40	84	86	89	91	94	96	99	101	104

No heat stress
Moderate heat stress
Severe heat stress
Dead cows

From www.nadis.org.uk

THI = 0.72 (Tdb + Twb) + 40.6

Where, Tdb is Dry bulb temperature in ºC, Twb is Wet bulb temperature in ºC

The mean and maximum THI may calculate by following formulae (Hahn *et al*., 1969;

McDowell *et al.*, 1979, Thom, E.C. 1959)

Mean THI = (0.8 x mean *T* + mean RH (%)/100 x (mean *T* – 14.4) + 46.4)

Maximum THI = (0.8 x mean *T* + minimum RH (%)/100 x (mean *T* – 14.4) + 46.4)

Where, T is temperature and RH is the relative humidity.

When THI exceeds 72, IT will result in heat stress to the animal (Johnson, 1980). Many previous studies reported that milk yield of cows in to be negatively correlated with temperature-humidity index (Shinde *et al.,* 1990; Mandal *et al.,* 2002).

Effects of climate in reproductive performance of animals

Reproductive efficiency is the key factor affecting profitability in many livestock production systems. Previous experiments showed that heat stress has detrimental effect on the reproduction of cattle and buffaloes (Tailor and Nagda, 2005). The stress condition causes the release of ACTH from the anterior pituitary which stimulates release of cortisol and other glucocorticoids from the adrenal cortex. Glucocorticoids inhibit the release of luteinizing hormones. (Singh *et al.,* 2013) reported that hyperprolactinaemia as a result of thermal stress inhibits the secretion of both FSH and LH at hypophyseal level. The low fertility occurs during heat because the embryo loses its ability to alter prostaglandins synthesis in a manner that favours the maintenance of the corpus luteum. These effects, combined with the other endocrine changes which occur during heat stress, accounts for the more pronounced effect of heat stress on reproduction than is seen with other stressors (Moberg, 2000).

MUSHROOM CULTIVATION FOR DOUBLING THE FARMERS INCOME IN NORTH EAST INDIA

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Mushrooms have been identified as priority item in government's recent programme along with the promoting production of vegetables and fruits. Mushrooms, also called 'white vegetables' or 'boneless vegetarian meat' contain ample amounts of proteins, vitamins and fibre apart from having certain medicinal properties. Mushroom contains 20-35% protein (dry weight) which is higher than those of vegetables and fruits and is of superior quality. Mushrooms are now getting significant importance due to their nutritional and medicinal value and today their cultivation is being done in about 100 countries. There are many types of mushrooms produced and marketed worldwide but the white button mushroom has the maximum share towards the consumption by the consumers in India. Whereas in North East Region, due to non availability of button mushroom, oyster (*Pleurotus* sp.) mushroom has the maximum share in north east including Nagaland towards its production and marketing. Hence, North-East Region has very good prospects of cultivation because of prevailing of favourable weather condition for the production and lack of supply of mushroom from other parts of India. Along with this, majority of the people in the north east are well accepted to eat the mushroom. Therefore mushroom cultivation as an economic opportunity in Northeast India.

Mushroom cultivation in North East India

Even though prevailing weather condition is favourable for all the mushrooms, the commercial cultivation is restricted to oyster mushroom cultivation because of its simple cultivation practice, low investment and other reasons. A dozens of mushroom have been recommended for commercial cultivation. However, only six mushrooms are widely preferred for large-scale cultivation. They are

1) Oyster mushroom - *Pleurotus* spp.
2) Shiitake mushroom - *Lentinus* spp.
3) Paddy straw mushroom - *Volvariella* spp.
4) Button mushroom - *Agaricus* spp.
5) Milky mushroom - *Calocybe* spp.
6) Jew's ear mushroom - *Auricularia* sp.

1) Oyster mushroom - *Pleurotus* spp.

This mushroom has species suitable for both temperate and sub-tropical regions. For temperate region *Pleurotus ostreatus, P. florida* (winter strain) and *P. fossulatus* (Kabul dhingri), *P. eryngii* (King oyster) are ideal. The areas suitable for button mushroom are equally suitable for the cultivation of these species. Most of the oyster mushroom species are subtropical in nature and grow well in temperature range of 20-32°C. The most popular ones are *P. sajor-caju, P. flordia, P. flabellatus* and *P. eous*. These varieties particularly *P. florida* and *P.sajor-caju* are most popular in the country.

Table 4. Scientific name of different Oyster mushrooms and temperature requirements:

Common name	Scientific name	Optimum Temperature Range
Grey Oyster	*Pleurotus sajor-caju*	20-28ºC
Black Oyster	*Pleurotus ostreatus*	18-22ºC
White Oyster	*Pleurotus florida*	20-28ºC
Pink Oyster	*Pleurotus djamor*	20-26ºC

Gray Oyster   Black Oyster   White Oyster   Pink Oyster

Advantages:

1. It grows on wide range of agricultural wastes and temperatures
2. Its conversion rate i.e. fresh mushroom production from the dry substrate is high.
3. It is less prone to diseases and competitor moulds than other mushrooms.
4. Faster growth rate and easy cropping.
5. Low cost of production.
6. Most suitable for rural areas and can create self employment.
7. Easy post harvest processing particularly dehydration/sun drying.

2) Shiitake mushroom - *Lentinus* spp.

Lentinula edodes is a kind of wood rot fungus. In nature, it grows on dead tree trunks or stumps. In general, the wood for the mushroom growth consists of crude protein 0.38%, fat 4.5%, soluble sugar 0.56%, total nitrogen 0.148%, cellulose 52.7%, lignin 18.09% and ash 0.56%. The optimum temperature of spore germination is 22-26°C. The temperature for mycelial growth ranges from 5-35° C, but the optimum temperature is 23-25° C.

Shiitake mushroom

It belongs to low temperature mushrooms, the initial and development temperature of fruiting body formation is in the range of 10-20°C and the optimum temperature of fructification for most varieties of the mushroom is about 15°C. Some variety can fruit in higher temperatures, e.g. 20-23°C. These high temperature mushrooms usually grow faster and have a bigger and thinner cap (pileus), thin and long stalk (stipe). Their fruiting bodies are easily opened and become flat grade mushrooms, which are considered to be low quality. The optimum pH of the substrate used in making the mushroom bag/log is about 5.0-5.5. The strains of Shiitake mushroom can be grown in temperature range upto 24-25°C. Hence subtropical area is very much ideal for its cultivation.

3) Paddy straw mushroom - *Volvariella* spp:

In India this mushroom was first cultivated in early 1940's and 19 edible species of *Volvariella* have been recorded but only cultivation methods have been devised for three of them *viz*; *V. esculenta, V. diplasia* and *V. volvacea.* The optimum temperature and moisture for the growth of this mushroom are 35°C and 57-60%, respectively. It can be cultivated in North-Indian plains from July to September and in peninsular India from March to November.

Paddy straw mushroom

Advantages:

1. This variety is most popular for its taste and flavour in South East and north East Asian countries.
2. Its flavour is excellent and cropping cycle is short.
3. It can be grown in temperature range of 25-40°C.
4. Pasteurized paddy straw substrate supplemented with cotton seed hulls gives better productivity.

4) Button mushroom - *Agaricus* spp.

White button mushroom (*Agaricus* spp.) is the most widely cultivated mushroom in the world, contributing around 31% of the world mushroom production. The genus has two cultivated species namely *A. bisporus* and *A. bitorquis*. This mushroom is a low temperature species requiring 16±2°C for its fruiting and mushroom having longer shelf life. Cultivation technology of this mushroom is not popular due to its long cultivation method and lack of facilities. At present in Nagaland, there is no single farmer practicing button mushroom cultivation besides great demand.


Button mushroom

Advantages:

1. There are good opportunities in India both for domestic and export market for button mushroom
2. Seasonal production is possible in big way in Jammu and Kashmir, Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Uttaranchal, Bihar, West Bengal, North Eastern Region, Madhya Pradesh and other areas where temperature remains below 20°C during winter season. In this situation cost of production is low.
3. Raw materials are easily and cheaply available for compost and casing material
4. Awareness about food and medicinal values is increasing in the country thus creating better domestic market
5. There is increasing market for postharvest products like pickle and soup powder

5) Milky mushroom - *Calocybe* spp.

This is indigenous tropical mushroom, most suitable for tropical regions. At present this variety is being commercially cultivated in South India (Tamil Nadu, Andhra Pradesh and Karnataka). Recently its production has started in North India. Now, there is a great scope in North East India for its cultivation. The milky mushroom is snow white in colour with a long stipe and a small pileus. The stipe is fleshy and constitutes the bulk of the mushroom. This mushroom is grown on wheat straw after steam pasteurization at 65ºC for 8 hours, in polythene bags. The spawning rate used was 5% of the wet weight of substrate. The bags after spawning were maintained in a cropping room at 28ºC. The mushrooms attained the height of 4-6 inches at harvest time. One kg of mushroom will have 10-12 fruiting bodies. This mushroom has a superior shelf life, and can be transported to short distances for marketing without damage to its quality.


Milky mushroom

Advantages

1. It can be grown on wide range of agricultural wastes.
2. It grows on higher temperature range hence suitable for tropical region.
3. Attractive white mushroom with excellent keeping quality.
4. Its conversion rate (BE) is very high (about 100%).
5. It is suitable for pickling and chutney.

6) Jew's ear mushroom - *Auricularia* sp.

Auricularia mushrooms are kind of jelly fungi, which are widely distributed in areas of the tropics and subtropics. *Auricularia*, the Jew's ear fungus, is a traditional food in China. Its nutritive and medicinal value has long been praised as "Health food". *Auricularia* mushrooms are moderate temperate fungi. The temperate range for mycelia growth is 6-36°C with the most suitable temperature 22-30°C. The evolution and development of the fruiting body occurs between 15-27°C, but the best range is 20-24°C. The temperature range for basidiospore germination is 22-32°C. At present, this mushroom is collected and consumed in many North East states of our country and thus demand is already there. There is tremendous scope for its cultivation in temperature range of 20-32°C. It needs high RH (90-95%).

Jew's ear mushroom

Advantages:

1. It grows on wide range of temperature and substrates
2. High biological efficiency (100-150%)
3. Very good keeping quality
4. Good for health particularly for stomach and used as medicine in China.

Table. Comparison of important commercially cultivated mushrooms and economics

Characters	Oyster Mushroom	Button Mushroom	Milky Mushroom	Paddy Straw Mushroom
Species	*Pleurotus* spp	*Agaricus* spp	*Calocybe indica*	*Volveriella* spp
Substrate	Paddy straw	Compost	Paddy straw	Paddy straw
Growing Temperature	20-25°C	15-20°C	30-35°C	30-35°C
Relative Humidity	85%	85-95%	85%	85-95%
Total Life Cycle	35-45 days	90 days	45-50 days	90 days
Days for first harvest	20-25 days	60-70 days	24-28 days	10-15 days

Yield	635g (500g Paddy straw)	800-900g/bed (4Kg compost)	720g (500g Paddy straw)	800-900g/bed (4Kg compost)
Shelf Life (days)				
i. Normal condition	1	2	3	2
ii. Refrigerated	2	3	5	3
Protein	23.6%	23.9%	32%	23.9%
Production cost/kg (Rs.)	Rs. 50-55	Rs. 100-110	Rs. 65-70	Rs. 35-40
Sale of 1 kg of mushroom	Rs. 120.00	Rs. 200.00	Rs. 150.00	Rs. 120.00
Net income per kg	Rs. 65	Rs. 90	Rs. 80	Rs. 80.00

Production Technology of Oyster Mushroom

Oyster mushroom can grow at moderate temperature ranging from 20 to 30 °C and relative humidity of 70-90% and enough ventilation during cropping. It is possible to cultivate this mushroom around the year due to availability of maximum number of commercially cultivated species. The cultivation technology of oyster mushroom is very simple and does not require controlled environmental conditions as like button mushroom.

Requirements:

• Paddy straw • Chaff cutter/Dao • Mushroom spawn • Firewood • Transparent polythene bag (60x45cm/ 50x35cm)	• Water boiling container • Bamboo/cane basket/wire mesh • Disinfectant (Detol) • Hand sprayer

Procedure:

- Cut the straw into 3-5cms long and soak the cut straw in water for 8-12 hours
- Drain off the water and boil the straws in hot water for 15-20 minutes
- Drain off the excess water and allow it to cool
- Make holes on the poly bags at a distance of 10 cm and tie the bags at the bottom end
- Disinfect the hands with detol solution (2 tablespoon in 1 litre of water) and Remove the spawn from the bag in to a clean tray
- Fill 5cm of a perforated poly bag with the straw and press slightly
- Sprinkle the spawn uniformly over the straw including periphery of poly bag and fill again with straw to another 5cm
- Repeat the process 4-5 times and then, tie the mouth of the poly bag
- Place the filled poly bags on the shelves in a dark room for 15-25 days till white thread like mycelium growth covers the straw fully (Spawn run).
- Remove the polythene cover carefully and keep it in 6-8 hrs light with good air circulation (cropping room) and irrigate the bed by spraying water 2-3 times in a day
- In 6-8 days of removal of poly bag, pinheads (initial stage of mushroom as small heads) start emerging from

the bed

- In about 5-7 days the first flush of fruiting bodies appears which can be harvested by twisting at base. Subsequent flushes appear about 10 days apart. Altogether 3-4 flushes appear in a single life cycle.
- Remove the beds from room and used it for making compost/vermicompost.

Points to be remembered:

- Oyster can be grown within a temperature range of 20-30°C.
- Keep the poly bags in well aerated dark room for spawn run.
- Watering should be done at least twice a day (morning and evening) after removal of poly bag.
- Excess water should be removed to avoid the growth of unwanted moulds.
- During spawn run, ventilation is not important. However, during cropping, fresh air is required. Hence rooms should be provided with proper ventilation.
- Keep the surrounding areas neat and clean. Put fine wire on the ventilation to check flies.

Economics of oyster mushroom production (250 beds/crop - 4 crops in a season):

(A)	**Non-recurring expenditure**	**Amount (Rs.)**
1.	Cost of mushroom cropping room (thatched roof) of 6m x 3m size (Capacity of 250 beds)	25,000.00
2.	Chaff cutter	5,000.00
3.	Aluminium pan (120 litres)	3,500.00
4.	Hand sprayer (1no.)	400.00
(B)	**Recurring expenditures (Cost of raw materials)**	
1.	Paddy straw 1 ton (1000kg)	7,000.00
2.	Spawn 150 packets (200g) @Rs. 25	3,750.00
3.	Polythene bags (5 kg)	1,000.00
4.	Labour 20 man days @ 200	4,000.00
5.	Fire wood	2,000.00
6.	**Chemicals (**Bavistin @ 7g for treating 10 kg straw)	100.00
7.	Miscellaneous	1000.00
	Sub Total	**18,850.00**
8.	(a) Building depreciation 10% + interest 10%	6,780.00
	(b) Building cost for one crop	1695.00
	Total expenditure for one crop (Rs. 18,850.00+ 1695.00)	**20545.00**
(C)	**Income**	
1.	Gross Income (Sale of 375 kg of mushroom @ 100/kg)	**45000.00**
2.	Net income for one crop	24455.00
	Net income (4 crops in a season)	97820.00
3.	B:C ratio	**2.19:1**

Conclusion: Among different agro-based enterprises, mushroom cultivation is one of the profitable, sustainable and potential enterprises towards doubling the income level of farmers and this enterprise can easily be adopted by any category of farmers irrespective of their landholding size. In north east India, there is a great scope of marketing of oyster and other mushrooms. Mushroom cultivation is a strong means to diversify livelihoods and strengthen the small and marginal farmers by recycling the farm waste. Mushrooms cultivation is a wonderful enterprise, can be grown at a very low cost, less inputs and in relatively short period as compared to conventional crops.

INTEGRATED FISH FARMING SYSTEM FOR ENHANCING LIVELIHOOD OF THE FARMERS

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Introduction

Fish has been an important component of diet for millions of people of the world.In addition to its nutritive properties it is also a livelihood for many people across the world in various ways. Aquaculture has been considered as one of the most important sector that will contribute to poverty alleviation and food security. Fish culture may be a domestic activity in backyard pond for subsistence to large scale industrial enterprise. It is generally categorized in terms of inputs levels: Extensive, semi-intensive and intensive. In extensive fish culture, production and inputs are usually very low. Natural productivity of pond plays an important role in production. In semi-intensive fish culture, moderate level of inputs are used in terms of feeds, fertilizers etc. which influences the fish production accordingly. Intensive fish culture involves high level of inputs for higher stocking density.Since fish farming is a long term venture requiring lot of patience and recurring expenditure in the form of feed, fertilizers, lime, coupled with high input cost, farmers often gets discouraged and shows less interest in adopting the technology. To retain interest, farmer needs an alternate source from where they can earn revenue to meet their requirements for maintenance. Integrating fish farming with livestock, poultry, paddy and horticultural crops is one of the best options. Through this, farmer can generate revenue by selling some of their produce at regular intervals without depending on fish, which can be harvested at the end of culture period. The cost incurred on critical inputs like feed and fertilisers for fish farming is reduced as the system depends on the concept of recycling of farm waste. The land resources can be used for growing different crops depending on the season. This way the farmers can earn additional revenue.

In general, the farmers mainly practice mixed farming system, where crop/fishery/livestock subsystemsare independent of each other. By interlinking these subsystems, the farmer can maximize production with minimal financial or labour costs. In integrated fish farming system, two or more farming systems are integrated in order to reduce the input cost and enhance the production per unit area. The farming is mainly divided into two group *viz.*, composite fish culture and animal husbandry/crop farming practices.

Composite fish culture

Composite fish culture is the major fish farming practiced in the north-eastern part of the country. In this system, fast growing and compatible fish of different feeding habits and habitats are cultured in the same pond in order to occupy the same ecological niches and where the natural fish food organisms (phytoplankton and zooplankton) are effectively utilized to maximize fish production. Carps remain the mainstay in composite fish culture. Three Indian Major Carps viz. Rohu*(Labeorohita)*, Catla*(Catlacatla)*, Mrigal*(Cirrhinusmrigala)* and three

Exotic carps viz. Grass carp (*Ctenopharyngodonidella*), Silver carp*(Hypopthalmichthysmolitrix)* and Common carp *(Cyprinuscarpio)*are usually the candidate species for composite fish farming. Besides, species like *Chitalachitala, Puntiusgonionotus, Labeocalbasu, L. gonius, L. bata, Cirhhinusreba,* etc. can also be reared following suitable stocking densities.Under composite fish farming system, a stocking density of 8000 – 10000 fingerlings/ha is considered ideal from which a production of upto3000 - 4000 kg/ha can be achieved provided proper management measures are adopted.

Prior to stocking fish in a pond, it is important to take some pre-stocking management measures; as this form the base for a better production. Before the onset of monsoon, preparatory measures like, de-silting, renovation of pond bottom and embankment, liming, manuring, etc. has to be taken up so that the fish gets a congenial environment to grow. In case of dried pond, the bottom has to be raked and exposed to sunlight. Thereafter powdered lime should be applied on the bottom surface and the pond bank should be renovated, if required. In case of pond, where dewatering is not possiblerepeated netting with drag net should be done to eradicate the small size fishes and insects. In case where complete removal is not possible, bleaching powder with 30% chlorine @ 350 kg/ha can be applied. The ideal water depth for fish culture is 1.5 – 2.0 m andwhen this level is reached, liming should be done depending on the pH of the water. The optimum range of pH for better fish growth should be in between 7 – 9. One-third of the total lime required should be applied initially as basal dose. Fifteen days after application of lime, pond should be manuredby applying raw cow dung. Urea and SSP should be applied after seven days of application of organic manure. Manuring facilitates the growth of fish food organisms. Appearance of greenish colour indicates that there is sufficient growth of fish food organisms and the pond is ready for stocking fish.

Selection of suitable fish is of utmost importance prior to stocking. Usually, the six species composition comprising three IMC and three exotic carps is considered standard. In order to achieve higher production and taking into consideration the water retention capacity of fish pond in various regions, it is advisable to stock fish seed of bigger size. Stocking of stunted yearlings gives promising result, if available. The stocking density of fish varies depending on the type of farming practiced.In composite fish culture system, three type of farming can be followed viz. Single Stocking Single Harvesting (SSSH), Single Stocking Multiple Harvesting (SSMH) and Multiple Stocking Multiple Harvesting (MSMH). Under SSSH system stocking is done once @ 8000 fingerlings/ha initially and harvesting is done at the end of rearing period. In SSMH system, stocking is done once @ 10000-12000 nos. /ha and partial harvesting can be done after four months of stocking at regular interval on monthly basis. Similarly, in MSMH system stocking is done initially @ 8000-10000 nos. /ha and after each partial harvest equal number of fingerling are stocked again in the pond. The six species should be stocked in ratio of 25:15:20:10:20:10 (Catla :Silver carp : Rohu : Grass carp : Mrigal : Common carp). As far as possible, stocking should be done during cool hours of the day especially in morning time.

After stocking, regular monitoring of the pond water quality and fish health is necessary. Since natural food alone cannotmeet the complete feed requirement of the fish, it is essential that the fishes are fed with artificial feed daily. Mixture of Mustard oil came/groundnut oil cake and wheat/rice bran or rice polish at 1:1 ratio are commonly used as supplementary feed. The fishes should be fed with supplementary feed @ 5 % of their body weight initially and later reduced to 3 %. The daily ration should be provided twice daily by dividing the total feed into two split dose. The feed should be mixed with water and provided in dough form. Alternatively, commercial feed available in market can also be given according to the recommended dose specified. For Grass carp, banana leaves and grasses like para, napier should be provided at regular intervals. Other management measures such as liming;manuring should be done on monthly basis. After ascertaining the pH, the dose of lime should be fixed. Raw cow dung, urea and SSPshould be applied every month as per the requirement. Occurrence of algal bloom when noticed, feeding and manuring should be stopped until the bloom disappears. Prophylactic measures should be taken to prevent outbreak of fish disease. The entire crop can be harvested at the end of the rearing period or when the water level in the pond declines.

Integrated fish farming

In composite fish farming a considerable portion of the total expenditure goes in feeding. Integrating fish farming with other enterprise such as livestock, poultry, horticultural crop, paddy etc. offers a solution to the problems. In this type of system, the waste/by-product produced by one system becomes the input for other system. For example, the waste produced by the animal shed becomes manure for the fish pond that facilitates the growth of natural fish food organisms (phytoplankton and zooplankton). Further, species like common carp and mrigal directly utilizes the organic particles. Thus the necessity to purchase fertilisers and fish feed is reduced. This way the wastes are recycled and also it ensures efficient utilisation of farm space for multiple productions. The integration of aquaculture with livestock and crop farming offers greater efficiency in resource utilisation, reduction of risk by crop diversification with production of additional food and income. The continuous flow of money from one or other component system minimises the financial burden on the farmers. The number of livestock to be reared depends on the size of the pond, the species ratio, the target output of the fish and the nutrient composition of animal dung.On an average 40-50 kg of organic manure is required for producing one kg of fish, while the pond silt can be utilised as fertiliser for fodder crops; which in turn help in raising livestock and poultry or as fish feed. Overall, a production to the tune of 3000-4000 kg/ha can be achieved from this system. In addition to fish, the system provides meat, milk, eggs, fruits, vegetables, mushroom, fodder and grains depending on the components of| integration.

Integrated pig-fish farming:

It is one of the most profitable farming methods.With superior manurial value over cowdung and poultry manure, the waste from 30-40 pigs is sufficient to fertilise one-hectare pond area. Improved variety of pig such as Hampshire, White Yokshire, Landrace, etc, is preferred over local breed because of their fast growth and good meat quality and attains slaughter size (60-70 kg) in six months. After six months of rearing, the first batch of pig is removed from the culture system and a new batch is introduced. Thus two crops can be raised within fish culture duration of one year. Two or three months old weaned piglets are to be introduced in the sty at least 15 days prior to stocking fish, so that the flushed waste facilitates the growth of natural food. The pig has to be fed with commercially available balanced dietdaily. Besides, feed prepared from locally available ingredients can be given on frequent interval.

Integrated cattle-fish farming:

Cattle-cum-fish farming is considered as an excellent approach for efficient utilization and recycling of organic wastes and means of enhancing production per unit area at low cost. Owing to its easy availability and its properties as a manure, cattle excrete is widely and most commonly applied manure in fish farming. The urine and faeces are extremely beneficial for filter feeding and omnivorous fish such as catla and silver carp.About 5-6 cows can provide adequate amount of manure for one hectare pond. Integration of cattle and fish culture can results in a production level of 3000-4000 kg/ha/year of fish with an additional income from milk which markedly increases the revenue an reduces the expenditure for work. The raw cattle dung besides fertilising the pond can also be used for growing other crops. It is advisable to build one small pit to store the dung. The remaining part of the embankment can be utilised for growing other crops. Fodder crops to feed the cattle can also be grown on the embankment. Water needed for irrigation can be obtained from the pond, while the dung can be used as manure.

Integrated goat-fish farming:

Integrated farming of fish and goat is having high potential for increasing the income of fish culture by reducing the cost on supplementary feeds, fertilizers besides giving an additional income from the meat and milk of goat. Goats excreta can be effectively used as manure as it contains 2.7% nitrogen, 1.78% phosphorus, 2.88% potassium and 60% organic carbon. The urine of goat is also equally rich in both nitrogen and phosphorus. For manuring one hectare pond, a herd of 50-60 goats is sufficient.Housing of goat should be in dry, comfortable, safe, protected from excessive heat, properly ventilated and sanitation condition. Adequate free space and grazing area which is free from pits also needs to be ensured. The house of goats can be conducted on the shady portion of the pond dyke.

Integrated rabbit-fish farming:

Rabbit farming of late has gained much popularity. Owing to its low fat content in comparison to other livestock, it has emerged as an important alternate meat source. Rabbit excreta have high nitrogenous (more than cow dung) and low moisture content. The nutrients of rabbit excreta are released gradually in water thereby helps in sustaining high plankton production over a long period of time, which makes it an excellent source of manure for fish production. The excreta provided by 300-400 rabbits are sufficient to fertilize one hectare pond area. Selection of rabbit breed depends on the purpose of rearing i.e., meat type or wool type. Breeds like Soviet Chinchilla, New Zealand White is considered suitable for meat, while Russian Angora, German Angora, Russian fur Chinchilla are preferred breed for wool. Rabbits can be reared in Cage system, Hutch system or floor system. The house can be built alongside the embankments so that the wastes and washings are drained directly into the pond. Management of rabbit involves proper and hygienic housing, feeding with balanced ration and providing adequate water. Extra care is needed at the time of mating, kindling and care of the new born.

Integrated poultry – fish farming

The advantage of integrating poultry with fish farming is that from the same place poultry meat, eggs and fish can be obtained. Poultry dung helps in increasing the biological productivity of the pond. In addition, the fish also feed on the poultry droppings directly. Poultry-fish integration practice is either direct or indirect. In direct integration, the poultry droppings are allowed to fall directly to the fish pond by constructing the poultry house above the water surface or by making provision for direct flushing of droppings into the pond. On the other hand, in indirect system, the poultry house is built at a convenient place and the poultry droppings are stored and allowed to decompose to form built up litter. The fully built up litter are then applied to the pond in daily doses @ 40 - 50 kg per hectare per day every morning after sunrise. The application oflitter is temporarily suspended on the days when algal bloom appears in the pond. The selection of poultry birds depends on the purpose of rearing i.e., for meat or egg laying. Broilers are usually preferred for meat purpose, while poultry birds like Rhode Island, Leg horn, etc. are suitable for egg production. Apart from these, improved variety of birds like *Vanaraja, Gramapriya, Kamrupa,* and *Srinidhi* are recommended as they can be reared for meat as well as egg-laying. Birds are reared in pens @4-5 nos./sq m. A stocking density of 500-600 birds is recommended for one hectare of pond area under integrated fish farming system. The poultry birds are stocked one month prior to stocking of fish seed in order to facilitate the growth of fish food organisms. The birds are fed with balanced feed available in the market. The daily requirement of feed varies depending on the age of the birds. Proper care has to be taken to protect the bird from diseases. Keeping the poultry house clean and timely vaccination of the farmed birds shall help in maintaining a healthy condition.

Integrated duck-fish farming

Fish pond being a semi-closed biological system with several aquatic animals and plants provides an excellent environment for ducks.Duck droppings go directly into the pond fertilising the water homogenously, which in turn provides essential nutrients for growth of natural food organisms. Besides increasing productivity of the pond, ducks play an important role in controlling variety of organisms like snails, flies, earthworms, insects, etc.,thus serving as effective biological controller. Ducks keep the water clean by feeding on green algae and weeds. Ducks also act as pond aerators. Their swimming, chasing and dipping habit disturbs the surface of the pond and aerates the water. The manurial requirement of one-hectare pond can be met through introduction of 200-300 ducks. After four to five months of rearing the male ones can be sold, keeping the females for egg production till end of the culture period of one year. The harvested ones can be replaced with fresh stock of ducklings. In India, duck breeds like Sylhat mate, Nageswari, Indian runner, Khaki Campbell are used for rearing. Among these, Khaki Campbell is recommended for integration as they are prolific layers and rearing is economical. Further, breeds like *Patihanh*, Sera chameli, Muscovy (China hanh), etc. are also gaining popularity among the households of the northeast region. Housing of duck is similar to that of poultry. The duck house can be either built on the pond surface or on the embankment. The house should be comfortable, hygienic, must have facilities for egg laying and should be well protected from natural animals (foxes, dogs, cats, rats, crows, etc.) and strong enough to withstand natural calamities. The house should provide adequate supply of fresh air and sunshine and always remain dry to prevent sudden outbreak of diseases. While integrating with fish, care should be taken that the entire area of the farm is properly fenced so that the duck does not go out of the farmed area. Under normal circumstances, when the pond is stocked with small sized fish seed; duck should not be allowed to enter the pond for atleast one month in order to allow the stocked fish to grow to a considerable size that cannot be predated. As far as possible, under such system advanced fingerling or stunted yearling should be stocked. A production level of 3000 – 4000 kg/ha of fish with additional income from egg and meat of duck can be ensured from this system.

Integrated horticulture-fish farming

The horticulture-fish farming system includes the culture of fruits, vegetables and flowers on the embankment of the pond.The top, inner and outer dykes of ponds as well as adjoining areas can be best utilised for horticulture crops. The advantage of this system is that the farmer gets additional income by growing these crops on the pond embankment that normally lies fallow. Further the nutrient-rich pond mud can be used as fertilizer for growing crops and water for irrigating the plants can be obtained from the pond itself. In addition, fruit and vegetable residues can be used as feed for the fish. Selectionof plant variety is important for success in this system. As far as possible dwarf variety plant that does not obstruct sunlight as well as less shady, evergreen, seasonal and highly remunerative plants are considered ideal. Fruit bearing plants like mango, banana, papaya, coconut, lemon can be grown on the pond embankment. Pineapple, ginger, turmeric, chilly can be grown as intercrops. Seasonal vegetables like brinjal, tomato, chilli, gourds, cucumber, melons, ladies finger, peas, beans, cabbage, cauliflower, carrot, beet, radish, turnip, spinach, etc. can also be raised on the pond embankment. Leaves of such vegetables as well as of banana can be used to feed fishes especially grass carp. Floriculture has now become a booming industry. Thus a farmer can grow market-oriented flowers like tuberose, rose, jasmine, gladiolus, marigold, chrysanthemum etc. that will generate additional income.

Integrated rice-fish farming

Rice fields form the natural habitat for a larger variety of indigenous species of fish which gain entry from the nearby natural water resources. The practice of collecting wild, naturally occurring fish for food from rice field is probably as old as rice cultivation itself. The fishes feed and growon natural food available and the farmers usually collect the fish during rice growing seasonand/or when the water level subsides. This type of practices has several advantages such aseconomical utilisation of land, reduction of labour costs and supplementary feed cost, enhanced rice yield, additional income and diversified harvest such as fish and rice from water and horticultural crops through cultivation on bundhs.

Paddy fields where water is retained for 3-8 months in a year andare free from floodingare suitable for rice-fish integration.Some modifications in the design of rice-fish plots depending on its topography are needed to make the system more profitable. In general, peripheral trench with 1.5 m depth and 2-3 m width excavated around the rice growing area are more suitable. The excavated earth material can be used to raise the dyke where, horticultural crops can be cultivated. Further, this system ensures retention of water and prevents escape of the cultured fish. Fishes such as Common carp, murrels, singhi, maguretc are suitable as they are tolerant to shallow water. Catla, rohu, mrigal and common carp are stocked in equal proportion @10,000 fingerlings/ha and are fed with rice bran and groundnut oil cake @2-3% of body weight. The rice plots needs to be fertilized using cow dung @10 t/ha/yr prior to stocking. Periodical harvesting may be done once the fish attain marketable size and along with the receding water level.Scientific rice-fish systems can ensure higher productivity and increased farm income.

Conclusion:

The scope of integrating fish farming with one or the other enterprise is considerably wide. A sound knowledge on the farming practices is pre-requisite in order to achieve better production. A farmer can achieve this through the guidance of a technical expert. This system holds great promise and potential for augmenting production, betterment of rural economy and generation of employment.

References:

Das, D. N. (2002). Fish farming in rice environments of north eastern India. *Aquaculture Asia,*April-June 2002 (Vol. VII No. 2), 43-47.

Kumar, K and Ayappan, S. (1998). Integrated aquaculture in eastern India, Working Paper 5. Paper prepared for the Integrated Aquaculture Research Planning Workshop, Purulia, India, March 1998.

Tripathi, S. D. and Sharma, B. K. 2001.Integrated fish-horticulture farming in India.FAO Fisheries Technical Paper 407.

SOIL FERTILITY MANAGEMENT IN AGRICULTURE

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Introduction:

India is losing 5,334 million tonnes of soil every year which is about one millimeter of top soil being lost due to soil erosion because of indiscriminate use of fertilizers, insecticides and pesticides over the years (The Hindu, 2010). India is on the verge of a looming soil crisis that can potentially impact its agriculture in the near future. A third or 120 million hectares of soil of the total 350 million hectares has already turned problematic. The reason for the declining soil health is because soils are either acidic, saline, sodic or alkaline soil leading to poor impact on agriculture productivity, sustainability and also on human health. The organic matter content, on an average, has gone down to a critical level of 0.3 to 0.5 per cent and several micro-nutrient deficiencies are surfacing rather quickly in different parts of the country (The Hindu, 2017).

Nagaland loses an average 30.62 metric tonnes of soil area per hectare annually due to 'jhum', shifting cultivation. The department's annual report of 2017-18 says the average loss of land area in Nagaland is in the form of soil erosion and 'turbulent velocity of run-off'. This leads to destruction of prime agriculture and forest lands due to landslides, flash floods and sedimentation. Around 1,35,339 rural households practice shifting cultivation on 947.37 sq km of land on hill slopes, which is 5.71% of the State's geographical area (The Hindu, 2018).

Soil Fertility:

Soil fertility is the status of the soil to supply nutrients to plants in adequate amounts and in suitable proportions. It is a combination of soil physical, chemical and biological properties which directly or indirectly affect the nutrient dynamics and availability. Soil fertility management is of utmost importance for optimizing crop nutrition on both short term and long term basis to achieve sustainable crop production.

Soil Productivity: Soil productivity is the capacity of the soil to produce crops with specified system of management and is expressed in terms of yields. "All productive soils are fertile but all fertile soils need not to be productive". It may be due to some problems like water logging, saline or alkaline condition, adverse climate etc. Under these conditions, crop growth is restricted though the soil has sufficient amounts of nutrients. It is the resultant of various factors influencing soil management

Soil Quality: Soil quality is the capacity of a soil to sustain biological productivity and at the same time maintenance of environmental quality. Soil fertility, erodibility and compactability together describe the soil quality. However, soil quality is synonymous to soil productivity but more recently the concept of soil quality has been broadened to include attributes of food safety and quality, human and animal health and environment quality. Soil quality may be defined as "the capability of a soil to produce safe and nutritious crops in a sustained manner over the years and to enhance human and animal health without impairing the natural resource base or harming the environment".

The essential nutrient elements comprise the key components of soil fertility vis-a-vis plant nutrition and therefore these are referred to as plant nutrients or nutrient elements. The management of these nutrients is very important for optimum crop production. Plant nutrients are classified into 2 groups: macronutrients (primary and secondary) and micronutrients. The primary nutrient elements are nitrogen (N), phosphorus (P) and potassium (K), because they are required in larger quantities than other nutrient elements. Secondary nutrient elements are calcium, magnesium, and sulphur that are applied through fertilizers and soil amendments. The remaining essential elements are the micronutrients (Fe, Mn, Cu, Zn, B, Mo, Cl and Ni) that required in very small quantities.

IMPACT OF CLIMATE CHANGE ON SOIL PARAMETERS

Climate is one of the most important factors affecting the formation of soil with important implications for their development, use and management perspective with reference to soil structure, stability, topsoil, water holding capacity, nutrient availability and erosion.

- **Soil water:** Soil water are influenced by climate change such as precipitation causing rapid changes in soil water, temperature increase results in greater evapo-transpiration loss of water from the soil and lastly the type of land use. The integral influence of climate-hydrology-vegetation-land use changes are reflected by the field water balance and soil moisture regime.

- **Soil temperature:** There is a close relationship between air temperature and soil temperature and increase in air temperature leads to an increase in soil temperature. The temperature regime of the soil is governed by gains and losses of radiation at the surface, the process of evaporation, heat conduction through the soil profile and convective transfer via the movement of gas and water.

- **Soil structure and texture:** Soil structure is an important property which indicates how the soil particles combine together. Soil structure is responsible for the movement of gases, water, pollutants/contaminants, seepage, nutrients, maintenance of water quality, building foundations, soil fauna and the emergence of crops. The nature and quality of the structure is strongly influenced by the amount and quality of organic matter present, inorganic constituents of the soil matrix, cultivation methods and natural physical processes such as shrink-swell. A decline in soil organic matter levels lead to a decrease in soil aggregate stability, infiltration rates and increase in susceptibility to compaction, run-off furthermore susceptibility to erosion. Soil texture has direct impact of climate change.

- **Soil organic matter:** Soil organic matter is undoubtedly the most important soil component as it improves soil quality though the influences in soil structure, water holding capacity, soil stability, nutrient storage and turnover and oxygen-holding capacity and also as the prime habitat for immense numbers and variety of soil fauna and microflora, which play a critical role in the health and productivity of soils. Soil organic matter is highly susceptible to changes in land use and management, soil temperature and moisture. Changes in land use and management led to a significant decline in organic matter levels in soils which increase the susceptibility to soil erosion.

- **Soil fauna and soil flora:** Soil fauna and flora are essential components of all soils which play vital role in the retention, breakdown and incorporation of plant remains, nutrient cycling and their influence on soil structure and porosity. Global warming may not have a direct effect on the ecological composition because soil fauna and flora have a relatively broad temperature optimum. However, changes in ecosystems and migration of vegetation zones seriously affect less migratory soil flora and fauna through increased temperature and rainfall changes. A further significant impact of climate change on soil fauna and flora is through enhanced CO_2 levels in the atmosphere which leads to enhanced plant growth and allocation of carbon below ground rendering the microbial population to accelerate nitrogen fixation rates, nitrogen immobilisation and denitrification, increased mycorrhizal associations, increased soil aggregation and lastly increased weathering of minerals.

- **Chemical processes in soils:** The most rapid processes of chemical or mineralogical change under changing external conditions is loss of salts and nutrient cations where leaching increases and salinization where net upward water movement occurs because of increased evapotranspiration or decreased rainfall or irrigation water supply. Changes in the surface properties of the clay fraction is generally slower than salt movement which take place much faster than changes in bulk composition or crystal structure. Such surface changes have a dominant influence on soil physical and chemical properties

- **Acidification, salinization, sodicity problem in soil:** Significant increases in rainfall will lead to increases in leaching, loss of nutrients and increasing acidification, depending on the buffering pools existing in soils. The direction of change towards increased leaching or increased evaporation will depend on the extent to which rainfall and temperature change and consequent changes to land use and its management.

Increased salinization and alkalization occur in areas where evaporation increase or rainfall decreases. Transient salinity increases as capillary rise dominates, bringing salts into the root zone on sodic soils. Increased subsoil drying increases concentration of salts in the soil solution. Conversely, the severity of saline scalds due to secondary salinisation abates as groundwater levels fall in line with reduced rainfall (Karmakar *et al*., 2016)

SOIL TESTING:

Soil testing is an integral part of field in the area of agriculture. Soil sampling should be done in order to find out the quantity of essential nutrients available to plants and other relevant physical and chemical characteristics which influence plant growth such as water retention, acidity, salinity, alkalinity etc. It is also required for the determination of various physical and chemical properties of the soil. Soil analysis is a useful tool to know in advance the fertility status of the soil with respect to the essential plant nutrients limiting the crop growth

WAYS TO MANAGE SOIL FERTILITY STATUS IN AGRICULTURE

I. ACIDIC SOIL AND ITS MANAGEMENT:

Acid soils are defined as any soil that has a pH of less than 7.0 (neutral). Acidity is due to hydrogen (H+) ion concentrations in the soil. The higher the H+ concentration level, the lower the pH.

Soil acidity is among the important environmental factors which influences plant growth, and limits crop production particularly in high rainfall, hilly and mountainous regions of North East India. Maintenance of specific soil acidities is important in soil management because it controls the adaptation of various crops and native vegetation to different soils. Crops growing on soils with high acidity tend to have poor root systems, poor growth and low yields, so when lime is applied, and it improves root growth and nutrient availability.

The following are few methods to manage soil acidity by raising the pH to a desired value:-

a. **Flooding:** In lowlands systems, flooding is an effective technique in raising the pH of the soil. However, this effect is only good for the time for which the soil is flooded. Flooded or paddy mineral soils are ‘self-liming’. Example Taro and rice

b. **Use of organic matter:** Regular application of well decomposed organic matter in acid soils is essential to prevent sudden fluctuation of soil pH as it improves the buffer capacity of soils. Moreover, it increases the availability of P and reduces the toxicity of Fe and Al in acid soils. Fresh mulches (mostly weed biomass) of Ambrossia, Lantana etc. also reduces the adverse effect of soil acidity substantially

c. **Additions of wood ash:** Application of wood ash increases base saturation and forms chelates with aluminum.

d. **Liming:** A soil should be limed to reduce the harmful effects of low pH (aluminum or manganese toxicity) and to add calcium and magnesium to the soil. The amount of lime needed to achieve a certain pH depends on the pH of the soil and the buffering capacity of the soil. The optimal pH range for most plant is between 6.0-6.5. Lime is calcium oxide or calcium hydroxide and agricultural lime is usually calcium carbonate or lime stone. The most widely practices of lime application are –

- Surface broad casting: Liming @ 4-5t/ha increases the pH to 5.5 along with effective neutralization of exchangeable Al, increase in phosphorus and calcium uptake and thus increase soil productivity.
- Furrow application: Furrow application of lime @ 250-300 kg/ha can increase the crop yield, which is applied one-two weeks before sowing of the crop.

e. Growing of acid loving and tolerant crops: Radish, potato, peppers, sweet potatoes, beans, broccoli, cabbage, carrot, sweet corn, tomatoes, squash, turnips, blueberries, cranberries, currants, gooseberries, apples, grapes, raspberries, straw berries.

II. BIOFERTILIZERS

Biofertilizers are the preparations containing live micro-organisms which on application to seed, root or soil, mobilize the availabilty of nutrients by their biological activity in particular and help build up the microflora and in turn improve the soil health. Biofertilizers are usually available either in moist powdered form or in liquid form. There are two types of biofertilizer:-

A. Nitrogen fixers

i) Rhizobium for legume crops eg, Soybean, pea, groundnut, cow pea, green/blackgram.

ii) Azotobacter and Azospirillum for non-legume crops.

iii) Blue green algae (BGA) and Azolla for lowland paddy.

B. Phosphate solubilizers/mobilizers

Phosphotika: Phosphotika can be applied for all types of crops.

Methods of application:

1. **Seed treatment:** Mix 200gm each of nitrogen biofertilizer + phoshotika biofertilizer in 300-400 ml of water and mix thoroughly. Mix this paste with 10-12kg of seeds with hand till all the seeds are uniformly coated. Dry the treated seeds in shade and sow immediately. For acidic soils, it is always advisable to use 1kg of slacked lime powder for coating the wet biofertilizer treated seeds.

2. **Seedling roots dip treatment:** Mix 1 kg each of Azotobacter and Phosphotika biofertilizer in sufficient quantity of water and dip the roots of seedlings to be transplanted in 1 acre and keep them immersed for about 20-30 minutes and transplant them immediately. In case of paddy, prepare a small bed in the field and fill with 3-4 inches of water and put 2 kg each of Azospirillum and phosphotika and mix thoroughly.

Dip the roots of seedlings in this bed for 8-12 hrs and then transplant.

3. **Soil treatment:** Mix 4kg of Azotobacter/Azosirillum and 4kg phosphotika in 2-4 litres of water separately and sprinkle this suspension on two heaps of 50-100 kg of FYM. Mix the two heaps separately and leave for incubation overnight. After 12 hrs, mix the two heaps together and this mixture is broadcasted evenly in the moist field and mixed with soil and sow the seeds. In plantation crops, flowers etc apply this mixture near the root zone and cover with soil and water may be applied.

III. AZOLLA:

Azolla is one of the potential components available for nutrient management in organic agriculture. Azolla, a small free floating water fern belonging to the family Azollaceae, is available naturally on moist soils, water surface of flooded rice fields, small ponds and canals. Its size is about 1.5-3.0 cm in length and 1.0-2.0 cm in breadth. The locally found Azolla is *Azolla pinnata*, while some better species like *Azolla caroliniana* can be obtained from research institutes. Azolla supplements nitrogen to rice crop by fixing atmospheric nitrogen in the soil for crop growth, crop production and thereby maintaining of soil fertility.

Azolla can be incorporated in paddy field as it fixes atmospheric nitrogen which increases rice yield by 20-30 %, reduces evaporation from water surface and increases water use efficiency in rice. In lowland field, small beds of the size 3x2x1 m is made in the field and only 10-15 cm standing water is allowed in the ponds. Fresh Azolla of about 400gm is mixed and spread in the beds for further growth and multiplication of Azolla. Azolla multiplies rapidly and form a thick mat in just 2 weeks. This Azolla is harvested and released in the transplanted rice field for further multiplication, as dual cropping with rice for fixing nitrogen to rice crop. A thick Azolla mat does not allow the aquatic weeds to grow in rice field thus, azolla suppresses the weed growth and creates a congenial condition for rice production.

Besides fixing atmospheric nitrogen, Azolla can also be used as a feed for pig, duck and fish. It has high protein content and on dry weight basis, Azolla can be mixed up to 10 % of the purchased animal feed and Azolla can also be used as compost.

IV. VERMICOMPOSTING

Vermicompost is a method of making enriched compost with the use of earthworms which generally lives in soil, eat biomass and excrete it in digested form which is rich in humus. Earthworm breeds commonly used for vermicomposting are *Eisenia fetida*, *Eudrilus eugeniae*, *Lumbricus rubellus*,*Perionyx excavates*, *Perionyx arbicola and Jai Gopal (Perionyx ceylanesis).* Almost all types of biologically degradable and decomposable non-toxic are used for vermicomposting.

Procedure of vermicomposting

- ✓ A vermicomposting box of the size 2m length x 1m width x 1m deep is required to be constructed and provision of a shed is essential to prevent entry of rainwater and direct sunshine.
- ✓ Spread a layer of farm wastes (30cm thick) for aeration.
- ✓ Above that layer spread partially decomposed dung (30-40cm thick) of about 1-2 months old. The whole material is sufficiently moistened and they act as the reserved food for the earthworms.
- ✓ Release about 2-3 kg earthworms per ton of biomass or 350 earthworms per cubic meter.
- ✓ The last top layer of feeding materials i.e, kitchen waste, crop residues, cattle dung etc of about 30-40cm which is to be used as compost are added and cover it with gunny bags.
- ✓ Sprinkle water over the gunny bags to maintain proper moisture.
- ✓ Provision of a shed over the compost is essential to prevent entry of rainwater and direct sunshine.
- ✓ After every 10 days feeding materials should be added and turning should be done at an interval of 15 days to facilitate proper aeration to the bin.

When the mixture becomes brownish or blackish brown in colour and there does not remain any odour of dung, then the vermicompost is ready. Hence, watering should be stopped. Worms will migrate to the lower layers. Then, take out the ready compost, separate out the worms, dry in shade and sieve out the compost that can be kept in plastic bags for use. The whole biomass will be converted to vermicompost in about 2-3months. The number of vermi worm shall also be increased by 20-30 times more than the number introduced earlier. The collected worms can be released in other prepared bins. Vermicompost is granular and looks like tea leaves.

Application of vermicompost doses

Crops	Doses per acre
Cereal Crops	2 tons
Pulses	2 tons
Oil Seeds	3-5 tons
Spices Crops	4 tons
Vegetable Crops	4-6tons (50gms/plant)
Fruit Crops	2-3 kg/plant

Cash Crops	5 tons
Ornamental Plants	4 tons
Plantation Crops	5 kg/plant

V. **GREEN MANURING :**

Green manuring is the practice of ploughing or turning into the soil the green plant tissue for improving the physical condition as well as fertility status of the soil. Green manuring crops should be fast growing, produce abundant green materials, well adapted to local condition, legume family, quickly decomposable and tolerant to pest and diseases

Methods

i. Green manuring in Situ:

Green manuring crops are grown and buried in the same field, which is to be green manured, either as a pure crop or as an intercrop with the main crop. Eg. Sun hemp, dhaincha, cluster bean etc.

ii. Green leaf manuring:

It refers to the collection of leaves and tender twigs from shrubs and trees grown on bunds, wasteland and nearby forest areas. This is a very ideal practice for hilly areas. The common shrubs and trees used for green leaf manuring are Ipomea, karanj (*Pongamia glabra*), *Gliricidia sepium*, *Sesbania speciosa*, *Jatropa gossipifolia*, *Sesbania grandiflora*, *Leucaenea leucocephala* and several species of *Acacia* and *Prosopis.*

Criteria for selection of green manure crops:

- Choice of crop: Leguminous crops should be given preference over non-leguminous crops.
- Time of sowing: The best time of sowing for green manure is immediately after first monsoon showers. Seeds with 25-30% higher seed rate can be sown by broadcasting.
- Time of incorporation into the soil: The green manuring crop should be incorporated in to the soil at the time of flowering. Most of the Green manure crops take 6-8 weeks to attain flowering stage.
- Time gap between incorporation and sowing of next crop: The time required for complete decomposition of the turned green matter before planting the next crop depends up on:-
  - Weather condition-Hot and humid condition favors rapid decomposition.

- Nature of burying green materials-Succulent tissues take lesser time in decomposition than woody tissues.
- Soil texture: In light textured soil with optimum moisture sowing or planting can be done after 2-7days, while in heavy textured soil with high moisture to waterlogged conditions, sowing or planting can be done after 7-12days.

VI. **MULCHING**:

Mulch is a protective layer of a material that is laid out on the top of the soil. Mulching not only help to improves soil temperature and moisture regime but on decomposition enriches the soil. Organic mulches are straw, dry leaves, grass clippings, bark chips and other similar materials. Inorganic mulches refer to stones, brick chip, plastic etc. Mulching improves drainage property of the field which is mainly clayey in nature which otherwise leads to water stagnation and rotting of the root system, Secondly, it reduces the use of chemical fertilizers and pesticides and the yield is also increased. Apart from the sugarcane trashes, straw, dry leaves, green manure plants like dhaincha, sunhemp, cluster bean etc can also be grown in the fields and cut and placed as mulches.

VII. **CROP ROTATION**:

Crop rotation method involves growing of set of crops in a regular succession over a same piece of land (field with) in a specific period of time. Crop rotation is practiced so that the soil of farms is not used for only one set of nutrients. It helps in reducing soil erosion and increases soil fertility and crop yield.

Growing the same crop in the same place for many years in a row (Mono-cropping) disproportionately depletes the soil of certain nutrients. With rotation, a crop that leaches the soil of one kind of nutrient is followed during the next growing season by a dissimilar crop that returns the nutrient to the soil or draws a different ratio of nutrients. In addition, crop rotation mitigates the buildup of pathogens and pests that often occurs when one species is continuously cropped, and can also improve soil structure and fertility by increasing biomass from varied root structures.

VIII. FARM YARD MANURE (FYM)

Farmyard manure refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. It supplies all the macro and micro nutrients in almost all balanced proportions. It has been estimated that FYM from all the animal excreta in India can potentially supply 6.33 million tonnes of N, P_2O_5 and K_2O per year.

IX. INTEGRATED NUTRIENT MANAGEMENT (INM)

Integrated Nutrient Management (INM) envisages the use of chemical fertilizers in conjunction with organic manures, legumes in cropping systems, use of biofertilizer and has shown to produce higher crop yields than when each is applied alone. This is attributed to the proper nutrient supply as well as creation of better soil physical and biological conditions. Fertilizers supply available forms of nutrients readily to plants on application while organic manures make available only a fraction of total nutrients in the first few weeks after application. The major INM components are:

- **Chemical Fertilizers**: Urea, di-ammonium phosphate (DAP) to supply Nitrogen and Phosphorus, super phosphate and rock phosphate supply phosphorus, muriate of Potash (MOP) and sulphate of potash (SOP) to supply potash.
- **Organic source:** Farm Yard Manure (FYM) , Compost, biofertilizers , Azolla, crop residues, vermicompost, Oil cakes etc.

Table 1. State-wise area affected by various kinds of land degradation in India

Name of State	Area (000 ha) affected by various kind of land degradation							Geographical area (000 ha)
	Water and wind erosion*	Water logged	Alkali/ sodic soils	Acid soils	Saline soils	Mining/ industrial waste	Degraded area	
Andhra Pradesh	8864	36	194	1	60	39	9194	27505
Arunachal Pradesh	380	5	0	1769	0	0	2154	8374
Assam	2366	210	0	1995	0	0	4571	7844
Bihar	1049	133	106	41	40	2	1371	9416
Chhattisgarh	2422	0	13	2342	0	7	4784	13481
Goa	1	6	0	103	0	12	122	370
Gujarat	1012	1	545	0	1559	12	3129	19603
Haryana	303	4	184	2	46	12	551	4421
Himachal Pradesh	984	4	0	76	0	1	1065	5567
Jammu & Kashmir	2001	14	0	78	0	1	2094	22224
Jharkhand	3181	6	0	735	0	21	3943	7972
Karnataka	7799	3	145	93	2	51	8093	19179
Kerala	117	44	0	2426	21	1	2609	3886
Madhya Pradesh	13464	1	124	482	0	24	14095	30864
Maharashtra	8822	27	421	269	171	16	9726	30771
Manipur	150	21	0	1597	0	0	1768	2233
Meghalaya	706	3	0	1023	0	0	1732	2243
Mizoram	0	0	0	1163	0	0	1163	2108
Nagaland	31	3	0	1516	0	0	1550	1658
Odisha	3328	52	0	203	131	8	3722	15571
Punjab	302	034	152	0	0	6	494	5036
Rajasthan	20191	0	152	0	82	0	20425	34224
Sikkim	2	0	0	58	0	0	60	710
Tamil Nadu	2134	39	352	427	11	34	2997	13006
Tripura	74	25	0	709	0	0	808	1049
Uttarakhand	1009	25	0	400	0.	1	1435	5584
Uttar Pradesh	12884	176	1320	0	22	3	14405	23857
West Bengal	1264	43	0	418	408	7	2140	8875
A & N Islands	0	0	0	0	71	0	71	825
Delhi	28	0	0	0	0	0	28	148
Chandigarh	0	0	0	0	105	0	105	11
D & N Haveli	0	0	0	0		0		0.49
Daman & Diu	0	0	0	0		0		0.11
Lakshadweep	0	0	0	0		0		0.03
Pondicherry	0	0	0	0		0		0.48
Total (000 ha)	94868	915	3708	17926	2729	258	120404	328726
Total (M ha)	94.87	0.91	3.70	17.93	2.73	0.26	120.40	328.73

*Includes area affected by wind erosion of 11560 thousand ha (Gujarat-1 thousand ha & Rajasthan-11559 thousand ha).

Source: NAAS (2010)

Table 2. Nutrient content (%) of weed biomass, crop residues, livestock excreta and compost.

	Nitrogen(N)	**Phosphorus(P)**	**Potassium (K)**
WEED BIOMASS			
Eupatorium odoratum	3.36	0.10	0.82
Lantana camara	2.41	0.08	1.37
Mikania micrantha	2.94	0.18	1.71
Azolla	2.38	0.51	2.75
Ipomea sp	2.01	0.33	0.44
CROP RESIDUES			
Rice straw	0.36	0.08	0.71
Maize stover	0.42	1.57	1.65
Pulse stover	0.72	0.18	0.53
Oilseeed stover	0.30	0.13	0.33
Groundnut stover	1.6	0.23	1.37
LIVESTOCK EXCRETA			
Cow dung	0.4	0.2	0.1
Pig manure	1.19	0.39	1.01
Rabbit manure	1.82	0.47	1.07
Poultry manure	1.87	0.54	2.15
Sheep manure	1.6	0.2	0.95
COMPOST			
Farmyard manure	0.93	0.25	0.91
Azolla compost	2.73	0.67	2.93

Vermicompost	1.68	1.06	1.57

Source: Das *et al*.(2006), Sharma (2002), Hazarika *et al*.(2006)

References

1. Das, Anup., Hazarika, U.K., Munda, G.C., Patel D.P., Kumar, Rajesh., Tomar, J.M.S., Chandra, A., M.Sharma and Bordoloi, Jurisandhya. 2006. Non-conventional source of organic nutrient supplyin crop production.Extended summaries. National on standards and technologies of non-conventional organic inputs.8-9 April. Project Directorate of cropping system Research. Modipuram, U.P.

2. Hazarika, U.K., Munda, G.C., Bujarbaruah, KM., Das Anup., Patel D.P., Prasad Kamta, Rajesh Kumar., Panwar, A.S., Tomar, J.M.S., Bordoloi, Jurisandhya, Sharma Mehgna and Gogoi Girin. 2006. Nutrient management in organic farming. Bulletin no.ICAR Research Complex for NEH Region, Umiam, Meghalaya.

3. https://www.thehindu.com/sci-tech/agriculture/India-losing-5334-million-tonnes-of-soil-annually-due-to-erosion-Govt/article15717073.ece https://www.thehindubusinessline.com/economy/agri-business/india-on-verge-of-looming-soil-crisis-report/article9985289.ece (M Somasekhar)

4. https://www.thehindu.com/todays-paper/tp-national/tp-otherstates/nagaland-loses-soil-heavily-due-to-jhum/article23552211.ece

5. Karmakar, R, Das, Indranil, Dutta, Debashis and Rakshit, A , 2016. Potential Effects of Climate Change on Soil Properties: A Review. Science International, 4: 56-62

6. Sharma, A.K.2002. A hand book of organic Farming 2002. Agrobios (India), Jodhpur.

7. NAAS (2010) Degraded and Wastelands of India: Status and Spatial Distribution. Indian Council of Agricultural Research and National Academy of Agricultural Sciences, New Delhi. p. 158.

ANIMAL GENETIC DIVERSITY AND ITS CONSERVATION

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Animal Genetic Resources (AnGR) is a well-known term in the parlance of genetics of animal and livestock species which is diverse in nature. Animal Genetic resources and its diversity are referred to as a subset of genetic resources (defined by the Convention on Biological Diversity as "genetic material of actual or potential value" and a specific element of agricultural biodiversity. The term animal genetic diversity refers specifically to the genetic diversity of avian and mammalian species, which are used for food and agriculture purposes. There are other terms referring to AnGR may be "farm animal genetic resources" or "livestock diversity" (Wikipedia, 2018).

AnGR can be embodied in live populations or in conserved genetic materials such as cryo-conserved semen or embryos. The diversity of animal genetic resources is consisting of diversity at species, breed and within-breed level. Presently there are 8,800 different breeds of birds and mammals within 38 species used for food and agriculture (FAO, 2015).

Over the past twenty years substantial efforts and progress have been made in conserving animal genetic resources for food and agriculture (AnGR). Across the continents and regions, national programs, NGOs (e.g., breed associations), and producer based activities have been initiated for in situ and ex situ (gene banking) conservation. These activities have been as diverse as the countries implementing such programs and the area of conserving AnGR itself (Paiva et al., 2014).

Exemplary efforts include: development of in situ conservation of rare breeds across All regions and recognition of locally adapted breeds by governments. Globally there exist both well – established and newly formed national gene banks operating and providing genetic security for commercial and rare breeds. Also, at the global level a more formal structure among nations leveraging their mutual interests in AnGR conservation through direction given via FAO has become prominent. High points of this mutual action were: the development of the country driven State of the World's Animal Genetic Resources report; the Global Plan of Action and the Interlaken Declaration, which 107 nations are implementing (FAO, 2007).

Global drivers of population growth, income, and climate change are already impacting the way AnGR are used globally and it is expected that additional changes will be required to meet the projected 2.4% annual increase in meat consumption from 2013 to 2022 in developing countries (USDA, 2013). Increased animal productivity (unit of output/animal) should be a primary format for addressing food security needs in a sustainable manner. Unfortunately, for the least developed countries, spread across regions, animal productivity has been stagnant or decreasing, especially for ruminant species (FAOSTAT). This finding suggests greater emphasis is needed on a variety of mechanisms to increase animal productivity and that if the livestock sectors of the least developed countries are to contribute to improving food security and meeting national demands. A substantial alteration in production practices is needed, especially for ruminant species. In addition, the climate is expected world-wide to become highly dynamic and extreme, which in turn will impact food security (e.g. Jones and Thornton, 2009; Godfray and Garnett, 2014).

Policy for Animal Genetic Resources

The management of issues regarding animal genetic resources on the global level is addressed by the Commission on Genetic Resources for Food and Agriculture (CGRFA), which is a body of FAO. The access and benefit sharing of animal genetic resources are currently regulated by the Nagoya Protocol on Access and Benefit sharing, which is an agreement to the 1992 Convention on Biological Diversity. The Nagoya Protocol entered into force on 12 October 2014 and aims to provide a legal framework for the fair and equitable distribution of benefits arising from the utilization of all genetic resources, including animal genetic resources for food and agriculture (). This protocol may have both positive and negative impacts on the exchange of animal genetic resources between signatory countries.

Within the Agenda 2030 for Sustainable Development, AnGR are addressed under the target 2.5: "By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed."

Which is monitored by the following indicators:

"2.5.1: Number of plant and animal genetic resources for food and agriculture secured in either medium or long term conservation facilities.

2.5.2: Proportion of local breeds, classified as being at risk, not at risk or unknown level of risk of extinction."

Other than a few attempts to animal evaluation primarily connected with animal improvement programmes, there is still some lacking in understanding and awareness of the animal genetic diversity we possess, and the threats these animal diversity are facing. The wealth which has been gifted to us by our ancestors and nature needs to be carefully managed and conserved. In our legitimate concern for assuring animal products for today we should not forget to conserve and manage resources for the benefit of generations yet to be born (Bhat, 1978).

As per Mason (1974), there are mainly three reasons for conservation of Animal Genetic Resources. These are -

1. Agricultural: Reduction in genetic variation through past and current improvement schemes which have removed flexibility for future improvement. In particular progressive removal of local hardy breeds, which may eventually mean loss of breeds and species suitable for low-input agriculture.
2. Scientific: Animals adapted to specific conditions are needed for study of agricultural production, besides the basic nature of the adaptations and their possible use later.
3. Cultural: Diversity being part of our natural heritage, its preservation is part of our culture.

There are three main sources of information on animal genetic resources in India:

- Government departments concerned with development of livestock
- Forest departments who operate wild life programmes
- Universities and research institutes.

Conservation Methods: In general, two major systems of conservation works-

• *In situ* conservation is the maintenance of live populations of animals in their adaptive environment or as close to it as is practically possible. For domestic species the conservation of live animals is normally taken to be synonymous with *in situ* conservation.

- ***Ex situ*** conservation involves the conservation of plants or animals in a situation removed from their normal habitat. Collection and freezing in liquid nitrogen of animal genetic resources in the form of living semen, ova or embryos. It may also be the preservation of DNA segments in frozen blood or other tissues.

Comparison between these two methods (Salces, 2016)

Ex Situ In Situ	***Ex-situ***	***In-situ***
Cost - initial set up cost	Relatively high	Low to high
Maintenance cost	Low	Relatively low to high
Applied to all species	No	Yes
Genetic drift - initial	Relatively high	None
Genetic drift - Annual	None	Moderate to high
Safety/reliability	Good to bad	Moderate
Local access	Moderate to poor	Moderate to poor
International access	Good	Not good
Population monitoring	None	Good

Environmental adaptation	None	Good
Selection for use	None	Good

Conclusion

Since many new breeds and strains are being identified and characterized regularly having special qualities/traits of their own, documentation and evaluation are essentially required to prepare an inventory so that decisions can be taken about what to conserve and formulate breed improvement and conservation policies.

References

Bhat, P.N. (1978). Problems, prospects and approaches to collection, evaluation and conservation of animal genetic resources. Proceedings of symposium on plant and animal genetic resources, I.A.R.I., New Delhi, pp. 1-16.

FAO. 2015. The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture. Section A, p 5. Rome

Mason, I.L. (1974). The conservation of animal genetic resources, Introduction, Round Table 2. 1st World Congress on genetics applied to livestock production, Madrid, Spain.

Nagoya Protocol from the Convention on Biological Diversity https://www.cbd.int/abs/accessed Oct. 2016

Paiva et al. 2014. *Conservation of Animal Genetic Resources: the Next Decade*. Available from: https://www.researchgate.net/publication/267865791_Conservation_of_Animal_Genetic_Resources_the_Next_Decade [accessed Aug 20 2018].

Rendel, J. 91978). Personal Communication, reestablishment of Bureau of Animal Genetic Resources.

"SDG 2. Zero hunger | Sustainable Development Goals | Food and Agriculture Organization of the United Nations". www.fao.org. Retrieved 2018-05-28.

PRECISION FARMING FOR SUSTAINABLE CROP PRODUCTION

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Introduction

Precision farming is information and technology based farm management system to identify, analyse and manage variability within fields by doing all practices of crop production in right place at right time and in right way for optimum profitability, sustainability and protection of the land resources. Information, technology and management are the keys to success in this production system (Roberson, 1998). The precision farming developments of today can provide the technology for the environment friendly agriculture of tomorrow. Aspects of precision agriculture encompass a broad array of topics including variability of the soil resource base, weather, plant genetics, crop diversity, machinery performance and most physical, chemical and biological inputs used in crop production. Precision farming concept was initiated for site specific crop management as a combination of global positioning system (GPS) technology, variable rate technology (VRT), remote sensing, yield mapping etc. to optimize the profitability, sustainability with a reduced environmental impact. With rich land, abundant water and a favourable climate, hill agriculture in India has considerable potential to grow, and contribute towards improving farm incomes, enhancing food and nutrition security, and accelerating the overall growth of the region. Precision farming is the best remedy for the problems faced by farmers on hills. Various issues of lack of system-specific production technologies, difficult terrains, inaccessible habitations, crushing of crops by wild animals, management of small, scattered, fragmented, uneven lands etc. can be sought out easily with the methods of precision farming. Precision farming methods helps in recognizing areas by farmers that have productivity problems and to select the best solution, as on hills much of the land strips may have productivity problems due to erosion, runoffs, low temperature etc. The precision farming technology would be a viable alternative to improve profitability and productivity (Shanwad *et al*., 2002).

Need for precision farming

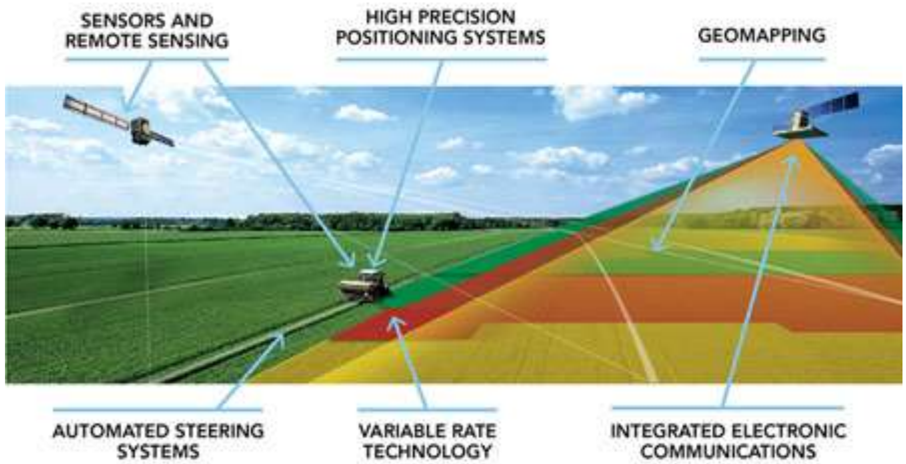
a) For assessing and managing field variability – Our fields have variable yields across the landscape because of variations to management practices, soil properties and environmental characteristics. The level of knowledge of field conditions is difficult to maintain because of variable farm sizes and undulating terrain. Precision farming offers the potential to simplify the collection and analysis of information.

b) For doing the right thing in the right place at the right time – After assessing the variability precision farming allows management decisions to be made and implemented in right time in right places on small areas within larger fields.

c) For higher productivity – Precision farming prescribe a tailor made management practices hence it will definitely increase the yield per unit of land.

d) For increasing the effectiveness of inputs – Increased productivity per unit of input used indicates increased efficiency of inputs.

e) For maximum use of minimum land unit – After knowing the land status, a farmer tries to improve each and every part of land and uses it for the production purpose.



Components of precision agriculture

I. Information or data base

- Soil – Soil Texture, Structure, Physical Condition, Soil Moisture, Soil Nutrients, etc.
- Crop – Plant Population, Crop Tissue Nutrient Status, Crop Stress, Weed patches (weed type and intensity), Insect or fungal infestation (species and intensity), Crop Yield, Harvest etc.
- Climate – Temperature, humidity, rainfall, solar radiation, wind velocity, etc.

II. Technology: Technologies include a vast collection of tools of hardware, software and equipments. It is important for anyone considering precision farming to be familiar with the technological tools available (Jensen *et al.*, 2000).

1. Global Positioning System (GPS) – GPS is a navigation system based on a network of satellites that helps users to record positional information (latitude, longitude and elevation) with an accuracy of between 100 and 0.01 m (Lang, 1992). GPS allows farmers to locate the exact position of field features, such as soil

type, pest occurrence, weed invasion, water holes, boundaries and obstructions.

2. Differential Global Positioning System (DGPS) – This is a technique to improve GPS accuracy that uses pseudo range errors measured at a known location to improve the measurements made by other GPS receivers within the same general geographic area.

3. Geographic information systems (GIS): Geographic information systems (GIS) are computer hardware and software that use feature attributes and location data to produce maps. An important function of an agricultural GIS is to store layers of information, such as yields, soil survey maps, remotely sensed data, crop scouting reports and soil nutrient levels. A farming GIS database can provide information on: filed topography, soil types, surface drainage, subsurface drainage, soil testing, irrigation, chemical application rates and crop yield. Once analysed, this information is used to understand the relationships between the various elements affecting a crop on a specific site (Trimble, 2005).

4. Remote sensing: It is the collection of data from a distance. Data sensors can simply be hand held devices, mounted on aircraft or satellite based. Remotely-sensed data provide a tool for evaluating crop health, plant stress related to moisture, nutrients, compaction, crop diseases and other plant health concerns are often easily detected in overhead images. Remote sensing can reveal in-season variability that affects crop yield, and can be timely enough to make management decisions that improve profitability for the current crop.

5. Variable Rate technology: Variable rate technologies (VRT) are automatic and may be applied to numerous farming operations. VRT systems set the rate of delivery of farm inputs depending on the soil type noted in a soil map. Information gathered from the GIS can control processes, such as seeding, fertilizer and pesticide application, and herbicide selection and application, at a variable (appropriate) rate in the right place at the right time (Batte and VanBuren, 1999; NESPAL, 2005).

6. Grain yield monitors for mapping: A monitor mounted on a combine continuously measures and records the flow of grain in the grain elevator. When linked with a GPS receiver, yield monitors can provide data for a yield map that helps farmers to determine the sound management of inputs, such as fertilizer, lime, seed, pesticides, tillage and irrigation (Davis *et al*., 2005).

III. Management

a) Information management – The adoption of precision agriculture requires the joint development of management skills and pertinent information databases. A farmer must have clear idea of objectives of precision farming and crucial information necessary to make decisions effectively.

b) Decision support system (DSS) – Combination of information and technology into a comprehensive and operational system gives farmers a decision to treat the field. For this purpose, DSS can be developed, utilizing GIS, agronomic, economic and environmental software, to help farmers manage their fields.

c) Identifying a precision agriculture service provider – It is also advisable for farmers to consider the availability of custom services when making decisions about adopting precise or site specific crop management.

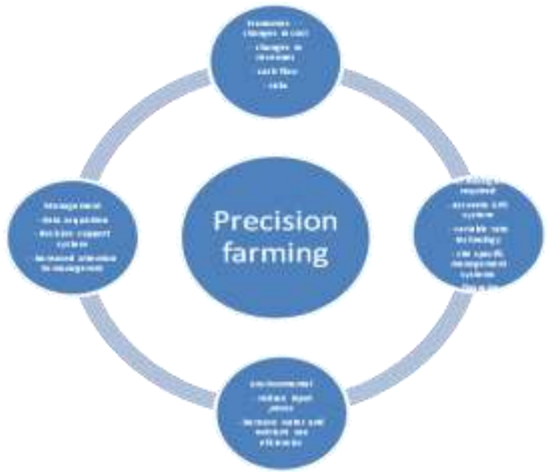


Fig.: Important issues related to precision farming (adapted from Davis , undated)

Steps in precision farming

I. Identification and assessment of variability:

a) Grid soil sampling – Grid soil sampling uses the same principles of soil sampling but increases the intensity of sampling compared to the traditional sampling. Soil samples collected in a systematic grid also have location information that allows the data to be mapped. The goal of grid soil sampling is to generate a map of nutrient or water requirement, called an application map.

b) Crop scouting – In-season observations of crop conditions like weed patches (weed type and intensity), insect or fungal infestation (species and intensity), crop tissue nutrient status, flooded and eroded areas. These observations can be helpful later when explaining variations in yield maps.

c) Use of precision technologies for assessing variability – Faster and in real time assessment of variability is possible only through advanced tools of precision agriculture.

II. Management of variability:

a) Variable rate application – Grid soil samples are analyzed in the laboratory and an interpretation of crop input (nutrient/water) needs is made for each soil sample. Then the input application map is plotted using the entire set of soil samples. The input application map is loaded into a computer mounted on a variable-rate input applicator. The computer uses the input application map and a GPS receiver to direct a product-delivery controller that changes the amount and/or kind of input (fertilizer/water), according to the application map.

b) Yield monitoring and mapping – Yield measurements are essential for making sound management decisions. However, soil, landscape and other environmental factors should also be considered when interpreting a yield map. Yield information provides important feedback in determining the effects of managed inputs such as fertilizer amendments, seed, pesticides and cultural practices including tillage and irrigation. Since yield measurements from a single year may be heavily influenced by weather, it is always advisable to examine yield data of several years including data from extreme weather years that helps in pinpointing whether the observed yields are due to management or climate induced.

c) Quantifying on farm variability – Every farm presents a unique management puzzle. Not all the tools described above will help determine the causes of variability in a field, and it would be too expensive to implement all of them immediately. An incremental approach is a wiser strategy, using one or two of the tools at a time and carefully evaluating the results and then proceeding further.

Benefits of precision farming

- The concept of "doing the right thing in the right place at the right time" has a strong perceptive appeal which gives farmers the ability to use all operations and crop inputs more effectively.
- More effective use of inputs results in greater crop yield and/or quality, without polluting the environment.
- Precision agriculture can address both economic and environmental issues that surround production agriculture.

Drawbacks of precision farming

- It has proven difficult to determine the cost benefits of precision agriculture management. At present, many of the technologies used are in their infancy, and pricing of equipment and services is hard to pin down.

- Lack of technical expertise knowledge and technology: The success of precision agriculture depends largely on how well and how quickly the knowledge needed to guide the new technologies can be found

- Not applicable or difficult/costly for small land holdings
- Heterogeneity of cropping systems and market imperfections

CONCLUSION

Precision farming can address both economic and environmental issues that surround production agriculture today. Questions remain about cost-effectiveness and the most effective ways to use the technological tools we now have, but the concept of "doing the right thing in the right place at the right time" has a strong intuitive appeal. In this context, there is a need to convert this green revolution into an evergreen revolution, which will be triggered by farming systems approach that can help to produce more from the available land, water and labour resources, without either ecological or social harm. Researchers and farmers must move speedily to an era of precision farming, which helps to reduce the cost of production and improve productivity on an ecologically sustainable basis. Precision farming methods, which can help to enhance income and yield per drop of water and per units of land and time, need to be standardized, demonstrated, and popularized speedily, if a reduction in the cost of production is to be achieved without reduction in yield (Swaminathan, 2006). Precision farming has created scope of transforming the traditional agriculture, through the way of proper resource utilization and management, to an environmental friendly sustainable agriculture.

References:

Batte, M.T. & VanBuren, F.N. 1999. Precision farming – Factor influencing productivity. Paper presented at the Northern Ohio Crops Day meeting, Wood County, Ohio, 21 Jan. 1999.

Davis G. Undated. Precision Agriculture: An Introduction. Water Quality. Published by University Extension, University of Missouri.6.Dawson CJ.

Davis, G., Massey, R. & Massey, R. 2005. Precision agriculture: An introduction (available at www.muextension.missouri.edu/explore/envqual/wq0450.htm).

Jensen AL, Boll PS, Thysen I, Pathak BK (2000) Pl@nteInfo: a web based system for personalized decision support in crop management. Comput.Elect.Agric. 24: 271 - 293

Lang, L. 1992. GPS+GIS+remote sensing: An overview. Earth Observation Mag ., April: 23-26.

NESPAL. 2005. Benefits of precision agriculture (slides, available at www.nespal.cpes.peachnet.edu/PrecAg/)

Ram M. Manglia. 2010. Precision agriculture at a glance. (Available at www.mragronomist.yolasite.com)

Roberson, G.T. 1998. Precision agriculture: A comprehensive approach. 1 June 1999. <http:// www.bae.ncsu.edu/programs/extension/ agmachine/precision/index.html>.

Shanwad UK, Patil VC, Honne Gowda H. 2004. Precision farming: Dreams and realities for Indian Agriculture. KSRSAC, Bangalore.

Swaminathan M.S. (2006). "An Evergreen Revolution". Crop Science. 46 (5): 2293.

Trimble. 2005. Precision agriculture (available at www.trimble.com).

CLIMATE CHANGE AND ITS MITIGATION MEASURES

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Introduction:

Climate change is the biggest environmental issue of the present time. It is affecting all sphere of life, be it weather, ecosystem, agriculture, infrastructure, health and biosecurity. If measures have not been taken, it will seriously impact the socio-economy of the people and will pose great risk to the life on the planet earth. It is now more certain than ever that extensive and unmindful exploitation of natural resources by human is changing the Earth's climate. Global warming, rise in sea level, melting of glaciers, decline in Arctic ice, changing rain pattern etc. are the evidences that clearly indicate the climatic aberration. These are the signals being given by the nature and if we are not acting to mitigate these changes then humanity has to suffer.

Climate Change:

The Sun is primary source of energy for the Earth. There is a balance between the incoming energy from the Sun and outgoing energy from the Earth. Any disturbance to this balance will affect to the climate change. Part of the solar energy received from the Sun is reflected back into the space from the clouds, bright surfaces of Earth from total incoming solar radiation, however remaining is absorbed by the Earth's surface and the atmosphere. Much of this absorbed solar energy is re-emitted as heat and maintains the atmospheric temperature and some amount of this energy again escapes to space. But any disturbance to this balance impacts the climate. Further, Sun also goes through changes and the amount of radiation output from Sun also deviates, which affects total energy received on Earth thus disturbs the energy balance and causes the climate change.

The Greenhouse Effect:

The energy trapped on Earth plays important role in warming of the Earth. If all heat energy emitted from the surface passed through the atmosphere directly into space, Earth's average temperature would been 33^0C colder (Karl and Trenberth 2003). But, this is not happening because of the greenhouse gases like; carbon dioxide, ozone, methane, water vapour and nitrous oxide, present in the atmosphere trapes the heat and keeps the atmosphere warmer. Without this greenhouse effect, life as we know, could not have evolved on the planet Earth.

The present global warming and climate change is directly related with greenhouse effect, which is occurring due to anthropogenic activities. The combustion of fossil fuels (oil, coal, and natural gas) has led mainly to an increase in the CO_2 concentration in the atmosphere, which is the main candidate of global warming. CO_2 concentration during preindustrial revolution (sometime during 1800) were approximately 280 ppm, which has reached toady above 380 ppm and now it is increasing with a rate of approximately 2 ppm annually. According to the IPCC Special Report on

Emission Scenarios (SRES) (IPCC 2010a), CO_2 concentration may reach 490 to 1,260 ppm by the end of the twenty-first century.

Sources of human-emitted greenhouse gases:

Carbon dioxide has both natural and human sources, but its levels are increasing mainly due to combustion of fossil fuels, cement production, deforestation, and other land use changes. Increases in CO_2 level is the single largest contributor to global warming.Methane levels have risen significantly due to human activities such as raising livestock, growing paddy, filling landfills, and natural gas.Nitrous oxide concentrations have risen primarily because of agricultural activities such as the use of nitrogen-based fertilisers. Chlorofluorocarbons (CFCs) and fire retardants also contribute significantly to green house effect.

Agriculture and global climate change:

Agriculture is not only at risk due to climatic aberration but it is a major factor of environmental and climatic change. It has the largest human impact on land and water resources. About 1.4 billion ha of arable land are used for crop cultivation, 2.5 billion ha for pasture and 4.0 billion ha for forest. In addition to land resources, agriculture is a major user of water. Over 200 million ha of arable land is under irrigation, utilizing 2500 billion m^3 of water annually, representing 75 percent of fresh water resources withdrawn from aquifers, lakes and rivers by human activity. Apart from this significant quantities of chemical inputs are applied to get higher yields. As a result of these large-scale activities, agriculture becomes significant contributor to land degradation and a major emitter of greenhouse gases. As per a crude estimate agriculture emits 13-15 billion tonnes CO_2 annually into the atmosphere. This amounts to 25 percent of total carbon dioxide produced annually. Agriculture also contributes 50 percent of methane (rice and enteric fermentation), and more than 75 percent of N_2O (largely from fertilizer application) emitted annually by human activities (Tubiello, 2012).

Mitigation and Adaptation to Climate Change

To combat the ill effect of the climate change some of the mitigation measures that can be taken are as follows:

1. Practicing energy efficient technologies

2. Higher use of green and renewable energy

3. Electrification of industrial processes

4. Efficient means of transport and promotion of public transport

5. Carbon crediting

6. Landscape restoration (natural landscape) and reforestation

7. Flexible and diverse cultivation to be prepared for natural catastrophes

8. Research and development on possible catastrophes, temperature behavior, etc.

9. Preventive and precautionary measures (evacuation plans, health issues, etc.)

Policies contributing to climate mitigationwith specific reference to India:

India is fifth largestgreenhouse gas (GHG) emitter, accounting for about 5% ofglobal emissions. Emissionhas increased 65% between1990 and 2005 and are projected to grow another 70% by2020.On a percapita basis, India's emissions are 70% below the world averageand 93% below to the United States. In recent times India has adopted some corrective measures to reduce its carbon foot print and mitigate the effect of climatic aberrations. Factors contributing to the decline inenergy intensity includes improved energy efficiency, increaseduse of renewable and nuclear power, expanded public transport, and energy pricing reform. Some of the policies adopted by the country for climate mitigation are as follows:

A. Energy

a. Renewable Energy - Currently, renewable energyconstitutes 4% of the total installed capacity of the power generatingsector. Government of India is promoting renewable energy generation through installation of solar panels at private and public building and providing loans and subsidies to encourage the people. The Electricity Act (2003) encourages the development of renewableenergy by mandating that State Electricity RegulatoryCommissions (SERCs) allow connectivity and sale of electricity toany interested person and permit off-grid systems for rural areas.The National Tariff Policy (2006) stipulates that SERCs mustpurchase a minimum percentage of power from renewablesources, with the specific shares to be determined by each SERCindividually.

b. Wind Power - India ranks fourth in terms of wind power generationworldwide. The Ministry of New and Renewable Energyestimates the overall potential for wind power at 45,000 MW,with only about 6270 MW currently developed.The central government is providing concessions on import duties, sales tax and excise duties; and a 10-year income tax exemption for profits from wind generation.Subsidies also are provided for demonstration projects instates where commercial activity has not begun.

c. Other Renewables –Government is providing subsidies, income taxholidays, excise duty and sales tax exemptions, and accelerateddepreciation for biomass gasifiers projects for power generation. Hydropower presently contributes 33,642 MW (or 26%) of electricitygenerated in India. Further, it has been planned to enhance the Hydro power capacity and a target of 50,000 MW of new capacity has been planned to achieve by 2025-26.

d. Coal - Currently, coal accounts for 55% of electricity generation, which is to be reduced in phase wise manner.

e. Nuclear Power - Nuclear power presently accounts for 3% of total power generation and goal of increasing installed nuclear capacity have been fixed to 20 gigawatts (GW), by 2020.

B. Energy Efficiency and Conservation

Bureau of Energy Efficiency (BEE) was established under the Energy Conservation Act (2001) with the objective of improvingenergy efficiency in various sectors. BEE has developed codes for various kind of electrical appliances and conducts energy audits for large energy consuming industries.

C. Transportation

a. Vehicles - The National Auto Fuel Policy (2003) mandated thatall new four-wheeled vehicles in eleven cities meet Bharat StageIV emission norms for conventional air pollutants. CNG vehicle fleet introduced in metros to reduce the pollution.

b. Mass Transit - The Delhi Metro subway system began constructionin 1998 and will cover the entire metropolitan region by2021. Similarly mass transit projects are being implemented in many other cities.

D. Biofuels

The Ministry of Petroleum and Natural Gas is implementing amandatory program for the introduction of ethanol-blendedgasoline (5% gasohol) nationwide by April 2008. Further alternate biofuels are also being developed/tested at different laboratories.

E. Forestry

In 2005, the forest and tree cover in India was 24%.The 11thFive Year Plan proposes an increase in the forest and tree coverof 1% a year through 2012. In 2007, the Prime Ministerannounced the Green India program to reforest 6 millionhectares of degraded forest lands.

F. Agriculture

Agriculture sector accounts for roughly one fourth of greenhouse gas (GHG) emission. This is a massive number, comparable in scale to other sector but very little attention paid by policy makers to slow down the climate change.

Some of the policy level strategies suggested to mitigate the impact includes; sustainable intensification,improving nitrogen fertilizer management and production, reducing emissions from enteric fermentation, sequestering carbon in agricultural systems, reducing methane emissions from rice cultivation, managing manure, reducing food wastage, shifting food habits etc.

References:

Karl TR, Trenberth KE (2003) Modern global climate change. Science 302(5651):1719–1723

Tubiello, F. 2012. Climate change adaptation and mitigation: challenges and opportunities in the food sector. Natural Resources Management and Environment Department, FAO, Rome. Prepared for the High-level conference on world food security: the challenges of climate change and bioenergy, Rome, 3-5 June 2008.

APPROACHES FOR HORTICULTURE DEVELOPMENT THROUGH NATURAL RESOURCE MANAGEMENT

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Introduction

India is the seventh largest country in the world with a geographical area of 328.7 million ha having a population of more than 1.3 billion. About 70% of the India’s population is engaged in agricultural and allied activities and contributes to 16.4 per cent of GDP (Anonymous, 2018). In India, 78% of the farmers are small and marginal occupying 32% of the land total land area. The production and productivity of crops solely depends on the natural resources of a region i.e. climate, land, water, soil and biodiversity. It is also sound business practice to ensure the resources we depend on for production are used efficiently and are in optimal condition without causing any future adverse environmental consequences.

Horticultural crops play an important role in ensuring livelihood security of farming community. Effective management of natural resources plays important role in improving the productivity of horticultural crops. Approaches like genetic resource management, appropriate land use, maintaining soil fertility, efficient management of water resources, adoption of farming system approach for integrating different components ensures sustainable horticulture production with minimum harm to the nature.

Status of Horticulture in India & North East

India is the second largest producer of fruits and vegetables next to china. Horticulture as a sector has performed remarkably in recent years. Production of fruits and vegetables has outstripped that of food grain for the 3rd consecutive year in 2015-16. During the 2015-16 India’s horticulture production stood at 300 Million Tonnes and around 30 Million Tonnes more than food grain production. Share of horticulture in agricultural production was more than 33%. According to survey, over the past decade the area under horticulture crops has grown by 2.7% per year fuelling production which increased at an annual pace of 7%. (Pradip,2017).

Northeast India has a total geographical area of 26.2 million ha which is nearly 8% of the total geographical area of the country. In the whole of NE region, about 35% area is plain and the remaining 65% area is under hills. About 0.88 million ha area is under shifting cultivation in whole NE region. The total area under horticulture in the region is 1482.62 (000 ha) and production is 12773.55 (000 tonnes). Horticulture based land use is getting popularity in the Northeastern region of India. Kiwi and is being grown in large area of Arunachal Pradesh and Nagaland. Mandarin and pineapple is grown is all the NE states. Ginger and turmeric is mostly cultivated in Mizoram, Meghalaya and

Nagaland, large cardamom in Sikkim, tea in Assam and rubber in Tripura (Das *et. al.*, 2013).

Table 1. State-wise area, production and productivity of horticultural crops

States	Area under horticultural crops (‘000ha)	Production (‘000tonnes)	Productivity (t/ha)
Arunachal Pradesh	84.42	422.98	5.01
Assam	707.55	6842.87	9.67
Manipur	105.18	810.72	7.71
Meghalaya	131.96	1117.14	8.47
Mizoram	134.08	613.31	4.57
Nagaland	101.60	1045.47	10.29
Sikkim	75.05	238.69	3.18
Tripura	142.78	1682.37	11.78
Total	**1482.62**	**12773.55**	

Source: Horticultural statistics at a glance, 2017, Govt of India

Impact of climate change in horticulture

Climate change affects livelihoods, food security, health and economic activities of any nation. Two major factor of climate change that has been taken under consideration for affecting the agriculture in general and horticulture in particular are increasing temperature and changes in the rainfall enhancing the biotic and abiotic stresses in crops. Datta (2013) reported some of the climate change impacts on horticultural crops:

- ✓ Due to the rise in temperature, fruit crops viz. Citrus, grapes, melons etc. will develop more rapidly and mature earlier.
- ✓ With rise in temperature rises photosensitive crops viz., onion will mature faster leading to small bulb size. Strawberries will have more runners at the expense of fruits.
- ✓ The winter regime and chilling duration will reduce in temperate regions affecting the temperate crops.
- ✓ The faster maturity and higher temperature induced ripening will reduce the storage period in trees and will over ripe.
- ✓ Pollination will be affected adversely because of higher temperature. Floral abortions will occur.

- ✓ Soil temperature will increase much earlier in spring hence the planting time also will advance.
- ✓ Higher temperatures will reduce tuber initiation process in potato, reduced quality in tomatoes and poor pollination in many crops.
- ✓ Soil conditions may pose problems with an increase in acidity, alkalinity and salinity.

To mitigate climate change, horticulture biodiversity is very important. According to Inter-Governmental Panel on Climate Change, there may be rise in temperature of 0.88-3.16 ^{o}C by 2050.

Conservation & management of genetic resources of horticultural crops

India harbours a rich flora and is one of the 12 "mega-biodiversity centres", housing an estimated 12 percent of the world flora. It contains three of the 34 biodiversity "hotspots", the Himalayas, the Indo-Burma region and the Western Ghats, with thousands of endemic flora (Conservation International, 2005). Indian is Primary centre of diversity Jackfruit, banana, mango, jamun, large cardamom, black pepper and Secondary centre of diversity for Cowpea, cluster bean, okra, tomato, muskmelon/*Cucumis* species, pumpkin /*Cucurbita* species, and iii) Regional diversity for crops: cucumber, bitter gourd, bottle gourd and snake gourd (Singh & Yadav, 2013).

Shadeque (1989) reported that, the North eastern region has rich diversity of fruits and vegetables. It is considered to be the centre of origin of fruits viz. Mango, Banana, Citrus. The area is also a diversity hot spot for different vegetable ie. cucurbits, brinjal, chilly, beans, colocasia, yams, sweet potato, turmeric, bamboo etc. The enormous diversity makes the region a gene pool for the varietal improvement.

Table 2. Genetic Resources of Horticultural Crops (Das *et.al.*, 2013)

Crops	**Total accessions**
Fruits	9240
Vegetables	25400
Ornamentals (including orchids)	5300
Plantation & Spice crops	25800
Medicinal & Aromatic plants	6250
Mushroom	984

Despite of the rich diversity of horticultural flora, there is a threat to these plant genetic resources. Disappearance of genetic recourses due to deforestation, rapid urbanization, hybridization, selection or genetic drift and other natural calamities like earth quake, land slide, flood etc. has led to genetic erosion. The loss of variation in crops or varieties due to the modernization of agriculture has been described as genetic erosion (Wouw *et al.*, 2009). Genetic diversity gives species the ability to adapt to changing environments, including new pests and diseases and new climatic conditions.

Conservation measures are being taken care by the ICAR-National Bureau of Plant Genetic Resources which networks 30 National Active Collection Sites in various Agri- horticultural crops. The two approaches to plant genetic resource conservation are *ex situ* and *in situ*. *Ex situ* approach generally involves storing the seeds in low temperatures (-20^{o}C), maintaining plants in the field genebank, botanical gardens, maintaining cells, tissues, pollen *in vitro* in liquid nitrogen and DNA storage, all of which are outside the natural habitat/environment of the plants concerned. *In situ* approach involves maintaining the genetic resources in their natural reserves, where the species are allowed to remain in their ecosystems within a natural or properly managed ecological continuum. Conservation and exploitation of underutilized fruits for nutritional security is of utmost important. Various indigenous fruits exist in the region i.e. Jackfruit, bael, jamun, carambola, aonla, pummelo, delinia etc. However, these fruits are not utilized for any commercial purpose resulting in diminishing of these valuable resources.

This rich diversity of the region can be utilized for improving the crops through breeding programme for various growth and yield attributes, pest and disease resistance and overcoming abiotic stresses. Hence, a large number of accessions were evaluated for yield, fruit setting, quality and other traits and promising donors were identified for horticultural crops. In solanaceous crops, concerted efforts have resulted in release of varieties and hybrids in tomato (varieties: 64, hybrids:13), brinjal (varieties: 74, hybrids:17), chilli (varieties: 40, hybrids:3). In India, tomato is one of the best example of utilization of wild species in crop improvement. Tomato variety H24 tolerant to tobacco leaf curl virus was developed using L. *hirsutum f. glabtrtum* as a donor. Cucurbits constitute an important and large group. Characterzation and evaluation of germplasm resulted in identification of donors and 12 genetic stocks have been registered at NBPGR. Direct selection of germplasm, or recombination and through mutation breeding resulted in release of 95 varieties of cucurbits. (Anonymous, 2007).

Sustainable land use approach in horticulture production system

With the increasing population of the country, there is increase demand of the agricultural as well as horticultural produce. Land being a constant factor, needs to be efficiently utilized for increasing the production and productivity of horticultural crops. Approaches like multistoried cropping system, high density planting, protected cultivation, mixed cropping etc. have proven to be efficient in proper utilization of exiting natural resources.

a. Multistoried cropping system

Multistoried cropping system in horticulture is found to be a perspective approach for sustainable productivity in fruit crops (Mango, Ber, Amla, Pomegranate) and Plantation crops (Coconut, Areca nut, Coffee, Cashew) by which natural resources are utilized efficiently to enhance productivity of main crops (15-20%) and high revenue realization per unit area (50-90%). The system accommodates crops of different heights, canopy patterns and rooting systems to maximize the sunlight, nutrients and sustainable land use. Seventy per cent of the world small farms are in China and India. India accounts for 93 million (23 %) small farms out of 404 million small farms in the world (Nimbolkar et al., 2016).

A multi-storied approach is often viewed as a sustainable alternative farming system particularly on small and marginal lands and it can provide greater economic return per unit area (Rahim, 1995). The system consists of three main components viz. main crop, filler crop and inter crops which occupy three different tiers in space of the production system.

The basic principles of multi-storey cropping system include (i) Opportunities for crop diversification on scientific, ecological & economic principles; (ii) Maximize system productivity with additional income (iii) Utilization of resources with higher efficiency; (iv) Intensive input use and (v) Sustainability of farm resources & environment on long term perspective (Nimbolkar *et. al.*,2016).

Types of multistoried cropping system followed are:

- ✓ **Coconut Based Cropping System (**7.5 X 7.5 m): In the initial 5 years of plantation, suitable inter crops of short and medium duration with crop rotation recommended are banana-turmeric-ginger-pineapple-vegetables. After 20-25 years, more than 40 % of light falls on the ground and also have efficient shade. Therefore, shade loving crops could be grown in the multistoried cropping pattern eg: Coconut + Black pepper + Cocoa + Pineapple/ Turmeric / Ginger (Mathew *et. al.*, 1993).

The Coconut based cropping system model Coconut + Cocoa + Banana + Moringa + Pineapple with integrated nutrient management at AICRP Aliyarnagar revealed that the cropping system recorded highest nut yield of 182 per palm and highest net income (Rs. 3.80 lakhs per ha) and B:C ratio (2.71) compared to monocrop coconut.

- ✓ **Areca nut Based Cropping System (**2.7X 2.7m**):** Arecanut + Tapioca and Areacanu + Ginger cropping system showed higher profit of 9.3% and 61.2% over control i.e. sole crop-arecanut (Hegde, *et.al.*,2015). In Assam, Arecanut-Mandarin-Pineapple base multistoried cropping system is followed.

Table 3. List of fruit crop based system with their intercrops (Nimbolkar *et. al.*, 2016)

No.	**Crop**	**Main crop with intercrops**
1.	Mango	Mango + Guava + Cowpea
2.	Guava	Guava + Ground nut + Black gram
3.	Mandarin	Mandrin + Ginger
4.	Mandarin	Mandarin + Pea
5.	Lemon	Lemon + French bean
6.	Passion fruit	Passion fruit+Bean (*Phaseolusvulgaris*)
7	Banana	Banana +Sweet potatoes

b. High density planting (HDP)

Highdensity planting is the practice of accommodating higher number of plants of the same species per unit area by planting at a closer spacing than that is planted under traditional system. Two important components of HDP are 1. Dwarf scion varieties 2. Dwarfing rootstock.

Table 4. High density planting in some fruit crops

Crop	**Spacing**	**Planting density (Plants/ha)**	**Yield (t/ha)**	**% increase over traditional methods**
Mango cv. Amrapali	2.5m x 2.5m	1600	19.2	250%
Citrus (Kinnow)	1.8m x 1.8m	3000	20	200%
Banana	1.2m x 1.2m	5200	80.0	150%
Pineapple	25cm x 35 cm x 90cm	64000	90.0	200%
Guava	1mx2m	5000	50	250%

c. Protected cultivation technology

Protected cultivation of horticultural crops is also an important approach to efficient use of natural resources. The main objective of the technology is to create a favourable environment for sustainable growth of crops under protected structure i.e. polyhouse, shade net, poly tunnel etc. so as to realize its maximum potential even in adverse climatic condition (Hasan and Singh, 2012). It is suitable for marginal farmers with small land holding for growing vegetable, flowers and nursery raising during offseason for higher income.

Benefits:

- ✓ Growth is faster compared to open condition
- ✓ Easy for pest and disease management
- ✓ Suitable for organic production
- ✓ High yield and income

d. Organic farming in horticulture

Use of fertilizer and pesticide has no doubt increased the production and productivity of grains making the country self sufficient. However, due to non judicious use of these inorganic substances, there has been negative impact on soil properties, human health and environmental pollution. Thus, organic farming has the following benefits:

- ✓ Improvement in the biological properties of soil is the main focus in organic fruit production.
- ✓ Conservation of energy and resources in production system.
- ✓ Control of pests, diseases, and weeds is achieved largely by the development of an ecological balance within the system and by the use of bio-pesticides, bio-control agents and adopting good agricultural practices.
- ✓ Recycling of all wastes and manures within a farm.

e. Horticulture based integrated farming system for NE hill region

Integrated farming system is an approach where different components of farming are incorporated together for efficient land use and sustainable income generation.

Importance of integrated farming system

✓In situ recycling of organic residues.

✓Decrease in cost of cultivation through enhanced input use efficiency.

✓Integration of primary or secondary produce/waste of one component for the benefit of other components.

✓Upgrading soil and water productivity.

✓Nutritional security.

✓Environmental security.

✓Continuous flow of income and employment throughout the year.

In hills of North East India, the development of horticultural land use system with mixed horticultural crops including fruits, vegetables, root crops, spices and ornamentals grown under optimum management conditions can be more remunerative on long term basis with least gestation cycle. Horticultural crops are taken up on the steep slopes, bunds, half moon terraces and low land terraces ensuring proper soil and water conservation. Selection of crops based on altitude is the most important in horticultural based farming in hills (Sahoo, *et.al.*, 2015). Crops can be classified into three catagories based on altitude and climatic requirement i.e i) High hills: 900-2000m above MSL (apple, peach, pear, plum, apricot, potato, cabbage, cauliflower, radish, beans, etc. ii) Mid hills: Below 500 m (citrus, banana, pineapple, passion fruit, papaya, guava, ginger, turmeric, chilli, brinjal, tomato, bean, sweet potato, tapioca, colocasia, etc. iii) Foot hills: Bordering areas of hills (jackfruit, areca nut, black pepper etc. Horticulture based integrated farming suitable for hills are:

1. Horticultural land use (with fruit crops only): The land use under pure horticultural system also has high potential in the region e.g. Kiwi, Persimmon, Banana etc. This system of cultivating the land will be highly profitable in long run and area will be developed as a fruit growing belt.

4. **Mixed horticultural land use:** Farmers of the region practice mixed farming system with no proper crop geometry. However, with proper planning of available land area (Jhum), different horticultural crops i.e fruits and vegetables can be grown together for sustainable production and income.

5. Agri- horticulture: Fruit crops are grown on the higher hill for which half moon terraces and contour bunds are prepared on the slope and at the foot hill cereals, pulses, oilseeds etc. are grown.

6. Agri-horti-silvi : In this system horticultural crops are grown together with forest and cereals. The upper area of the hill consist of forest trees, the middle is utilized for fruits and at the foot hill, cereal crops are grown

7. Horti-silvi-pastoral system: The horti-silvi-pastoral system has great potential to provide a sustainable land use system, which would maintain an acceptable level of production of fruits, vegetables, fuel wood, timber, fodder etc. and at the same time, conserve the basic resources (mainly soil) on which production depends. This system was found economically viable and socially acceptable alternative to *jhuming* in this region.

f. Soil fertility management in horticulture based production system

Soil organic matter depletion is a prime cause for declining soil health and soil productivity (Sharda et al, 2010). Deficiency of N, P, K, S, Zn, and B are wide spread in India resulting low productivity of crops. Therefore, balanced fertilization is important for maintaining proper fertility status of the soil with respect to the crops. Balance has to be maintained in the soil - crop system to ensure that there is no toxicity /deficiency of any element. Too much nitrogen fertilizers result in excess vegetative growth and reduce the reproductive growth which otherwise

isneeded to maintain large yields of fruits. Excess nitrogen can result in soft fruits with poor colour in apple and predispose vegetables to attacks of pests and diseases.

Table 5. Plant tissue sampling guideline for horticultural crops

Table 2. Plant tissue sampling guidelines for horticultural crops

Crop	Plant part	Growth stage/ Time
Fruit Crops		
Banana	Petiole of 3rd open leaf from apex	Bud differentiation stage.
Cashew	4th leaf from tip of matured branch	At beginning of flowering
Custard Apple	5th leaf from apex	2 months after new growth
Fig	Fully expanded leaves, mid-shoot current growth	July-August
Grapes	5th petiole from base	Bud differentiation stage for yield forecast. Petiole opposite to bloom time for quality
Citrus	3 to 5 month-old leaf from new flush. 1st leaf of the shoot	June
Guava	3rd pair of recently matured leaves	Bloom stage (August or December)
Mango	Leaves + petiole	4 to 7 months old leaves from middle of shoot
Papaya	6th petiole from apex	6 months after planting
Passion Fruit	Matured leaf opposite to last open flower	Bloom
Pineapple	Middle 1/3rd portion of white basal portion of 4th leaf from apex	4 to 6 months
Pomegranate	8th leaf from apex	Bud differentiation. In April for February crop and August for June crop.
Sapota	10th leaf from apex	September
Phalsa	4th leaf from apex	One month after pruning
Ber	6th leaf from apex from secondary or tertiary shoot	Two months after pruning
Vegetable Crops		
Bean	Upper most recent fully developed trifoliate leaves	
Cabbage	Wrapper leaf	2-3 months old
Carrot	Most recent fully matured leaf	Mid-grown
Cauliflower	Most recent fully matured leaf	At heading
Peas	Most recent fully developed leaflet	First bloom
Cluster bean	1st fully developed leaf	
Cucumber	5th leaf from tip	Flower bud start to small fruit
Brinjal	Leaf blades with midribs minus petioles from most recent fully developed leaf	
Garlic	Most recent fully matured leaf	Pre-bulb
Onion	Top-no white portions	1/3 to ½ grown
Tomato	Leaves adjacent to inflorescence	Mid bloom
Crop	Plant part	Growth stage/ Time
Plantation crops		
Coconut	Pinnal leaf from each side of 4th leaf	
Oil palm	Middle 1/3rd minus midrib of 3 upper and 3 lower leaflets from 17 frond of mature trees and 3rd frond of young trees	
Coffee	3rd or 4th pair of leaf from apex of lateral shoots	
Tea	Third leaf from tip of young shoots	
Clove	10th to 12th leaves from tip of non- fruiting shoot	End of blooming period
Ornamental crops		
Jasmine	Most recent fully developed leaves	
Chrysanthemum	4th leaf from tip, omit unfurled	Bud burst
Hibiscus	Most recent fully developed whole leaves	
Lilly	Most recent fully developed leaf	
Rose	Most recent fully developed compound 5th leaflet leaf	Flower bud pea size

Source: Bhargawa and Chadha (1993)

Fertility of the soil can be improved through various soil management practices such as:

- ✓ Cover crops: Protects the soil from erosion and supplies nutrients when incorporated into soil
- ✓ Green manuring crops: Green manuring crops also called nitrogen fixing plants/crops viz. Dhanchia, legumes supplies nitrogen to soil, adds organic matter when incorporated in soil, improves soil structure, suppresses weeds and reduces soil erosion.
- ✓ Crop rotation: Growing of different crops in a particular area in sequence for better soil nutrient and insect pest & disease management.
- ✓ Crop residues: Crop residues can be an important source of nutrients to subsequent crops. The quantity and quality of crop residues will clearly influence the buildup of soil organic matter. Weed management through incorporation into the soil, improves nutrient status of the soil.
- ✓ Animal manures: For increasing organic matter and supplying nutrients. Manure is an excellent soil amendment, providing both organic matter and nutrients.
- ✓ Compost: Application of different compost i.e. vermicompost, azolla etc. improves the soil properties and nutrient status.
- ✓ Biofertilizers are considered to be the most safe, promising and economic component of sustainable agriculture. Biofertilizer is a substance which contains living or latent microorganisms which, when applied to seed, plant root or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by providing and essential nutrients or increasing the supply or availability of primary nutrients to the host plant. biofertilizers have potential to reduce the use of chemical fertilizers to the tune of 50 per cent and increase the productivity upto 20 per cent (Sabalpara and Mahatma**,** 2016)

g. Soil and water conservation measures in horticulture based farming

Rain-fed agriculture supports nearly 40% of India’s estimated population of 1210 million in 2011. India ranks first among the rainfed countries in the world in terms of rainfed area, but ranks among the lowest in rainfed yields (<1t/ha). The northeastern region is highly susceptible to acute soil erosion problems due to its undulating topography and high intensity rainfall. The primitive cultivation practices like *jhum* further enhances these degenerative trends and rampant deforestation, wild fires, extensive grazing etc., are adversely affecting the overall ecological condition of the region. Land and water are natural resources that are essential for the existence of. It takes nature 600-1000 years to build 2.5 cm of top soil but get displaced in a year only due to misuse. It has been reported that 6000 million tones of productive soil are lost every year from about 80 million hectare of cultivated land alone in India. It has also been proved that soil lost from unprotected land is about 120 tonnes /ha/yr and may go as high as 300 tonnes /ha/yr (Das et. al, 2013).

Measures for soil and water conservation:

Contour bunds: Bunds are either mechanical or vegetative barrier created across the slope. The purpose is to divert the excess run-off during rain to the waterways and to retain eroded

soil.

Bench terrace: Bench terraces are flat beds constructed across the hill slope; spaces between two contours are leveled by cut and fill method.

Half moon terrace: These are level circular beds having 1 to 1.5 m diameter cut into half moon shape on the hill slopes.

Water harvesting: Harvesting of rain water using plastic lining or concrete structure helps in proper utilization of the stored water for fruits and vegetable production. Diversion of the rain water through bamboo is practiced in the region.

Mulching: Placing organic or synthetic material at the base of fruits and vegetables provides favourable environment for growth and production.

Benefits:

1. Reduces evaporation loss of moisture from soil.
2. Reduces weed growth
3. Increases soil temperature
4. Reduces soil erosion
5. Early crop growth and maturity
6. Reduces peast and disease infestation.

Conclusion

Proper management of natural resources can play an important role in reducing the gap between existing and potential productivity of different horticultural crops. Efficient use of land, soil and water ensures higher productivity, profitability and sustainability of horticulture based production system. Natural resource management approaches will help in protecting the existing native vegetation for greater biodiversity, improving soil properties and fertility status and provide a suitable environment for crop growth and human sustenance.

References:

1. Anonymous (2007). State of Plant Genetic Resources for Food and Agriculture in India (1996-2006): *A Country Report. National Bureau of Plant Genetic Resources*, Indian Council of Agricultural Research, New Delhi. pp 70.

2. Anonymous (2018). *Economic Survey* 2017-18. Vol.2.pp 19

3. Bhargava, B.S. and Chadha, K.L. (1993). Leaf nutrient guides for fruit crops. In: Advances in Horticulture (Fruit crops), 2 (Ed., Chadha, K.L and Parees, O.P.), Malhotra Publishing House, New Delhi. pp 973-1030

4. Conservation International, 2005. *Biodiversity Hot Spots*, 1919 M Street, NW, Suite 600, Washington, www.conservation.org.

5. Das, B.; Singh, A. K.; Kumar, S and Bhatt, B.P. (2013). Natural Resource Management for Horticulture Development, Satish Serial Publishing House, New Delhi pp 1-151

6. Datta , S. (2013). Impact of Climate Change in Indian Horticulture - A Review , *International Journal of Science, Environment and Technology*, Vol. 2 (4), pp 661-671

7. Hasan, M. and Singh, B. (2012). Protected cultivation technology for growing high value horticultural crops. www.cafeextension.org.in/CAFE 2012 Lectures/18.pdf

8. Hegde, N. K., Vijayakumar, B. N. and Pushpa, P. (2015). Importance of multistoried cropping systems in Horticulture. In: Winter School on Multistoried cropping system and canopy management in horticultural crops. College of Hort. Sirsi, Karnataka, pp.10-13.

9. Horticultural Statistics at a Glance, 2017, Ministry of Agri.& Coop., Govt of India

10. Mathew, P. A., Nagabhushanam, S. and Dhandhar, D. G. (1993). Multi-cropping trials in coconut in Goa. In: Advances of Coconut Research and Development, Oxford and IBH, New Delhi. pp. 437-439.

11. Nimbolkar, P.K., Chandrakant, A., Chander, S. and Husain, F. (2016). Multi Storied Cropping System in Horticulture-A Sustainable Land Use Approach. International Journal of Agriculture Sciences, Vol. 8 (55),

pp 3016-3019.

12. Pradip, K. (2017). Horticultural crops and current scenario in India. http://www.sakshieducation.com/Story.aspx?nid=178550

13. Rahim, M. A. (1995). Horticultural crops for crop diversification. In: An adoption to Farmers Field. University Press Limited (UPL). Dhaka. pp. 7-20.

14. Sabalpara, A. N. and Mahatma, L. (2016). Commercial Horticulture. (Eds., Patel, N.L. Chawla, S.L. and Ahlawat, T.R.) New India Publishing Agency, New Delhi, pp 185-192

15. Sahoo, M. R., Roy, S. S., Prakash, N. and Ngachan, S. V. (2015). Horticutlture based farming system for sustainalbility and higher profitability. In: A comprehensive manual on Integrated Farming system: An approach towards livelihood security and Natural Resource conservation. pp 46-50 www.researchgate.net

16. Shadeque, A. (1989). Genetic Resource Diversity in Horticultural Crops in North Eastern Region. *Proc. Indian natn. Sci. Acad*., B55 Nos.5&6, pp 473-476

17. Singh, A.K. and Yadav, J.P. (2013). Horticultural Biodiversity Heritage Sites. In: Biodiversity in Horticultural Crops, (Ed., Peter, K.V.), Daya Publishing House, New Delhi, Vol. 4, pp 25-59

18. Wouw, M., Kik, C., Hintum, T., Treuren, R. and Visser, B. (2009). Plant Genetic Resources: Characterization and Utilization 8(1), pp 1-15

CLIMATE CHANGE IN NORTH EAST AND ITS LIKELY IMPACT ON SOIL HEALTH

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Introduction:

India's North Eastern Region consists of eight states–Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura–occupying 262,179 square kilometres and with a population of over 45.58 million (Census 2011) which is 3.77% of India's population. The North Eastern Region is socially, culturally, and politically very complex and contains great environmental and natural resource diversity. The region falls under high rainfall zone (>2000 mm annual rainfall) and is characterized by having difficult terrain, wide range of slopes and elevations, varied land tenure system, ethnic diversity, diverse food habit and cultural practices. More than 200 dominant tribes and many sub-tribes reflect the complex social structure of the region. Agriculture is the mainstay of the economy of northeast India, where more than 80 percent of the total population is rural. Although the region was very resourceful in terms of natural resources, the agricultural production and productivity had not been substantial even during the green revolution period. *Jhum*(shifting) cultivation is the predominant land use system in the hilly states of the region covering an area of 0.76 million hectares. Shifting cultivation (*Jhum*) is still practiced in almost all the hill states (except Sikkim) on steep slopes with reduced fallow cycle of 2-3 years as against 10-15 years in the past. The *jhum* is not only a farming practice in the north east hill region, but a way of life of the tribal farmers.

Climate change in north east India:

There have been some conspicuous changes in temperature as well as rainfall pattern in northeast India over the past century. The annual mean maximum and mean temperature in northeast India during 1901-2003 has increased significantly by a rate of 1.02^{0}C and 0.60^{0}C/100 years, respectively (Deka et al. 2009). Atmospheric temperature in the region is further projected to rise by approximately 3^{0}C to 5^{0}C during the latter third of this century (*Cline, 2007)*. There is reduction in the annual as well as the monsoon rainfall over the years in the north-east. In the recent times, the alarming deficits in annual as well as monsoon rainfall resulted in severe droughts across the hill region. The shift in the climatic scenario and lack of mitigation strategies with the farmers makes the challenges in agriculture further complex. Since 80% of the crop area is under rainfed, future climate change and variability will potentially impact agricultural production pattern in the region (Ministry of Environment and Forests Report 2004, GOI). Results of the recent study (Ravindranath*et. al*., 2011) indicates that majority of the districts in north east, presently and in future, are subjected to climate induced vulnerability. The monsoon rainfall decreased by 4.4-24.6% in the region except Sikkim, Meghalaya and Manipur (4.1- 10.5% ↑). During last five years (2011-2015), the gain in monsoon rainfall further increased in Manipur (29%) and Meghalaya (35%) over 1971-2010 (40 yrs.). Monsoon rainfall decreased further in Mizoram (-27%), Sikkim (-18%) and Tripura (-7%) during 2011-2015 (5 yrs.) over 1971-2010 (40 yrs.). Annual rainfall also followed similar pattern in the NE states. Gain of annual rainfall at Manipur and Meghalaya were 11 and 21%, respectively during 2011-2015 over 1971-2010. There is a sign of improvement in Arunachal Pradesh but deteriorating in Sikkim (-10%) and Tripura (-13%). Maximum temperature showed an increasing trend from 1985 (24.3^{0}C) to 2009 (26.5^{0}C), whereas minimum temperature showed irregularities with slight reduction in Umiam, Meghalaya. The annual mean maximum temperatures in the region are rising at the rate of +0.11°C per decade.

Regional Climate Model (RegCM3) projected an increase in the annual mean surface temperature by about 0.64 °C in the 30 years from 2011 to 2040 and by 5.15 °C at the end of the century (2071–2100). It also projected an increase in annual mean precipitation by about 0.09 mm/day in the near future and by 0.48 mm/day at the end of the century (Das et al., 2012).

Climate change vulnerability profiles for North East India (Ravindranath et al., 2011) showed that in Tripura, Mizoram, Manipur, parts of Meghalaya and Nagaland, the flood magnitude is likely to increase by about 25% in the future compared to the present. Arunachal Pradesh, Assam, Sikkim and parts of Meghalaya are likely to experience floods of lower magnitude (about 5–10% less) in future.

The numbers of drought weeks during monsoon months shows an increasing trend in Arunachal Pradesh, parts of Assam, Meghalaya, Mizoram, Tripura and Manipur, to the tune of about 25% increase in future. A few districts in Assam, Nagaland, Meghalaya and Mizoram show improvement in drought situation during the onset of monsoon. Many parts of the Brahmaputra basin show a tendency of extreme soil moisture stress during monsoon months, which is likely to lead to moderate to extreme drought condition (Ravindranath et al., 2011).

A few facts on climate change in north east India are given hereunder:

- 2009: North east India observed one of the severe most drought
- 2012: Severe most flood (Assam, Meghalaya, Arunachal Pradesh and Mizoram)
- 2013: Drought like situation in many NE districts
- 2014: Flood in Assam and Meghalaya in July and September; Drought in Manipur
- 2015: Warmest year on record over 116 years (1910-2015)
- 2015: Unseasonal (26 February-04 March) heavy rainfall in Arunachal Pradesh (209% high, Normal: 38.3 mm, Actual: 118.6 mm)

- 2016: Delayed onset of monsoon by 10 days, Meghalaya 49% rainfall deficit; Severe flood in Assam (July-August), 200,000 ha crop area damaged, tea production reduced by 21-30% due to continuous rain.

Impact of climate change on soil health :

Poor soil health (soil acidity, toxicity and deficiency of nutrients, low SOM etc.) is often a yield limiting factor for crop production in the north east and increases the potential for runoff, erosion and other environmental losses, as well as drought. These problems are anticipated to become more severe with climate change. The anticipated effects of climate change on soil health of north east are:

- *Intensification of soil acidity:* More than 80% of NE soils are acidic in nature and aluminium toxicity and Ca, Mg, P, B and Mo deficiency are the major soil related constrains for production of crops/fodders in these soils. In areas where climate is expected to become warmer and wetter, microbial activity in soil may increase, resulting increased soil air CO_2 concentrations leading to production of more carbonic acid in soil. Research finding reveals that a rise in average soil temperature by 2^0C would result in an increase in soil respiration by 22%. High carbonic acid concentration and increased rainfall events result in intense leaching of basic cations from the soil system which implies more acidification of soil. Intensification of soil acidy due to climate change may emerge as major challenge for maintaining sustainable soil health in the region.

- *Increasing top-soil loss due to erosion:* Soil loss due to water erosion in north east hilly region is substantially higher (>40 t/ha/annum) than the national average (16 t/ha/annum). Increased frequency of high intensity precipitation, even for short span of time, will further intensify the soil loss from the disturbed hilly slopes of the region.

- *Loss of soil organic matter (SOM):* Soil organic matter is undoubtedly the most important soil component as it improves soil quality though the influences in soil structure, water holding capacity, soil stability, nutrient storage and turnover and oxygen-holding capacity. Organic matter is particularly important as the prime habitat for immense numbers and variety of soil fauna and microflora, which play a critical role in the health and productivity of soils. Loss of SOM due to rise in temperature (increased decomposition), decreased precipitation (reduction in NPP) and short-term increased frequency of high intensity precipitation (SOM loss due to erosion)will have serious consequences on soil health. In the absence of mitigating action, SOM losses through organic matter decomposition due to rise in temperature are likely to exceed levels gained from increased plant growth, thus adding to atmospheric CO_2 levels and the greenhouse gas effect and to lower levels of soil organic matter. Study revealed that Climate change caused soil carbon to decrease overall, with a loss of 4 Pg global grasslands after 50 years (Parton et al., 1995). Loss of SOM due to climate change may lead to gradual decline in soil health and crop productivity in the region.

- Increased denitrification loss of nitrogen due to intensification of soil acidity as soil acidity increases the denitrification potential of soil.

- Increased nutrient loss through leaching and surface runoff due to increased frequency of high intensity precipitation.

- Expected higher loss of organic matter in soil (reasons stated above) and associated increase in soil bulk density (more soil compaction) will reduce the soil water availability to crops. Higher evaporative loss of water from soil under the rising atmospheric temperature and increased frequency of drought (winter months) will enhance the water requirement in agriculture. Decline in water availability (less rainfall events) against rising demand of water will emerge as one of the major challenges to the agricultural productivity in the region.

Strategies to counteract/minimize the effect of climate change on soil health: Soil health management provides a holistic approach with economic and environmental benefits through better soil functioning in the context of climate change adaptation.Thus more holistic soil health management will become increasingly necessary as an adaptation and mitigation strategy.

- *Organic matter management:* Improved soil health increases soil infiltration and soil aeration, which reduce the effects of high precipitation on runoff, erosion, and compaction, and thus also reduce denitrification and nitrous oxide losses. Increased soil water retention and rooting depth decrease the soil's susceptibility to drought stress. To address these issues, SOM management can play a significant role. The options for managing SOM are reduced tillage, cover cropping, better crop rotations, or application of organic matter like manure and compost. Better management of carbon biomass and increasing soil carbon levels results in net sequestration of carbon from the atmosphere to the soil.

- *Controlling soil pH change:*Given that soil acidification is a continuous process in most soils, re-acidification after lime application will result in release of CO_2 from bicarbonate. Hence, improving SOM status in soil should be the priority to obtain long-term benefit since it moderates fluctuations of soil pH through improvement in buffer capacity of soil. In place of lime, application of other soil amendment such as livestock manure (poultry/pig- have high ash alkalinity), compost and biochar may be other options to manage soil acidity.

- *Controlling soil erosion:* Soil erosion is a widespread and serious degradation process in the hill regions of north east. High intensity rains, even for short span, can cause devastating soil erosion on cultivated lands on moderate to steep slopes where runoff rates are high and the ground has inadequate vegetative cover. Runoff and resulting soil erosion can be substantially reduced through the adoption of minimum to no-tillage techniques combined with optimizing soil cover (cover crops, residues, mulch). On steeper slopes, soil erosion can also be reduced by planting cross-slope vegetation; using soil and water conservation structures, such as terraces, earth bunds and tied ridges to optimize water capture and infiltration; and creating grassed waterways to convey excess water safely off the slopes.

- *Improving water storage in soil (more crop per drop):* Water storage in the soil depends on many factors, including rainfall, soil depth, soil texture (clay content) and soil structure. Soil management can influence rainwater infiltration and the capacity of the soil to reduce soil water evaporation and store water in the soil. Groundcover management can have highly beneficial effects on soil surface conditions, SOM content, soil structure, porosity, aeration and bulk density. Improvements in these properties influence infiltration rates, water storage potential and water availability to plants. These improvements also increase the effectiveness of rainfall and enhance productivity. They also reduce rates of erosion, the dispersion of soil particles and the risks of water logging and salinity in dry lands.

- *Improving soil structure:*Soils are compacted due to repetitive hoeing or ploughing. Compacted soils are seriously affected by dry spells as well as high intensity rainfall. During dry period, compaction limits root growth and the plant's access to moisture and nutrients. Compaction facilitates water erosion during high intensity precipitation. Sub-soiling to break up compacted layers can have a huge beneficial effect on root growth and soil productivity. Prevention measures such as minimum tillage in combination with a plant or litter cover should be adopted to avoid soil compaction. This provides organic matter that enhances the activity of soil fauna (e.g. earthworms and termites). The burrowing of these soil organisms breaks up compacted layers and incorporates SOM from the surface into the soil. Also, specific cover crops with strong roots such as radish or pigeon peas can be used to penetrate and break up compacted soils layers. In time, practices such as conservation agriculture (that combine minimized soil disturbance with increased soil cover and crop diversification) will allow SOM to build up and increase the soil's resilience to climate change. Such practices build up a cover of protective vegetation or litter that foster the biological-tillage activity of macro-fauna (such as earthworms) that burrow and make channels for air and water. These practices also incorporate and break down organic matter in the soil.

- *Biocharapplication :* It is a carbon rich material similar in its appearance to charcoal. Biochar application has been promoted in agricultural practice that creates a win-win situation by improving soil quality and enhancing agricultural sustainability concomitant with mitigating greenhouse gases (GHG) emissions. Recently biochar application gained momentum because of its capability of carbon sequestration, reducing soil compaction, improves soil physical condition, controlling soil pH, enhancing nutrient uptake from the soil and helps to reduce nitrous oxide emission (Lehmann and Rondon, 2005; Lehmann, 2007). Production plant biomass in the north east is substantial and there is ample scope to produce biochar from these biomasses. Soil application of biochar may be one of the options to minimize the impact of climate change on soil health of this region.

Conclusion:

It is now well understood that climate variability and climate change are reality. Different estimates predict that changes in temperature, precipitation and evaporation will cause significant effect on soil health through organic matter turnover and CO_2 dynamics.Maintaining soil health is fundamental for sustained agricultural productivity and the maintenance of vital ecosystem processes. As a matter of fact, the impact of climate change on soil system should be monitored in different agro-ecological regions on regular basis. Climate change and land degradation are closely linked issues and conservation farming has shown promise in minimizing land degradation.

Literature cited:

Annon (2004).Ministry of environment and forests, Gal, India's National communication to UNFCC (NATCOM), New Delhi, 2004.http://www.natcomindia.org/natcomreport.htm.

Das, S. K. *et al*. (2012). Temperature and precipitation changes in the north-east India and their future projections.Global Planet. Change (2012) doi: 10.1016/j.gloplacha.2012.07.006.

Deka, R.L., Mahanta, C. and Nath, K.K. 2009.Trends and Fluctuations of Temperature Regime of North East India. In S. Panigrahy, S. S. Ray, J.S. Parihar (ed.) Impact of Climate Change on Agriculture. ISPRS Archives XXXVIII-8/W3 Workshop Proceedings. Space Application Centre, Ahmedabad. pp. 376-380.

Cline, William R., 2007, Global Warming and Agriculture: Impact Estimates by Country (Washington: Center for Global Development and Peterson Institute for International Economics).

Lehmann, J. and Rondon, M.: 2005, ‘Bio-char soil management on highly-weathered soils in the humid tropics’, in N. Uphoff (ed.), *Biological Approaches to Sustainable Soil Systems*, Boca Raton, CRC Press, in press.

Lehmann, J. (2007). A handful of carbon. Nature 447, 143–144.

Ravindranath, et. al., (2011). Climate change vulnerability profiles for North east India Current science Ministry of environment and forests, Gal, India's National communication to UNFCC (NATCOM), New Delhi, 2004.

http://www.natcomindia.org/ natcomreport.htm. 101 (3): 384-94.

Parton, W.J., J.M.O. Scurlock, D.S. Ojima, D.S. Schimel, D.O. Hall and S.G. Members, 1995.Impact of Climate Change on Grassland Production and Soil Carbon Worldwide. Global Change Biol., 1: 13-22.

MICRO-LEVEL PERCEPTION TO CLIMATE CHANGE AND ADAPTATION ISSUES: A PRELUDE TO MAINSTREAMING CLIMATE ADAPTATION INTO DEVELOPMENTAL LANDSCAPE IN INDIA

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Abstract

Climate change adds another dimension of challenges to the growth and sus-tainability of Indian agriculture. The growing exposure to livelihood shocks from climate variability/change and limited resource base of the rural community to adapt has reinforced the need to mainstream climate adaptation planning into developmental landscape. How-ever, a better understanding of micro-level perceptions is imperative for effective and informed planning at the macro-level. In this paper, the grass-root level perspectives on climate change impacts and adaptation decisions were elicited at farm level in the Moga district of Punjab and Mahbubnagar district of Telangana, India. The farmers opined that the climatic variability impacts more than the long-term climate change. They obser-ved change in the quantum, onset and distribution of rainfall, rise in minimum as well as maximum temperature levels, decline in crop yield and ground water depletion. The key socio-economic effects of climate change included decline in farm income, farm unem-ployment, rural migration and increased indebtedness among farmers. In order to cope with climate variability and change thereon, farmers resorted to adaptation strategies such as use of crop varieties of suitable duration, water conservation techniques, crop insurance and participation in non-farm activities and employment guarantee schemes. Farmers' adap-tation to changing climate was constrained by several technological, socio-economic and institutional barriers. These include limited knowledge on the costs–benefits of adaptation, lack of access to and knowledge of adaptation technologies, lack of financial resources and limited information on weather. Besides, lack of access to input markets, inadequate farm labour and smaller farm size were the other constraints. Further, on the basis of the grass-root elicitation a 'Need-Based Adaptation' planning incorporating farmers' perceptions on climate change impacts, constraints in the adoption of adaptation strategies and plausible adaptation options were linked with the most suitable ongoing programmatic interventions of the Government of India. The study concluded that micro-level needs and constraints for various adaptation strategies and interventions should be an integral part of the programme development, implementation and evaluation in the entire developmental paradigm.

1 Introduction

Climate change poses serious threats to the food security and sustainability of livelihood across diverse ecosystems. Scientific research has well established that global climate change has significant adverse impacts on many economic sectors, agriculture being the worst hit (Mendelsohn et al. 2006; Nelson et al. 2009; Lobell et al. 2011). In the recent decades, changing temperature, precipitation pattern and recurrence of extreme weather events have further intensified the distress of the Indian agriculture system, which continue to remains the major mainstay for rural folks. Substantial scientific works have been undertaken to determine the trend in climatic parameters and to quantify the consequential impact on different agricultural commodities in India. These studies indicate that the effect of climate change on agriculture is manifested through various ways; besides reducing crop productivity (Jha and Tripathi 2011; Auffhammer et al. 2012; Rao et al. 2014) through changes in water availability, soil erosion and proliferation of pest and diseases (Porter et al. 2014), it produces large scale socio-economic impacts. Lobell et al. (2012) using 9 years of satellite measurements of wheat growth in northern India examined the rate of wheat senescence following exposure to a temperature greater than 34 LC. The study found a statistically significant acceleration of senescence from extreme heat; above and beyond the effects of increased average temperatures. This result implies that warming presents a greater challenge to wheat. Rao et al. (2014) analysed trends in minimum temperature for the period 1971–2009 were using 0.5L grid data for annual, kharif and rabi cropping seasons at the district level. Annual minimum temperature over 52.7% of India showed warming at the rate of 0.24 LC/decade. The study also found that warming during rabi (Oct–Mar) was faster than kharif (June–Oct) by 0.09 LC/decade, yields of 57.2% kharif paddy area were influenced by rise in minimum temperature, and district-level kharif paddy yields of 1971–2009 period declined by 411–859 kg/ha/LC rise.

In a recent study, Padakandla (2016) examined the impact of climate change on five major crops in the former state of Andhra Pradesh using district-level panel data for the period 1981–2010. Analysis of data shows that crop yields are significantly impacted by climate for rice, tobacco and groundnut and crops grown in rabi are more susceptible to changes in climate than those in kharif. Moreover, climate-induced productivity shocks affect farm income and prices and further aggravate poverty level in the country. Using Ricardian approach, Sanghi and Mendelsohn (2008) estimated that a 2 LC rise in tem-perature with 8% increase in precipitation may results in a loss of 12% of agricultural net revenue for India. Hence, adaptation to climate variability and change in the system are thus imperative to sustain the productivity and profitability for the farmers in developing country like India in short to medium run (Singh et al. 2015a).

The process of adaptation intends to soften the climatic vulnerability and reap the potential benefits through modification in the operations, practices and structures ranging from short-term coping to long-term, deeper transformations (IPCC 2001; Tompkins and Adger 2003). Further, adaptation interventions could be undertaken both at the farm level in response to the perceived and anticipated risks and at the top decision-making level

through conscious policy actions. It is important to understand that adaptation is not a one-size fit all approach as it is driven by the potential climate impacts, agro-climatic and socio-economic factors hence vary across regions (Berry et al. 2006; Adger et al. 2009). Normative adaptation choices and its universal application across the space could further exacerbate the prevailing vulnerability. Farming and rural communities adopt a range of strategies and practices owing to traditional/experiential knowledge evolved over the years in response to various risks (Singh et al. 2015b). However, these autonomous strategies might be less effective in India, where 85% of the farming population consists of small and marginal farmers, with limited financial and technical capacity to withstand climatic shocks. Hence, the onus falls on the government to enhance resilience of Indian agriculture system, through deliberate and informed policy decisions.

It has been emphasized that adaptation planning must be developed and promoted within the broader economic developmental landscape and hence mainstreamed into the policy apparatus of the government for wide scale applicability. Mainstreaming adaptation is an iterative process of integrating considerations of climate change adaptation into policy-making, budgeting, implementation and monitoring processes at different levels of government: national, sectoral and sub-national levels (UNDP-UNEP 2011). The approach aims to create an enabling environment essential for successful adaptation. One major component of mainstreaming adaptation involves integrating climate science projections and analysis into the decision-making to develop climate resilient technologies, for example adoption of improved (drought/pest-tolerant) and short-duration crop varieties by the farmers over the possibility of declining rainfall. However, this climate proofing approach alone fails to fully address the non-climatic factors contributing to vulnerability and also does not realize the potential of development interventions to achieve climate resilience (Ayers et al. 2014; Klein 2008). Lemos and Boyd (2009) argued that designing programmes and policies for enhancing resilience to climate stress without considering the multitude of others factors that shape the vulnerability of different systems is of little worth.

Thus, eliciting and understanding farmer's perceptions and various coping mechanism adopted in addition to climate proofing is a prelude for effective adaptation planning (Jodha et al. 2012; Ayanlade et al. 2017). The efficacy of these perceptions largely depends on the awareness of changing climatic parameters, length of farming experience and access to information. However, several studies have recognized that despite perceiving climate change farmers do not respond because of various constraints like access to credit, lack of infrastructure, etc. (Fankhauser et al. 1999; Bryant et al. 2000; Schneider et al. 2000; Tripathi and Mishra 2017). Hence, a better understanding of grass-root level realities helps in designing effective and informed planning at the macro-level for successfully enhancing resilience of agriculture sector to climate change and variability (Bryan et al. 2009; Singh et al. 2015c).

An attempt has been made in this paper, to elicit farmers' perceptions on climate change impacts, adaptation strategies followed in response to climatic risks, and the various barriers in their adoption in two different agro-climatic regions comprising, Moga district of Punjab and Mahbubnagar district of Telangana in India. Further, premised on grass-root elicitation the paper suggests 'Need-Based Adaptation' planning which integrates various farm-level needs and constraints with existing programmatic interventions, thus depicting various entry points where climate adaptation planning can be mainstreamed with the developmental framework of a country like India.

2 Methodology

2.1 Data collection method

We conducted a household survey to assess farmers' perceptions of climate variability/change and adaptation methods in an attempt to embed these responses with the existing developmental programmes. Multi-stage sampling method was used for selecting the sample households. In the first stage, Mahbubnagar district of Telangana and Moga district of Punjab were purposely selected to capture different agro-climatic and socio-economic attributes. After choosing the sample districts, in the second and third stage, two blocks from each district and two villages from each block were selected.[1] Finally, random sampling was used in selecting 20 respondents from each of the selected villages. Thus, a total of 160 farmers were selected for the study with different farm characteristics across various landholding categories: small and marginal (\ 2 ha), semi-medium (2–4 ha) and medium and large ([4 ha).

Primary information was collected through informal interviews with the respondents and focused group discussions (FGDs) with 15–20 stakeholders in the selected villages. During the survey respondents were asked open-ended questions about whether they observe any change in the pattern of climatic variables (rainfall and temperature) over the period of time, frequency of extreme weather events and are they making any changes in the crops and enterprises thereon. Farmers were also asked to explicate the socio-economic impacts perceived due to weather variability, the strategies/measures adopted at the farm level and the various constraints they face to cope up with the changing climate.

2.2 Study area

The study was conducted in two distinct agro-climatic regions of republic of India, in northern and southern region, namely Punjab and Telangana States (Fig. 1). From, southern region, Mahbubnagar, lying in the agro-climatic zone of southern plateau and hill and one of the largest districts of Telangana state was selected for grass-root enquiry. It has a geographical area of 1.84 Million hectare (Mha), with 47% net sown (0.86 Mha) area and 1.12 cropping intensity. Majority of the population (85%, 2011 Census) in the district resides in rural areas with agriculture as their primary occupation. The district has tropical climate with mean temperature varying from 25.0 to 40.9 LC and receives an average annual rainfall of 692 mm. Mahbubnagar is the most drought-prone and backward district in Telangana. Farmers in the district are heavily dependent on groundwater due to lack of irrigation facilities. Successive crop failure on account of inadequate water availability and recurrence of dry spells in the last few years has further accentuated the distress among the farmers in the region leading to large scale migrations.

From northern region, Moga district which forms a part of Indo-Gangetic Plain and covers an area 4.44% in the state of Punjab was selected for survey. The district has a total net sown area of about 83% having a cropping intensity of 205%. It is also predominately an agricultural district with 77.2% rural population (2011 census). The climate of the district can be classified as tropical and dry sub-humid, with a normal annual rainfall of about 498 mm spread around 24 rainy days. Mean maximum temperature in the region is 40.0 LC (May), while the mean minimum is about 5.0 LC (January). Moreover, maximum area in the district is irrigated through groundwater, which is declining at an alarming rate,

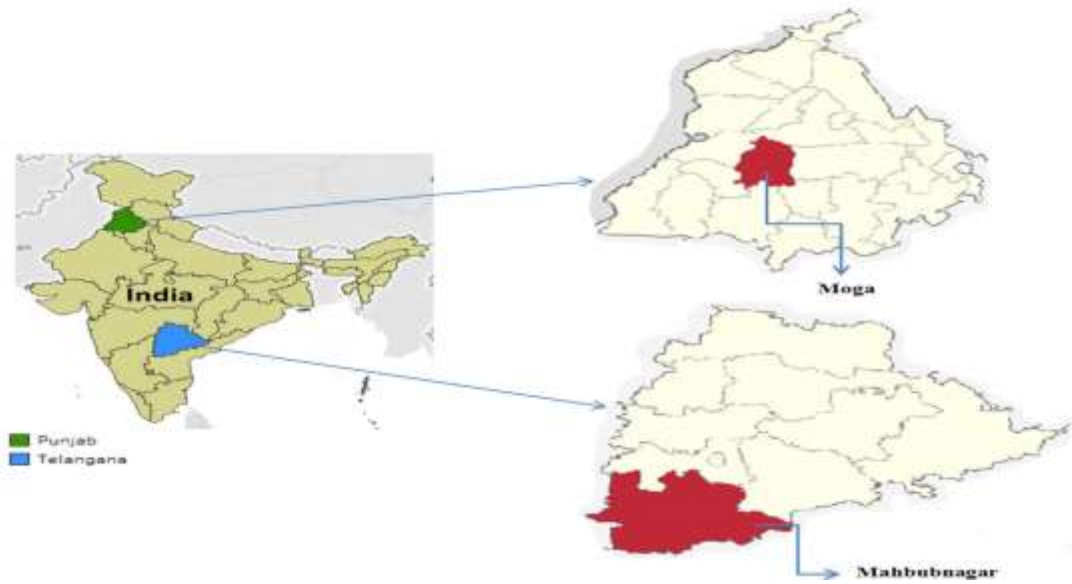


Fig. 1 Map showing geographical location of the selected districts (Moga and Mahbubnagar) in Punjab and Telangana, India (not to be scaled; only for illustration purpose) producing severe consequences for the farming community. Thus, the descriptions and facts about two selected districts aptly reveal their sensitivity and vulnerability to climate change and variability.

3 Results and discussion

3.1 Socio-demographic profile of the respondents

Formation of perceptions and choice of adaptation strategies are largely driven by the socio-economic-demographic attributes of the farmers. Table 1 reveals that large number of the participants in Mahbubnagar district had small landholdings, while in Moga the sample represented a mix bag of respondents belonging to each farm size category. The average age and average workers in the sampled districts were nearly 47 years and 2 people per household. The length of the farming experience among the respondents belonging to different landholdings categories was approximately 22 years. On an average, 43.75% of the total sampled farmers had primary education, 35% completed secondary level, and 21.25% had education up to higher secondary or above. This signifies that the

Table 1 Socio-demographic profile of farm households in selected districts, India

Variable	Small and marginal (\ 2 ha)		Semi-medium (2–4 ha)		Medium and large ([4 ha)		Total	
	Mahbubnagar, Telangana	Moga, Punjab	Mahbubnagar, Telangana	Moga, Punjab	Mahbubnagar, Telangana	Moga, Punjab	Mahbubnagar, Telangana	Moga, Punjab
Proportion of households (%)	56.20	36.30	33.80	22.50	10.00	41.20	100.00	100.00
Average family size (persons)	5.20	5.70	5.10	5.40	5.30	5.20	5.20	5.43
Average age (years)	46.90	47.90	46.20	47.80	48.10	46.40	47.07	47.37
Average household workers (persons)	2.00	2.40	2.10	2.20	2.00	2.20	2.03	2.27
Average farming experience (years)	22.50	21.90	22.40	22.90	23.00	22.60	22.63	22.40
Average land holdings size (ha)	0.10	0.90	2.50	3.60	6.40	8.10	3.00	4.20
Primary education (%)	51.10	58.60	29.70	44.40	34.00	36.40	41.25	46.25
Secondary education (%)	33.30	20.70	37.00	44.40	42.00	39.40	36.25	33.75
Higher and above (%)	15.60	20.70	33.30	11.20	24.00	24.20	22.50	20.00

Source: Field survey

Sample size = 160 (Mahbubnagar = 80 households; Moga = 80 households)

respondents were educated and experienced enough to understand the changing course of climatic variables and undertake farming decisions across all farm size groups.

3.2 Farmers' perceptions on climate variability and change

For effective adaptation of farm-centred strategies, farmers' knowledge about the climatic changes and its repercussions are pertinent for eliciting the grass-root imperatives. It is observed that the farmers could better recall the latest observations and much of their overall perceptions are influenced by the recent developments (Granjon 1999; Bryant et al. 2000). Majority of the surveyed farmers' perceived reduction in the number of rainy days and continuous delay in the onset of monsoon over the past few years (Fig. 2). They reported increasing stress on groundwater aquifers on account of increased erraticism in the distribution of rainfall and expressed their inability in growing traditional crops. Besides, farmers from Mahbubnagar district perceived significant change in quantum of rainfall (83%) and increasing water scarcity in surface water bodies (65%) on account of weather variability. They also expressed that varying temperature has encouraged prolif-eration of pest and diseases (54%) and this along with prolonged dry spells has signifi-cantly affected the crop yields in the region. Several studies have found that increasing atmospheric temperature adversely impact crop yield and further induces water stress (Singh et al. 2014;

Rao et al. 2014). Similar situation seems to prevail in Moga district of Punjab, where farmers perceived a gradual increase in the temperatures during summer and winter (81%) resulting in high rate of evapo-transpiration. This increase in temperature coupled with water intensive cropping pattern in Punjab is further aggravating the ground water depletion which is a cause of concerns for policy makers. Moreover, many farmers reported that water logging due to heavy rainfall/floods during monsoon is increasing year on year, adversely affecting their farm outputs due to crop lodging.

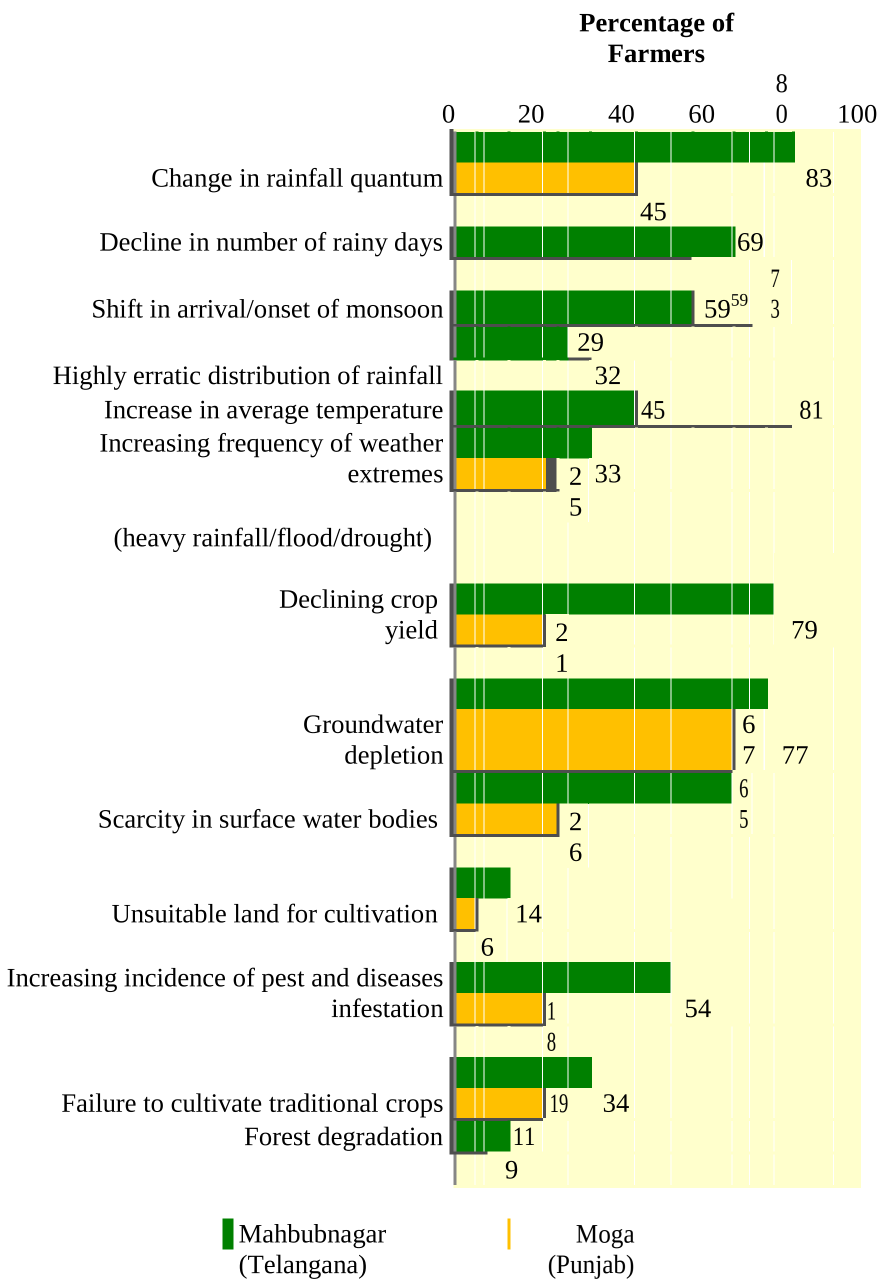


Fig. 2 Farmers' perceptions on changes in climatic and non-climatic factors

The farmers in the study area unanimously voiced that unpredictable weather perils often jeopardizes the village economy and are considered an important factor affecting livelihoods and socio-economic stability. In both the districts, large number of farmers reported declining farm income and increasing indebtedness due to successive crop failures (Fig. 3). Farmers were in the opinion that high unemployment (54%, Mahbubnagar; 41% in Moga) during distress years compelled them to mortgage their productive assets for meeting domestic needs. There was also rise in considerations related to education of children and family health, insufficient food for self-consumption and erosion of social/community support system evident from growing water disputes in the society. 77% of the farmers in Mahbubnagar and 51% of the farmers in Moga district stated that climatic variability has escalated the prices of necessary food items, putting pressure on their pockets. Moreover, prolonged dry spells and inadequate alternate livelihood opportunities were leading to forced migration in Mahbubnagar district.

Marriage and festivals celebrations constitute an important part of household and village traditions. Rao (2001) reported that a typical rural household spends approximately seven times of its annual income on social events such a marriage; moreover, on an average, 15% of its expenditure are spent on celebrating village festivals. However, the surveyed farmers expressed reduction in such expenditures due to increased climatic uncertainty and risks. Moreover, increased incidence of farmers' suicide has been reported both in Mahbubnagar, Telangana, and Moga, Punjab. Drought along with inadequate government policies, debt and societal issues might be the driving forces behind the spur in farmers' suicides.

3.3 Adaptation strategies followed by the farmers

Farmers resort to different strategies to reduce vulnerability and losses due to climate variability. Several studies have been undertaken in developing countries to understand micro-level strategies adopted to withstand weather adversities. Majority of the farm-level

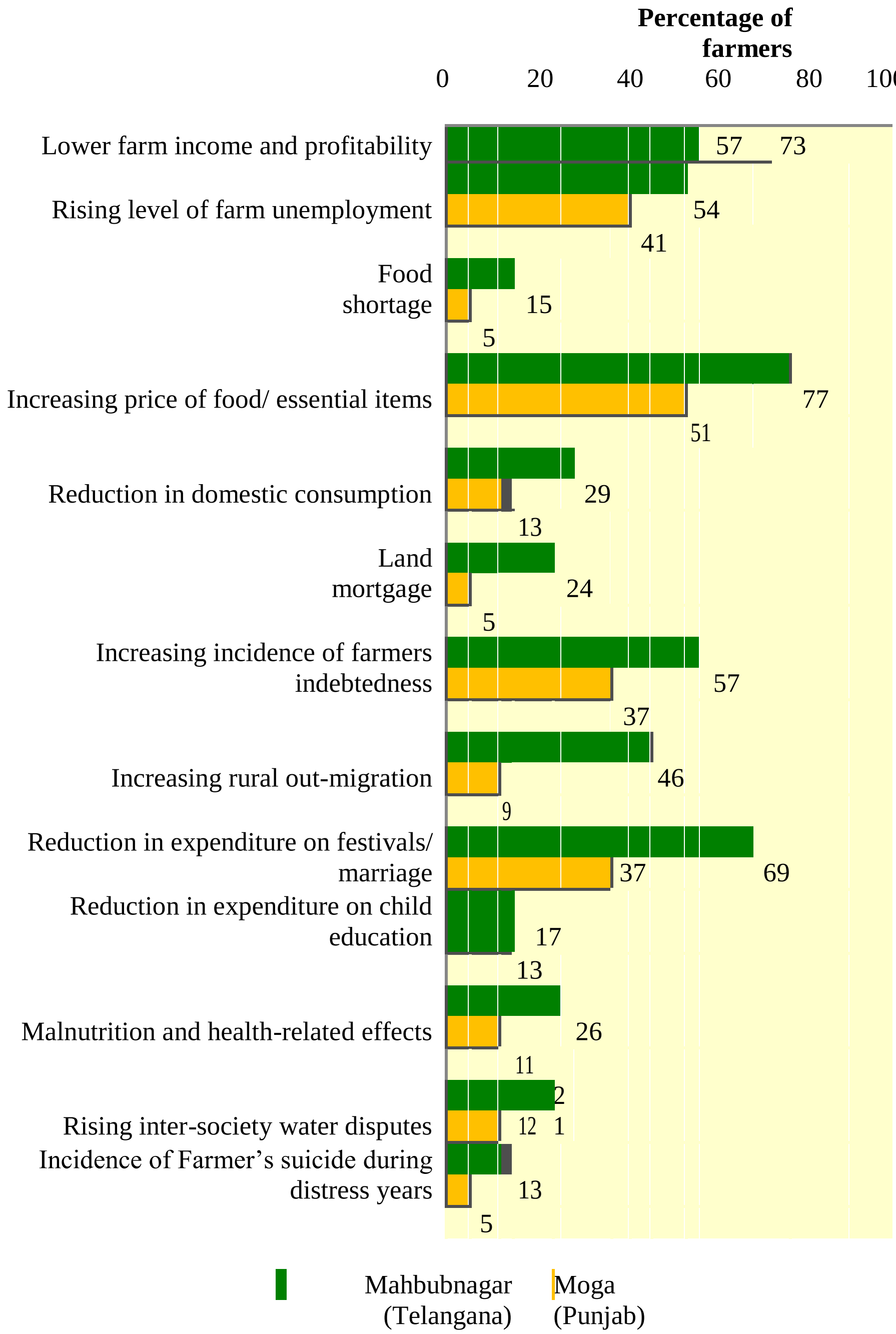


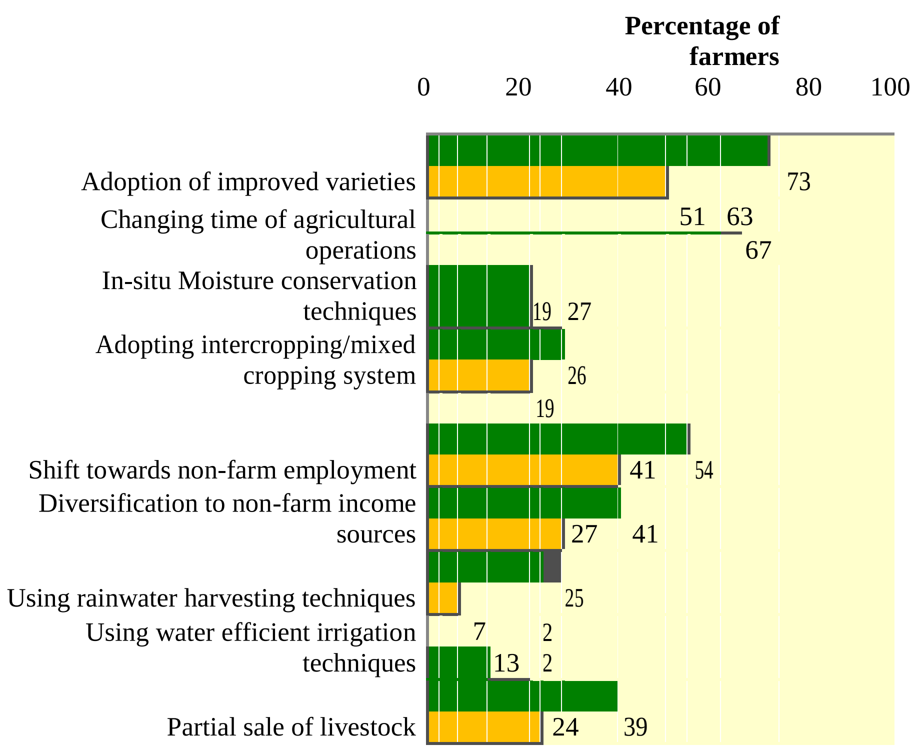
Fig. 3 Farmers' perceptions on changes in socio-economic factors

adaptation strategies are based on agronomic practices, use of resource conservation technologies, water management and risk management measures (Alauddin and Sarker 2014; Sapkota et al. 2015; Pathak et al. 2014;

Tadesse et al. 2015; Tripathi and Mishra 2017).

The primary investigation revealed that there was not much differences in terms of the response strategies adopted by the farmers across different farm size categories within the same district as cropping pattern and biophysical environments is largely homogenous. A large proportion of the farmers in the selected villages were using drought/pest-tolerant and short-duration crop varieties as an adaptation measure (Fig. 4). They were also making suitable changes in the cropping operations like changing planting dates, the amount of land grazed. According to Deressa et al. (2009), seasonal modifications in planting schedule and crop varieties are an effective way of dealing with increased climatic vari-ability. These practices were found to be relatively affordable and easier to implement. Farmers were also shifting towards mixed cropping system as a way of minimizing risk of crop failure. A lesser proportion of the respondents in the study area reported on availing the crop insurance facilities.

For conserving water, farmers in the sampled district were switching towards more economical and technologically efficient techniques like sprinklers and drip irrigation as an adaptation measure. However, their adoption remains low due to high initial cost of pur-chase and complexity of the technology. Many farmers in Moga mentioned rescheduling of loan payment (49%), whereas farmers in Mahbubnagar resorted to higher borrowing (56%) on account of yield loss and low profitability. Furthermore, to reduce exposure to liveli-hood shocks out-migration, diversification to non-agricultural enterprise and increasing participation to rural employment and social security programmes were observed as other adaptation strategies followed by the farmers.



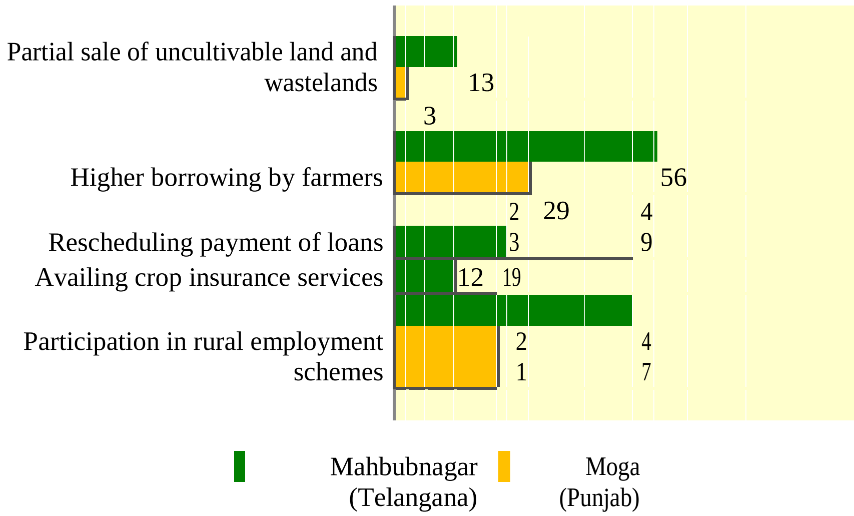


Fig. 4 Climate adaptation strategies adopted by the farmers

3.4 Barriers to climate change adaptation

There are a large number of institutional, technological, socio-economic and infrastructural barriers that limit the range of plausible climate adaptation options. Identifying these barriers to adaptation is crucial for finding possible opportunities to overcome them (Eisenack et al. 2014). Farmers cited lack of information on water efficient crops (Mah-bubnagar 79%; Moga 61%), limited access to agricultural extension service (Mahbubnagar 75%; Moga 63%) and delayed weather information (Mahbubnagar 65%; Moga 58%) as the major obstacles in adaptation (Table 2). They also stated that limited knowledge on social costs and benefits of adaptation measures, high cost of farm inputs and limited access to agricultural markets curtails their ability to adopt better farm management practices to cope up with the climate induced distress. Besides, lack of access to formal credit has been cited as one of the major constraints to adaptation by the farmers especially in Mahbub-nagar. Lack of awareness on the need for adapting to the changing climate, uncertainty on the success of climate adaptation strategies/technologies, financial constraints and limited farm size were the farm-level socio-economic barriers identified. Addressing these con-straints that impede the process of adaptation by the farmers is crucial for enhancing their adaptive capacity.

Table 2 Barriers to adaptation as perceived by the farmers

Barriers to adaptation	Farmers perceptions	Percentage of responses
Institutional barriers	Limited knowledge on societal cost and benefits of adaptation strategies	(MN 59%; MO 52%)
	Passive attitude of many policy makers	(MN 23%; MO 74%)
	More attention towards other major policy issues	(MN 59%; MO 52%)
	Inefficient governance/time lag in implementation of policy reforms	(MN 52%; MO 28%)
	Limited access to credit	(MN 72%; MO 12%)
Technological barriers	Insufficient scientific research on climate change adaptation	(MN 45%; MO 50%)
	Limited technological measures available to adapt	(MN 62%; MO 57%)
	Lack of information on water efficient crops, varieties, etc.	(MN 79%; MO 61%)
	Lack of timely weather information	(MN 65%; MO 58%)
Socio-economic barriers	Uncertainty on success and benefits of adaptation measures	(MN 67%; MO 36%)
	Limited financial resources	(MN 77%; MO 39%)
	Lack of awareness on importance of adaptation	(MN 81%; MO 64%)
	Inadequate farm labour	(MN 21%; MO 33%)
	Smaller farm size	(MN 72%; MO 23%)
Infrastructural barriers	Lack of access to agricultural subsidies	(MN 63%; MO 41%)
	High cost of farm input	(MN 59%; MO 49%)
	Limited access to agriculture extension services	(MN 75%; MO 63%)
	Lack of efficient market access	(MN 57%; MO 27%)

MN: Mahbubnagar (Telangana), MO: Moga (Punjab)

3.5 Need-Based Adaptation: Aligning micro-level perceptions and macro-level interventions

Among the various factors that create an enabling environment for farming community to adapt effectively, public policy plays a significant role (Singh et al. 2015b). The magnitude of the need for adaptation and the potential for mitigation in agricultural development has major implications for successful agricultural development planning to support food security and poverty reduction (FAO 2009). Indian rural and agricultural development policy, though documents the likely consequences of climate change, it often lacks a plan of adaptation actions. Most of these policies are blanket or highly aggregative in nature and thus fails to address and understand the various micro-level suffering and constraints. According to Singh et al. (2015c), macro-level projections and analysis often do not offer inspiring and sufficient lead lines due to information gaps and large scale uncertainties. There is a considerable diversity in impacts and constraints faced by the farmers across different agro-climatic and socio-economic locale. Such variations and the repercussions triggered by the climatic variability and change can be reconciled with the programmes/ schemes implemented across various departments and ministries of the government for better targeting and efficiency.

Based on the field level observations, we attempted to broadly categorize the oppor-tunities for mainstreaming adaptation in the form of several options that can help to minimize or soften the climate-induced vulnerability, thus ensuring food and livelihood security. The following 'Need-Based Adaptation' matrix (Table 3) integrates various farm-level impacts and constraints and the corresponding plausible options with the existing developmental interventions of the Government of India. The approach represents various entry points where climate adaptation planning can be incorporated. Further, it also unravels the programmatic interventions that not only achieve conventional macroeco-nomic objectives but can hasten the process of developing resilience to climatic variability in the rural landscape.

Making farmers aware about the changes in the climate parameters and the importance of adaptation to these changes is prerequisite for minimizing the risks and securing their livelihoods. In line with the commitments to the global negotiations, since 2008 India has initiated various climate centric interventions like National Action Plan on Climate Change (NAPCC), National Adaptation Fund and National Innovations on Climate Resi-lient Agriculture (NICRA). NICRA an initiative by the Indian Council of Agricultural Research (ICAR), launched in the year 2011, is playing a significant role in fostering the process of climate adaptation through strategic research and technology demonstrations in the area of crops, livestock, fisheries and natural resource management. Development and dissemination of climate smart technologies will greatly help in improving agriculture productivity and production, while ensuring management of natural resources in the country. Further, the National Mission for Sustainable Agriculture, one of the eight mis-sions under the NAPCC, aims to promote sustainable agriculture through a series of adaptation measures focusing on ten key dimensions encompassing Indian agriculture, namely improved crop seeds, livestock and fish cultures, water use efficiency, pest man-agement, improved farm practices, nutrient management, agricultural insurance, credit support, markets, access to information and livelihood diversification.

Agriculture research system has generated a large number of technologies; however, their adoption at farmers' level remains at a very low level especially in marginal envi-ronments and disadvantaged regions. Building an active extension system with

Table 3 Issues and plausible options for mainstreaming climate change adaptation planning with existing development programmes

Issues	Plausible options	Ongoing development programmes for mainstreaming adaptation strategies
(a): Grass-root constraints to adaptation and options for potential adaptation strategies		
Lack of information/awareness on adaptation technologies and limited agricultural extension services	Strengthening dissemination of climate change adaptation technologies and building extension infrastructure	National Mission on Agricultural Extension and Technology: Sub-Mission on Agriculture Extension Rashtriya Krishi Vikas Yojana National Mission on Oilseeds and Oil Palm National Food Security Mission National Innovations on Cimate Resilient Agriculture
Limited technologies for climate change adaptation	Promoting R&D activities for developing improved technologies such as less water consuming, early maturing, high yielding for climate resilience in agriculture	National Mission on Sustainable Agriculture National Innovations on Climate Resilient Agriculture
Limited knowledge on adaptation costs and benefits	Promoting research on climate change adaptation costs and benefits Building capacity and awareness	National Mission on Sustainable Agriculture National Innovations on Climate Resilient Agriculture

	among various stakeholders on impacts and adaptation options Encouraging the role of NGOs for enhancing adaptation preparedness	
High cost of farm inputs	Improved access to subsidized seeds (stress tolerant varieties), planting material, machinery (conservation agriculture), plant protection chemicals, etc.	National Mission on Agricultural Extension and Technology: Sub-Mission on Seed and Planting Material Sub-Mission on Agricultural Mechanization Sub-Mission on Plant Protection and Plant Quarantine Rashtriya Krishi Vikas Yojana National Mission on Oilseeds and Oil Palm National Food Security Mission

Table 3 continued

Issues	Plausible options	Ongoing development programmes for mainstreaming adaptation strategies
(b): Climate change impacts and options for potential adaptation strategies		
Direct impact of climate change perceived by the farmers		
Change in quantum of rainfall/ rainy days/altered onset of monsoon as well as variations in temperature Ground water depletion	Improving irrigation and drainage infrastructure Promotion of micro-irrigation methods (drip and sprinklers) Groundwater recharge, aquifer mapping Water harvesting infrastructure at farm level and community level Use of short-duration varieties/	Pradhan Mantri Krishi Sinchayee Yojana: Accelerated Irrigation and Flood Management Programme Integrated watershed management programme On Farm Water Management National Water Mission

	stress tolerant varieties	National Mission on Sustainable Agriculture National Innovations on Climate Resilient Agriculture Groundwater Management and Regulation Scheme National River Conservation Plan
Extreme weather events	Accurate weather forecasts and early warning system Disaster relief mechanisms and funding Active weather-based agro-advisories at the farm level	Flood Forecasting Numerical Modelling of Weather and Climate Agro-Meteorological Services Programme
Increased pest and disease incidence	Integrated pest and disease management	National Mission on Agricultural Extension and Technology: Sub-Mission on Plant Protection and Plant Quarantine Rashtriya Krishi Vikas Yojana National Mission on Oilseeds and Oil Palm National Food Security Mission
Land degradation	Land management Nutrient management	National Project on Management of Soil Health and Fertility Soil Health Card Scheme
Forest degradation	Afforestation and regeneration of degraded forest Strengthening of infrastructure for forest protection Sustainable and equitable distribution of forest products Encouraging local participation in decision-making	National Afforestation Programme Intensification of Forest Management Scheme Green India Mission Van Bandhu Kalyan Yojana

		Nat Hazards

Table 3 continued

Issues	Plausible options	Ongoing development programmes for mainstreaming adaptation strategies
Indirect impact of climate change perceived by the farmers		
Crop failure	Risk management through crop insurance with universal coverage	Pradhan Mantri Fasal Bima Yojana Weather Based Crop Insurance Scheme
	Improved access to credit to cover weather extremes	Interest Subvention Scheme for Short-Term Crop Loans
	Addressing middle and last mile challenges	Kisan Credit Card Scheme Pradhan Mantri Jan Dhan Yojana
Decline in farm income	Integrated farming/enterprise diversification	Integrated Scheme for Agricultural Marketing
	Diversification to high value crops (HYCs)	e-National Agriculture Market Scheme
	Improvement in food processing capacity and value addition	Price Stabilization Scheme Agri-Tech Infrastructure Fund
	Improved market access and building rural infrastructure	Paramparagat Krishi Vikas Yojana National Project on Promotion of Organic Farming Mission for Integrated Development of Horticulture Mega Food Parks Cold Chain Value Addition and Preservation Infrastructure Pradhan Mantri Gram Sadak Yojana

		Deen Dayal Upadhyaya Gram Jyoti Yojana
Rising farm unemployment and rural migration	Creation of off-farm and non-farm employment vista for diversifying income	Mahatma Gandhi National Rural Employment Guarantee Scheme National Rural Livelihood Mission Pradhan Mantri Kaushal Vikas Yojana Prime Minister's Employment Generation Programme Dairy Entrepreneurship Development Scheme National Dairy Plan Development of Inland Fisheries and Aquaculture
Food shortage and malnutrition	Astute management of food supply	Buffer Stock Policy Targeted Public Distribution System

establishment of technology management agencies at district level, capacity building and knowledge delivery via ICT/Mass Media through National Mission on Agricultural Extension and Technology, Rashtriya Krishi Vikas Yojana, and National Food Security Mission will encourage farmers in adapting to climate variability. Improved access to

subsidized seeds (stress tolerant varieties), planting material, machinery (conservation agriculture), plant protection chemicals will further help them in exercising adaptation practices.

Higher risk of crop failure owing to erratic distribution of rainfall discourages invest-ment in agriculture. Insurance against climate-induced crop failure through Pradhan Mantri Fasal Bima Yojana and Weather Based Crop Insurance Scheme implemented by Ministry of Agriculture and Farmers' Welfare will ensure continued investment in crop production. Further, easy access to credit to cover weather-based adversities on subsidized interest rates through Interest Subvention and Kisan Credit Card Scheme can reduce indebtedness and enable them to buy modern inputs.

Improving water efficiency through price modifications, promotion of location-specific water conservation and management technologies, and development of infrastructure, via Pradhan Mantri Krishi Sinchayee Yojana, Groundwater Management and Regulation Scheme and National Water Mission under NAPCC, can help in stabilizing farmers' income. Reliable early warning system of environmental changes coupled with policies to support the diffusion of this information can also help farmers, agriculture-dependent industries and policymakers in informed decision-making (Jat et al. 2016). Interventions like flood forecasting, agro-meteorological services can be of great support in this context. Continuous supply of electricity (via, Deen Dayal Upadhyaya Gram Jyoti Yojana) and road connectivity (via, Pradhan Mantri Gram Sadak Yojana) facilities are crucial for accelerating growth and development of agriculture sector.

Integrated scheme for Agricultural Marketing, e-National Agriculture Market (e-NAM) and Mission for Integrated Development of Horticulture through improved market access and post-harvest management will encourage farmers to diversify towards high value products. Also development of food processing sector through ventures like Mega Food Parks programme is crucial for value addition to agricultural produce and improving farmers' income. Further, creation of adequate off-farm and non-farm employment opportunities will greatly help farmers in diversifying their income leading to lesser out-migrations. Employment diversification, however, requires minimum level of education and skills which can be addressed through schemes like Pradhan Mantri Kaushal Vikas Yojana and other skill and education enhancement interventions of the government.

All the above programmes operationalized by the Government of India possess great potential in addressing the vulnerability of the farmers and rural households to climate change and variability, but for the want of adaptation focus and lack of convergence in programme implementation, the desired outcomes are far from reality. Thus, there is a dire need of coherence in climate adaptation planning.

4 Conclusion and implications

Climate change induced increased variability in temperature and rainfall and intensity of extreme weather events like drought and flood creates disturbance to agro-ecosystems ultimately leading to yield and income loss to farmers. Though the farmers are not aware about the climate change as a long-term phenomenon, they often understand the changes in rainfall events and temperature and resort to farm-level or household-level coping mechanisms or adaptive strategies. Further, though coping mechanisms can help in finding short-term and immediate solution for weather-induced stress in agriculture, it is very important to have sustainable adaptation strategies for achieving climate resilience in agriculture. Micro-level survey showed that change in crop management (use of crop varieties of suitable duration or tolerance to climate stress) or change in land use man-agement is the most widely used adaptation strategy at the farm-level. Livelihood diver-sification of the households by engaging in non-farm activities and employment guarantee schemes was also found to be prominent adaptation strategies of agricultural households to climate change. Various factors such as endowment of human capital, physical and financial capital often influenced the adaptation decision of these households.

Farmers follow voluntary strategies to cope with the climate change based on perceived impacts which might be less effective. Thus, it is very important to facilitate informed decision-making among farmers on sustainable adaptation strategies in a location-specific manner. To satisfy location-specific needs of climate resilience agricultural technologies and practices, continued R&D efforts are also needed.

Moreover, the promotion of adaptation related activities could be done with the fol-lowing major ongoing programmes; Rashtriya Krishi Vikas Yojana, National Mission on Agricultural Extension and Technology, National Mission on Sustainable Agriculture (Paramparagat Krishi Vikas Yojana, Soil Health Card Scheme), Pradhan Mantri Krishi Sinchayee Yojana, Integrated Scheme on Agricultural Marketing, Mahatma Gandhi National Rural Employment Guarantee Scheme and Pradhan Mantri Fasal Bima Yojana.

In nutshell, it is construed that integrating grass-root perceptions to climate change and adaptation strategies in the development planning is essential for better targeting and enhancing the adaptive capacity of the vulnerable sections. The government should create conducive environment for diversification of rural income, managing village resources through community participation, access to credit, reduce information asymmetries, strengthening irrigation and post-harvest management facilities, thereby enhancing resi-lience of Indian agriculture system to withstand climate shocks.

References

Adger WN, Dessai S, Goulden M, Hulme M, Lorenzoni I, Nelson DR, Naess LO, Wolf J, Wreford A (2009) Are there social limits to adaptation to climate change? Clim Change 93(3):335–354

Alauddin M, Sarker MAR (2014) Climate change and farm-level adaptation decisions and strategies in drought-prone and groundwater-depleted areas of Bangladesh: an empirical investigation. Ecol Econ 106:204–213

Auffhammer M, Ramanathan V, Vincent JR (2012) Climate change, the monsoon, and rice yield in India. Clim Change 111(2):411–424

Ayanlade A, Radeny M, Morton JF (2017) Comparing smallholder farmers perception of climate change with meteorological data: a case study from south-western Nigeria. Weather Clim Extremes 15:24–33 Ayers JM, Huq S, Faisal AM, Hussain ST (2014) Mainstreaming climate change adaptation into devel-opment: a case study of Bangladesh. Wiley Interdiscipl Rev Clim Change 5(1):37–51

Berry PM, Rounsevell MDA, Harrison PA, Audsley E (2006) Assessing the vulnerability of agricultural land use and species to climate change and the role of policy in facilitating adaptation. Environ Sci Policy 9:189–204

Bryan E, Deressa TT, Gbetibouo GA, Ringler C (2009) Adaptation to climate change in Ethiopia and South Africa:

options and constraints. Environ Sci Policy 12(4):413–426

Bryant RC, Smit B, Brklacich M, Johnston RT, Smithers J, Chiotti Q, Singh B (2000) Adaptation in Canadian agriculture to climatic variability and change. Clim Change 45:181–201

Deressa T, Hassan R, Ringler C, Alemu T, Yesuf M (2009) Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Glob Environ Change 19:248–255

Eisenack K, Moser SC, Hoffmann E, Klein RJ, Oberlack C, Pechan A, Rotter M, Termeer CJ (2014) Explaining and overcoming barriers to climate change adaptation. Nat Clim Change 4(10):867–872 Fankhauser S, Smith JB, Tol RSJ (1999) Weathering climate change: some simple rules to guide adaptation decisions. Ecol Econ 30(1):67–78

FAO (2009) Climate change and agriculture policies: how to mainstream climate change adaptation and mitigation into agriculture policies. Advanced draft of policy guidelines. Easypol draft of policy guidelines. FAO, Rome, Italy

Granjon D (1999) Ennqueˆtes et resultants sur l'adaptation del'agriculture aux different types de stress: le cas de la zonede Napierville, Research report submitted to Singh, B. and Bryant, C.R. as part of a research contract with atmospheric environment services, Environment Canada, Downsview

IPCC (2001) Climate change 2001: impacts, adaptation and vulnerability. Contribution of working group II to the third assessment report of the intergovernmental panel on climate change. In: McCarthy JJ, Canziani OF, Leary NA, Dokken DJ, White KS (eds) Cambridge University Press. Cambridge, UK and New York, USA, pp 981–996

Jat ML, Dagar JC, Sapkota TB, Govaerts B, Ridaura SL, Saharawat YS, Sharma RK, Tetarwal JP, Jat RK, Hobbs H, Stirling C (2016) Chapter three-climate change and agriculture: adaptation strategies and mitigation opportunities for food security in South Asia and Latin America. Adv Agron 137:127–235 Jha B, Tripathi A (2011) Isn't climate change affecting wheat productivity in India? Indian J Agric Econ66(3):353

Jodha NS, Singh NP, Bantilan MCS (2012) Enhancing farmers adaptation to climate change in arid and semi-arid agriculture of India: evidences from indigenous practices: developing international public goods from development-oriented projects. Working paper series no. 32. ICRISAT, Patancheru, AP, India

Klein RJT (2008) Mainstreaming climate adaptation into development policies and programmes: a European perspective. In: Parliament European (ed) Financing climate change policies in developing countries. European Parliament, Brussels, pp 38–50

Lemos MC, Boyd E (2009) The politics of adaptation across scales: the implications of additionally to policy choices and development. In: Boycoff MT (ed) The politics of climate change: a survey. Taylor and Francis, London

Lobell DB, Schlenker W, Costa-Roberts J (2011) Climate trends and global crop production since 1980. Science 333:616–620

Lobell DB, Sibley A, Ortiz-Monasterio JI (2012) Extreme heat effects on wheat senescence in India. Nature Clim Change 2(3):186–189

Mendelsohn R, Dinar A, Williams L (2006) The distributional impact of climate change on rich and poor countries. Environ Dev Econ 11(2):159–178

Nelson GC, Rosegrant MW, Koo J, Robertson R, Sulser T, Zhu T, Ringler C, Msangi S, Palazzo A, Batka M, Magalhaes M (2009) Climate change: impact on agriculture and costs of adaptation, vol 21. International Food Policy Research Institute, Washington

Padakandla SR (2016) Climate sensitivity of crop yields in the former state of Andhra Pradesh, India. Ecol Ind 70:431–438

Pathak H, Pramanik P, Khanna M, Kumar A (2014) Climate change and water availability in Indian agriculture: impacts and adaptation. Indian J Agric Sci 84:671–679

Porter JR, Xie L, Challinor AJ, Cochrane K, Howden SM, Iqbal MM, Lobell DB, Travasso MI (2014) Food security and food production systems. In: Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL (eds) Climate change 2014: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK and New York, pp 485–533

Rao V (2001) Poverty and public celebrations in Rural India. Ann Am Acad Polit Soc Sci 573(1):85–104 Rao BB, Chowdary PS, Sandeep VM, Rao VUM, Venkateswarlu B (2014) Rising minimum temperature trends over India in recent decades: implications for agricultural production. Glob Planet Change 117:1–8

Sanghi A, Mendelsohn R (2008) The impacts of global warming on farmers in Brazil and India. Glob Environ Change 18:655–665

Sapkota TB, Jat ML, Aryal JP, Jat RK, Khatri-Chhetri A (2015) Climate change adaptation, greenhouse gas mitigation and economic profitability of conservation agriculture: some examples from cereal systems of Indo-Gangetic Plains. J Integr Agric 14(8):1524–1533

Schneider SH, Easterling WE, Mearns LO (2000) Adaptation: sensitivity to natural variability, agent assumptions and dynamic climate changes. Clim Change 45(1):203–221

Singh NP, Bantilan C, Byjesh K (2014) Vulnerability and policy relevance to drought in the semi-arid tropics of Asia—a retrospective analysis. Weather Clim Extremes 3:54–61

Singh NP, Bantilan C, Byjesh K, Nedumaran S, Rao VUM, Venkateswarulu B, Niranjan F, Jayatilaka W, Deb UK, Ha PQ, Suddhiyam P (2015a) Moving along adaptation pathways toward grass-root resilience: a synthesis. In: Singh NP, Bantilan C, Byjesh K, Nedumaran S (eds) Climate change challenges and adaptations at farm-level: case studies from Asia and Africa. CABI Private Limited, Boston, pp 197–211

Singh NP, Byjesh K, Bantilan C, Rao VUM, Nedumaran S, Venkateswarulu B, Niranjan F, Jayatilaka W, Deb UK, Ha PQ, Suddhiyam P (2015b) Analytical framework and methodologies for analysing farm-level vulnerability. In: Singh NP, Bantilan C, Byjesh K, Nedumaran S (eds) Climate change challenges and adaptations at farm-level: case studies from Asia and Africa, vol 9. CABI Private Limited, Boston, pp 11–33

Singh NP, Byjesh K, Bantilan C, Rao VUM, Venkateswarulu B, Niranjan F, Jayatilaka W, Deb UK, Ha PQ, Suddhiyam P, Nedumaran S (2015c) Changing climate-responding to the inevitable. In: Singh NP, Bantilan C, Byjesh K, Nedumaran S (eds) Climate change challenges and adaptations at farm-level: case studies from Asia and Africa. CABI Private Limited, Boston, pp 58–85

Tadesse MA, Shiferaw BA, Erenstein O (2015) Weather index insurance for managing drought risk in smallholder agriculture: lessons and policy implications for Sub-Saharan Africa. Agric Food Econ 3(1):26

Tompkins EL, Adger WN (2003). Building resilience to climate change through adaptive management of natural resources. Tyndall working paper 27. Tyndall Centre for Climate Change Research, University of East Anglia, Norwich, UK

Tripathi A, Mishra AK (2017) Knowledge and passive adaptation to climate change: an example from Indian farmers. Clim Risk Manag 16:195–207

UNDP-UNEP (2011) Mainstreaming climate change adaptation into development planning. A guide for practitioners. UNDP-UNEP Poverty-Environment Facility, Nairobi

EFFECT OF CLIMATE CHANGE IN THE PREVALENCE OF PARASITIC DISEASES OF DOMESTIC LIVESTOCK

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Climate change is a most concerned issue nowadays, due to increased human exposure to vector borne diseases which are transmissible between human and animal. Recent increase of temperature can lengthen the season and make humans as well as animals susceptible to different types of epidemic diseases. Climate change can be defined as a long term statistical shift of the weather, in terms of temperature, humidity and rainfall in particular geographic area for a long period of time.

There has been an average temperature rise of -1.5 to 5.8°c across the globe during 21st century, accompanied by increased extreme temperature, as predicted by Intergovernmental Panel on Climate Change (IPCC). The climate change may affect the pathogens, vectors, hosts and their environment indirectly through its changing biology. Thus the unstable climate plays an important role in the emergence of epidemic and infectious diseases to both domestic animals and human beings.

Direct climate change effects on disease vectors

Climate change results in the changes of temperature, precipitation and humidity which influence the reproduction, development, behaviour and population dynamics of insects, different pathogens including microbes, insects and different parasitic agents

Insect by physiology cannot regulate body temperature and thus causing shifting vector range patterns and risk to new threat or mutation of particular insect in order to accommodate particular environment, according to particular situation.

Humidity and water is crucial for vector breeding, so more insect can hatch in areas with standing water and high precipitation. The incubation period of pathogens within vector is also temperature-dependant and become shorter in warmer condition.

Factors through which climate change affected:

1. Molecular biology of the pathogen itself

The ability of the microorganism to mutate the corresponding gene due to adverse effect of climate is the potential impact of climate change, e.g., the single amino acid substitution of glycoprotein envelope of venzulean equine encephalitis virus helps to adapt to epizootic vector of mosquito (*Ochlerotatus taeniorhynchus*). Due to climate change, this RNA virus could easily respond to changes in vector population. In comparison to DNA viruses, RNA viruses have higher evolutionary rate due to their proof reading capacity of gene. Mutation of virus/microbes may easily change the nature of various biotic and abiotic factors that affect the geographical transmission of the organism.

2. Vector:

Climate change may not affect only geographical range and abundance of vectors, but it also affect interaction between vector and pathogen. Generally different viral disease like Blue tongue virus, African Horse Sickness and tick borne encephalitis virus is transmitted by arthropod borne vector.

The range of vector or shifting of vectors affected by particular range of climate which indirectly influences the occurrence of disease in particular geographic area. The increased prevalence of blue tongue virus in Southern Europe is due to increase in population of traditional vector culicoides mosquito. Vector competence may be affected by different range of temperature. For example, blue tongue virus is transmitted most efficiently at lower temperature and not at below 10°c. Likewise, activities for transmitting African Horse Sickness increases with increasing temperature. Reversely, at higher temperature, the occurrence of western equine encephalitis virus is suppressed.

The feeding rate of many arthropod increases at higher temperature, thus increasing exposure of livestock to pathogens and thereby increasing the spread of diseases. However, activity of insect vector always increases during night time. A pathogen can infest in a vector for longer of period of time due to adaptation to particular environment in the body of insect’s vector as a result of prolong effect of temperature and associated climatic factors in the environment.

3. Farming practice and land use:

There will be change in the nature and intensity of livestock farming during drought, scarcity of grass, new types of animal feed supplement and extreme heat waves due to climate changes. Adaptation to this climate change may lead the traditional livestock farming to more intensive and protected farming.

4. Wildlife habitat:

The habitat of wildlife and food sources will change along with feeding pattern will be changed according to climate change which will ultimately change their social structure along with new introduction of domestic livestock. Climate change. It also promotes biological invasion of non-indigenous species with their adapted variety of newly introduced pathogens.

Impact of climate change on helminth parasites

There has been a steady rise of helminthes prevalence along with intensity of infection in both temperature and tropical areas due to change of climate in terms of relative humidity and rainfall. Infections of these damaging parasites to the host animals is characterized by weight loss, lower milk yield, loss of condition, abortion, infertility and sporadic death of the animals.

The latest climate change projections indicate an expected rise of summer temperatures by 2.0°C to 2.8°C by 2050, for different regions of different countries. The survival, development of parasitic free living stages is mostly dependant on different biotic and abiotic conditions of climate which entirely impact on the epidemiology and transmission of the parasite. Temperature is the main factor which affects free living stages of parasite for increased development of helminthes. However, extreme temperatures are lethal for larval survival and reduce pasture contamination and sometimes it is the cause of mutation among larvae. Relative humidity has also been shown to influence larval survival and development. However, humidity inside host species gives provides a favorable environment for hatching and full larval development. In addition to influencing the survival and development of larvae within a grazing season, climate also affects over-winter survival and thus availability of infective larvae at the start of the following grazing season.

Long-term climatic trends influence the distribution of different parasites at different geographic area, however the timing and intensity of outbreaks will be dependent on favorable and suitable congenial environment. In addition to general warming trends, increased weather variability is predicted and temperatures are projected to rise faster in summer than winter. Temperature fluctuations impact on population dynamics of parasites on domestic livestock which along with seasonal change of parasitic incidence, which affects the entire epidemiology of parasites in particular season of the particular area of the country.

In addition to affecting outbreak patterns of endemic species, climate change could also influence the spread of different emerging parasites with changing different species composition. Generally, helminthes infections of livestock were limited to species that adapted better to colder climates e.g. *Ostertagia ostertagi*, *Teladorsagia circumcincta*, *Cooperia Spp*, *Trichostrongylus Spp*, and *Nematodirus Spp*. However, in general, *Haemonchus contortus* is more prevalent in warm regions with warm moist humidity in summer causing severe mortality in ruminants like sheep, goat, cattles and buffaloes including mithun in NEH region. In a recent survey *H. contortus* was found to be present on temperate region with high outbreak. In general, parasite burdens are not high enough to lead to clinical cases, however heavy infections occur sporadically and pathological cases of heamonchosis are becoming an increasing problem for farmers due to calves' mortality. In addition to changing the intensity of parasite burdens, the periods of the year when transmission is possible could also change. Moreover, climate change may be the cause of the emergence of anthelmintic resistance.

In this article, how climate change could affect the transmission cycle of helminthes parasites in different ways has been summarized below:

i. Changing development rates of the parasites' free living stages

ii. Changing death rates of the free-living stages

iii. Over-winter survival of the parasites free-living stages

iv. Host resistance under changing conditions

v. Changes in seasonal temperature fluctuations on the transmission windows of temperate and tropically adapted parasite species.

Fasciola hepatica

Fasciolosis is one of the important ruminants' fluke disease which is characterized by weight loss, decreased milk yield, diarrhea, severe fibrosis of liver, clay pipe appearance of larvae and occasionally mortality. The prevalence and incidence of disease has been increased in entire globe due to changing epidemiology and infection pattern of flukes. There is also report of increase in its outbreak in sheep/cattle. There was an exceptional rise in *F. hepatica* and *F. gigantic* infections in both temperate and tropical climate due to increase construction of dam and irrigation facilities which helps in propagation of snail intermediate host. Summer rainfall is quite congenial for growth and propagation of snail epidemiology and the completion of their life cycle. The long term changing distribution is attributed to warmer average temperatures year round, increased rainfall in winter and autumn, and increased humidity that leads to 4-week extension of the herbage growing season over the years.

Nematodirus battus

N. battus is a highly pathogenic nematode found in the small intestine of ruminants, including cattle, buffalo and mithun. Unlike other livestock parasites, development of the free-living stages into infective larvae was thought to only occur after prolonged periods of exposure to low temperatures (around $0^{o}C$) followed by a rise in temperatures. Changes in the pattern of infection and their epidemiology have been observed and it is now thought that the ability of *N. battus* eggs to hatch without a chilling period coupled with increased temperature is a predisposing factor for increased prevalence in domestic livestock.

Haemonchus contortus

H. contortus, an abomasal nematode of ruminants, is typically a parasite of tropical climates, and it's the main cause of calves' mortality. There is a high prevalence and widespread distribution of *H. contortus*, but low outbreak intensity with few clinical cases has been observed in sheep and goat. This could be due to climate change, as warm temperatures lead to high larval activity which leads to increased infection rate. Higher autumn temperatures also encourage the ingested larvae to develop into disease inducing adults rather than enter hypobiosis, increasing the number of eggs released later in the year and extending the transmission window later into the autumn and major cause of spring rise phenomenon. It has been observed that larvae can withstand more desiccation during the hotter and drier summer months.

The increased incidence of *H. concortus* has also been attributed to different non climatic factors like, increased anthelmintic resistance and changing of animal husbandry practice along with repeated exposure to anthelmintic.

Impact of climate change on ticks

Nowadays, the most severe impact of climate change has been noticed particularly in ticks like, the brown dog tick, *Rhipicephalus sanguineus*, which is endemic not only in mediterranean regions but also in tropical climatic regions like India. Sporadic occurrence of these ticks in Europe, Asia including India, has also established their role of transmission of rickettsial organism in dogs.

Regarding *Ixodes ricinus*, the caster bean tick is the most common among hard ticks, and plays a significant role in their development and transmission pattern among hosts with their epidemiology in domestic livestock in Europe due to suitable climatic conditions. The decrease of winter days with temperature below a certain cut-off was identified by several authors as a key factor in the increased density of ticks of the genus *Ixodes.* Using larva, nymph and adult ticks, documented that it need certain environment of temperature and humidity for perpetuation of their life cycle. Increased prevalence of these ticks in scandavian countries is due to increased temperature which is suitable for its survival, development and completion of their life cycle

Impact of climate change on fleas

The impact of climate change on fleas is very difficult to ascertain due to its continuous life cycle through an entire year. A particular temperature >25°C and humidity > 85% is quite congenial for growth and propagation of different flea particularly of cat flea *Ctenocephalides canis*.

Control

Parasitism is one of the most important causes for reduced production in terms of meat and milk. Their life cycle and propagation is always restricted to certain climatic conditions. Under changing climate scenario, increased prevalence and intensity leads to heavy infection and thus control to certain extent becomes difficult. It is therefore crucial to consider these possibilities and begin to prepare for these changes that are planning for methods to limit epidemic eruptions and prevalence and incidence of parasitic diseases on a global scale in the context of climate change picture. Moreover, scientists have predicted occurrence of different parasites in particular area based on different forecasting model. Now it is a time for particular clinical practitioner to play a role in taking up some urgent steps to mitigate these climate change issues by evolving some good management programme along with planting of plants which will not only reduce emission of green house gases but also absorb such gases. It is also a time for the scientific communities to unite against climate change by evolving some biological steps in order to control climate change.

POST HARVEST HANDLING AND PROCESSING OF FEEDS AND FODDERS FOR MAXIMIZATION OF PROFIT

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Grasslands and forests are the major feed resource in Himalayan region. Grazing in the forest areas and sub-alpine and alpine pastures is the mainstay for the animals. Fodder trees and shrubs also contribute significantly. Though livestock rearing is an important occupation of farmers in that area, the forage cultivation has remained almost neglected. The natural resources of the Himalaya have been exploited for centuries in an unplanned manner leading to degradation all along. Reckless felling of trees, indiscriminate use of grazing areas and absence of rehabilitation programmes has lead to denudation of hill slopes, which has resulted in critically low biomass availability and adverse effects on livestock production. Climate, topography, physiographic factors, altitude and related aspects have influenced the distribution of various grass species, which determine the grassland production both qualitatively and quantitatively.

Present Status of forage production

Though Arunachal Pradesh and **Mizoram** are surplus in green fodders, overall North Eastern Himalayan region is deficient by 57.76% (Table 1). Similarly, in crop residue production **Mizoram** is in surplus position with overall deficiency by 51.61%. However, all the states in the North Western Himalayan region are deficient in green fodders as well as crop residues with an overall figure by 49.88 and 57.77% which corresponds to 53.95 and 54.58%, respectively for all the regions of Himalaya.

Plenty of vegetations are available in this region during rainy season. However, no systematic methodologies have been developed for this heavy rainfall region for preservation of fodders available during rainy season. The objective of this training schedule is to prescribe the techniques or methodologies for handling and processing of feeds and fodders for preservation as well as efficient utilization.

Table 1. Requirement and availability fodders in Himalayan region (Dry matter) (estimated in 2008)

States	Availability (million tonnes)		Requirement (million tonnes)		Deficit (million tonnes)		Deficit / Surplus (%)	
	Crop residues	Greens	Crop residues	Greens	Crop residues	Greens	Crop residues	Greens
Arunachal Pradesh	0.47	1.57	1	0.53	0.53	1.04 (Surplus)	53.00	196.23 (Surplus)
Assam	5.82	0.95	12.39	6.61	6.57	5.66	53.03	85.63

Manipur	0.36	0	0.72	0.38	0.36	0.38	50.00	100.00
Meghalaya	0.31	0.4	1.17	0.62	0.86	0.22	73.50	35.48
Mizoram	0.15	0.5	0.06	0.03	0.09 (Surplus)	0.47 (Surplus)	150.00 (Surplus)	1566.67 (Surplus)
Nagaland	0.56	0.3	0.74	0.4	0.18	0.1	24.32	25.00
Sikkim	0.23	0.01	0.25	0.13	0.02	0.12	8.00	92.31
Tripura	0.53	0.19	1.09	0.58	0.56	0.39	51.38	67.24
NEH region	**8.43**	**3.92**	**17.42**	**9.28**	**8.99**	**5.36**	**51.61**	**57.76**
Himachal Pradesh	2.3	1.98	4.6	2.45	2.3	0.47	50.00	19.18
J&K	2.53	0.64	6.79	3.62	4.26	2.98	62.74	82.32
Uttaranchal	2.05	1.73	4.9	2.61	2.85	0.88	58.16	33.72
NWH region	**6.88**	**4.35**	**16.29**	**8.68**	**9.41**	**4.33**	**57.77**	**49.88**
NEH + NWH	**15.31**	**8.27**	**33.71**	**17.96**	**18.4**	**9.69**	**54.58**	**53.95**

(http://www.indiastat.com/table/agriculture/2/fodder19971998to20112012/449338/466304/data.aspx (Lok Sabha Unstarred Question No. 726, dated 24.11.2009)

It has been observed that cutting management of fodders might help in increasing the productivity as shown in Table 2. It is also true for tree fodders and other naturally grown grasses in this region

Table-2. Cutting management of Broom grass and its effect on total yield

Particulars	With cutting		Without cutting
	1st cutting (August)	2nd cutting (November)	1st cutting (November)
Yield (q / hac)* (DM basis)	38.03 ± 3.92^{b}	28.24 ± 5.88^{b}	50.74 ± 4.33^{a}
Residue (%)* (DM basis) (after feeding animals)	24.72 ± 2.01^{b}	20.51 ± 2.18^{b}	32.34 ± 2.89^{a}
DM digestibility (%)*	61.6 ± 1.61^{a}	59.8 ± 1.80^{a}	53.5 ± 2.24^{b}
Available digested DM (q/hac)	17.6	19.3	18.4

Factors Affecting Fodder Quality

The major challenge in fodder production is preserving the feed quality especially during the dry season. Factors that affect the feed quality of fodder include:

The stage of harvesting. As the fodder matures in the field, it becomes fibrous and loses almost all its feeding value.

The method of harvesting. Poor harvesting methods can lead to loss of biomass that has the highest nutritive value.

Handling and storage. Poor handling and storage can lead to spoilage of fodder, especially when it is exposed to adverse weather conditions such as rain and/or too much sunshine. It may be preserved either by making hay or silage

Hay

Hay is grass, legumes, or other herbaceous plants that have been cut, dried, and stored for use as animal fodder, particularly for grazing animals such as cattle, buffalo, mithun, goats, and sheep. *Hay* is also fed to smaller animals such as rabbits and guinea pigs.

Types of Hay

Following are types of hay.

Legume Hay: Legume hay has high feeding value and is especially rich in digestible crude protein, vitamins and minerals. It is highly palatable. Examples are cowpeas, berseem, etc

Non-Legume Hay (All Grass Hay): This is hay from all other fodders (predominantly grasses) and it is generally less palatable than legume hay. The quality largely depends on the stage of harvesting. Protein content, minerals and vitamins are usually lower than in legumes and examples are Rhodes grass, buffel grass, natural grass, and maize stover.

Mixed Hay: This is hay made from mixture of grass and legumes. The nutritive value depends on the type of mixture and the ratio of legumes and non-legumes used in the mix.

Examples of mixtures are:

- Cowpeas and para grass, Guatemala grass or maize;
- Rice beans with sorghum and/or maize.

How to Make Good Quality

When to Harvest Hay

Harvest at the end of the rainy season, when there is plenty of sunshine and when the grass fodder is still green and tender. Hay is best made during rain free days. However, in North Eastern Hilly (NEH) region due to high rainfall during rainy season it is difficult to get sunny days for drying fodders.

How to Harvest Hay

Step 1: Cut the fodder with a sickle or specially made fodder cutter at its pre-flowering or flowering stage, when its growth is levelling off and its feeding value is still high. This is the best stage to optimize both quality and quantity of grasses and legume.

Step 2: After cutting, dry the fodder as quickly as possible, spread the fodder in the field to dry for about 4 hours. Once the top is dry, turn the fodder and dry again for approximately 4 – 5 hours. Follow the same process the following day, provided there has not been rain. The hay can be removed from the field for storage on the second or third day.

Alternatively in the places like NEH region with high rainfall it may be dried in the poly-house (Photos 1 &2) even during rainy days.

Photo 1. Poly-house for drying fodders

Photo 2. Drying of fodders in poly-house

As a guide it can be suggested that hay is ready to store when no sap (moisture) can be drawn from the stem when pressed with the fingernail.

Crops with thick and juicy stems should be dried after chaffing and conditioning, which will speed up the drying process and slow down the loss of nutrients. It may be crushed in a feed block machine and dried in the polyhouse (Photo 3). It will enhance the drying rate. In this way some high moisture content agro-industrial by-products like spent grain and wet distillery grain and solubles might also be dried in polyhouse during rainy season and made into feed blocks.

Photo 3. Feed block machine

Curing and Storing Hay

Curing and storing hay includes handling, bailing, storing and feeding, as follows.

Handling

Hay should be handled gently after drying, as the leaves especially of legumes become crisp and will easily break from the plant. This will lead to loss of the most nutritious part of the plant. To prevent loss of feeding value, the drying period should be as short as possible and after drying hay should be handled as little as possible.

Legumes should be raked in the morning hours to avoid leaf shattering;

Hay should be raked only a few times during the drying process in order to avoid the shattering of leaves and the bleaching of the hay.

Hay can be gathered loose or can be baled for easier storage and transport. Baling is strongly encouraged as it saves storage space, avoids wastage at feeding and facilitates easy measurement for sale/marketing. To bale hay the following are required:

• A simple rectangular wooden box measuring 100 x 60 x 60cm (Length, width and height) open both sides.

• A string.

Baling

Steps for bailing are:

• Fill a wooden box and press the hay tightly in the box by stomping feet on it or using any heavy object, such as a metal bar, to compact the hay.

• Once the box is full, tie the bale with the string.

• Lift the box to release the bale.

Alternatively, hay can be tied in small bundles of 5-8kg each.

Where a wooden box is not available, a pit with the same measurements as the box can be used

Storing

After drying and curing, baling and/or stacking should be done as early as possible.

The bales and bundles should be stored under a roof and stacked on raised wooden structures (hay racks).

The hay rack provides sufficient ventilation and it helps avoid spoilage caused by rain, sun, or insects like termites.

Attributes of Good Quality Hay

Good quality hay has the following attributes:

• Remains slightly greenish in color

• Leafy

• Clean

• Soft

• Palatable

• Nutritious

Silage Making

Silage is a preserved feed prepared from green forage that is fermented in absence of air and fed to cattle, buffalo, mithun and sheep. The process of silage making is called ensiling and the container for keeping silage as silo. Silage can be made in the NEH Region during rainy season when the forage is abundant. It can be used during winter season when feed scarcity is very high. In general silage making does not get popularity to small and marginal farmers because of high capital investment to construct silo-pits. However, the method described here is cheaper and user – friendly.

Materials required

Chaff cutter, high-density polythene bag, rope, green grasses, tree leaves, crushed maize, crop residues like maize stover, millet stover, pulse straw, *etc*.

Ensiling Method

Green forage chopped into small pieces with chaff cutter of about 4 – 5 cm length is mixed with 3% crushed maize (Photo 4). The well-mixed materials are then filled into high-density polythene bags layer-by-layer, trampled by foot or any wooden thick stick to release air in between (Photos 5, 6 & 7). After complete filling the mouth of the bag is tied with rope and kept inverted on the ground (Photo 8). Silage is ready to feed the animals after 2-3 months.

Photo 4. Chaffing of fodder

Photo 5. Mixing the chaffed fodders

Photo 6. Filling in the polythene bags

Photo 7. Compacting

Photo 8. Storage

Silage making overcomes the following constraints:

- Large permanent silo pits can be replaced with high-density polythene bags (Silpaulin-90) which is easily available in the market.
- This can be a part-time job for a family to fill a bag having size 7′ x 30’ with a capacity of 250 kg.
- These bags can be used for three to four years if used carefully.
- Ensiled bags can easily be stored any where in the premises.
- A farmer can preserve green forage as per his requirement.
- Forages of high moisture content can be ensiled with available crop residues.
- There will be no effluent run off hence, no contamination of water resource.
- No run off nutrient loss.

Character of good silage

It should smell like acetic acid (vinegar) without the smell of ammonia. The color should be yellowish or brownish green without mould formation.

Steps to be taken to ensure good quality silage

- Chopped pieces should not exceed 4-5 cm length.
- Chopped material should be uniformly distributed in the silo.
- Material should be trampled well for minimum retention of air.
- High moisture content forages such as jungle grasses, tree leaves should be mixed with low moisture content forages like crop residues, maize stover, millet stover, cowpea, pulse straw, *etc*.
- Whole operation of harvesting of crop, chaffing, filling and sealing of silo, *etc* should be completed as early as possible on the same day.
- Ensure the bag should not be torn off during filling or storage period.

Advantages of ensiling

- Ensure supply of feed during lean season.
- Ensure a consistent level of production throughout the year.
- Green forage can be stored for a long period (12-18 months).
- Thick stems of mature forages become soft, more palatable and better utilized.
- Acids produced during ensiling are easily utilized as a source of energy by the animals.
- Many undesirable worms and their eggs present in the fresh crop are eliminated after ensiling.

EFFICIENT UTILIZATION OF AGRO INDUSTRIAL BY-PRODUCTS FOR DOUBLING THE FARMERS' INCOME

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Agro industrial by-products are the waste from agricultural-based industries that are produced during processing of the main products and in large quantities every year. Usually these by products have problems of either low palatability or the shorter shelf life therefore cannot use them to their potential. Although cattle feed industry is utilizing such feed ingredients by blending them with conventional feeds but large number of ingredients is underutilized due to low, scattered and seasonal availability. Therefore in maximum reports it disposed of either by burning, dumping or unplanned land filling.

Source of agro-industrial by-products (AIBP)

Agriculture residues are two types:

(1) Field residues

(2) Process residues or industrial residues.

Field residues

Residues that present in the field or after separation of main crop during harvesting are the field crop residue or waste. These field residues consist of leaves, stalks, stems, straw, stalk, shell, pulp, stubble, peel, root, seed pods etc. produced mainly from annual crops and some of them are used for animal feed, soil improvement, fertilizers, manufacturing, and various other processes. Huge amount of field residues are generated and most of them are underutilized.

Process residues or industrial residues

These residues present even after the crop is processed into alternate valuable resource. Various crops like rice, lentils, maize, chickpeas, fruits, and vegetables are produced all over the world. In addition a huge amount of organic residues and related effluents are produced every year through the food processing industries like juice, chips, meat, confectionary, and fruit industries. These organic residues can be utilized for different energy sources. As the population increases continuously, the requirement of food and their uses also increased. So, in most of the countries, different industries of food and beverage have increased remarkably in that region for fulfillment of need of food. These fruit industrial wastes constitute different compositions of cellulose, hemicellulose, lignin, moisture, ash, carbon, nitrogen, etc. and these constituents have potential to biochemically digested to produce useful products like production of biogas, bio-ethanol, and other commercially useful examples like bio-preservatives.

Approximately, 20% of the production of fruits and vegetables in India are going waste every year because of unorganized production, lack of support system for marketing, storage and processing adjacent to the cultivation area. However, in recent past scientific information and intervention in agriculture sector has increased production of diverse food products in the country and simultaneously it also increased the percentage of waste produced from them. Most of these wastes are left unutilized or untreated, which caused adverse effect on environment as well as human and animal health. However, these agro-industrial by products considered as wastes contains a large number of organic compound and could be a potential raw material to produced a variety of value-added products and also reduced the cost of production. Single cell protein, alcohols, petrochemicals, fuel, fine chemicals, antibiotics etc. are some of the products derived from fermentation technology where agro industrial by products used as primary raw materials.

Priorities of utilization

In livestock production system the cost of feed accounts for approximately 70 % therefore, any saving in the cost of feed would increase the profitability. Therefore, priority for selection of feed ingredients should be based on the nutritive value and economical availability to meet the nutrients requirement of that particular animal. Basically feed stuffs are grouped into energy and protein supplement and grouped into primary or supplementary as per the digestive system of the animals. Primary feedstuffs constitute about 70-80% in the diet and Secondary feedstuffs or minor ingredients constitute up to 20-30% in the diet. Ruminants are more efficient to convert poor quality feed ingredients into high quality food is meat and milk whereas non- ruminants are fast converter of low quality feed into high quality food like meat & eggs but they compete with human for some food ingredients.

Primary and secondary Agro industrial by products from various sources

	Feed source	Feed stuffs
1.	Paddy	Paddy straw, Rice husk, Rice bran, Broken rice
2.	Wheat	Wheat bhusa, Wheat bran
3.	Maize /	Maize stover, Maize cob, Maize bran, Maize germ meal
4.	Millet	Stover and bran
5.	Sugarcane	Sugarcane bagasse, molasses
6.	Tea industry	Spent tea leaves
7.	Cassava , sweet potatoes	Leaves, vines, haulms
8.	Leguminous plant residues eg Groundnut, soybean ,others	Stems, leaves, Cakes /meals
9.	Pulse processing unit	Pulse hulls/ bran
10.	Guar	Guar meal
11.	Coca	Pods / husk
12.	Brewers & distillery industry	Brewers grain & distillery by product (wet & dry)

13.	Fruit crops & industry	Leaves, Pulp, kernel (high moisture)
14.	Various type of oil seed plants (mustard, groundnut, soybean, sunflower, cotton, caster etc)	Oil cakes/meal /hulls
15.	Tree seeds (Tamarind neem, karanj, mahuwa, salseed, oak, coconut, rubber seed etc.	Oil cakes / meal /hulls

Animal feed resources

The crop field residues mainly fibrous materials are by-products of crop cultivation. These field residues have in general low crude protein content in the range 3.3 - 13.3% on dry matter basis (eg. paddy straw, wheat straw, maize stalks, cereal stalks etc.) and deficient in fermentable energy that leads to lower voluntary intake as well as digestibility. Whereas process residues or industrial by products are in comparison to field crop residues, less fibrous, more concentrated and have a higher nutrient content (eg. rice bran, oil cakes, molasses, fruit waste distillery, breweries waste etc.)

For animal feeding the agro-industrial by-products have been categorised as conventional and non-conventional feed resources based. The origin of conventional or traditional feeds is mainly from annual crops whereas non-conventional feed resources refer to all those feeds that have not been traditionally used in animal feeding and or are not normally used in commercially produced rations for livestock. Most of the unconventional by products contain some toxins and or incrementing factors resulting to poor palatability thereby poor production.

Strategies for utilization of Agro industrial by products

1) In ruminants the primary feed stuffs are high fibre less digestible crop residues like paddy straw or other cereal crop residues. The shelf life of these materials varies according to their moisture content. Materials having moisture content approximately 10% could be stored as such for longer period.
2) High moisture containing materials from fruit waste like bananas, citrus fruits, pineapple, sugarcane and root crops are potent energy source but shorter shelf life because it posses suitable environment for microbial growth. Material could be fed to livestock as supplemental feedstuff.
3) These moisture containing materials could also be mixed with dried crop residues to balance its moisture content, to increase palatability of less palatable crop residues.
4) Blocks may also be prepared from such mixture for easy handling and storage and to increase its shelf life depending upon moisture content, weather condition and season.
5) High moisture and soluble starch containing field crops such as maize stover may be preserved after removal of maize cobs by using scientific techniques of fodder preservation like silage making. Some plants and agro waste having preservative characteristics may be mixed and used as bio-preservers to

increase shelf life of the material for feeding for extended or during scarcity period.

6) Crop residues like paddy straw if chopped into 3-4 inches increased the surface area for microbial activity that results to increased digestibility.
7) Straw are deficit in nitrogen content therefore feeding of urea treated straw meets the N requirement of the microbes and enhances digestibility. To increase N status and readily available carbohydrates fibrous feed ingredients could be mixed with other by products like oil cakes, haulms of potatoes, sugarcane tops etc.
8) Commercially available urea molasses block lick may also be provided to maintain optimum microbial activity in the rumen to use maximum potential of the agro industrial by product.
9) The secondary feed stuffs are either high protein or high energy feed ingredients. Agro industrial by products from oil industry produces oil seed cakes after extraction of oil from conventional and non conventional seeds. It is rich source of nitrogen and used as protein supplements an ingredient for compounding concentrate feed mixture.
10) According to availability different agro industrial by products may be used in proper combination as maintenance ration, finishing or flushing ration to different age group and categories of livestock.

Other uses of agro industrial wastes

11) These residues can be used as an alternative source for the production of different products like biogas, bio fuel, and as raw material for mushroom cultivation and proction of many fermentation products such as single cell protein used a food and feed item for human and animals, alcohols, petrochemicals, fuel, fine chemicals, antibiotics etc.
12) Some agro industrial by product from citrus and cocas have excessive potential as mobilization carrier for solid state fermentation. These can be utilized as economical and environmental friendly way of waste management.

Economics of utilization

- The agro industrial by products are rich in bioactive compounds. The bio- molecules present should be identified for its suitable utilization with minimum investment.
- In general cost of transportation of these material limits its utilization. Therefore, additional cost involved must be taken care and inclusion of such by product should reduce the unit cost of production of the particular sector and without compromising healthy environment at the site of production.
- Suitable zero waste integrated farming where waste of one production system could be the primary substrate of other need to be identified. And it should be ethical, environmental friendly and acceptable to the surrounding society without marketing problems.

Conclusion

Agro industrial by products rich source of various bioactive molecules that need judicious utilization to produce many value added products at low cost. In addition this will help to reduce the disposal and environmental problems associated with these materials.

List of Participant for Model Training Course

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