COMPENDIUM

ICAR-CIWA

ICAR SHORT COURSE

"Integrated Farming System: An Approach towards Livelihood Improvement of Farm Women and Natural Resource Conservation"

(14-23 December, 2016)

Sponsored by
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ICAR- Central Institute for Women in Agriculture

(Indian Council of Agricultural Research)

Bhubaneswar-751 003, Odisha

COMPENDIUM

ICAR SPONSORED SHORT COURSE
on

"INTEGRATED FARMING SYSTEM: AN APPROACH TOWARDS LIVELIHOOD IMPROVEMENT OF FARM WOMEN AND NATURAL RESOURCE CONSERVATION"

(14– 23 DECEMBER, 2016)

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Integrated Farming System: An Approach towards Livelihood Improvement of Farm Women and Natural Resource Conservation *(Compendium: ICAR sponsored Short Course on "Integrated Farming System: An Approach towards Livelihood Improvement of Farm Women and Natural Resource Conservation" organized at ICAR-CIWA, Bhubaneswar during 14– 23 December, 2016)*

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FOREWORD

There is a vast scope to improve the household profitability by judicious utilization of family labour using innovative practices and ensuring multiple uses of various household and farm resources. This is possible through women empowerment by way of specific trainings and critical need based support. The close association between women and natural resources exists because of their social and economic roles which have for generations required them to provide food, fuel and fodder from the surroundings. The gender perspective on resource management is important at the farm as well as household level because women are often the primary users of various resources for agriculture, livestock as well as health and sanitation. This is mainly attributed to the fact that there exists a clear gender demarcation with regard to tasks both at farm level and at household level. It is true that women have much more pragmatic knowledge of the practices in which they are engaged, leading to a kind of specialization. When we talk of managing and preserving traditional knowledge, the pivotal role played by women cannot be ignored. Another rationale for enhancing the skill of women with regard to Integrated Farming System (IFS) is due to the fact that they are the key custodians of traditional knowledge. Thus women especially need to be given training on the latest developments in IFS. For which, the researchers and extension functionaries or the trainers involved in women development programmes, need to be empowered with the latest developments in the field of IFS and natural resource conservation.

In this backdrop, this *ICAR sponsored Short Course on "Integrated Farming System: An Approach towards Livelihood Improvement of Farm Women and Natural Resource Conservation"*" has been organized at ICAR-CIWA, Bhubaneswar from 14th to 23rd December, 2016. I appreciate the efforts of the course team for bringing out this Compendium, which will be an useful reference material for the stakeholders.

Date: 23-12-2016
Place: Bhubaneswar **Director**

PREFACE

To meet the multiple objectives of poverty reduction, food security, competitiveness and sustainability, several researchers have suggested farming systems approach to research and development. An integrated farming system represents multiple crops (cereals, legumes, tree crops, vegetables etc.) and multiple enterprises (animal husbandry, bee keeping, fish farming etc) in a single farm. It is widely accepted as a means of achieving sustainable agriculture. A farming system is the result of complex interactions among number of interdependent components where an individual farmer allocates certain quantities and qualities of four factors of production, *viz.,* land, labour, capital and management to which he has access. Farming system research is considered as a powerful tool for the management of natural and human resource in developing countries like India. This is a multi-disciplinary whole-farm approach for solving the problems of small and marginal farmers. This approach aims at increasing income and employment from small-holdings by integrating various farm enterprises and recycling crop residues and by-products within the farm itself. Under the gradual shrinking of land holding, it is required to integrate the land-based enterprises like fishery, poultry, duck rearing, apiary, field and horticultural crops etc. within the bio-physical and socio-economic environment of the farmers to make farming more profitable and dependable. In this context, this *ICAR sponsored Short Course on "Integrated Farming System: An Approach towards Livelihood Improvement of Farm Women and Natural Resource Conservation""* has been organized at ICAR-CIWA, Bhubaneswar from 14th to 23rd December, 2016, to share knowledge on the latest developments in gender mainstreaming in IFS and sensitize the research and extension functionaries and scientists of KVKs.

The objectives of this training programme are: to provide advance training to the scientists of ICAR/SAUs/KVKs and improve their skills in the area of IFS and natural resource conservation, to show the trainees live demonstrations/experiments on IFS to improved resource-use efficiency, and to provide an opportunity to discuss and exchange ideas/ knowledge sharing between the academies and with the experts/resource persons who have made notable contributions in this area. Keeping this in view, the course contents have been plannned accordingly, and this compendium has been brought out for the benefit of the participants. We express our sincere gratitude to ICAR for sponsoring this course. We are highly indebted to Dr. Jatinder Kishtwaria, Director, ICAR-CIWA for necessary guidance and support in organizing the programme and for bringing out this compendium. The technical services rendered by Shri. Manoranjan Prusty, Shri. Sanjay Kr. Behera and Shri. Subrat Kr. Das are also acknowledged.

Course Team

Role of ICAR-CIWA in Empowering Women in Agriculture

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Higher and sustainable agricultural growth is essential for eradication of poverty, hunger and undernourishment. But agriculture is underperforming in many developing countries and one of the reasons being poor access of women to resources and opportunities needed to make the most productive use of their time. Although women have entered the labour force in large numbers across much of the developing world in the past quarter century, this increasedparticipation has not translated into equal employment opportunities or equal earnings of menand women. Globally, about 42% of economically active women are engaged in agricultureand they comprise about 43% of total work force in agriculture. In developing countries, 52.7% of women workers are in agriculture. In India, a high proportion of economically active women are engaged in agriculture. In 2001, about 72% of women workers were engaged in agriculture as cultivators and agricultural labourers. But after a decade in 2011, about 65% of such women workers and about half of total men workers are engaged in agriculture as cultivators and agricultural labourers. With more men migrating to non-farm sector, the share of women in total agricultural work force may increase in the coming days. In this context human Resource development and management is critical for realizing the potentials of agriculture and our progress would depend largely on the attitude and capacity of the rural women to more effectively participate in and contribute to agriculture. No doubt, during the past three decades efforts have been made in research on women in agriculture. But today there is a necessity for more focused and context specific research in a coordinated way to tackle the prevailing as well as emerging problems.

Genesis and Progress of ICAR-CIWA

Realizing that the importance of women in agriculture on one hand and dearth of gender related information and technologies on the other, the Working Group on Agricultural Research and Education constituted by the Planning Commission for the formulation of the Eighth Five Year Plan (1992-97) recommended establishment of National Research Centre for Women in Agriculture (NRCWA) to undertake research relevant to the needs of farmwomen in agriculture and home management. It also focuses on research for generation of jobs involving flexibility in time, duration and place of work for women. Accordingly, the ICAR established the NRCWA in 1996 at Bhubaneswar, Odisha. The Centre was subsequently upgraded as Directorate of Research on Women in Agriculture (DRWA) in 2008 and as Central institute for Women in Agriculture (CIWA) in 2015. The operational and administrative control of All India Coordinated Research Project on Home Science is vested with it. This unique institution is expected to catalyze and facilitate R&D institutions to bring in farm women perspectives in their programmes to achieve gender equity**.** Recently, the mandate of the institute has been revised as follows;

- Research on gender issues in agriculture and allied fields
- Gender equitable agricultural policies/programmes and gender-sensitive agricultural sector responses
- Coordinate research on Home science

Activities for Gender Mainstreaming in Agriculture

ICAR-CIWA carries out research programmes in various dimensions related to women in agriculture. These activities are carried out through the in-house, inter-institutional, network or collaborative and coordinated modes of research. The All India Coordinated Research Project (AICRP) on Home Science is operating at 11 centres at ten Agricultural Universities such as, AAU, Jorhat (Assam); PJTSAU, Hyderabad (Andhra Pradesh); CCSHAU, Hisar (Haryana); CSK HPKV, Palampur (Himachal Pradesh); GBPUAT, Pantnagar (Uttarakhand); MAU, Parbhani (Maharashtra); MPUAT, Udaipur (Rajasthan); PAU, Ludhiana (Punjab) and UAS, Dharwad (Karnataka) and UAS Bengaluru (Karnataka). Three more new centres viz., Central Agricultural University, Tura, Tamil Nadu Agricultural University, Madurai and Sardakrushinagar Dantewada Agricultural University, Dantewada have been included in the XII five year plan. The technical plan of the project during XI plan period focused on development of gender specific database and training modules for farm women, technology interventions for drudgery reduction in agriculture, nutritional security & health promotion of farm families, promotion of vocational skills among adolescent girls, value addition to under utilised natural fibre resources and empowerment of rural women for livelihood security. Since its inception the ICAR-CIWA has focused its R&D activities in following thrust areas:

- **Creating a repository of gender disaggregated data and documentation :** Gender disaggregated information in the field of agriculture and allied areas are scanty and scattered. Such information need to be collected, collated, synthesized and published in order to make it available to the users. Therefore, a web portal 'Gender Knowledge Centre' has been created to share information among stakeholders.

- **Technology assessment & evaluation:** Research efforts in NARES have, by and large, bypassed the needs of women which very often differ from that of men. As a result, there is differential adoption of technologies between men and women. It ultimately affects the productivity of women and agricultural production. Therefore, ICAR-CIWA has identified relevant technologies in the fields of crop production, horticulture, animal husbandry, agricultural engineering and aquaculture and tested them in women perspective, and suggested refinement to make them women friendly. Technologies were assessed through on-farm participatory research involving women.

- **Farming system approach:** In the wake of emerging problems related to sustainability, the focus has been shifted to farming system approach to produce agricultural commodities. Moreover, as farmwomen struggle to meet their diverse needs from different sources, they eventually spend a lot of time and energy in supporting their households. Therefore research on micro-level farming/agricultural systems has become urgent to develop sustainable livelihood options for women and their households.

- **Drudgery assessment and reduction:** Farmwomen face a lot of drudgery while performing farming operations and household activities. Even women suffer from different health problems, which adversely affect their working efficiency and family welfare. But, data on the extent to which women are affected in the working environment and the effect on their work output are limited. Hence, studies were commissioned on drudgery assessment and development of reducing tools and implements suitable drudgery.

- **Gender sensitive extension:** Access of farmwomen to extension/information is very limited due to various reasons. One reason is lack of required degree of gender sensitivity of our extension system and lack gender focused extension approaches and models for dissemination. Extension modules on various subject matter areas like integrated farming system, post-harvest technology, integrated pest and nutrient management, poultry and fish farming, home garden and homestead farming were be prepared for rural women.

- **Capacity building of R & D functionaries:** Scientists, both in research and extension systems, need orientation to appreciate the vital role of women in agriculture and the areas in which their efficiency of work could be enhanced either by technological intervention in agriculture and allied sectors on important problems or by improving their knowledge and skills for better job performance. In the first instance the scientists of ICAR-CIWA need to be given required training in certain identified areas so that the centre can address researchable issues on priority. Based on the research outcomes, suitable training capsules are being developed according to the need of various stakeholders like, directors, scientists, policy makers, KVK & development functionaries and women leaders.

- **Resource management:** Resources, both natural and household, provide an important base for livelihood of women and their families. The means of livelihood that women adopt depends on resource endowment of a particular region, their households and access to such resources. The resources can be common property resources such as forest, water bodies, fallow lands etc. and household resources like cultivable lands, ponds, livestock and different assets. Lack of adequate resources at household level and poor management of existing resources have made poor in general and women in particular vulnerable to livelihood insecurity. More importantly there is need to improve the resource use efficiency on one hand, and make sustainable use of resources on the other. Hence, studies taken up related to women's role in resource conservation and management; and S&T options to harness sustainable benefits assume immense significance.

- **Gender mainstreaming:** Gender mainstreaming in agriculture encompasses three major aspects. The first and the foremost is Women's Empowerment (human capital formation, exposure, leadership, autonomy, self esteem, and food security), second by Capacity Building in Agriculture (dissemination of information and technology) and Access to Agricultural Inputs as well as technology and resources and services (including land, water and credit besides agri-inputs). Poor implementation of policies and programs and delivery to farm women at different levels are the gaps which have to be taken care of by the researchers in the domain of policy analysis &programs development in gender perspective. There is a need for gender sensitive approaches and methodologies to enhance access of women to critical resources, programs and services. Realization of the full impact of policies and initiatives like gender budgeting and making institutions work for women are some of the challenges faced by policy makers. Lack of reliable data and evidences on women in agriculture and lack of gender sensitivity in the system are the major impediments in engendering agriculture. ICAR-CIWA has taken steps to carry out research on evaluation of existing systems from gender perspective, alternative approaches, models and methods are required to address the information and extension needs of the rural women and for the gender mainstreaming.

- **Nutrition and livelihood security:** Studies and surveys revealed that malnutrition is the complex problem with multifaceted dimensions factors like poverty, purchasing power, health care, ignorance on nutrition and health education, female illiteracy, social convention etc. Poor livelihood leads to nutritional insecurity which manifests into malnutrition. Poor delivery mechanism and implementation of mitigating policies to be addressed the food & nutrition needs through various methods / models to combat malnutrition and livelihood security highlighted the need for more focused in different level involving women. Livelihood security, the poverty line defining inadequate income, consumption, nutritional level, health status, life expectancy and assets of holding people, can be increased by generation of income and ownership of productive assets to reduce vulnerability of marginalized communities. Women from the lower socioeconomic status tend to have a weaker control over household resources, more time constraints, less access to information and health services, poorer mental health, and lower self-esteem. Lack of adequate and sustainable livelihood options and poor asset base make it pertinent to undertake researches on resource based sustainable livelihood interventions and human resource development by ICAR-CIWA.

Conclusion

ICAR-CIWA, with its mandate of research on gender, has been striving to address gender issues in agriculture for achieving higher efficiency and productivity in agriculture. In order to demonstrate the output and utilities of gender research, ICAR-CIWA is forging partnerships with ICAR institutions, KVKs, SAUs, development agencies, NGOs and international organizations to strengthen the efforts of gender mainstreaming which is very much required to achieve gender equality which is one of the Sustainable Development Goalsbefore the global community.

Gender Concepts and Analysis Tools in Agriculture

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Gender Concepts

i. **Sex:** Means the biological differences between women and men, which are universal, obvious and generally permanent.

II. **Gender:** Gender refers to the socially constructed differences in roles and responsibilities assigned to women and men in a given culture or location and the societal structures that support them.

iii. **Gender roles:** The role refers to the activities performed by men and women in different situations and in different times and within the different cultures, classes, castes, ethnic groups etc. The roles of men and women are shaped by various forces such as social, cultural, economic, environmental, religious and political.

iv. **Triple roles:** These roles are (tasks and responsibilities) related to: production (producing money value), reproduction (the child bearing and rearing responsibilities), community management/ community politics (producing community goods and well beings).

v. **Gender analysis:** It is a tool to better understand the realities of the women and men whose lives are impacted by planned development. These include gender issues with respect to social relations; activities; access and control over resources, services. etc.

vi. **Access to productive resource:** Refers to right and opportunity of men and women to use the resources as per one's need to carry out his/ her activities.

vii. **Control over productive resources:** Refers to the rights and power of men and women to decide on the use and destination of the resources.

viii. **Practical gender needs:** Practical gender needs are the needs women identify in their socially accepted roles. They are practical in nature and often are concerned with inadequacies in living conditions such as water provisions, health care and employment.

ix. **Strategic gender interests:** Strategic gender needs are the needs women identify because of their subordinate position to men in their society. These vary according to particular context. They relate to gender divisions of labour, power control and may include such issues as legal rights, domestic violence, equal wages etc. Meeting strategic needs helps women to achieve greater equality.

x. **Gender equality:** Gender equality means that women and men enjoy the same status, have equal conditions for realizing their full human rights and potential to contribute to national, political, economic, social and cultural development, and to benefit from the results. Gender equality is therefore the equal valuing by society of both the similarities.

xi. **Gender equity:** Gender equity is the process of being fair to women and men. It means to ensure fairness which leads to equality.

xii. **Gender blind:** Gender blind is a person who does not recognize that gender is an essential determinant of life.

xiii. **Gender bias:** Perception that both sex are not equal and do not have similar rights to resources.
xiv. **Gender discrimination:** The systematic, unfavorable treatment of individuals on the basis of their gender, which denies them rights, opportunities or resources.
xv. **Gender sensitization**: To sensitize men and women on needs and interests of gender.
xvi. **Gender issues**: Problems faced by women in different sectors.
xvii. **Gender mainstreaming:** It is a strategy for making women's, as well as men's concerns and experiences, an integral dimension of the design, implementation, monitoring and evaluation of policies and programmes in all political, economic and societal spheres so that women and men benefit equally and inequality is not perpetuated. The ultimate goal is to achieve gender equality.
xviii. **Gender concern:** Needs and interest of women seeking attention from researchers and policy makers.
xix. **Gender lens:** Seeing and analyzing things with a gender perspective.
xx. **Drudgery:** Physical and mental strain, agony, fatigue, monotony and hardship experienced by human being as a result of tedious, menial or unpleasant work.
xxi. **Women In Development (WID):** WID usually seeks to integrate women into development by making more resources available to women.
xxii. **Women And Development (WAD):** WAD focuses on relationship between women and development process and examines the nature of integration. It is concerned with women's productive role to improve women's position.
xxiii. **Gender planning:** Gender planning is undertaken with the objectives of achieving gender equity, equality and empowerment through practical and strategic gender needs.

Tools for Gender Analysis:

Now, the researchers and policy makers have realized the importance of gender equality. Therefore, to bring equal status, gender analysis is a must to understand the gender issues, their roles, responsibilities, needs, etc. So, out of many available tools, ***SEAGA*** tool is very much appropriate for gender analysis in agriculture. Some of the ***SEAGA*** tools are as follows:

SEAGA tools: SEAGA is a technique for gender analysis which has been developed by FAO. It stands for Socio-Economic And Gender Analysis and helps in participatory identification of priorities of women and men to bridge the gap between them. It helps the participants to better understand the ground realities of the women and men, to identify the gender issues with respect to activities, access to and control over resources, decision making, needs and problems and also to formulate projects for gender mainstreaming in research and extension. On the other hand, it is for analysis of the current situation and planning for the future.

Broadly, all the tools are classified into three categories of gender analysis as:

a) **Development context toolkit:** Here, the focus remains on current situation (What is) for learning economic, environment, social and institutional patterns that act as supports or constraints for development.
b) **Livelihood analysis:** Here, the focus is on current situation (What is) for learning the flow of activities and resources for living.

c) **Stakeholders' priorities**: Here, the focus is on future (What should be) for planning development activities based on women's and men's priorities.

A. Tools under Development Context:

(i) Village Resource Map
(ii) Transects
(iii) Village social map
(iv) Trend line
(v) Venn Diagram
(vi) Institutional profile

(i) Village resource map: Helps for learning about the environmental, economic and social resources in the community. This map focuses on available resources like roads, buildings, houses, water bodies, agriculture land, grazing land, forest area, shops, health clinics, educational institutions, religious institutions, bus stop, etc.

(ii) Transects: It gives more details about environmental, social and economic resources in a community and provides a cross sectional picture of an area through direct observation. Helps for learning about the community's natural resource base, land forms, and land use, location and size of farms or homesteads, and location and availability of infrastructure and services and economic activities.

(iii) Village social map: It gives a perceptional picture of resources existing in the community. It helps for learning about the community's population, local poverty indicators and number and location of households by type (ethnicity caste, female-headed, wealthy, poor, etc.).

(iv) Trend line: It is a simple graph depicting change over time. It gives a picture of what is getting better and what is getting worse over time. It helps for learning about environmental trends (deforestation, water supply); economic trends (jobs, wages, costs of living), population trends (birthrates, out-migration, in-migration), and other trends of importance to the community.

(v) Venn diagram: Through this tool we can identify the potential conflicts between different socio-economic groups. It helps for learning about local groups and institutions and their linkages with outside organizations and agencies.

(vi) Institutional profile: It helps for learning about the goals, achievements and needs of local groups and institutions.

B. Tools under Livelihood Analysis:

(i) Farming system diagram
(ii) Benefits analysis flow chart
(iii) Daily activity clock
(iv) Seasonal calendar
(v) Resource picture card
(vi) Income and expenditure matrix

(i) Farming system diagram: It is a diagram to highlight the farming systems in family. It helps for learning about household members' on-farm (crop production), off-farm (fuel collection) and non-farm (marketing) activities and flow of resources to and from the home. It shows how livelihood depends upon various types of agro-eco-systems like forest, river, grazing land, etc which are in common use.

(ii) **Benefits analysis flow chart:** Through this analysis, we may be able to understand what the 'fruits' are from people's livelihood activities and who enjoys that. It also helps for learning about benefits use and distribution by gender. The bi-products are the result of any resource. Example, 'tree' as resource has bi-products like leaves, bark, fruits, seeds, fiber, fuel wood, fodder, etc, Here, who is the gender to enjoy these can be understood.

(iii) **Daily activity clock:** It gives a total picture of activities performed by gender in a day and who does more and also who does less. Helps for learning about the division of labour and labour intensity by gender and socio-economic groups. It helps to identify the workloads and leisure time for the community people including men, women, rich, poor, young and old. The clear picture comes that who works for longest hours and who does little activities.

(iv) **Seasonal calendar:** Helps for learning about the seasonality of women's and men's labour and seasonality of food and water availability and income and expenditure patterns and other seasonal issues important for the community. The calendars can be used to know the changes in income over the time and the work opportunity for the people at different periods of time.

(v) **Resource picture card:** Helps to know the gender based resource use and control within the household. This exercise facilitates us to know who is likely to be looser and who is likely to be gainer because of a particular development activity. It gives idea about who has access over the household resources (land, livestock, trees) and who takes decisions for its use.

(vi) **Income and expenditures matrix:** Helps to find out about sources of income, sources of expenditures and changes in expenditure at crisis. Analyzing their items of expenditure the priorities and limitations can be understood. It helps to understand the security or vulnerability of livelihood, meeting basic needs and saving if possible for rainy days.

C. Tools under Stakeholders' priorities:

(i) Pair wise ranking matrix
(ii) Flow diagram
(iii) Problem analysis chart
(iv) Preliminary community action plan
(v) Venn diagram of stakeholders
(vi) Stakeholders conflict & partnership matrix
(vii) Best bets action plans

(i) **Pair wise ranking matrix:** Helps to know the most important problems in the community, the priority problems of women and men and of different socio-economic groups.

(ii) **Flow diagram:** This analysis helps to identify about the causes and effects of their problems and can be used for possible solutions. This identifies the major problem in the community and decides which problem to be solved by the community, which can be solved by the external source and which has no solution like natural disasters.

(iii) **Problem analysis chart:** It is used for bringing together the priority problems of all the different groups in the community, to explore local coping strategies and to identify opportunities to address the problems.

(iv) **Preliminary community action plan:** It is helpful for planning possible development activities, including resources needed insider and outsider groups to be involved and timing.

(v) **Venn diagram of stakeholders:** Stakeholder is anyone who has interest in and is going to be affected in any developmental work. It helps us to know who is going to be affected by the proposed development plan. Gives a picture about the insider and outsider stakeholders for each action proposed in the Preliminary Community Action Plan. The extent of interest of a stakeholders is determined by the size of their stake in it.

(vi) **Stakeholders conflict and partnership matrix:** This analysis helps for learning about conflicts of interests and common interests between stakeholders.

(vii) **Best bets action plans:** Facilitates for finalization of action plans for development activities meeting priority needs as identified by women and men of each socio-economic group

Based on their communities, priorities and needs these tools for gender analysis can be used by the researchers with little modification.

Techniques/Tools for Field Analysis

Trend Line: A group of older men and women should be involved in discussion as they know more about the past events. Ask them about important changes in the community (may be better or worse) related to natural resources, populations and economic opportunities.

Sl. No	Years	Events	Intensity of events
1.	1990		
2.	1995		
3.	2000		
4.	2005		
5.	2010		
6	2015		

Daily Activity Clock

Time	Women	Men
0 to 1 am		
1 to 2 am		
2 to 3 am		
3 to 4 am		
4 to 5 am		
5 to 6 am		
6 to 7 am		
7 to 8 am		
8 to 9 am		

9 to 10 am		
10 to 11 am		
11 to 12 noon		
12 to 1 pm		
1 to 2 pm		
2 to 3 pm		
3 to 4 pm		
4 to 5 pm		
5 to 6 pm		
6 to 7 pm		
7 to 8 pm		
8 to 9 pm		
9 to10 pm		
10 to 11 pm		
11 to 12 pm		

Analysis of Access and Control Over Resources

Resource	**Access**			**Control**		
	Male alone	**Female alone**	**Joint**	**Male alone**	**Female alone**	**Joint**
Land (i) Family land (ii) Lease land Capital (i) Family income (ii) Credit from bank Water Seeds/seeding materials Labour (manual) Manures and fertilizers etc. Machines/equipments Farm produce Food Technologies Trainings Extension services Market information Farm profit Co-operatives societies						

Pair Wise Ranking Matrix: Organize two separate focus groups: one of women one of men with a mix of socio-economic groups. Ask the participants to list 6 problems important to them. Write the list of 6 problems on both the vertical & horizontal axis of the paper. Also write the problem in separate six cards, show the participants a pair of problem cards asking them the more important .One with reasons of choice. Record their choice on the prepared matrix.

Example

Problems	Cost of Inputs	Insect pest	Technical knowledge	Climate	Irrigation	Land
Cost of Inputs		Cost of Inputs	Cost of inputs	Cost of inputs	Irrigation	Cost of inputs
Insect pest			Insect pest	Climate	Irrigation	Insect pest
Technical knowledge				Climate	Irrigation	Technical knowledge
Climate					Irrigation	Climate
Irrigation						Irrigation
Land						

Problems	Number of Times Preferred	Rank
Cost of inputs	4	2
Insect Pests	2	4
Technical knowledge	1	5
Climate	3	3
Irrigation	5	1
Land	0	6

SOURCE: *FAO SEAGA FIELD TOOL KIT. GENDER ANALYSIS FOR SUSTAINABLE LIVELIHOODS*

Integrated Farming Systems and Natural Resource Conservation: Concepts and Importance

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Introduction

The Indian economy is predominantly rural and agricultural. But the declining trend in average size of landholding poses a serious challenge to the sustainability and profitability of farming. The average size of the landholding has declined to 1.1 ha during 2010-11 from 2.28 ha in 1970-71. If this trend continues, the average size of holding in India would be mere 0.68 ha in 2020, and would be further reduced to 0.32 ha in 2030 (Agriculture Census, 2010). As per estimates, more than 95% of the holdings will be under the category of small and marginal holders in 2050. The smallholders are major (78%) contributors to the total production but weak in terms of generating adequate income and sustaining their own livelihood. The livelihoods of the smallholder farm families are the major concern. In fact, our past experience has clearly evinced that the income from cropping alone is hardly sufficient to sustain the smallholder's livelihood. Hence, it is imperative to promote integration of different farm enterprises in the existing socio-economic condition of smallholders for additional employment and income generation round the year. Under the gradual shrinking of land holding, it is necessary to integrate land based complementary enterprises on small farms which require less space, less external inputs, optimum resource utilisation and give maximum returns. This kind of synergies and complementarities between different farm enterprises form the basis of the concept of Integrated Farming System (IFS).

Integrated Farming System (IFS)

It refers to agricultural systems that integrate livestock and crop production. IFS is judicious mix of one or more enterprises with cropping having complimentary effect through effective recycling of wastes and crop residues and encompasses additional source of income to the farmer. It could be crop-fish integration, livestock-fish integration, crop-fish-livestock integration or combinations of crop, livestock, fish and other enterprises. IFS activity is inter-dependent, inter-related and inter-linked production system. Crops, livestock, birds and trees are the major components of any IFS;

a) Crop may have subsystem like monocrops, mixed/intercrops, multi-tier crops of cereals, pulses, oilseeds, fodder, vegetables, etc.
b) Livestock component may be cows, buffaloes, goats, sheep, pigs, etc.
c) Bird component may include poultry, duckery, etc.
d) Tree component may include timber, fuel, fodder and fruit trees.
e) Other enterprises may include apiculture, sericulture, mushroom cultivation, etc.

Benefits of IFS

a) **Productivity:** IFS provides an opportunity to increase economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises.
b) **Profitability:** Use waste material of one enterprise at the least cost as input for other enterprise. Thus, reducing the cost of production, by utilizing of waste material and elimination of middleman interference in most input used.
c) **Sustainability:** Organic supplementation through effective utilization of by-products of linked component is done thus providing an opportunity to sustain the potentiality of production base for much longer period.
d) **Balanced food:** IFS links components of varied nature enable to produce different sources of nutrition for farm families.
e) **Environmental safety:** In IFS, waste materials are effectively recycled by linking appropriate components, thus minimize environmental pollution.
f) **Income round the year:** Interaction of enterprises with crops, eggs, milk, mushroom, honey, fish, cocoons, etc. provides source of income to the farmers round the year.
g) **Adoption of new technologies:** Money flow round the year due to IFS gives an inducement to the small and marginal farmers to go for the adoption of new technologies.
h) **Saving energy:** By effective recycling technique, the organic wastes available in the system can be utilized to generate biogas. Energy crisis can be postponed to the later period.
i) **Meeting fodder crisis:** Every piece of land can be utilized by planting of perennial fodder trees on field borders. These practices can address the problem of non-availability of quality fodder to the animal.
j) **Solving fuel and timber crisis:** By linking agro-forestry the production level of fuel and industrial wood can be enhanced without determining effect on crop production.
k) **Employment generation:** Combing crop with livestock enterprises would increase the labour requirement significantly and would help in reducing the problems of unemployment to a great extent. IFS provide enough scope to employ family members round the year.
l) **Agro–industries:** When the farm production in IFS is increased to commercial level there is surplus production leading to value addition which leads to the development of allied agro-industries.
m) **Increasing input efficiency:** IFS provide good scope to use inputs in different components efficiently and effectively.

Gender issues in integrated farming systems

The term *'gender'* was derived from the french word '*gendre'* means kind, type or sort. Gender refers to socially constructed roles, behaviours and expectations. It refers to a set of qualities and behaviours expected from males and females by society. Some important gender issues need to be addressed for sustaining livelihood of smallholder women farmers. Integrated farming system can address these gender issues as it involves both the male and female farmers, and both the counterparts are equal contributors in various activities of the different enterprises. IFS can integrate gender perspectives and different farm enterprises in the existing farming system. The issues pertaining to gender are;

a) **Women's triple role:** Women play reproductive, productive and community management roles in the society. Hence, time constraint is important issue of women in agriculture. Women spend less time on farm activities but work longer on reproductive activities which are not valued. The child care, household responsibilities and socio-cultural norms limit mobility of women in and outside the society.
b) **Invisible face:** Agriculture is the major activity in which 83.30% of workforce is comprised of women but this increased participation has not translated into equal employment opportunities or equal earnings for women. The census enumeration has consistently ignored the contribution of women in the unorganized sector.
c) **Access to and control over productive resources:** According to the Food and Agriculture Organization (FAO), even though women are major producers of food, they lag well behind men in ownership of agricultural land and access to income from land. It is mainly caused by cultural and traditional behaviours and norms, and can be mitigated through gender sensitive interventions.
d) **Access to extension services:** There is huge gap in number of men and women extension workers in India. About 85% of extension workers are men in India (NSSO survey, 2005). Women farmers have less contact with men extension workers than men farmers. In fact, agricultural knowledge is transferred inefficiently from men to women and vice-versa.
e) **Access to financial services:** Women have less access to credit services because of less control over economic assets, illiteracy, socio-cultural barriers, the nature of their economic activities, and inability to provide collateral requirements.
f) **Access to markets:** Despite their major role in the crop and livestock production, women frequently have poor access to markets than men, and play a limited role in the commercialization of farm products. This tendency often arises from poor marketing skills, low levels of literacy and customary practices that prevent women from freely leaving the house premises.
g) **Participation and decision-making power:** Both men and women have differences in access to productive resources, information, literacy and attitude towards suitable work for them which limit their active participation in agricultural activities. In many rural areas, cultural and social norms tend to prevent women from actively engaging in the decision-making process. Women's lower status and input into household decisions gives them restricted control and decision-making power over productive resources and income generated from farming activities.
h) **Occupational health and safety:** Women and men's close proximity to crop and animals expose them to various health risks and hazards. Women are traditionally the household members responsible for handling food for both family consumption and sale. As a result they tend to have greater exposure than men to occupational hazards and diseases.

Extension strategies for gender mainstreaming

Women farmers are less productive because they do not have enough access to technical information, credit facilities, extension services, inputs and markets. This less productiveness occurs despite their working longer hours than men. Hence, it is pertinent to build their capacity and ability to shoulder new challenges and increase their efficiency. Important extension strategies to improve women's access to productive resources are as follows;

a) **Gender balanced extension system: A**gricultural knowledge is transferred inefficiently from men to women and vice-versa. Hence, there is need to increase number of women extension workers thus leading to a gender balance in extension system. Thus, women farmers will have easy access to agricultural information and technologies.

b) **Mass media support:** The access of farm women to mass media is limited due to number of reasons. But it has potential to carry messages to a large number of farm women. However, we should examine how different media support and extension model can contribute to the dissemination of farm information and technologies to the women.

c) **Women friendly technologies:** The scope of agricultural knowledge & technologies for women farmers is increasing gradually. There are many technologies developed and standardized for agriculture by the National Agricultural Research System, but their potential for women and agriculture has not been adequately demonstrated. There is dire need to harness the potential of science and technology by demonstrating their benefits thus empowering women. Extending the women friendly tools and technological innovations will reduce the burden, and save time and energy of women.

d) **Credit and technical support:** Technical support should be provided to farm women which facilitates their multiple tasks. Credit facility should be given to women SHGs to increase income by way of developing micro-enterprises.

e) **Capacity building of women:** Different agricultural training programmes in different areas will largely improve the access to agricultural knowledge and information among farm women. Therefore, gender sensitive extension training materials should be developed.

f) **Reorientation of extension and research system:** Extension and research system should be reoriented and priorities should be given to women farmers.

g) **Women farmer groups:** There is need to organise the women farmers into groups in order to strengthen their way from subsistence cultivator to commercial cultivator. Extension workers can be trained to work more closely with women and organise them into groups.

h) **Women friendly IFS model:** Involvement of women in crop and livestock production varies according to the type of crop grown and livestock reared, and socio-economic conditions. There is need to develop scientifically designed, economically profitable and socially acceptable integrated farming systems models especially for women farmers having integration of women friendly farm enterprises.

Some women friendly farm enterprises

a) Apiculture b) Pond fishery c) Vegetable cultivation d) Vermi-composting e) Backyard Poultry f) Goatery g) Sericulture h) Piggery i) Duckery j) Marigold cultivation k) Mushroom cultivation l) Nursery m) Value added agro-products n) Biogas

The smallholder farmers having sufficient farm resources can integrate horticultural crops *viz;* fruits, vegetables and flowers as an additional enterprise along with prevailing ones. Marginal farmers living nearby fruit orchards can integrate apiary and mushroom. Farmers having sufficient irrigation water or living in low lying riverbed areas can choose fishery as an additional enterprise. Farming systems under small land holdings can only be made profitable if farmers adopt a conservative approach at all stages of farming. For this they have to utilize each and every piece of land for raising suitable crops, select viable enterprises for diversification, recycle all farm wastes and crop residues within the system itself and make productive use of farm boundaries and waste lands. They can make use of renewable sources of energy such as solar and biogas.

Constraints encountered in practicing different integrated farming systems

The integrated farming systems with different enterprise combinations practiced by farmers have some inherent constraints and can reduce some constraints of farm family. These are;

Constraints in practising IFS:

a) High initial capital investment
b) Difficult to manage various enterprises simultaneously
c) Difficulty in intercultural operations
d) Competition for resources
e) Effect of shade and defoliation on yield
f) Long transition period in tree component
g) Difficulty in animal care during peak agricultural season
h) High skill requirement
i) Difficult to market of diverse farm products

Constraints can be addressed through practising IFS:

a) Nutritional insecurity to farm family
b) Dependency on single income source
c) Low crop residue recycling
d) Off season unemployment
e) Financial risk
f) Dependency on external inputs
g) Unutilization of waste land
h) Shortage of fuel and fodder
i) Difficulty in sustaining livelihood

Natural Resource Conservation

Conservation is the proper management of a natural resource to prevent its exploitation, destruction or degradation. Conservation is the sum total of activities, which can derive benefits from natural resources but at the same time prevent excessive use leading to destruction or degradation.

Need for Conservation of Natural Resources

There is an urgent need to conserve the nature. Some of the needs are : 1) To maintain ecological balance for supporting life. 2) To preserve different kinds of species (biodiversity). 3) To make the resources available for present and future generation. 4) To ensure the survival of human race.

Classification of Natural Resources

a) Inexhaustible Resources: The resources which cannot be exhausted by human consumption and other uses, are called inexhaustible resources. These include energy sources like solar radiation, wind power, water power (flowing streams) and tidal power, and substances like sand, clay, air, water in oceans, etc.

b) Exhaustible Resources: On the other hand, there are some resources, which are available in limited quantities and are going to be exhausted as a result of continuous use. These are called exhaustible resources. For example, the stock of coal in the earth is limited and one day there will be no more coal available for our use. Petroleum is another important exhaustible resource.

1) Renewable Resources: Some of the exhaustible resources are naturally regenerated after consumption and are known as renewable resources. e.g. The living beings (both animals and plants) reproduce and can thus, replace the dying or killed individuals. However, if the consumption of these resources exceeds the rate of regeneration they may also get totally exhausted. Some examples are fresh water, fertile soil, forest (yielding wood and other products), vegetation, wildlife, etc.

2) Non-renewable Resources: The resources, which cannot be replaced after the use, are known as non-renewable Resources. These include minerals (copper, iron etc.) fossil fuels (coal, oil etc.). Even the wildlife species (rare plants and animals) belong to this category.

Participatory Rural Appraisal (PRA) tools for studying farming systems

PRA is a methodology for interacting with farmers, learning from them and analyse their strengths, weaknesses, opportunities and threats to formulate research plan. The problems involved in farming systems can be understood through PRA. There are some important PRA tools to identify the farming systems and scope for integrating different farm enterprises as follows;

a) **Transect walk:** Transect is the walk through the village in a particular direction along with some key informants. A transect walk is a tool for describing and showing the location and distribution of resources, features, landscape, main land uses along a given transect. The main objective of transect walk is to understand and study the cause and effect relationships among topography, natural vegetation, cultivation, and other production activities.

b) **Agro-ecological map:** Agro-ecology map indicates the relation between agriculture and environment which includes average temperature, average rainfall, fragmentation of holdings, natural vegetation, drainage system, weeds, etc. It indicates the macro and micro ecological features. The flora, fauna, basic land use pattern such as agro-forestry, forest cover and wasteland are also depicted in the map.

c) **Bio-resource flow**: It is made to study bio-resources and their utilization in different farm enterprises. The purpose is to study the limitations in existing bio-resource utilization and suggesting alternatives for sustainable bio-resource flow. Bio-resource flow diagram reflects the inflow and outflow of farm produce and its by-products from and to the household as well as among different farm enterprises.

d) **Seasonal calendar:** It depicts month-wise activities for different farm enterprises (crops, animals, etc.) in a year. Seasonal calendar of agricultural practices depicts the time-to-time different farm enterprises related operations being carried out on the farm.

e) **Gender disaggregated seasonal calendar:** The gender disaggregated seasonal calendar indicates the differential involvement of men and women in different farm enterprises according to agricultural seasons.

f) **Livelihood analysis:** This is an analytical technique of exploring behaviours, decisions and coping strategies of households with different socio-economic backgrounds. While analyzing the livelihoods, all the household members including both men and women should be involved. The livelihood analysis indicate the major enterprise on which farm families are dependent, their income and expenditure patterns of the enterprises, thereby enabling for planning the developmental activities based on their livelihoods.

g) **Technology map:** The technology map indicates the technology decision behaviour of the farmers in terms of adoption, over adoption, reinvention, rejection and discontinuance with reference to the agricultural technologies. Technology map comprises of type and frequency of adoption of latest farm technologies. It helps scientists and extension workers to identify the problems of the farmers in technology adoption.

Conclusion

As one of the most populous nations with a high percentage working in agriculture, this is time to focus on women's skill improvement, women friendly technology development, organisation of women groups, providing equal access to and control over productive resources, collecting gender-disaggregated data for designing women friendly policies and bottom-up gender sensitisation will help in creating space for women farmers in Indian agriculture. Generating educated, trained, self-reliant, self-motivated, innovative, responsible and visionary women farmers who can lead our agriculture out of their multiple roles is the great challenge ahead especially when India is on the verge of a second green revolution. The choice of enterprise and crops in any combination should take into account the available resources, crop geometry and environmental conditions. The marketing channels for inputs and outputs for a particular enterprise combination should not be excessively risk-prone. The particular enterprise combination can be successful once credit, information about know-how, market and other farm inputs are well established. Potential improvements and increased productivity from the various enterprises can only come from a better understanding of the nature and extent of the interactions various enterprises and natural resources, economic benefits, as well as the impact on the livelihoods of small farmers and the environment. Research on these aspects provides major challenges for sustainable agricultural development through integrated farming systems in the future.

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Integrating Tuber Crops in IFS for Livelihood Enhancement of Farm Families

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1. Introduction

ICAR 2050 vision document emphasizes raising of agricultural income and employment opportunities (ICAR, 2015). Per capita availability of land has been declining continuously in India. It has declined from 0.5 ha in the year 1950 to 0.15 ha during 2000 A.D (Mahapatra, 2008). It is expected to reach 0.08 ha by 2021. Hence, income through arable farming alone is insufficient for small and marginal farmers. Activities such as piggery, dairy, poultry, pisci-culture, sericulture, biogas, agro-forestry, agro-horticulture *etc*. assume critical importance in supplementing farm income. It fits well with farm level infrastructure and ensures fuller utilization of byproducts such as poultry manure as fish feed in poultry-fish farming system. The only alternative left for the small and marginal farmers is Farming System Approach (FSA). Etienne (2011) writes that the next stage of green revolution may be more complex and knowledge based. He also highlighted the importance of availability of energy and connectivity.

2. Farming system approach

2.1. Definition

The term 'farming system' can also mean different things to different people. To avoid ambiguity and confusion, both terms 'farming' and 'system' should be clearly understood. Farming is the process of harnessing solar energy in the form of economic plant and animal products and the system implies a set of inter related practices/processes organized into a functional entity.

Farming System therefore defined as '*a set of agricultural activities organized while preserving land productivity, environmental quality and maintaining desirable level of biological diversity and ecological stability*'.

The emphasis is more on a system rather than on gross output. In other words, farming system is a resource management strategy to achieve economic and sustained agricultural production to meet diverse requirements of the farm household while preserving the resource base and maintaining high environmental quality. The farming system in its real sense will help in productivity, profitability, potentiality/sustainability, balanced food, recycling resources and employment generation to lift the economy of Indian agriculture and standard of living of the farmers of the country as a whole.

2.2. Basic principles of FSA

FSA is based on the following basic principles:

Make the farm household self sufficient; make the farm free from being vulnerable to external forces. Enterprise diversification aims to increase income, minimizes the spread risks, enhance natural resources and the environment and improve the diet of farm families.

Farming system seems to be the answer to the problem of increasing food production, for increasing income and for improving nutrition of the small-scale farmers with limited resources without any adverse effect on environment and agro-ecosystem.

2.3. Advantages of farming system

Farming system aims at maximum utilization of on-farm inputs and minimum of purchased inputs for higher productivity. Byproducts of one enterprise (i.e. poultry manures) are used as input (i.e. fish feed) into other enterprises, which can reduce the cost of production.

2.3.1. Productivity

Farming system provides an opportunity to increases economic yield per unit area per unit time by virtue of intensification of crop and allied enterprises. Time concept by crop intensification, space contact by building of vertical dimension through crop and allied enterprises are the ways to increase the productivity indicated above.

2.3.2. Profitability

The system as a whole provides opportunity to make use of the produce /waste material of one component to another component at the minimal cost. Thus the cost of production is reduced in the components and the profitability per rupee invested is enhanced by eliminating the interference of middle man in most of the input use. While working out the net income for the farm as a whole, the benefit cost ratio increases.

2.3.3. Potentiality

Of late, within enthusiasm to produce more and more food from the land area available to meet the requirement of population increase of 2.2% per year (Srinivasulu Reddy and Nedunchezhiyan, 2008), huge quantity of inorganic fertilizers, pesticide and herbicide are applied. Thus soil and environment are becoming increasingly polluted. Once when we loose large land areas by such degradation the productivity of the soil gets drastically reduced in course of time. In farming system organic supplementation through effective utilization of byproducts of linked components is done thus providing an opportunity to sustain the potentiality of production base for much longer periods.

2.3.4. Balanced food

In the farming system, components of varied nature are linked to produce different sources of nutrition viz. protein, carbohydrates, fat, minerals, vitamins etc. from the same unit area. This will provide an opportunity to solve the malnutrition problem that exists in the diet of the average Indian.

2.3.5. Recycling

Farming system establishes its stability due to effective recycling of produces/waste materials of any one of the components as input to the other component linked in the programme. Thus by way of recycling his/her own material at the farm level, the farmers could reduce the cost of production and increase the net income of the farm as a whole.

2.3.6. Nutrient management

In farming system the nutrients requirement of the crop is met through the use of on-farm available resources. Further in farming system nutrients are applied considering whole cropping patterns and cropping sequences. Hence nutrient losses through various farms are minimized in farming systems.

2.3.7. Soil microbial productivity

Intercropping stimulates horizontal transfer of beneficial rhizospheric microorganisms such as non-symbiotic N_2 fixing bacteria (*Azospirillum* spp.), phosphorus solubilizing bacteria, sulphur oxidizing bacteria etc. among the component crops rhizosphere (Ghai and Thomas, 1989; Schnurer et al., 1986). It ensures enhancement in microbial numbers and biomass dynamics in the cropping system and is influenced by seasonal changes.

2.3.8. Employment generation

Combining crop with livestock enterprises would increase the labour requirement significantly and would help in reducing the problem of under employment to a great extent. Farming system provides enough scope to employ family labour round the year.

Various enterprises that could be included in the farming system are crops, dairy, poultry, goat rearing, fishing, sericulture, agro-forestry, horticulture, mushroom cultivation etc.; thus, it deals with whole farm approach to minimize risk and increase the production and profit with better utilization of wastes and residues. It may be possible to reach the same level of yield with proportionately less input in the farming system and the yield would be more sustainable because the waste of one enterprise becomes the input for another, leaving almost no waste to pollute the environment or to degrade the resource base (soil and water). To put this concept into practice efficiently it is necessary to study the linkage and complementarities of different enterprises in various farming systems.

2.3.9. Climate changes

Over 80% of our farms are less than 1 ha in size and mostly mono cropped. It will be extremely difficult for small and marginal farmers to face individually the adverse impact of climate change leading to higher frequency of drought and flood. Under such situations the immediate need is introduction of multitier cropping system which can confer on farmers with small holding the power and economy.

3. Farming system classification

Predominant farming systems classified based on the net returns which are more than 50% derived from single enterprise. Horticultural farming was identified as the pre-dominant farming system in the western zone of Tamil Nadu and it was practiced by 46.2% of total farmers followed by agriculture farming (17.2%) and livestock farming system (9.0%) (Saravanakumar et al., 2012). Diversified farming was the major farming system being practiced by all categories of farmers where the income derived from cereals, vegetables and livestock sources (Saravanakumar et al., 2012).

Labour scarcity, high input cost, non-availability of time sensitive critical inputs and low price of outputs were the major constrains faced by the farmers under various farming systems which was also reported by Saravanakumar and Jain (2008).

4. Tropical tuber crops

Tropical tuber crops are the most important food crop after cereals and grain legumes. They are known as energy banks of nature serving either as primary or secondary staple to one fifth of world's population. Tuber crops have myriad and complex roles to play in the food and nutritional security as well as hunger reduction. They are used for food, medicine, animal feed and raw material for starch based industries. International Food Policy Research Institute (IFPRI), Washington has predicted that there is likelihood of shortfall of 41% in food production in India by 2020 and need to produce 300 m t of food by 2010. To meet out food requirement, Indian agriculture has to go for horizontal as well as vertical increase in crop production. As the cultivable area is decreasing year after year, increasing cropping intensity by multiple cropping has little scope; however, the vertical increase in production has tremendous potential. Further, most of the crops have reached its genetic potential and achieved yield maxima. Tuber crops are however yet to exploit its genetic potential with sustainable production technologies. The commonly cultivated tropical tuber crops are: Cassava (*Manihot esculenta*), Sweet potato (*Ipomoea batatas*), Elephant foot yam (*Amorphophallus paeoniifolius*), Taro (*Colocasia esculenta* var. *anticorum*), Bunda (*Colocasia esculenta* var. *esculenta*), Swamp taro (*Colocasia esculenta* var. *stoloniferum*), Tannia (*Xanthosoma sagittifolium*), Lesser yam (*Dioscorea esculenta*), Greater yam (*Dioscorea alata*), White yam (*Dioscorea rotundata*), Aerial yam (*Dioscorea bulbifera*), Yam bean (*Pachyrhizus erosus*), Chinese potato (*Solenostemon rotundifolius*), Arrowroot (*Maranta arundinacea*) etc.

Tuber crops are capable to utilize available resources more efficiently especially in partial sunlight and residual moisture (Nedunchezhiyan and Laxminarayana, 2006). Great flexibility in planting and harvesting are additional characters of these crops which are optly suitable to include in any farming systems.

Tuber crops based farming system includes growing tuber crops with other seasonal, horticultural and silvi-cultural crops either mixed/intercropping or sequential cropping; utilization of tubers and leaves in animal production either in fresh or processed form. Further byproducts of tuber crops such as cassava bagasse are utilizing in allied activities.

5. Cassava

Cassava is a popular crop among all the tropical tuber crops. It is grown in Asia, Africa, South America and Latin America. In India, cassava is being cultivated on an area of 0.24 m ha with a production of 6.7 m t (FAOSTAT, 2005). Cassava is an important crop in South India (Kerala, Tamil Nadu and Andhra Pradesh) and is slowly spreading to Western (Maharastra) as well as Eastern (Orissa) and Northeastern (Assam, Meghalaya and Tripura) India.

Cassava tubers are utilized primarily as human food after boiling, frying, baking or steaming. They are used in a variety of food products like sago, noodles, wafers, rava, jam, chips, flakes, puddings and other confectionary items. Leaves and tubers also form an important component of animal feed and are extensively used in feed for cattle, poultry and swine. The other uses of cassava are in industry where it is used for production of starch, liquid glucose, dextrin, high fructose syrup, alcohol and preparation of biodegradable plastics.

The biochemical constituents in cassava tuber on fresh weight basis are as follows: dry matter 40%; starch 32.5%; total sugars 0.5%; protein 0.8%; fibre 0.5%; fat 0.2%; ash 1%; calcium 0.05%; phosphorus 0.04%; vitamin C 0.025%; cyanoglucoside 25-400 μg cyanide/g of tuber. The biochemical constituents in cassava leaf on fresh weight basis are as follows: dry mater 22%; starch 8%; protein 8%; fibre 2%; fat 1.7%; ash 1.5%; calcium 0.125%; phosphorus 0.08%; vitamin C 0.25% and cyanoglucoside 350-600 μg cyanide/g (Kay, 1987; Bradbury and Holloway, 1988). Some cassava genotypes are rich in β-carotene. The rind of the tubers and seed extract are found to have biopesticidal properties especially for nematodes and insect pests.

5.1. Cassava and livestock production

Farmers' part of their cassava produce can be fed to livestock by properly storing and processing. This will reduce the purchase of feed from out side sources. Cassava dried chips are fed to livestock and poultry in India, China, USA and South East Asian countries. Cassava foliage made into silage is fed to livestock in Brazil. In animal feed, both fresh and dried cassava tubers in different forms such as sliced, chopped, grounded and pelleted are used. In the European countries large quantities of cassava chips, pellets and meals are being imported for animal feeding. Inclusion of cassava up to 65% in pellet form had not affected health, carcass quality or overall performance of pigs. Feed formulae for cattle wherein cassava chips form ingredients from 24 to 43% has been recommended in Kerala, India (KAU, 2001). As cassava tubers contain low amount of protein (1-2%), its use as animal feed for monogastric animals is limited. However, it is found that cassava meal could be included in poultry rations up to 40% without any detrimental nutritional effect, provided nutrient content of ration meet the poultry requirements (Kompiang *et al*., 1994). Raw chopped cassava tubers supply major source of energy for growing finishing pigs if properly supplemented with protein, minerals and vitamins. Pigs given chopped raw tubers with a protein supplement gained less weight but feed conversion ratio (FCR) was similar when compared to maize-soybean (*Glysine max*) meal ration (Ly *et al*., 2008). Under humid conditions, it is difficult to dry cassava tubers and hence, root silage can be processed. The silage feeding had similar performance for growing and finishing pigs as those were given with fresh cassava tubers (Buitrago *et al*., 1978). One of the major factors for restricted use of cassava tuber in swine diets is the presence of cyanogenic glucosides and linamarin. Various processing methods like boiling, chopping, crushing followed by sun drying remove cyanogenic glucosides (Maner, 1973; Tewe, 1992). The low cyanogenic glucosides varieties can be used in feed preparations.

In Central Vietnam, cassava roots are preserved by making silage under village conditions for feeding pigs. After harvesting, the roots are cleaned, grated and mixed with 0.5% salt. The mixture is put into large plastic bags of 20-30 kg, the wet mass is compacted to expel inside air and the bags are tied. The roots are left to ferment naturally. The mixture can be ready in 2-3 weeks after ensiling and is stored for 6-8 months (Ly *et al*., 2008).

Cassava meal is prepared by chopping whole tuber followed by drying. Cassava meal can substitute maize about 16% crude protein (CP) diets (Sankaran *et al*., 2008). A slight decrease in ADF was noticed as the level of cassava meal is increased. But intake was similar indicating that palatability is not a problem in cassava meal based diets. A level of 680-770 g ADF could be reduced using cassava meal based ration. Piglets from weaning to 20-25 kg body weight (BW), given diets containing 20-25% cassava meal showed similar performance as those given with maize-soybean meal ration (Sankaran *et al*., 2008). Cassava bagasse, a byproduct of starch extraction from cassava tubers can be successfully used as feed for growing and lactating cows which possesses 2.0% digestible crude protein (DCP) and 64% total digestible nutrients (TDN) (Ranjan, 1980).

The crude protein content (dry basis) of cassava tubers can be increased by solid state fermentation with *Aspergillus niger* from 3 to 18-42%. The product is named as protein enriched cassava or 'Cassapro", brand name which is quite popular in Indonesia (Kompiang *et* *al*., 1994). The dried fermented cassava tubers may be fed directly to ruminants or may be grounded to a 1.0 mm mesh before feeding to monogastrics.

Cassava leaf yield is ranged from 2-8 t of dry matter /ha/year depending up on variety and soil fertility. The leaves are high in crude fibre (CF) and crude protein as compared to tubers. Cassava leaf meal is deficient in methionine but rich in lysine. Ensiling of cassava leaves is an appropriate way to conserve them. Nutritional value of cassava leaves may be increased by fermentation with *A. niger* using a similar process as for cassava tubers. Other advantages obtained through this process are that the toxic content of cyanogenic glucosides in leaves may be significantly reduced and fermented product may be stored for an extended period as they are in the form of powder and easily transported to other places if required. The bioprocess technology using *A. niger* to cassava leaf meals increased protein content and digestibility of dry matter and protein (Darma, 1994, 1995). As cassava leaf meal is an important source of β-carotene, it has great potential as feed for poultry and fish.

Ensiling cassava leaves with either rice bran or cassava root meal at 5 or 10% or with fresh grated cassava roots at levels of 20-50% (on fresh weight basis) produced good quality silage that could be stored for up to five months (Ly *et al*., 2008). Under village conditions using 20-60% ensiled cassava roots in the diets (as DM) of growing pigs increased the live weight gain, decreased the feed conversion ratio and reduced feed cost by 7.3-18.3% (Ly *et al*., 2008). Using a 13-15% of DM inclusion of ensiled cassava leaves in the pig ration containing 30% ensiled cassava roots (as DM) as replacement for sweet potato vines and partial replacement of fish meal in diets of growing pigs did not significantly affect the growth rate but reduced feed cost/kg gain by 12-26% (Ly *et al*., 2008). Supplementation with 0.1% methionine in diets containing 30% ensiled cassava roots and 15% ensiled cassava leaves of growing pigs improved the performance of these pigs (Ly *et al*., 2008). Ensiled cassava leaves can also be used as a supplemental source for feeding pigs (Ly et al., 2008). In Hue province of Vietnam, ensiled cassava roots and leaves were used for pig feeding. In 2003, there were 1172 households used this technology for feeding 2910 pigs and obtained gross income of 185.060 million VND over three years (Ngoan, 2008).

During harvesting season cassava stems are available in plenty which have many uses in rural areas. Dried stems after removal of bark are used as fuel and the stem scrapping are fed to cattle. Tender stems are used for feeding livestock after crushing into pieces.

5.2. Cassava and fish production

Starch is one of the important ingredients in fish feeds. It is the source of energy as well as excellent binder. Cassava is being utilized as fish feed ingredient in several parts of the world. In fact all parts of cassava are useful in fish culture. Cassava leaf is an excellent fodder rich in protein and can be utilized for feeding fishes like grass carp and *Barbus gonionotus* (Sankaran *et al*., 2008). Cassava stem is an excellent material for periphyton development and fishes like tilapia, rohu, and mrigal browse the partially decomposed skin with periphyton (Sankaran *et al*., 2008). Dried and powdered tubers are utilized as a starch source as well as a binder to have good quality pelleted feed.

Falayi *et al*. (2001) evaluated the economic losses due to leaching of feed nutrients in fish farming at Nigeria and reported that cassava tuber was the most efficient ingredient tested in terms of nutrient retention, higher growth, feed utilization and economic evaluation indices as compared to all other binders tested. Adebayo *et al*. (2003) reported that cassava meal can be used at 2% level to reduce nutritional loss in fish feed. Boscolo *et al*. (2002) reported that cassava meal can be incorporated up to 24% in the feed of Nile Tilapia for reducing feed cost without any adverse effect on its growth and performance. El-Baki *et al*. (1999) reported that the cassava root meal can be incorporated upto 50% replacement of corn meal without affecting performance of Nile tilapia in Egypt.

Oresegun and Alegbeley (2002) reported that 30% of the starch ingredient can be replaced by cassava peel with an addition of 0.4% methionine in pelleted feeds to maintain the serum and tissue thiocyanate concentration for tilapia. Akegbejo-Samsons (1999) reported that cassava flour can replace the yellow maize totally in the fish feed for African catfish. Cassava flour can be used for replacement of starch source without any noticeable change in fish production in common pond fish culture in Tripura, India (Santhosh *et al*., 2006). Cassava is the second most commonly used fodder for integrated fish culture in Malaysia (Ahmad, 2003). The palatability tests conducted using grass carp in Tripura, India also showed that cassava leaves are preferred by grass carps than other plant materials tested. Better growth rate of grass carp fingerlings were observed when green cassava leaves were fed compared to five commonly used grasses in laboratory level experiments (Santhosh, 2006).

Cassava stem with its soft coating easily disintegrates in pond water and forms a thick mass of periphyton that fishes prefer to browse upon. It is popularly advised to small farmers to go for cassava cultivation around the ponds and feed the fishes with the green fodder produced out of it. Even in lean season, cassava produces good vegetation and can be used for feeding fishes. The varieties which are having luxuriant foliage are ideal for this purpose.

Cassava bagasse can be utilized for phytase production after addition of a nitrogen source and mineral salts (Hong *et al*., 2001). Rajeshwarisivaraj *et al*. (2001) found that activated carbons prepared from waste cassava peel are efficient as adsorbents for dyes and metal ions.

6. Sweet potato

Sweet potato is ranked seventh in food crops and next to cassava among the root and tuber crops grown in the world. It is cultivated through out the tropics, subtropics and warmer temperate regions. In India, sweet potato is cultivated in 0.112 million ha with the production of 1.09 million tonnes (NHB, 2013). Odisha ranks first in area (43,460 ha) and production (4,10,100 tonnes) (NHB, 2013). Sweet potato roots and tops are highly nutritious, which can be used to combate nutritional deficiencies in many parts of the developing world. The roots are primarily used as human food after boiling, frying, steaming and baking. Apart from source of energy, roots also contain significant quantities of water soluble vitamins *i.e.,* ascorbic acid, thiamin, riboflavin and niacin. The contents of pyridoxine, folic acid and pantothenic acid may be relatively high. Raw leaves and tender tips are also excellent sources of ascorbic acid and some of the B-vitamins especially riboflavin which is deficient in many Asian diets. However, high percentages of water soluble vitamins are lost on cooking (Woolfe, 1992).

The biochemical constituent of sweet potato tubers are energy 490 kJ/ 100 g; water 65-81%, protein 0.95-2.4%; fat 0.4-6.4%; carbohydrate 25-32%; fibre 0.9%; ash 0.9-1.4%; calcium 30-34 mg/ 100 g; iron 0.8-1.0 mg/ 100 g; magnesium 24 mg/ 100 g; phosphorus 49 mg/ 100 g; potassium 373 mg/ 100 g; sodium 13 mg/ 100 g; carotene trace to 12 mg/ 100 g; thiamine 0.1 mg/ 100 g; riboflavin 0.05-0.06 mg/ 100 g; niacin 0.6-0.9 mg/ 100 g; ascorbic acid 23-25 mg/ 100 g (Kay, 1987; Bradbury and Holloway, 1988; Wheatley *et al.*, 1995).

6.1. Sweet potato and livestock production

Culled and damaged tubers as well as green tops are used for feeding livestock (Nedunchezhiyan and Ray, 2010). Sweet potato is the common feed crop for livestock in many countries including China, India, Philippines, Vietnam, Taiwan, Uganda, Papua New Guinea and Indonesia (Naskar *et al.*, 2008). In India unmarketable roots and vines after harvest are fed to pig and other livestock. Both root and foliage provides energy and protein respectively which can be used fresh, boiled, dried or fermented into silage (Woolfe, 1992; Ray and Tomlins, 2010). The chemical composition of the tuber shows 17-23% dry matter contents and DM digestibility above 70% (Nedunzhiyan, 2001).

In China which is the leading sweet potato producing country in the world, half of the produce goes to feed pigs (Scott, 1991). It is hoped that higher global prices for corn and strong demand for animal meat will further escalate sweet potato demand as animal feed. Massey *et al*. (1976) reported that increased vitamin A content in milk and increased milk production up to 0.75 kg/cow/day were observed when sweet potato roots were fed. In a pig ration feeding substitution trial, Naskar *et al*. (2008) reported that boiled sweet potato tubers could be fed to the level of 40% of total dry matter intake to the weaned piglet for higher growth rate and nutrient utilization whereas up to 60% of total dry matter intake to grower pig along with good quality protein supplement for better growth performance.

Sweet potato vines can be fed to pigs either in fresh form or after drying. Nedunzhiyan *et al*. (2000) reported supplementary application of sweet potato fresh vines improved the digestibility of the pigs. Vines can be dried and grounded into a meal. Sweet potato vine meal can be used in compounded pig rations, but only at low levels. It should not be used more than 5% level in pig rations.

Sweet potato meal can also be included in poultry ration. In rations of young birds that are less than eight weeks old, sweet potato can be used up to 20%. As the birds grow bigger, it can be increased gradually and in rations of laying chickens it can be used up to 30%. Fresh green leaves of sweet potato can be chopped and given to birds in addition to mash to the tune of 3%.

Dried and powdered sweet potato can be utilized for fish feed along with other ingredients. Sweet potato leaves can be used as a fish feed for grass carp. Mokolensang (2003) reported that sweet potato distillery byproduct increased growth of common carp more than conventional feed in experimental conditions.

Pig manure produced in the farm is decomposed and applied to sweet potato field in China and Northeastern states of India. Pig manure application reduces cost of cultivation of sweet potato (Nedunchezhiyan and Srinivasulu Reddy, 2002). Application of pig manures in sweet field helps to rebuild the fertility status of the soil (Nedunchezhiyan and Srinivasulu Reddy, 2004). The pig-sweet potato system generates additional employment and improves the living standards' of the farmers (Srinivasulu Reddy and Nedunchezhiyan, 2008).

A fast growing sweet potato variety can be used as cover crop in pond slopes. The foliage can check siltation of the pond sand prevent shallowing the fish culture ponds. Thus it serves dual purpose, providing fodder to fish and strengthen the slopes/bunds of the ponds (Palaniswami and Peter, 2008). Harvesting of these cover crops should be restricted because it may loosen the soil.

7. Yam

Yam is grown throughout the tropics and sub-tropics, where rainfall is sufficient for their growth. In India, though yam is cultivated in all most all the state in homestead gardens. Yam is commercially cultivated in certain specific locations in Andhra Pradesh, Bihar, Gujarat, Kerala, Orissa, Madhya Pradesh, Tamil Nadu and Rajasthan. However no statistical data is available.

Yams are basically carbohydrate foods with relatively high protein and ascorbic acid contents. The edible portion of fresh tuber contains energy 439 kJ/ 100 g; water 72.4%; protein 2.4%; fat 0.2%; carbohydrate 42.1%; fibre 0.6%; calcium 22 mg/100 g; iron 0.8 mg/100 g; thiamine 0.09 mg/100 g; riboflavin 0.03 mg/100 g; niacin 0.5 mg/100 g; ascorbic acid 10 mg/100 g (Kay, 1987). In general avitominosis C (scurvy) is rare in yam growing countries.

8. Elephant foot yam

Elephant foot yam (*Amorphophallus paeoniifoilus*) is cultivated for its edible corms in India, phillipines and Malaysia. In India, it is grown in Andhra Pradesh, Tamil Nadu, Kerala, Orissa, Bihar, West Bengal, Uttar Pradesh, Maharastra and Gujarat.

The biochemical composition of elephant foot yam corms on fresh weight basis are energy 330 kJ/100 g; water 72-79%; protein 1.7-5.1%; fat 0.2-0.4%; carbohydrate 18-24%; fibre 0.6-0.8%; ash 0.7-1.3%; calcium 50-56 mg/100 g; iron 0.6-1.4 mg/100 g; phosphorus 20-53 mg/100 g; vitamin A 434 IU/100 g; thiamine 0.04-0.06 mg/100 g; riboflavin 0.05-0.08 mg/100 g; niacin 0.7-0.75 mg/100 g; ascorbic acid trace-3 mg/100 g. The most of the carbohydrate is starch (75-80%); the starch granules vary in shape and size (5.5-19 microns) (Kay, 1987).

9. Taro

Taro otherwise known as cocoyam is grown throughout the tropical and sub-tropical countries. Nigeria leads in area (0.735 m ha) and production (4.027 m t) in the world and it is followed by Ghana (0.270 m ha; 1.8 m t) (FAOSTAT, 2005). The highest productivity is reported from Egypt (FAOSTAT, 2005). In India, it is grown in all most all the states, but commercially cultivated in Andhra Pradesh, Tamil Nadu, Kerala, Orissa, Uttar Pradesh, Maharastra and Gujarat. However the area and production statistical data is not available.

Corms and cormels are rich in starch; the flesh is mealy to smooth and usually has a somewhat nutty flavor. The composition of the edible portion of the fresh corms has the following: energy 373-406 kJ/100 g; water 73-78%; dry matter 24-26%; carbohydrate 19-21%; starch 15.5-18.0%; total sugars 1.75-1.90%; protein 1.4-3.2%; fat 0.1-1.5%; fibre 0.4-2.9%;

ash 0.6-1.3%; calcium 32-44 mg/100 g; iron 0.8-5.27 mg/100 g; phosphorus 64-135 mg/100 g; manganese 0.19-0.26 mg/100 g; potassium 514-575 mg/100 g; sodium 7-9 mg/100 g; carotene trace-67 IU/100 g; thiamine 0.09-0.18 mg/100 g; riboflavin 0.03-0.04 mg/100 g; niacin 0.4-0.9 mg/100 g; ascorbic acid 0.10 mg/100 g (Kay, 1987).

10. Farming system involving tuber crops

10.1. Pond based farming system involving tuber crops

Kandhamal district in Odisha state is a hilly terrain dominated by Kandha tribes. They are resource poor small and marginal farmers. Tribal farmers cultivate extensively but harvest minimum because of their low resource use capabilities. They grow rice and ragi in uplands by direct seeding and low lands by transplanting. Being rainfed ecosystem, they cultivate during rainy season and land remains fallow during post rainy season. Food insecurity is regular feature in their life. Diversification into farming system mode in small holder farming appears promising to secure future and nutritional security at the grass root level (Singh, 2012). Farming system is integrating existing sub systems on a farm to harness maximum efficiencies and develop sustainable resource use systems which will optimize their use, minimize degradation with consideration to regenerative capacity and increase income and employment for farm families and promote quality of life and environment.

During the year 2013-14, four community pond based farming system involving tuber crops study was conducted at Gadragoan village according to the farmers conditions, resources and needs. The major objective was to develop an appropriate integration of crops, livestock and fish for round the year employment, income and sufficient food to farm family on the farm. Gadragoan was a typical tribal village in Chahali GP, Chakapad Block, Kandhamal District, Odisha state under Tribal Sub Plan programme by the ICAR-Central Tuber Crops Research Institute, Regional Centre, Bhubaneswar. The village was having uplands, medium lands and lowlands. The village was also having four farm ponds and 31 farm families. All the four farm ponds were renovated and able to collect run off water during rainy season. Each farm pond size was approximately 400 m^2. Four community pond based tuber crops involving farming system research was conducted with the components of rice, tuber crops, fish, vegetables, poultry and goat (Table 1). The area and components of all the four community pond based farming system involving tuber crops was same. Each farming system study was 2.5 ha with the total area of 10 ha. Seven to eight tribal families involved in each community pond based tuber crops involving farming system covering 31 farm families. The Goat and poultry manures collected from the sheds were composted and then applied to crops and fish ponds. Sweet potato vines after harvest, and culled and damaged tubers were fed to goats. Broken rice and maize kernels and surplus grains were fed to poultry birds. However, during day time goats were taken for grazing in near by forest and poultry were scavenging in backyards.

Shortage of water was observed for drinking and cleaning of livestock and shed, domestic use of farm family, irrigation to plantation crop during dry months in rainfed farming areas. Therefore for sustaining water availability in the farm, a farm pond and shallow dug well are the essential components of rainfed farming system that helps for life saving irrigation, rabi vegetable production and household domestic needs. A diversified farming with a farm pond received sufficient water to fulfill the water requirement for optimal productivity under limited water supply.

Yields of crops, goat, fish and poultry for the four community pond based farming system involving tuber crops were collected; averaged it and presented in the Table 1. In community pond based tuber crops involving farming system, apart from rice, tuber crops, vegetables etc. were produced along with goat, fish and poultry. The community pond based tuber crops involving farming system produced 19,479 kg of rice equivalent yield and net return of Rs 2,27,980/2.5 ha. Whereas cultivation of rice alone produced 8,960 kg of rice and net return of Rs 91,700/2.5 ha. Part of the yields of grains, pulses, tuber crops, vegetables, egg, meat and fish were sold for cash income. By marketing of vegetable, fruit, flower, and livestock product (milk and meat) a farmer is able to earn sufficient money to meet out daily needs. The cash income from each community pond based farming system involving tuber crops was distributed to the respective numbers of farm families which would be helpful in covering up major expenditures like festivals, ceremonies etc. Further availability of tubers for household consumption for long period due to high storability along with other vegetables, rice, fish, egg and meat enhanced food and nutritional security of the household. The cash income improved the livelihoods of the farm families.

Table 1. Community pond based tuber crops involving farming system components, yield and economics (Mean of four)

Sl. No.	Crop/animal	Area (ha)	Yield (kg)	Rice equivalent yield (kg)	Gross Income (Rs)	Expenditure (Rs)	Net income (Rs)	Employment generation (man-days)
1	Rice (Gangabali)	1.2	4300	4300	86000	42000	44000	264
2	Sweet potato (Kishan & ST 14)	0.4	4225	1690	33800	16000	17800	60
3	Yam bean (RM-1)	0.4	7540	3770	75400	22000	53400	56
4	Greater yam (Orissa Elite)	0.1	2400	2400	48000	18000	30000	26
5	Elephant foot yam (Gajendra)	0.1	2225	2225	44500	20000	24500	25
6	Taro (Muktakeshi)	0.1	1850	1850	37000	18000	19000	22
7	Cassava (Vellayani Hraswa)	0.1	1895	474	9480	4200	5280	22
8	Fish (pond) (Rogu, Catla, Mrigal)	0.04	150	600	12000	5000	7000	20
9	Vegetables (*Amaranthus*, bhendi,	0.02	1800	900	18000	5000	13000	30

	brinjal, beans, potato etc.)							
10	Poultry (Vanaraja): 20 Nos.	0.02	70	420	8400	1400	7000	10
11	Goat (Ganjam local): 5 Nos.		42.5	850	17000	10000	7000	25
Total		2.5	-	19479	389580	161600	227980	560

Check/Control

Sl. No.	Crop	Area (ha)	Yield (kg)	Gross Income (Rs)	Expenditure (Rs)	Net income (Rs)	Employment generation (man-days)
1	Rice (Gangabali)	2.5	8960	179200	87500	91700	550

Rice: Rs 20/kg; Sweet potato Rs 8/kg; Yam bean Rs 10/kg; greater yam Rs 20/kg; elephant foot yam Rs 20/kg; Taro Rs 20/kg; cassava Rs 5/kg; Fish Rs 80/kg; vegetables Rs 10/kg; poultry Rs 120/kg; goat meat Rs 400/kg

There is no additional employment generated in community pond based tuber crops involving farming system compared to monoculture of rice. This was due to inclusion of tuber crops cultivation. Tuber crops though long duration, cultivation was less labour intensive. But employment was distributed through out the year in community pond based tuber crops involving farming system. Whereas in monoculture rice, the total employment generated was spread within seven months (June-December) only. Thus dependency on out side family labours was much less in community pond based tuber crops involving farming system. Pali et al. (2012) also reported generation of additional 12 days employment in 0.4 ha pond based integrated farming system.

10.2. Farming system involving tuber crops (0.4 ha)

During the year 2014-15, participatory research on farming system involving tuber crops (0.4 ha model) under rainfed ecology was conducted in Khanjuguda (village), Chakapada (Block), Kandhamal (District), Odisha state. Farming system involving tuber crops (0.4 ha) was laid out in 52 tribal researcher fields. Sole rice cultivation 0.4 ha was laid out in four tribal researcher fields as a check. The components of farming system and their area of cultivation were given in the Table 2. The results revealed that farming system involving tuber crops produced 1739.1 kg of rice equivalent yield and net return of Rs 34770/0.4 ha. Whereas rice alone produced 800 kg of rice and net return of Rs 13000/0.4 ha. Farming system involving tuber crops generated 18 man days additional employment. Further the employment was spread throughout the year. Pali et al. (2012) also reported generation of additional 12 days employment in 0.4 ha pond based integrated farming system.

Table 2. Integrated farming system components yield and economics (0.4 ha)

Sl. No.	Crop/animal	Area (ha)	Yield (kg)	Rice equivalent yield (kg)	Gross Income (Rs)	Expenditure (Rs)	Net income (Rs)	Employment generation (man-days)
1	Rice	0.20	381	381.0	11430	5500	5930	44
2	Maize	0.03	62	31.0	930	350	580	3
3	Ragi	0.02	25	16.7	500	250	250	2
4	Redgram	0.02	14	23.3	700	250	450	2
5	Sweet potato	0.04	516	172.0	5160	1400	3760	6
6	Yam bean	0.03	514	257.0	7710	1200	6510	6
7	Greater yam	0.02	376	250.7	7520	2000	5520	10
8	Colocasia	0.02	305	203.3	6100	1400	4700	6
9	Elephant foot yam	0.008	115	76.7	2300	700	1600	3
10	Cassava	0.002	38	12.7	380	250	130	2
11	Vegetable (*Amaranthus*, Bhendi, bitter gourd, ridge gourd etc.)	0.01	237	158.0	4740	1500	3240	12
12	Backyard poultry	20 (nos.)	47	156.7	4700	2000	2700	10
Total		0.4	2630	1739.1	52170	17400	34770	106

Check/Control

Sl. No.	Crop/animal	Area (ha)	Yield (kg)	Gross Income (Rs)	Expenditure (Rs)	Net income (Rs)	Employment generation (man-days)
1	Rice	0.4	800	24000	11000	13000	88

Rice Rs 30/kg; Maize Rs 15/kg; Ragi Rs 20/kg; Redgram Rs 50/kg; Sweet potato Rs 10/kg; Yam bean Rs 15/kg; Greater yam Rs 20/kg; Colocasia Rs 20/kg; Elephant foot yam Rs 20/kg; Cassava Rs 10/kg, Vegetables Rs 20/kg; Poultry live bird Rs 100/kg

11. Conclusion

Wider adoptability and greater flexibility in planting and harvesting of tuber crops makes them fit into any cropping/farming systems. Partial shade tolerance of yams and aroids was found highly suitable to intercrop in grown up orchards and plantation crops. High dry matter production potential/ unit area/ unit time coupled with cheap source of energy encourages farmers to use tuber crops in livestock feeding. Tuber crops products can be used in fresh form or dried form or ensiled form in animal feeding, which is the uniqueness of tuber crops. In small holder farming systems growing tuber crops along with seasonal, horticultural and silvicultural crops, feeding green tops and excess/culled tubers either fresh or processed form to animals decreases the purchased inputs and increase the farm net income. In the changing climate, tuber crops are indispensable in small holder farming systems along with cereals, livestock and fisheries. Thus, food and nutritional security can be achieved through tuber crops based sustainable farming systems.

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Resource Efficient Horticulture Model for Livelihood Improvement

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Despite 70 per cent of the population being engaged in agriculture and allied activities, declining food grains production and lack of food security remain the two biggest problems confronting our country. Horticulture play a unique role in country's economy by improving the income of the rural people, ensuring livelihood security. Studies show that farmers engaged in the production of fruits and vegetables often earn higher farm incomes than farmers that are engaged in the production of cereal crops only. Also, horticultural crops are labour intensive and hence, generates lot of employment opportunities for the rural population. Fruits and vegetables are also rich source of vitamins, minerals, proteins, and carbohydrates etc. which are essential in human nutrition. Hence, these are referred to as protective foods and assumed great importance as nutritional security of the people. India is the second largest producer of fruits (89.80 million tonnes) and vegetables (162.98 million tonnes) in the world with an area of 24.19 mha during 2013-14 (NHB, 2014). Despite of significant growth of horticulture, there is huge gap between present production and availability. Consumption of fruits and vegetable per capita in India is only about 120 and 250 g/day/ person, which is less than the minimum dietary requirement of 200 and 300g/day/person. Forty per cent of the world's malnourished children are in India and 60 per cent of Indian women are anaemic. Moreover, the productivity of fruits (12.3 t/ha) and vegetables (17.30t/ha) are very low in our country as compared to other country. It has also played a significant role in the women empowerment, providing employment opportunities and income through mushroom cultivation, floriculture, processing, value addition, production of quality planting materials, vegetable seed production. Horticulture has emerged as an indispensable part of agriculture, offering a wide range of choices to the farmers for crop diversification. It also provides ample opportunities for sustaining large number of agro-industries which generate substantial employment opportunities.

The horticulture sector contributes about 24.5% of the GDP from about 8% of the area. Participation of women is more than 90 percent in some of the horticultural activities . Various activities like mixture preparation, filling of polybags, planting of seedlings in polybags, sowing of seeds, watering, transplanting, manuring, harvesting, grading, processing and marketing are perform by women. It is projected that India needs to produce 350 mt vegetables and 125 mt fruits by 2030 to meet the demand of the growing population. Since, there is not much scope for area expansion, the productivity enhancement is envisaged through adoption of good management practices including techniques of high density planting, rejuvenation of old and unproductive orchards, INM, IPM and improved post-harvest handling and management systems for reducing post-harvest losses. In this backdrop horticulture model with new enterprises and crop diversification will act as a potential tool to improve the income of the rural people and generation of employment opportunities. The model will be developed considering the resource availability to ensure more income per unit of area and time. The horticulture model will act as a tool to enhance income sustainability of farmers through technological interventions, crop and enterprise diversification.

Scope of horticulture

1. Source of livelihood generation: Horticultural crops are high value crops and are highly remunerative and profitable than the cereal crops. Small scale cultivation or homestead gardening of fruit, vegetable, flower, medicinal and aromatic plant crops, nursery raising, orchard maintenance, employment in agro-chemical industries, small scale processing, marketing of fresh fruits & vegetables and processed products are various alternatives for livelihood generation and nutritional security for women.

2. Enterprise development: There is a tremendous scope for urban and peri-urban women for developing several horticultural enterprises by organising themselves into women Self-help groups (SHGs), Farmer Producer Organisations (FPO), Women Empowerment Groups and various cooperatives. In India there are several successful enterprises in fruit crops, for instance in mango, 'Mahamango', is a co-operative society established with the support of Maharashtra State Agricultural & Marketing Board (Pune) for boosting the export as well domestic marketing of Alphonso mangoes. A similar type of association named 'MANGROW' has been formed for the export of Kesar mangoes from Aurangabad district of Maharashtra. These mango industries are highly lucrative and profitable. In case of banana, the Agriculture Marketing Board has established 'Mahabanana', a farmers' marketing organization with headquarters at Jalgaon. There are 26 co-operative societies registered under Mahabanana and each such member society has 300-350 small and marginal farmers. The organization was formed to boost export as well as domestic marketing.

3. Processing and value addition: Processing and value addition of fruit and vegetable crops are highly remunerative on account of increasing demand of processed products by the consumers. Women have an active role in several post production activities starting from harvesting, sorting, grading and processing. Orientation of women to this sector can be highly profitable not only to processing industries but also to the farming community. The fruit & vegetable processing industry in India is still in its infancy and only around 1-2 % of its total production is processed as compared to 70 % in Brazil and USA, 78% in Philippines, 80% in South Africa, 83% in Malaysia and 30 % in Thailand. Thus, a great scope exists in expanding the food processing and value addition, which will in turn also help in employment generation and better returns.

4. Export potential: India's diverse climate ensures the bulk availability of various fruits and vegetables round the year. There is a tremendous export potential for both fresh as well as processed horticultural products in International market. During 2014-15, India exported fruits worth Rs 2771.32 crores out of which major share was occupied by fruits like mango, walnut, grape, banana and pomegranate. The major destinations for Indian fruits are UAE, Bangladesh, Malaysia, UK, Netherland, Pakistan, Saudi Arabia, Sri Lanka and Nepal (APEDA, 2015).

5. Industrial uses: Fruit crops can be exploited for several industrial uses and landless rural women can be actively involved in such industries. Papain is extracted from papaya can be taken up on commercial scale to obtain additional income. Papain is used as a meat tenderiser, manufacture of chewing gum, in tanning industry and for degumming natural silk. Similarly, bromelin, a proteolytic enzyme is extracted from pineapple. Banana fibre is used in making items like bags, rope and good quality paper. Latex from sapota also has several industrial uses.

6. Germplasm conservation: India has a rich biodiversity of horticultural crops. On account of global warming and climate change, there is a constant genetic erosion of valuable germplasm of several plant species. On-farm conservation of biodiversity can prevent loss of these valuable resources.

Some of the resource efficient horticulture component/ intervention are discussed to improve the livelihood security of farming communities.

Application of mulching: In the present scenario of globalization and health consciousness demand for horticultural crops has increased world over. Apart from using high yielding varieties and good agricultural practices, there is a need to utilize environmental/biological energy for higher production. At present high tech interventions for quality enhancement are expensive and unaffordable for the producers to compete in the market. Therefore, effective and economical utilization of natural resources by low cost technologies and adaptable. Of late, mulch, being a natural resource, has become one of the most effective technologies for optimum yield and quality enhancement of crops besides reducing the cost of production. Mulching is one of the methods used since time immemorial for maintaining soil temperature around the plant for the benefit of fruit production.

Thickness of film: The thickness of film to be used in mulching determined by type and age of the horticultural crops (Table 1).

Table 1. Thickness of film

Crop duration	**Thickness**		**Area coverage per kg**	**Weight per m^2**
	Micron	**Gauge**	**m^2**	**gram**
Annual crop	25	100	42	23
Biennial crop	50	200	21	46
Perennial crop	100	400	11	93

Source: NCPAH, New Delhi

Time of mulching: The best time of mulch crop is just after planting as it checks germination of weeds. In vegetable crops mulching should be done at the time of bed preparation but in fruit crops it should be done before planting of the tree. In case of establish orchard mulching can be done in the month of October. Replacement of mulch largely depends on the mulching material. Grass clippings and leaves decompose very fast and replenished frequently.

Stud on mulching in vegetable of tomato, brinjal, chilli and cabbage to reduce weed load and moisture conservation: Weed control is essential for realizing production potential and imparting profitability in the vegetable crops**.** As women serve as labour for weeding, mulching may help in reducing drudgery of women In tomato, brinjal, chilli and cabbage four different mulches viz., M_0, M_1, M_2 and M_3 representing no mulch, mulching with transparent polythene, black polythene and with locally available *Glyricidia* leaves. Observation revealed that black polythene (0.25 mm thickness) was found most effective, as it registered significantly higher fruit yield i.e. 350q/ha in tomato, 294q/ha in brinjal, 250q/ha in chilli and

300q/ha in cabbage with negligible weed growth (1.97g/m^2 dw) than the other mulches. Number of fruits/ head weight and water use efficiency under black polythene mulch and *Glyricidia* leaves was statistically at par. It has been observed that mulched with blackpolythene plot registered significantly lower weed dry weight (67.3%) as compared to control. In tomato, brinjal, broccoli and knolkhol, imposition of weed management from 45-60 days and 30- 60 days period was found crucial for realizing their potential yield.

Protected cultivation of vegetable crops of cucumber, tomato, broccoli and capsicum

Low cost protected cultivation technology has been developed for tomato, cucumber, broccoli and capsicum under the hot- and humid tropical climate of Odisha. Crops and seedlings can successfully grown during February and March in the shed net houses, which is, otherwise, not possible outside due to prevailing high temperature. Package and practices for growing vegetables under low cost shed net have been developed and standardized. Tomato, cucumber, broccoli and capsicum are very important high value vegetable crops and having good market demand. With this objective an experiment was conducted to evaluate the performance of tomato, cucumber, broccoli and capsicum under protected conditions and open field condition. Observations revealed that higher yield (4kg/ plant) was recorded in tomato var Avinash-3, 2.5 kg/ plant in cucumber var Kion, 1.5kg/plant in capsicum var Swarna and 569 g in broccoli var Pusa KTS1 under protected condition against 1.3kg/ plant in tomato, 600 g/ plant in capsicum and 337 g/plant in broccoli in open field condition. Duration of tomato, capsicum and broccoli in protected condition was extended about 45 days as compared to open field condition. It has been observed that 40 percent mortality was recorded in tomato under open field condition due to wilting and blight as compared to protected condition. Moreover, fruit quality in terms of size, shining, colour, taste and shelf life of these vegetables was better under protected condition as compared to open field condition. Protective cultivation offers several advantages to produce vegetables and flowers of high quality and yields, thus using the land and other resources more efficiently (Srivastava and Babu, 2016).

Utilization of interspaced between fruit plants

Intercropping in banana: Different intercropping i.e. cowpea, amaranth (leafy vegetable) and elephant foot yam and radish in banana along with a control (Banana sole crop) were evaluated. Among the intercrops, banana + gave the maximum bunch weight (21.32 kg) and yield per ha (52.84 MT). Maximum additional income could be earned from elephant foot yam about Rs. 80000/- per ha/year, followed by cowpea (Rs 45000/-.).

Intercropping in drumstick: Drumsticks (*Moringa oleifera*) is an important multipurpose vegetable grown widely in Odisha for nutritional purpose and have good local demand. Six intercrop i.e. French bean, cow pea, amaranth (leafy vegetable), elephant foot yam and pineapple in drumsticks along with a control (drumstick sole crop) were evaluated. Among the intercrops, drumstick + French bean gave with maximum fruit yield per ha (45.50 t). Maximum income (Rs 190000/- per ha per year) could be earned from drumstick+ pineapple cropping system followed by drumstick+ elephant foot yam (Rs 135000/-.).

Intercropping in lime: In our country, limes (*Citrus spp.)* are grown for nutritional purpose and have good market demand throughout the year. Different intercropping i.e. French bean, cow pea, amaranth (leafy vegetable) and colocasia in lime along with a control (lime sole crop) were evaluated. Among the intercrops, lime + cowpea gave with maximum fruit yield per ha (28.30q/ ha). Maximum income (Rs 138000 per ha/year) was earned from lime + French bean cropping system followed by lime+ colocasia (Rs 128000/- per ha per year).

Nutrient management in banana: A field experiment was conducted to find out the effect organic and inorganic inputs on growth, yield and quality of banana variety G-9. Seven treatments viz.T_1- fresh cow dung @ 500g/ plant; T_2- fresh cow dung @ 250g/ plant + pond soil@ 250 g; T_3-fresh cow dung @ 500g /plant + 5g urea; T_4 - 500g fresh cow dung +5 g ammonium sulphate, T_5- 500g fresh cow dung + 10g sulphate of potash, T_6-fresh cow dung @ 500g/ plant + 5g ammonium sulphate and 10g sulphate of potash T_7- removal of male bud after completion of female phase (control) were applied to the selected plants. An application of 5 g ammonium sulphate and 10 g sulphate of potash blended with 500 g of fresh cow dung to the distal end of bunch showed 20% higher fruit yields and 22 days earlier fruit maturity in fruit yields as compared to control in G-9 variety of banana.

High density planting through canopy management: For obtaining higher productivity per unit area and quality fruits high density planting is the beneficial. In this method planting is done closer spacing as compared to traditional system and size of the plant can be maintained by canopy management. Light is the most important factor in the production of fruits, as it plays an important role in their growth and development. Trees with the vigorous and dense canopies were found to be less productive and suffer more from the diseases and pests. Pruning of the trees for canopy management depends on the bearing habit of a tree, it limits the height of a plant forcing to develop dwarf and spreading canopies. Normally guava planted at 6.0x6.0 m spacing (277 plants/ha) respond very well to pruning so it has bright prospects for high density planting to get high productivity per unit area. In this system plants should be planted at a spacing 2mx1m (5000 plants/ha). Pruning is a vital component for tree size management and improving the fruiting potential of guava trees under high density planting**.** In this way 50 t /ha fruit yield will be recorded as compare to 15 t/ha in normal spacing (6.0x6.0 m spacing). Plants were topped after 2 months of planting i.e. in the month of October. After appearance of new shoots, 50% of the shoots were pruned again in December- January for further induction of new shoots. This is done to attain the desired tree canopy architecture and strong framework. The emerged shoots are allowed to grow for 3 - 4 months before they are again pruned by 50 per cent. After pruning, new shoots emerge on which flowering takes place. It is found very much suitable technology for women in horticultural crop production as women can easily perform cultural operations due to manageable height of the plants. Moreover, guava is a hardy crop and requires little care and inputs for cultivation fetches remunerative price in market too.

Pressurized irrigation technology in fruit and vegetable crops: Micro irrigation is a low pressure, low volume irrigation system suitable for high-return value crops such as fruit and vegetable crops. If managed properly, micro irrigation can increase yields and decrease water, fertilizer and labor requirements. Micro irrigation applies the water only to the plant's root zone and saves water because of the high application efficiency and high water distribution uniformity. Micro irrigation can irrigate sloping or irregularly-shaped land areas that cannot be flood irrigated. Any water-soluble fertilizer may be injected through a micro irrigation system. Micro-irrigation including micro spray, surface drip and subsurface drip irrigation methods can deliver water precisely and efficiently. Various fruits like banana, papaya, pineapple, guava and vegetable crops tomato, brinjal, cabbage, broccoli, knol khol, beans are successfully cultivated by drip irrigation system.

Crop production through drip irrigation: In this system water can be applied in nearby the root zone o the plants. Through drip irrigation system water can be safe up to 40 percent depending upon the crops. In this system weed population in the crop are very less so labour cost may be reduced.

Economic feasibility and of model: A resource efficient horticulture model was developed for 2000 m2 area with different components like high density planting of banana, meadow orcharding of guava, high density planting of papaya, pineapple, lime and different green leafy vegetables viz., coriander, menthi, palak and amaranth; roots and tuber crops viz., elephant foot yam, yam and colocasia and other vegetables viz., tomato, brinjal, cauliflower, chilli, cowpea, French bean. The main objective of the model is to increased crop productivity and profitability with increased resource use efficiency. After the cyclone *phylin and Hudhud* in October, 2013and 2014 respectively this model gave 900 kg fruits (banana, pineapple, guava and lime); 350 kg green leafy vegetables (amaranth, coriander leaves, fenugreek leaves and palak), 340 kg root and tuber crops (radish, elephant foot yam, yam and colocasia) and 1740kg other vegetables (bitter gourd, bottle gourd , cauliflower, cabbage, capsicum, okra, tomato, brinjal, chilli, cowpea, French bean, onion broccoli, knolkhol and cauliflower). Net income of Rs 34770/ with BCR of 2.94 were estimated from this model (1660m^2) during the second year.

Table: Economic feasibility of horticultural crops

Crops	**Total area (m^2)**	**Yield (kg)**	**Total Expenditure (Rs.)**	**Gross Income (Rs.)**	**Net Income (Rs.)**	**BCR**
Perennial fruits	420	900	5500	18000	12500	3.27
Vegetables						
Green leafy vegetables	185	350	990	3500	2510	3.54
Roots and tubers	195	340	1320	5100	3780	3.86
Other vegetables	860	1740	10120	26100	15980	2.58
Total	**1660**	**3330**	**17930**	**52700**	**34770**	**2.94**

Standardization of of pinching for optimum flower yield in marigold

Marigold (*Tagetes erecta* L.) is very useful and easily grown flower by farmwomen which has exclusive use in religious and ceremonial functions. It is also grown as annual in pots and beds and blooms for 3-4 months in a year. The economic yield is depend upon varieties and pinching which play an important role in plant growth and flowering production. An experiment was carried out to identify varieties and standardize pinching for optimum flower yield with better flower quality in marigold during *Rabi* season. The treatments comprised of the four varieties *viz.*, Spun Gold (V1), Spun Yellow (V2) Sutton's Double Orange (V3) and Sutton's Double Yellow (V4) and three pinching treatments *viz.*, no pinching, 30 DAT, and 45 DAT. Maximum number of primary branches (20) and spread of plant (35 cm) were recorded with Spun Gold and pinching at 30 DAT. As regards yield parameters, the maximum number of flower (16) and flower yield (448 g/plant) were recorded by Sutton's Double Orange and pinching at 30 DAT followed by Spun Gold at 45 DAT

Development of coconut based multi-storey cropping model

Coconut is the important plantation crop grown in coastal area of Odisha. Cultivating intercrops in coconut provide higher productivity and income per unit area. Thus an integrated system with several crop combinations to maximize the production along with more income and employment generation would ensure a sustainable development of farmwomen and additional employment opportunities to farm families. Therefore an effort was made to standardize suitable intercrops in coconut based multistory cropping model with banana, papaya and guava as second storey crops. Different ground storey intercrops like cowpea, turmeric, elephant foot yam, colocasia and pineapple were cultivated in the interspaces of the main crop. Observation revealed that among the different intercropping combinations, highest yield were recorded by colocasia var Muktakesi (240 q/ha), followed by turmeric (208 q/ha) and elephant foot yam (170q/ha). Highest income (Rs 3, 42,000) were estimated with the combination of coconut + banana + colocasia var Muktakesi as compared to sole crop of coconut (Rs. 1,50,000.ha). The care of ground storey crops is taken by the farmwomen.

Conclusion

There is no doubt that horticultural crops are labour intensive and needs a care for making profitable for the farming community. Horticulture sector generates lot of employment opportunities for the rural population. Fruits and vegetables are also rich source of vitamins, minerals, proteins, and carbohydrates etc. which are essential in human nutrition. Despite of significant growth of horticulture, there is huge gap between present production and availability. Moreover, India needs to produce 350 mt vegetables and 125 mt fruits by 2030 to meet the demand of the growing population. Since, there is not much scope for area expansion, the productivity enhancement is envisaged through adoption of good management practices including techniques of high density planting and adoption of resource efficient horticulture model because of our natural resource are limited. Therefore, it is need of hour that judicious use of resources is the best option for increasing production and natural resources conservation. The effective and efficient utilization of resources will reduce the cost of crop production thereby increasing farmers' profits and reduction of environmental pollution.

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Improving the Livelihood of Farmwomen through Rice based Integrated Farming System

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Introduction

Rice being the staple food is grown in the country in around 43.5 million (m) ha under various ecologies of which about 50 % area is rainfed. More than 80% of the rice farmers belong to small and marginal groups and the average per capita land holding in India is only about 0.17 ha. In view of the population growth, competition of land with industrialization and urbanization, declining farm holding size and the dietary nutrition requirement of the farm families, it is necessary to look for the optimum use of resources through shift from conventional rice farming to integrated farming systems. Rice based farming system involving rice, other field and horticultural crops, agro-forestry, fish birds livestock and further income generating enterprises will be the right approach in this respect. However, this will be more relevant in the risk prone *rainfed* ecologies which are mostly located in the eastern part of the country. Rice based integrated farming systems can provide household food, nutrition, income and employment without degrading the environment.

Farming family in tropical India is mainly dependent on *rainfed* farming with high risk of weather uncertainty. In a constant struggle to survive, the small and marginal farmers over the years have evolved techniques which have benefited them immensely. But without knowing the scientific basis of such integration they have been practicing the system for a long time. In India, traditionally, farming has been family based and majority of them are smallholders. The success of farming family lies not in 'specialization' but in practicing farming to meet diverse household needs rather than market opportunities alone. Hence, income from seasonal field crops alone in small and marginal farms is hardly sufficient to sustain the farming family. As such agriculture in India is facing the challenge to achieve sustainable food security with shrinking land resources by producing an additional 50 million tonnes of food to meet the requirement of prognosticated population of 1000 million in the country. Because of declining per capita availability of land in India, there is hardly any scope for horizontal expansion of land for food production. Hence, intelligent management of available resources including optimum allocation of resources is important to alleviate the risk related land sustainability.

Role of women in Rice based IFS

Women are a vital part of Indian economy. They have played and continue to play significant role in every sphere of agricultural activity. Over the years there is a gradual realization of the key role of women in agriculture development and their vital contribution in the field of agriculture, food security, horticulture, processing, nutrition, sericulture, fisheries and other allied sectors. Women have been putting in labour not only in terms of physical output but also in terms of quality and efficiency. Women work harder and for longer hours than men and also conserve bio diversity in food, feed, fish and animal stocks which has narrowed down alarmingly.

Integrated farming system- a promising approach

Integrated farming system is the potential approach and powerful tool for management of vast natural and human resources in developing countries, including India to meet the multiple objectives of poverty reduction, food security, competitiveness and sustainability of small and marginal farmers. The approach aims at increasing income and employment from small-holding integrating various farm enterprises and recycling crop residues and by-products within the farm itself (Behera and Mahapatra, 1999; Singh *et al*., 2006). Under the gradual shrinking of land holding, it is necessary to integrate land-based enterprises such as dairy, fishery, poultry, duckery, apiary, field crops, vegetable crops and fruit crops within the bio-physical and socio-economic environment of the farmers to make farming more profitable and dependable (Behera *et al*.,2004). Integrated farming systems are often less risky, because if managed efficiently, they benefit from synergisms among the enterprises, leading to diversity in produce and environmental soundness (Lightfoot, 1998; Pullin, 1998).

The Traditional Rice based farming System in India

In irrigated rice ecology, carp fingerlings of natural stock are collected by traps in the inlet/outlets from rice fields irrigated from Godavari river in East Godavari district of Andhra Pradesh with fish yield of 3 kg/ ha. In rainfed lowlands and deepwater rice ecologies capture fisheries are mainly followed realizing around 3 to 300 kg of fish /ha during and after rice growing period in the rice field seeded/planted with mostly traditional rice varieties yielding around 1.0 to 3.0 t grain / ha.(Dehadrai, 1988, Ghosh, 1992)). The productivity of fish and prawn in coastal saline areas ranges from 100 to 2000 kg / h a / y r (Ghosh, 1992). In Meghalaya rice-fish farming as flow through system in the terraces and also in valleys/ plains. Trap-sum method is followed in *few* areas in the coastal part of Orissa (brackish water areas). In flood prone areas of Brahmaputra valley, rice-fish farming is extensively practiced. In West Bengal Rice-fish farming is practiced by the farmers mostly in rainfed and some irrigated areas mainly in Midnapore and 24 Parganas districts The field design includes one pond refuge of about 1.5 to 2 m deep covering around 8-10% of the area and raised bunds all around. Mostly Eucalyptus trees are planted 3 to 4ft apart since this plant is preferred because of fast growing and a cash crop, in demand for construction and fuel purpose. In this type of farming, a crop after rice (mostly Jaya cross in Midnapore district) taken in *rainfed* condition during *kharif*. Capture fisheries of mostly catfish, perch and murrel types are trapped in the pond along with the water and later harvested after drying of the field. Around Rs. 1,500/- to 2,000/- are obtained by the farmers from fish in one acre unit.

Improved rice based integrated farming system

Rice –fish farming system:

Eastern India, in particular with about 5.6 m ha irrigated area and 14.6m ha rainfed lowlands of the total 26.58 m ha rice area, offers high potential for rice-fish farming system, especially in view of the resources, food habits and socio-economic needs of the people. Rice-fish farming system with higher water and land productivity and employment opportunities can ensure food, nutrition and livelihood security for the farming communities, particularly for the largest groups of small and marginal farmers. Rice-fish culture systems can be mixed or concurrent, sequential or rotational. However, the techniques differ based on the physical, biological and socio-economic profiles of the target agro-ecosystem.

Rice –fish diversified farming system for rainfed lowland areas

In order to improve and stabilize farm productivity and income from rainfed water logged lowland areas, national Rice Research Institute, Cuttack has developed an adoptable technology of rice-fish diversified farming system. Farm size may vary from minimum of about one acre to one hectare or more. Field design includes wide bunds (Dykes) all around, a pond refuge connected with trenches on two sides(water harvesting come fish refuge system) and guarded outlet. The approximate area allotments will be, 20 % for bunds, 13 % for pond refuge and trenches and rest 67 % for main field. The pond refuge measures 10 m wideand 1.75m deep constructed in the lower end of the field. The two side trenches of 3 m width and average 1 m depth have gentle(0.5%) bed slope towards the towards the pond refuge. Small low cost (Thatched/asbestos top)duck house and poultry unit are constructed on bunds with a floor space of about 1.5 sq.ft. for each duck and 1 sq.ft. for each poultry bird. Poultry unit maybe projected upto 50 % over the water in the pond refuge to utilize the dropping as fish food and manure in the system. In such case birds can be housed in cage of made of wire net. A small goat house is made on the bund with floor space of about 2 sq.ft for each animal.

Production Technology

Production Technology broadly involves growing of improved photo-period sensitive semi tall and tall wet season rice varieties with field tolerance to major insect pest and diseases. The suitable rice varieties are Gayatri, Sarala, CR Dhan 500, CR Dhan 505, Jalmani, Varshadhan for Orissa, Sabita, Jogen, Hanseswari for West Bengal, Sudha for Bihar, Madhukar and Jalpriya for eastern uttar Pradesh and Ranjit, Durga and sabita for Assam. Management of insect pest in rice crop is done with the use of sex pheromen traps, light traps and botanicals (Netherin/ Nimbicidin spray at 1%). Indian major carps(Catla, Rohu , Mrigal) *Puntius sarana*, exoctic carps (common carp, silver carp silver barb) and fresh water giant prawn (*macrobrachium rosenbergii*) are grown along with the rice crop and later in the refuge after the rice crop is harvested. Fish fingerlings of 3-4" size and prawn juveniles of 2-3" size are released in a ratio of 75 % and 25 %, respectively at 10,000 per hectare of water area after sufficient water accumulation in the refuge and in the field. Fish and prawn are regularly fed at 2% of total biomass with mixture containing 95 % of oil cake +rice bran (1:!) and 5 % of fish meal. After ric, various crops like watermelon, mung sunflower, groundnut, sesame and vegetables are grown in the field with limited irrigations from the harvested rainwater. On bunds different seasonal vegetables are cultivated round the year including creepers on the raised platform, spices and pineapples are grown in shades. The fruit crops on bunds include varieties of dwarf papaya, banana T x D coconut and arecanut. Flowers like tuberose marigold etc. are also cultivated on the bunds. Both straw and oyster mushroom cultivation are done in the thatched or polythene enclose. Bee rearing is practice in 2-3 bee boxes on bunds. Agro-forestry component on the bund include short term plantation of mainly *Accacia* spp. (*A. mangium, A. auriculiformes).* Animal component constitutes improved breeds of duck, poultry birds and goats. Ducks are raised in the rice field upto the beginning of flowering stage and later in an enclose in pond refuge till the harvest of rice crop. Live *Azolla* is released @0.5 -1.0 t /ha and is maintained to supplement duck feed and also to some extent fish feed, besides nutrition to the rice crop. Fresh water pearl culture is integrated in the system using the host mussel (*Lamellidens marginalis)* which is normally available in the lowland rice ecology. Components can however, be included in the system based on location –specific requirements.

Productivity and economics

The rice fish farming system can annually produce around 16 to 18 t of food crops, 0.6t of fish and prawn, 0.55 t of meat, 8000-12,000 eggs besides flowers, fuel wood and animal feed as rice straw and other crop residues from one hectare of farm. The net income in the system is about Rs. 76,000 in the first year. Subsequently this increases to around 1, 30,000 in the sixth year. This system thus increases farm productivity by about fifteen times and net income by 20 folds over the traditional rice farming in rainfed lowlands. The rice fish system also generates additional farm employment of around 250 – 300 man-days/hectare/year.

Rice-Fish-prawn-horticulture-agro-forestry based farming system for deep water

With the aim of enhancing farm productivity in deep water areas (50—100 cm water depth), a multi-tier rice-fish –prawn horticulture crops-agro-forestry based farming system model has also been developed in 0.06 hectares area at NRRI, Cuttack. The design of the system includes land shaping in the form of uplands(Tier I and tier II) covering about 15 % of field area followed by rice field area of 40% as *rainfed* lowland (tier III) and deep water (tier IV). This rice field is connected to a micro water shed cum fish refuge (pond) of 20 % area for growing of fish and prawn with the rice crop. Raised and wide bunds are made all around using 25 % of the farm area. The production technology includes growing of high yielding varieties of *rainfed* lowland rice (Gayatri, Sarala. Pooja)in tier III and deep water rice (CR Dhan 500, CR Dhan 505, Jayanti Dhan and Varshadhan) in tier IV along with the fish and prawn during wet season. Dry season crops like sweet potato, mung, sunflower, groundnut, vegetables are grown after lowland rice in tier III. Dry season rice is cultivated after the deep water rice is harvested in their IV. Harvested rain water in the pond refuge is used for irrigation of the dry season crops. Improved varieties of perennial (mango, guava, sapota) and seasonal fruit crops (Papaya, Banana, Pineapple) are grown in upland (tier I). Round the year different seasonal vegetables and tuber crops (sweet potato, elephant foot yam, yam bean, colocasia and greater yam) are cultivated in tier II(Upland). Agro-forestry (*Acacia mangium*) and plantation crops (Coconut and areca nut) are planted on the northern side of the bunds. Greater yam is grown with the support of trunk of agro forestry tree. The productivity of the system is about 8 t of rice crop/hectare, one tone of fish and prawn per hectare, 20-25 t of vegetables/ha and 8.5 to 51.7 t of tuber crops/ha. The cropping intensity in this system greatly increases to 170 % in field and 360 % in the upland.

Rice-ornamental fish culture

In order to utilize the rice ecology for value added aquaculture, the technique of breeding and culture of ornamental fishes in irrigated waterlogged rice field has been developed at NRRI, Cuttack. The rice field is renovated to make a pond refuge and raise bunds all around. Ornamental fishes like Blue gourami, Red gourami, Pearl gourami, Guppies are bred and cultured with rice (lowland varieties) crop during wet season. During the dry season, rice (Naveen)crop is grown along with ornamental fishes with irrigation. About 25,000- 6, 00000 ornamental fish/ha can be produced in the system, in addition to 3.5t and 5.0t of rice grain during wet and dry season, respectively. Such farming can be taken up by women farmers including Self Help Groups.

Rice based farming system under irrigated condition

With the objective of improvement of livelihood of small and marginal farmers, rice based integrated farming system model for irrigated areas has been developed at NRRI, Cuttack.

Production Methodology

Site selection and layout: About an acre of integrated farm area is required for the farming system. 30% of the area is converted to two rice fish fields of 600 sq.m area each with a refuge of 15 % area and another 30 % area is developed into two nursery fish ponds of equal size of fingerlings rearing. The remaining 40% (1500 m2) area is utilized as bunds for growing vegetables, horticultural crops and agro-forestry. Three rice crops are grown in the sequence of kharif rice (var.,sarla/Durga) followed by rabi rice (naveen/Satabdi) and then summer rice(vandana/ Sidhant). Yellow stem borer pest is controlled by using sex pheromone traps or by applying1 % Nethrin/Nimbecidine. Fish culture is taken up with catla, rohu and mrigal species. The fish fingerlings are reared in the two nursery ponds and are used for culture with rice crop in the system. The excess fingerlings are sold out. On the bunds agro-forestry plants like teak, Accacia, sisoo, neem, aonla and bamboo are planted on the northern and southern bunds. Horticultural crops such as banana, papaya and arecanut are grown on the bunds. Pineapple and spices are cultivated in the shade.

Flowers like marigold. Hibiscus and Jasmine are also cultivated in the western bund in 50m^2 area. Two plants of lemon and each of guava, jackfruit, mango and litchi are also planted on the southern bund near the farm house to meet the household requirement. One poultry and one duckery unit are integrated in the system in which 40 poultry birds are raised during the dry seasons.(October to April) and 20 ducks are reared during the wet season (July to December).

Productivity and economics

Three crop of rice yields 800 to 1000 kg of grain per year. Entire produce is sufficient to cater the need of the small farm family. The straw is used for the cattle feed, mushroom base and roof of the farm house. Rest of the straw is sold to earn Rs. 500-1000 per year. Afetr two – three months of rearing, fish fry worth of Rs. 4000- 5000 is sold to the other farmers. Fish are harvested according to the need after the size becomes 250-300 g after 6 months or 0.5-1.0 kg after a year. The income from fish rearing in the system is Rs. 20,000. Pulses (mungbean, blackgram and pigeonpea) taken on the slope and bunds are just enough to meet the protein requirement of the farm family.

Crop Enterprises from the bunds

Seasonal vegetables grown on the bunds are the source income to the farm family and this practice is also labour intensive. Staggered sown vegetables on the bunds give a good return of Rs. 25-30/2.5 m^2/30 days. Binjal and chilly are the most profitable crops as these can be taken by rationing without much labour input in an area of about 200 m^2. Cucurbits taken on the bamboo frame over the trench give a good return. When the whole bund area managed properly with regard to unit area per unit of time, it fetches a return of Rs. 8000- 10,000. From the bund area, 50-60 bunches of banana and about 20 kg of papaya plant can be harvested in a year and the produce is used for consumption as well as sale. The surplus produce gives the net return of Rs 2000 to 3000 which can meet the mid term money requirement of the farm family. An additional amount of Rs 1600 t 1800 per year can be achieved from the disposal of arecanut, aonla, bamboo after 3-4 year, which will go up to Rs. 16000 to 18000 from fifth years onwards with the disposal of 15-20 sticks of bamboo per year, 5-6 quintals of arecanut, 40-50 kg of aonla and 30-40 kg of spices (turmeric and ginger)/ 20 m^2. This monetary return can be utilized by the farm family for the personal needs and the purchase of farm inputs. As the tree like Teak, Sisoo, Acacia have high monetary value after 20-25 years, a farmer can expect a high return upto rs. 1 lakh to 3.5 lakhs from the trees of farm unit. From the bird unit 40-50 kg of meat from red leghorn/ Giriraj is produced every two – three months which give a net return of Rs. 8000-10000 per year. Apart from the meat the 10-12 kg of poultry dropping is used as a manure. Mushroom beds each of $2m^2$ taken on the bunds is sold at a profit of Rs. 10 per kg with the expenditure of Rs. 40 per bed. Though flouri-culture is not a profitable but can be used to meet the household religious activity and aesthetic requirement. The system in the subsequent years provides net earnings of Rs. 1,500-3,300 per month besides, high employment generation of 450-500 man days per year, thus restricting the migration of farm community (Sinhababu *et al*., 2007)

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Gender and Livestock in Eastern India : Prioritizing Districts for Livestock Development

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In India, the livestock sector is increasingly being seen as an important sector providing income and livelihood on sustainable basis and a tool for rural development. Livestock will continue to play the traditional role of providing supplementary income, manure, draught power in a mixed-crop livestock farming system in India, but the farmers in rural areas and also in the urban areas are increasingly taking up dairying as a source of livelihood through the sale of milk and milk products. The agricultural sector engages about 57% of the total working population and about 73% of the rural labour force (Planning Commission, 2012). The livestock employs 8.8% of the agricultural work force which varies from 3% in North-Eastern states to 40-48% in Punjab and Haryana. The livestock sector also promotes gender equity because more than three-fourth of the labour demand in livestock production is met by women. In Punjab and Haryana, the share of women employment in livestock sector is around 90% where dairying is a prominent activity and animals are stall-fed.

India is the largest producer of milk in the world with an annual output of 146.3 million tonnes during 2014-15 which is 18.5 % of world production (Economic Survey, 2016). The milk production in the country in 2013-14 was 137.69 million tonnes which increased at the rate of 6.26% in the last year. The increase in world milk production between 2013 and 2014 was only 3.1% from 765 million tonnes in 2013 to 789 million tonnes (FAO, 2016). On the other hand, the food grain production in India in 2014-15 was 252.7 million tonnes and it showed a decline of 1.5 % over the last year. The per capita availability of milk in India has increased from 176 grams per day in 1990-91 to 322 grams per day by 2014-15 which is more than the world average of 294 grams per day during 2013. It shows that there has been a sustained growth in availability of milk and milk products for the growing population in India.

Dairy animals provide an important livelihood option and coping mechanism to farmers especially during drought years. In spite of the two consecutive drought years, the milk production in India increased from 137.69 million tonnes (mt) in 2013-14 to 146.31 mt in 2014-15 and 160.35 mt in 2015-16 (Damodaran, 2016). In spite of the drought years milk procurement by dairy cooperatives increased by 10.7% in 2014-15 and 11.5% in 2015-16, more than the corresponding growth rates of 6.3% and 9.6% for milk production. Similarly, in 2012-13 also, which was a drought year, procurement by cooperatives registered a 16.7% increase when the increase in milk output was only 3.5% higher. This indicates that during drought years, farmers choose to sell more milk to get cash in hand.

Eastern India is endowed with rich natural resources with fertile soils and abundant water resources, yet it has lagged behind in agricultural productivity compared to other parts of the country. To bridge the productivity gap the Government of India launched the National Food Security Mission (NFSM) Scheme in 2007 to increase production and productivity of major food crops wheat, rice and pulses on a sustainable basis so as to ensure food security of the country. Another programme 'Bringing Green Revolution to Eastern India (BGREI)' was launched in 2010-11 in seven states of eastern India namely; Assam (AS), Bihar (BI), Chhattisgarh (CGH), Jharkhand (JH), Odisha (OD), Eastern Uttar Pradesh (EUP) and West Bengal (WB) to maximize agricultural production on a sustainable basis. The two national programmes NFSM and BGREI, though primarily focus on the agricultural sector they do not exclude the allied sectors. In fact increased investment in agriculture can happen when increased capital formation takes place through allied sectors including animal husbandry and dairy production. The livestock production practices have changed significantly in many pockets in eastern India and hence it is need to identify the districts where priority attention is required for livestock development.

Area, population and gender indices: Eastern states comprises of six states namely, Assam, Bihar, Chhattisgarh, Jharkhand, Odisha, Eastern UP and West Bengal and has a total of 183 districts (Table 1). The total area of eastern states is 717.8 thousand sq km and has a human population of 406.5 million with a human density of 566 persons per sq km. The region has 21.9 percent of the geographical area of India and has 33.6 percent of human population. The density of human population (persons per sq km) in the eastern states varies from 189 in Chhattisgarh to 1102 in Bihar. The sex ratio (no of females per 1000 male) in eastern states is 948 compared to 943 for India. It varies from 918 in Bihar to 991 in Chhattisgarh. The total literacy (%) in eastern states is low (69.1) compared to all India average (74.0). Similarly, the female literacy (%) varies from 51.5 (Bihar) to 70.5 (WB) with an average of 60.2, which is lower than all India average (65.5). The gender gap in literacy (%) varies widely among eastern states with West Bengal having 11.2 to East UP (21.9). In India, 12.9% of the households are female headed (FHH) and the eastern states as a whole has FHH closer to national average. The number of landless household (LLHH) in India is 56.3%. West Bengal (69.6%) and Bihar (65.6%) have more number of landless households.

Table. Gender indices and other attributes in eastern states

	Assam	Bihar	CGH*	JH*	OD*	EUP*	WB*	Eastern states	India
No of districts	27	38	18	24	30	27	19	183	640
Percent area	10.9	13.1	18.8	11.1	21.7	12.0	12.4	100.0	
% human beings	7.7	25.5	6.3	8.1	10.3	19.6	22.5	100.0	
Human density (no/sq km)	397	1102	189	414	269	929	1029	566	382
Sex ratio	958	918	991	948	979	952	950	948	943
Total literacy (%)	72.2	61.8	70.3	66.4	72.9	67.4	76.3	69.1	74.0
Male literacy (%)	77.8	71.2	80.3	76.8	81.6	78.1	81.7	77.6	82.1
Female literacy (%)	66.3	51.5	60.2	55.4	64.0	56.2	70.5	60.2	65.5

Gender gap in literacy (%)	11.6	19.7	20.0	21.4	17.6	21.9	11.2	17.4	16.6
Female headed household (%)	12.1	11.5	12.0	11.7	12.0	12.0	11.9	11.6	12.9
Landless household (%)	56.7	65.6	46.7	37.6	54.1	40.4	69.6	56.9	56.3

* CGH: Chhatisgarh, JH: Jharkhand, OD: Odisha, EUP: Eastern UP, WB: West Bengal

Livestock population: The region is richly endowed with a total livestock population of 159.8 million which include 77.8 million cattle, 19.7 million buffalo, 4.8 m sheep, 52.3 m goats and 5.1 m pigs. The region has 31.2 percent of the total livestock in India. The species wise percent population (of India) in eastern states are cattle (40.8), buffalo (18.1), sheep (7.4), goats (38.7), and pig (49.3). There is a great variation in species wise composition of livestock in various eastern states. In Asam, Chhattisgarh, Odisha and West Bengal, cattle constitute more than 50 percent of the total livestock population, on the other hand Bihar and EUP has less than 37 percent cattle of the total livestock population in the respective states. On the contrary, Bihar has 23 percent buffaloes and EUP 33 percent buffaloes of the total livestock population of the respective states. In the other five eastern states, buffalo population is less than 10 percent of the total livestock population. There is wide variation in the composition of livestock within the states which indicate that there is a differential preference of livestock dictated by the socio-cultural environment.

The density of different livestock species also varies widely between the states. The density (no per sq km) of all livestock taken together in eastern states is 262 which is higher than the all India average of 162. Among the states, Chhattisgarh has the lowest (111) livestock density and Bihar the highest (350). Cattle density is highest in West Bengal (180) and the buffalo density was high in EUP (90) and Bihar (80).

The dependence of human on livestock is reflected in the ownership pattern defined as number of livestock per 1000 humans (PTH). Assam had highest PTH (612) followed by Chhattisgarh (589) and Jharkhand (547). Bihar had the lowest PTH (317) followed by Eastern UP (332). The data indicates a very high dependence on cattle in Assam, Jharkhand and Chhattisgarh.

Table 1. Human beings and livestock in eastern states

	Assam	Bihar	CGH*	JH*	OD*	EUP*	WB*	Eastern states	India
Livestock population (million)									
Cattle	10.3	12.2	9.8	8.7	11.6	8.6	16.5	77.8	190.9
Buff	0.4	7.6	1.4	1.2	0.7	7.8	0.6	19.7	108.7
sheep	0.5	0.2	0.2	0.6	1.6	0.7	1.1	4.8	65.1
goat	6.2	12.2	3.2	6.6	6.5	6.1	11.5	52.3	135.2
pig	1.6	0.6	0.4	1.0	0.3	0.5	0.6	5.1	10.3

Total livestock	19.1	32.9	15.0	18.0	20.7	23.7	30.3	159.8	511.9
Total Poultry	26.2	7.6	6.3	11.0	12.3	4.5	29.2	97.1	217.5
Exotic-Cattle	0.4	3.5	0.2	0.3	1.3	1.6	2.8	10.1	39.7
Percent composition of livestock species									
Cattle	54.0	37.2	65.2	48.4	56.1	36.3	54.4	48.7	37.3
Buffalo	2.3	23.0	9.2	6.6	3.5	32.8	2.0	12.3	21.2
Sheep	2.7	0.7	1.1	3.2	7.6	2.9	3.5	3.0	12.7
Goat	32.3	36.9	21.4	36.5	31.4	25.8	37.9	32.7	26.4
Pig	8.6	2.0	2.9	5.3	1.4	1.9	2.1	3.2	2.0
Total livestock (%)	100	100	100	100	100	100	100	100	100
Density (no/ sq km) of livestock species									
Cattle	131	130	73	110	75	100	186	108	60
Buffalo	6	80	10	15	5	90	7	27	34
Sheep	7	2	1	7	10	8	12	7	21
Goat	79	129	24	83	42	71	130	73	43
Pig	21	7	3	12	2	5	7	7	3
Total livestock	243	350	111	226	133	276	342	223	162
Ownership (no / 1000 humans) of livestock species									
Cattle	331	118	384	265	277	108	181	191	158
Buffalo	14	73	54	36	17	97	7	48	90
Sheep	17	2	7	18	38	8	12	12	54
Goat	198	117	126	200	155	77	126	129	112
Pig	52	6	17	29	7	6	7	12	9
Total livestock	612	317	589	547	494	297	332	393	423

* CGH: Chhatisgarh, JH: Jharkhand, OD: Odisha, EUP: Eastern UP, WB: West Bengal

Table . Milk production and its growth in eastern states

States	Milk production (000 MT) 2000-01	2013-14	% increase between (2000-01 to 2013-14)	Milk production (MT/sq km)	Growth rate (p.a.) 2000-01 to 2005-06 (5 yrs)	2005-06 to 2010-11 (5 yrs)	2010-11 to 2013-14 (5 yrs)	2000-01 to 2013-14 (13 yrs)
Assam	683	815	19	10.4	1.8	1.1	1.	1.4
Bihar	2489	7197	189	76.4	15.2	5.2	3.4	8.5
Chhattisgarh	777	1209	56	8.9	1.5	4.2	5.5	3.5
Jharkhand	910	1700	87	21.3	8.	3.1	3.	4.9
Odisha	876	1861	112	12.	8.9	4.5	3.7	6.
EUP	4269	7454	75	86.8	4.6	3.9	4.8	4.4
West Bengal	3471	4906	41	55.3	2.3	2.8	3.1	2.7
Total-ES	13475	25142	87	35.	6.6	3.9	3.8	4.9
All India	80607	137685	71	43.5	3.8	4.7	4.2	4.2

Prioritizing dairy development in districts: In the eastern states, there is a wide variation in the level of dairy development because of socio-cultural factors, dietary habits, access to information and services besides others. In states like Bihar, EUP and West Bengal the dairy development is well developed compared to other states of the eastern region. Nevertheless, the states having lower milk production have also realized that dairy enterprise provides income and employment on sustainable basis and is important in improving the dietary status of households. Therefore, prioritization of districts for milk production was made taking into account the density of female cattle and female buffalo, percent crossbred cattle, ownership of cattle and buffalo and milk production (MT/sq km) of all the districts. It was revealed that 49 out of top 50 districts for milk production was in Bihar, EUP and WB. In case of districts with priority rank 51 to 100, 29 belong to Bihar, EUP and WB and 21 in the other four states. Based on the study the states in eastern India was grouped into two: with high and low milk production priority.

Table . Number of districts* under different priority class in eastern states

		Milk production priority rank				**Total**
Sl no	**State**	**Top 50**	**51-100**	**101-150**	**151-183**	
1	Bihar	23	15			38
2	EUP	21	6			27
3	West Bengal	5	8	3	3	19

	Subtotal	***49***	***29***	***3***	***3***	***84***
4	Assam		6	19	2	27
5	Chhattisgarh		3	9	6	18
6	Jharkhand		6	13	5	24
7	Odisha	1	6	6	17	30
	Subtotal	***1***	***21***	***47***	***30***	***99***
	Grand Total	**50**	**50**	**50**	**33**	**183**

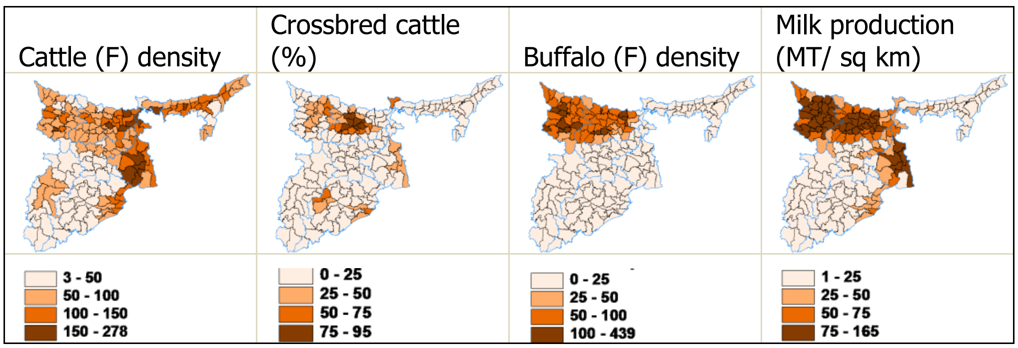

Fig. . Distribution of districts based density (no/sq km) of cattle, buffalo and milk production (MT/sq km) in eastern states

Conclusion : The ownership of livestock species has a strong spatial bias dictated by the socio-cultural-religious factors, dietary habits and level of development. Development plan in livestock sector should take into account the resource base i.e. density of a particular livestock species, the dependence of human population on the livestock species, the existing production and productivity levels, the cultural preference of the people of the region besides others. Since, district is the unit of planning and implementation in India, a prioritized list need to be prepared taking into account a number of parameters. After prioritization of the districts, the developmental plan should take into account the agro-climatic conditions, soil characteristics, irrigation facilities, the existing agricultural production and productivity levels, the socio-cultural indicators and other backward and forward linkages for sustainable livestock production.

Family Poultry: A Viable Enterprise for Small Scale Farm Integration

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Poultry eggs and meat with high quality nutrients and micronutrients provide food for good human nutrition. The importance of small scale poultry farming in rural areas has been recognized globally to alleviate poverty, hunger and malnutrition in developing countries. Family poultry encompasses the wide variety of small-scale poultry production systems found in rural, urban and peri-urban areas of developing countries with variable degree of success. India has nearly 70% of its population living in rural areas. However, in the present scenario, most of the commercial poultry production is concentrated in urban and peri-urban areas. Just 25% population living in urban areas consumes about 75-80 % of eggs and poultry meat. In rural areas, the poultry products are sold at 20-30% higher price than the prices at urban and semi urban areas. Non-availability of poultry products and low purchasing power of the rural people devoid them of access to the highly nutritious products like egg and meat. Under these circumstances there is a great potential for poultry farming in tribal / rural sector by adopting the concept of family poultry, which can improve the socio-economic conditions of rural / tribal people. An understanding of need for suitable technologies and support system is critical to improve the productivity of animals, quality assurance and market linkages to provide sustainable livelihood opportunities to the farm women.

What is Family Poultry?

Family poultry is small scale poultry keeping by households using family labour and wherever possible locally available feed resources. The poultry may range freely in the household compound and find much of their own food, getting supplementary amounts from the householder. A regular supply of low-cost feed, over and above maintenance requirements, is essential for improved productivity in all the three farming systems used in family poultry production such as free-range, semi-intensive and intensive. Poultry keeping is traditionally the role of women in many developing countries. Family poultry production represents an appropriate system to contribute to feeding the fast growing human populations and to provide income to poor small farmers, especially women. It offers advantages over other agricultural sectors and is an entry point for promoting gender balance in rural areas. An understanding of need for suitable technologies and support system is critical to improve the productivity of animals, quality assurance and market linkages to provide sustainable livelihood opportunities to the farm women.

Why Poultry farming?

- Poultry farming is an essential activity of the typical rural/tribal household system in India, touching their social, cultural and economic lives.

- Poultry is the choice of species because it needs minimal use of land, labour and capital.
- It also easy to handle and does not require special attention.
- Poultry has no religious sentiments, as it is acceptable to all sections of society irrespective of cast, creeds and colour. Presently poultry meat is accounting for about 27% of the total meat consumed and is the most popular meat from any single livestock species .
- Poultry farming gives quickly turnover as, the growth cycle is very fast, only 42 days (broiler chickens). So it generates fast cash.
- The poultry products like egg and meat is nutritious and the biological value of egg protein is very high (Table 1). Poultry meat is low in fat and cholesterol and hence choice of health conscious people.
- By going for poultry production in rural area it not only assures the availability of eggs and meat to cater the food need besides providing additional income. Thus has a potential to fight poverty and malnutrition and provide scope for high employment generation and solving gender issues in employment.

Table 1. Comparative nutritive value of eggs and other food stuffs

Foodstuffs	Biological value	Protein efficiency ratio	Net Protein utilization	Chemical Score	Digestibility%
Egg	96	4.5	93	100	97
Milk	85	3.0	81	65	94
Meat	80	2.8	76	70	82
Chicken	82	2.9	78	71	85
Fish	85	3.0	72	70	85
Soybeans	64	2.0	54	57	73
Peas	56	1.6	45	42	72

While going for family poultry production (FPP), it is essential to understand the local production system, their limitations and opportunity, the circumstances under which such traditional system came into existence and how they can be improved further. The indigenous breeds of fowl is the choice for rural poultry production as they are hardy, resistance to common diseases, heat tolerant and do not need special attention as compared to exotic breeds. These native breeds have also acquired considerable adaptability to the local climatic environments due to several years of natural selection. Some indigenous breeds possess few unique genes like necked neck and frizzle gene which help in better heat dissipation under tropical conditions. Dark meat chicken (Kadaknath) is a highly valued chicken at some regions for its nutritive properties is assumed to alleviate bone and kidney disease and also human lactation. Because of coloured pulmage, long shank bone and alertness, these birds can camouflage characters to protect themselves from predators. However, the growth rate and production performance of the birds are low. This could be the reason that improved chicken varieties have developed with higher performance. Some of the areas which need while going for family poultry production are

Suitable Chicken varieties

Realizing the importance of small scale poultry production in India, several research institutes have developed different chicken varieties (Table 2). These are the varieties that are being now effectively being raised in different parts of the country by the farmers. These birds were selected based on growth rate, egg production, immune competence and plumage colour. These birds are able to thrive in harsh climatic conditions of free range/ semi-intensive farming in India. Going by the present international consumer market trends, eggs and meat from free range farming will have a great demand in the days to come.

Table 2. Chicken varieties suitable for family poultry farming

Variety	Type	Developing agency
Giriraja	Dual	KVAFSU, Bangalore
Girirani	Egg	KVAFSU, Bangalore
Swarnadhara	Egg	KVAFSU, Bangalore
Vanaraja	Dual	ICAR-DPR, Hyderabad
Gramapriya	Egg	ICAR-DPR, Hyderabad
Krishibro	Meat	ICAR-DPR, Hyderabad
Srinidhi	Dual	ICAR-DPR, Hyderabad
CARI Debendra	Dual	ICAR-CARI, Izatnagar
CARIBRO Dhanraja	Meat	ICAR-CARI, Izatnagar
CARI Nirbheek	Egg	ICAR-CARI, Izatnagar
CARI Shyama	Egg	ICAR-CARI, Izatnagar
Krishna J	Egg	JNKVV, Jabalpur
Narmadanidhi	Dual	JNKVV, Jabalpur
Nandanam IV	Dual	TANUVAS, Chennai
Gramalakshmi	Egg	KAU, Kerala
Kalinga Brown	Egg	CPDO, Bhubaneswar

Utilization of locally available resources

Whatever may be the system of production, a regular supply of low cost feed over and above maintenance requirements, is essential for sustaining performance in poultry. The productivity of the birds under extensive system ultimately depends on the human population and its household waste and crop residues, and on the availability of other scavengable feed resources (household cooking waste; cereal and cereal by-products; roots and tubers; oilseeds and its by-products, insects, worms etc.). Under the free-range and backyard systems, feed supplies during the dry season are usually inadequate for sustaining production. When vegetation is dry and fibrous, the scavenging resources should be supplemented with sources of minerals, vitamins, protein and energy. Under most traditional village systems, a grain supplement of about 35 g per hen per day is given. Under the semi-intensive system, the birds meet part of its requirement through scavenging and rest of the nutrients required by the birds must be provided in the feed, usually in the form of a balanced feed. In the backyard poultry keeping, it is difficult to know the activity of the birds for their picking up habits and availability of feed ingredients. It is therefore suggested to identify the alternative feed resources available locally and evaluate their nutritional value for poultry. This will not only help in reducing the cost of production but also proper utilization of the local produce.

Health Measures

One of the most important area of FPP is proper health management. The single most important disease concerning to family poultry production has been reported to be Ranikhet Disease (RD) which is accountable for 60-80% mortality. Hence vaccination against most common poultry disease (Marek's disease and Infectious bursal disease) in general and Ranikhet disease in particular is very essential for success of rural poultry. Also there is a need for reliable diagnostic tests and facilities to differentiate various poultry diseases and also efficient vaccines must be made available at reasonable cost. Training on proper management and Bio-Security should be imparted to prevent spread of diseases. More women should receive training in husbandry practices and gain access to poultry health services for successful poultry activities.

Marketing system

Marketing may not be an issue for family poultry producers in which birds are raised in small numbers for which ready markets available locally. But a reliable market becomes critical for small scale market oriented poultry producers. A comprehensive system of input supply and marketing support are necessary often through established co-operative mechanisms. Formation of producer co-operatives/ Associations and Rural market yards will help in proper marketing.

Integrated Farming System with Poultry

Family poultry farming will be more profitable if undertaken in integration mode. Literal meaning of integrate is to combine two things in such a way that one becomes fully a part of the other. Integrated Farming System (IFS) is an interdependent, interrelated often interlocking production systems based on few crops, animals and related subsidiary enterprises in such a way that maximize the utilization of nutrients of each system and minimize the negative effect of these enterprises on environment. Integrated farming with chicken, fish and crops can play a significant role in increasing manifold production, income, and nutrition and employment opportunities of rural populations. The utilization of family labour round the year in pond based integrated production system contributed to improve the production as well as to create employment opportunity for income generation. For an hectare of farm 500-600 stocking density can be reared.

Rearing of improved chicken varieties through integrated farming system can fulfil the daily requirement of farmers (eggs) and provides static income which enhances their standard of living. Rearing of Improved chicken varieties through integrated farming system can be turned into a profitable business. Integrating chicken with fish farming can be done in two ways.

1. Direct Integration: In this method, fish farming was done with improved variety of chicken, poultry shed was built on top of the tank and hen waste automatically fall into the pond to fish as feed. Probably this is called double layer method. Fish in the lower layer, i.e, the upper layer of the water tank and country chicken in the upper layer is the growing method.

2. Indirect Integration: In this system, improved chicken varieties are reared in the pond bank, hen shed was cleaned weekly once and the excreta were spread on top of the pond or keep as heap in every corner of the pond. This practice may followed in the early morning. In both this method chicken can be reared with fish in integrating method. The management practices in the handling of such integrated country chicken with fish farming is very important and this has already discussed above.

<u>Benefits of fish cum chicken integration</u>

- The direct discharge of fresh chicken manure to the fish ponds produces enough natural fish feed organisms without the use of any additional manure/fertilizer.
- The transportation cost of the manure is not involved.
- The nutritive value of applied fresh manure is much higher than dry and mixed with bedding materials e.g. saw dust or rice husk.
- Some parts of the manure is consumed directly by the fish.
- No supplementary feed is needed for the fish.
- No extra space is required for chicken farming. Chicken sheds can be constructed over the pond water or on the dyke.
- More production of animal protein will be ensured from the same area of minimum land.
- The overall farm production and income will increase.

Integrating farming system approach is a powerful tool for improving livelihood security of small farm holders. Integrated farming with chicken, fish and crops can play a significant role in increasing manifold production, income, and nutrition and employment opportunities of rural populations. But the need of the hour is plan to practice it.

Occupational Health Hazards to Farm Women in Different Farming Systems

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Majority of the India farmers derive their livelihood from agriculture. Agriculture and allied activities support livelihoods of nearly 70 percent of India's rural population. In recent years, land based livelihoods of small and marginal farmers are increasingly becoming unsustainable, since their land has not been able to support the family's food requirements and fodder for their cattle. As a result, rural households are forced to look at alternative means for supplementing livelihoods. Besides the Indian economy is predominantly rural and agricultural, and the declining trend in size of land holding poses a serious challenge to the sustainability and profitability of farming. In view of the decline in per capita availability of land from 0.5 ha in 1950-51 to 0.15 ha by the turn of the century and a projected further decline to less than 0.1 ha by 2020, it is imperative to develop strategies and agricultural technologies that enable adequate employment and income generation, especially for small and marginal farmers who constitute more than 80% of the farming community. Under the gradual shrinking of land holding, farmers are willing to integrate land based enterprises like fishery, poultry, duckery, apiary horticultural crops, fodder etc. within the bio-physical and socio-economic environment of the farmers. Though, in farming system, a combination of one or more enterprises with cropping when carefully chosen planned and executed, gives greater dividends than a single enterprise, especially for small and marginal farmers but there is every possibility to face various occupational health hazards.

Occupational health hazards of farm workers may be due to exposure to weather/ climate, snakes & insect bites, sharp tools & use of farm equipment, physical labour- carrying loads, pesticides, dusts/fumes/gases/particulates, biological agents & vectors of diseases. In rural parts of the country, men and women, both are engaged in farm activities. Of both, women do the household work in addition to child bearing and nursing to old parents. Thus, their job in rural surroundings is more challenging than counter parts. This also reflects that they may be more prone to health hazards as they are involved in household's activities, animal caring, child rearing etc. Thus, there is every possible chance to face the hazard, which is something that can cause harm if not controlled. So the outcome is the harm that results from uncontrolled hazards. In favourable circumstances, work contributes to good health and economic achievement. However, the work environment exposes many workers to health hazards that contribute to injuries, respiratory diseases, cancer, musculoskeletal disorders, cardiovascular diseases, mental and neurological illnesses, eye damage and hearing loss, as well as to communicable diseases.

Occupational health hazard refers to the potential risks to health and safety for those who work outside and inside the home. As farm women involve both in household and farm activities, they are more prone to this. They are exposed both outdoor and indoor environment.

The joint International Organization/World Health Organization Committee on Occupational Health, in the course of its first session held in 1950 stated: Occupational health should aim at the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations; the prevention among workers of departures from health caused by their working conditions; the protection of workers in their employment from risks resulting from factors adverse to health, the placing and maintenance of the worker in an occupational environment adapted to his physiological and psychological equipment, and, to summarize , the adaptation of work to man and of each man to his job.

Most frequent hazards in agriculture

- Machinery such as tractors, trucks and harvesters and cutting and piercing tools
- Hazardous chemicals: pesticides, fertilizers, antibiotics and other veterinarian products
- Toxic or allergenic agents: plants, flowers, dusts, animal waste, oils etc
- Carcinogenic substances or agents: certain pesticides such as arsenicals and phenoxyacetic herbicides, UV radiations, parasitic diseases such as biharzias and facioliasis
- Transmissible animal diseases: brucellosis, bovine tuberculosis, rabies, lyme disease
- Confined space such as pits, cellars and tanks
- Noise and vibration
- Ergonomic hazards use of inadequate equipment and tools, unnatural body posture or prolonged static postures, carrying of heavy loads, repetitive work, excessive long hours
- Extreme temperatures due to weather conditions
- Contact with wild and poisonous animals insects, spiders, scorpions, snakes, certain wild mammals

Workplace Hazards

Work related diseases occur due to two factors:

Workers' susceptibility-Age, Life style, Genetic factors, Race, Gender, Medical history.

Work place factors- Multiplicity of exposure, Duration of exposure, Physical properties, Magnitude of exposure, Timing of exposure.

The major workplace hazards are physical hazards, chemical hazards, biological hazards, ergonomically hazards, and psychosocial hazards**.**

Physical hazards: Physical factors in the workplace such as noise, vibration, extreme temperature, illumination, radiation can affect health adversely.

Types of Noise-Induced Hearing Loss

- Temporary loss of hearing acuity after exposure to loud noise. Recovery within 16-48 hours.
- Permanent Threshold Shift. Irreversible loss of hearing

Other Harmful Effects of Noise

- Hypertension
- Hyperacidity
- Palpitations
- Disturbs relaxation & sleep

Vibration

Physical factor which affects man/ woman by transmission of mechanical energy from oscillating sources.

Types

- Segmental vibration(Health Effects: hand arm vibration syndrome, pain, tingling, blanching fingers)
- Whole body vibration (Health Effects: fatigue, irritability, headache, disorders of the spine)

Extreme Temperature

Sources of heat stress: Natural Conditions, Hot work process related to furnaces, kilns, boilers & smelting. Prickly heat, Heat cramps, heat exhaustion, heat stoke is the disorders.

Sources of Cold environment are ice plants and freezers in the food industry. Mostly farm women are the victims. The health effects are burning pain, numbness in fingers, toes, nose, and ears. Cramps, ulceration and gangrene are the disorders.

Inadequate Illumination

Sufficient light is necessary at the workplace to have better and safe performance from the workers. For Agricultural work in open space during day time, there is always sufficient light in normal working hours. During night, light is often poor & it may lead to accidents. It is important that proper light intensity is maintained at workplace so as to have safe and efficient performance. Otherwise the workers may develop visual fatigue, double vision, headache, painful irritation, lacrimation, conjunctivitis.

Radiation

Radiation may be due to ionizing (x-rays, gamma rays) and non-ionizing (ultraviolet, infrared, laser) rays. The health effects are cancer, death, skin redness, premature skin aging and eye problem.

Chemical hazards

About 100 000 different chemical products are in use in modern environments and number is growing. Routes of entry into the body through inhalation, ingestion, skin contact. Routes of excretion are gastro-intestinal, renal, respiratory and skin. Health effects include renal diseases, respiratory disease, and hematologic, cardiovascular, neurologic diseases, carcinogenic, teratogenic. Women exposed to toluene have reported a greater frequency of menstrual dysfunction including dysmenorrhoeal, irregular cycles and spontaneous abortions. This is mostly occurred in crop- based farming system.

Biological hazards

Exposure to some 200 biological agents, viruses, bacteria, parasites, fungi, moulds and organic dusts occurs in selected occupational environments lead to chronic diseases among agricultural workers. The diseases are cold, influenza, diphtheria, tuberculosis, anthrax, ring worm, tetanus, hook worm, rabies. This is mostly occurred in live stock-based farming system.

Ergonomically hazards

Ergonomics involve the environment, the tool, the workstation, the task, the organization. It goal to reduce work-related musculoskeletal disorders (MSDs) developed by workers. MSDs are injuries and illness that affect muscles, nerves, tendons, ligaments, joints or spinal disks. Common symptoms of MSDs are painful joints, numbness in hands, waists, forearms, shoulders, knees and feet, back or neck pain. Swelling or inflammations are common.

Risk factors are static posture, forceful exertion, repetitive movement, extreme range of motion, awkward posture.

Psychosocial hazards

Occupational stress is one of the major problems from a gender perspective. Stress caused by time and work pressures has become more prevalent during the past decade. Monotonous work, work that requires constant concentration, irregular working hours, shift-work, and seasonal-work can also have adverse psychological effects. Stress is the harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources or needs of the worker.

Most frequent hazards in animal farming

On average, two people die every year in accidents involving animals on Ontario farms. Inadequate animal handling facilities and poor animal handling methods increase the likelihood that accidents will occur. Animals are also the source of some infectious diseases that can be spread to humans. Handlers must always be on guard when working with or around animals.

General Responsibilities

1. The employer shall provide information, instruction and supervision to a worker handling large farm animals and shall ensure that the worker is competent to do so safely.
2. A worker coming into contact with an animal should wear appropriate personal protective equipment for the assigned work.
3. A worker coming into contact with an animal should be made aware of any transmittable diseases that the animal may carry and should be instructed on how to prevent transmission, to themselves and to other animals.
4. An employer should ensure that workers know how to safely separate themselves from an animal while working in an enclosure occupied by animals.

Animal Handling Hazards

Farm employers and workers handling large animals can be killed or injured in a number of ways, including being:

- stepped on,
- knocked down,
- kicked,
- bitten,
- pinned against a hard surface, or
- exposed to a transmittable disease.

Factors to Consider When Handling Large Animals

The measures set out below are general factors that employers and workers should take into account to reduce the likelihood that an animal will behave in an unpredictable or aggressive way and thereby endanger either people or other animals nearby.

1. The employer should ensure that proper equipment and facilities are available for housing and handling the type of animals in the operation with attention to:
    - Good housekeeping practices;

- Equipment, fencing and gates that are able to restrain animals safely for general maintenance or health care;
- Walking or working surfaces that are even and finished or constructed to prevent slipping under wet conditions;
- Even and diffused lighting; and,
- Alleys and chutes that are wide enough for animals to pass but not to turn around.

2. When approaching an animal, handlers should announce their presence by voice or by being clearly visible and gently touching the animal on the front or side.
3. Handlers should be aware of and avoid an animal's kicking region.
4. Noise and yelling should be kept to a minimum when working with livestock to enable the animal to feel secure.
5. When handling livestock with young, allow them to remain as close to their offspring as possible.

Background-Animal Characteristics and Behaviour

The points below are provided for information purposes only and may help those handling large animals to understand why certain precautions are necessary.

Animal Vision

Workers should be aware of the limitations of vision of the particular animal that they are working with. Animals may have:

- colour blindness;
- poor depth perception;
- sensitivity to contrasts, which may cause them to balk or hesitate at sudden changes in lighting (shadows), colour or texture;
- difficulty in picking out small details;
- sensitivity to distractions or sudden movement because of wide angled vision;
- a natural tendency to move from dimly lit areas to lighter areas;
- blind spots where they cannot see a worker.

Animal Hearing

Loud, abrupt noises can cause distress in livestock. Reduction of noise levels will have a calming effect on animals.

Maternal Instincts and Territorial Behaviours

Livestock with young exhibit a maternal instinct. They are usually more defensive and difficult to handle.

Most animals have a strong territorial instinct and develop a very distinctive attachment to certain areas such as pastures, buildings, water troughs and worn paths. Forcible removal from familiar areas can cause animals to react unexpectedly. Similar problems occur when animals are moved away from feed, separated from the herd or approached by an unfamiliar person.

Kicking and Biting

Each type of animal kicks differently. Some of the reasons animals kick include:

- Pain, injury or inflammation,
- Something in their blind spot,
- Sudden noise.

Animals may signal their intention to kick. For example, ears that are "laid back," or flattened backward, warn you that a horse is getting ready to kick or bite.

Approaching Animals

Most animals, like humans, have a comfort zone. The illustration below is specific to cattle but the principles apply generally to other animals as well.

A comfort or flight zone can be used to effectively move cattle and other animals. This works best when the handler works at the edge of the flight zone. These zones will vary from animal to animal and can be anywhere from five to twenty-five feet. Deep invasion into the flight zone may cause panic and confusion. Learning the principles of using the flight zone will allow a handler to move the herd safely.

How productivity will increase by analyzing and addressing OHH of farmwomen?

1-Use women- friendly tools and equipment help to achieve.

- Reduce drudgery
- Increase utilization efficiency of inputs
- Ensure timeliness in field operations and reduce turnaround time for next crop
- Increase productivity of worker-machine system
- Conserve energy
- Improve quality of work and also quality of produce
- Enhance the quality of work life of agricultural workers

2-Stipulations of rest periods

Every function of the human body can be seen as a rhythmical balance between energy consumption and energy replacement or between work and rest. This dual process is an integral part of the operation of muscles of the heart and of the organism as a whole. Rest pauses are indispensable for farm workers as they do more gruelling job and repetitive motions during agricultural activities. Farm women are exposed bending, squatting, stooping or standing posture for long periods during their work. Lifting or carrying heavy loads are also part of agricultural activities. These awkward postures and heavy work cause musculoskeletal injuries.

3-Improvement of Workstations and Work methods

By improving work station and work methods, it will increase the productivity. Simply a good working posture, which requires a minimum of static muscular effort, will be better and the body discomfort will be less.

Conclusion

Occupational Health Hazards have been a widespread problem in agriculture and allied sectors in more than a decade. As integrated farming system or integrated agriculture is a commonly and broadly used word to explain a more integrated approach to farming as compared to monoculture approaches. It refers to agricultural systems that integrate livestock and crop production or integrate fish and livestock and may sometimes be known as integrated bio-systems. So while a farmer involves in integrated farming system he or she has to perform multifarious activities in the home, farm and allied activities, which include milking of animals, cleaning animal sheds, mud plastering of house & preparing cow dung cakes for fuel, fetching of water & other house hold activities are not only fatiguing but also time consuming. He/ she performs these activities in his/ her own convenient posture like sitting, standing, bending or squatting without realizing the harmful affect on the body. Due to this ignorance he/she might be suffering from various health hazards.

Quality and Value Addition

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India got self sufficiency in primary agriculture (green revolution) but over the period, the contribution of agriculture to GDP has declined. India is a country of over 1.25 billion consumers; 300 million upper and middle-class consume processed food. There is a large untapped domestic market of 1,000 million consumers in the food processing sector and 300 million more consumers are expected to shift to processed food by 2016. The post-harvest losses of fruits and vegetables are estimated to be 18 to 40 %, hardly less than 2 % is processed and hardly 7 % is value added, although we have a middle class of 250-300 million people with adequate purchasing power to buy manufactured goods. Due to improper management, despite having more than 250 million tonnes of food grains production, nearly 130 million people go to bed hungry every day. Under the circumstances, there are greater opportunities for adding value to raw commodities because of increased consumer demands not only for food, health, nutrition but for convenience as well. Producers involved with adding value can fetch a larger share of the food money by producing what consumer's demand, instead of producing only raw commodities. Maintaining and enhancing quality and value addition of produce entails the opportunities to differentiate a product to comply with the requirements of a particular market.

Adding value is the process of changing or transforming a product from its original state to a more valuable state that is preferred in the market place. Value-added products are customer oriented and therefore, marketing is a value adding process. It involves exchanges where buyer and seller must benefit. Value may be added based on form, location, time, ownership, and information. Adding value to farm products becomes vital for rural growth by enhancing farm income and providing employment in processing businesses Adding value to products can be accomplished through innovation and/or coordination. It is not enough merely to increase and conserve the supply of raw food; it must be conserved against further loss by processing and be packaged, distributed to where it is needed. There is a huge opportunity to develop S&T capability and R&D in the sector. As such agricultural commodities that are produced in India if brought under the umbrella of quality maintenance and value addition; there are significant opportunities to add two to three fold value to primary agriculture. The food processing industry currently valued at about US$ 100 billion & is estimated to grow at 9-12 per cent, basis estimated GDP growth rate of >8 per cent and increasing disposable income. Value addition of food products is expected to increase from the current 8 per cent to 35 per cent by the end of 2025. Fruit & vegetable processing, which is currently around 2 per cent of total production will increase to 25 per cent by 2025. Growing population and rapid urbanization are expected to continue in the future and, therefore, will shape the demand for value added products and thus for food processing industry in India. India, having access to vast pool of natural resources and growing technical knowledge base, has strong comparative advantages over other nations in this industry. However, all these developments will need extensive logistics, quality storage and transportation, skilled manpower and R&D.

India has 52% cultivable land compared to 11% world average and gifted with all 15 major climates in the world. It has 46 out of 60 soil types exist in the world with 20 agro-climatic regions. Sunshine hours and day length are ideally suited for round the year cultivation. With this natural wealth India bears largest livestock population with largest milk production. It is also the largest producer cereals, second-largest fruit and vegetable producer and worldwide top producer of rice, wheat, groundnuts, tea, coffee, tobacco, spices, sugar and oilseeds. Though we are among the top few producers of many agricultural commodities in the world yet our share in world food trade is only 1.6%. The post-harvest losses of fruits and vegetables are estimated to be 18 to 40 %, amounting to more than Rs. 30,000 crores, hardly less than 2 % is processed (30 and 80% Thailand and Malaysia respectively). We have a middle class of 250-300 million people with adequate purchasing power to buy manufactured goods but our value addition to agricultural products is less than 7%. Despite having more than 250 million tonnes of food grains production nearly 130 million people go to bed hungry every day. India got self sufficiency in primary agriculture (green revolution) but over the period, the contribution of agriculture to GDP has declined. Lower rate of growth of agricultural opportunities has been recorded in terms of value, both in terms of production as well as on the processing side. Low productivity coupled with low value addition, less returns to farmers and lack of backward linkage between farmers, market and processors supplemented with climate vagaries are the matter of concern.

India is a country of over 1.25 billion consumers; 300 million upper and middle-class consume processed food. There is a large untapped domestic market of 1,000 million consumers in the food processing sector and 300 million more consumers are expected to shift to processed food by 2016. It is the second-largest producer of fruits and vegetables in the world. Further, India has tremendous potential to unleash large- scale process-based farm activities to exploit the emerging global business opportunities. As such agricultural commodities that are produced in India if brought under the umbrella of quality maintenance and value addition, there are significant opportunities to add two to three fold value to primary agriculture. At the same time, the secondary agriculture is highly complex and needs infrastructure, skilled manpower and R&D. The secondary agriculture brings quality not only in processed product but also in primary product and add value as well. Food quality is the quality characteristics of food that is acceptable to consumers. This includes external factors as appearance (size, shape, colour, gloss, and consistency), texture, and flavour; and internal factors such as chemical, physical and microbial activities.

India has made significant progress in agriculture due to profitability and opportunities, huge post harvest losses result in diminished returns for producers. Value addition, product diversification and by-product utilization has been given top priority in the recent years. The commercial utilization of traditional formulations and products by small scale enterprises may be helpful in the income enhancement and additional employment of rural households. Further the new products and changing preferences of the consumers are opening new avenues for the small and medium scale enterprises in post harvest handling and value addition.

Objectives of quality maintenance and value addition for products are :maintaining the quality and safety to fulfil the needs of the intended market; creating and capturing market opportunities; adding value and increasing income and profit; satisfying the customer and reducing costs and making processing more efficient. Maintaining and enhancing quality of produce entails: knowing the order of magnitude of problems likely to occur (losses in quality and quantity), their causes and opportunities to differentiate a product to comply with the requirements of a particular market; finding solutions to problems and available technologies to secure already identified market opportunities; assessing the impact of simple changes in product handling; training and involving the people responsible for these changes and identifying problems requiring more detailed research. Some solutions to quality losses will require farmers and entrepreneurs; others transport agents and package manufacturers, still others the resources of research institutions with innovative solutions and suitable technologies. Therefore, the support of different players is required.

The Indian government is making headway in quality assurance in the food processing industry by bringing in various rules and regulations. One can see them being well-implemented at various food fairs as well as industry body events taking place across the country throughout the year. Various laboratories are also being set up with the help of government for research and development in quality management. The rules and regulations are also looked into from time to time by industry body. Quality aspect is monitored and regulated by certain mechanisms at addressed and government level and company level (farm, trader, exporter, services, etc.).

There are vital rules and regulations that regulate quality. Fruit Products Order, 1955, BIS and the draft specifications in respect of 61 products by the Central Fruit Products Advisory Committee. A number of prestigious laboratories have been assisted in upgrading facilities for finding the quality revolution in the country. The Hazard Analysis Critical Control Point System (HACCP), have resulted in the industry taking greater responsibility for and control of food safety risks. The installation of ISO: 9000 Quality Management Systems and HACCP- based food safety system is also in place. The ministry of food processing industries (MoFPI) is implementing the scheme of Research and Development and Quality Control to enable adherence to stringent quality and hygiene norms to face global competition and export. It is also providing financial assistance to support research and experiment and adoption of food safety and quality assurance mechanism to keep the Indian food processing industry, technologically abreast of international best practices. The Codex Alimentarius Commission (CAC) is an intergovernmental body that coordinates food standards at the international level. The Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) have formulated scientific principles and guidelines, which address all sectors of the food chain.

Value addition is the process of changing or transforming a product from its original state to a more valuable state that is preferred in the market place. Generally they are raised by an agricultural producer; then sold by that producer for further processing. Many raw commodities have value in their original state. For example corn, wheat, weaned calves, market lambs, watermelons etc. all have value. They are worth something; however they also need attention to retain their worthiness.

There is a greater opportunities for adding value to raw commodities because of increased consumer demands regarding health, nutrition, and convenience. Producers involved with adding value can fetch a larger share of the food money by producing what consumer's demand, instead of producing only raw commodities. Adding value to products can be accomplished through innovation and/or coordination and adding value to farm products becomes vital for rural growth by enhancing farm. Producers get more money for their products if they can grow products differently, physically change their products before selling them and coordinate with an agribusiness to change the way their product was. Adding value to products can be accomplished in a number of different ways, but generally falls into one of two main types:

Creating Value – occurs with actual or perceived value to a customer for a superior product or service like innovative new products, enhance a product's characteristics, enhance services, create brand names and develop unique customer experiences. Another way of creating value is value through - industrial innovation such as processing traditional crops into non-food end uses like Ethanol from corn, Biodiesel from soybeans and particle board from straw. Capturing Value- through changing the distribution of value in the food/fiber production chain such as direct Marketing, Vertical Integration, Producer Alliances, and Cooperative Efforts.

Many times adding value requires a combination of techniques. These techniques provide producers with a competitive advantage in the market place. There are 6 strategies for adding value, these are changing physical state of products, producing enhanced value products, differentiating products, bundling products, producing more products that improve efficiency up the supply chain and owning assets up the supply chain.

The 'Food processing' is a type of value addition to the agricultural or horticultural produce by various methods like grading, sorting and packaging. In other words, it is a technique of manufacturing and preserving food substances in an effective manner with a view to enhance their shelf life, improve quality as well as make them functionally more useful. In general food processing /value addition is applied for one or more of the reasons like preservation, extending the harvest in safe and stable form, safety, quality, availability, convenience, innovations, health and wellness and sustainability.

Adding value to products can be accomplished through innovation and/or coordination. It's important to identify value-added activities that support investment in research, processing & marketing. Additional opportunities for adding value include: applying biotechnology, food engineering (raw product to consumable forms) and restructuring food distribution systems. The food processing industry currently valued at about US$ 100 billion & is estimated to grow at 9-12 per cent, basis estimated GDP growth rate of >8 per cent and increasing disposable income. Value addition of food products is expected to increase from the current 8 per cent to 35 per cent by the end of 2025. Fruit & vegetable processing, which is currently around 2 per cent of total production will increase to 25 per cent by 2025. All these developments will need extensive logistics, quality storage and transportation. New & Innovative Products: Pepsico's Nimbooz, Aliva snacks, Minute maid from Coca cola, Maggi Ataa Noodles etc may improve the scenario. Development of back end -Contract farming and investment in modern storage are the other grey area where attention is needed.

Horticulture based Farming Systems for Farmwomen

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Horticultural crops play a vital role to feed the global population and contribute for food security along with nutrition and human health. It provides opportunities for diversification of income through a wide range of crops e.g. fruit crops, vegetables crops, tuber crops, ornamental crops, medicinal and aromatic crops, spices and plantation crops. It contributes around 28 percent of the GDP from about 13.08 percent of the area and 37 percent of the total exports of the agricultural commodities. Our country has witnessed tremendous growth in this sector, which has brought out economic prosperity to the nation through 'Golden Revolution'. The area under this sector was 0.76 million hectares in 1950-51 which has increased to 23.4 million hectares in 2014-15 with the production of 283.46 million tonnes. Our country has got the status of 2nd largest producer of fruits and vegetables in the world and significant presence at global level. This important and indispensible segment of Indian agriculture would have not reached to the present heights without the notable work of the farm women.

The women are involved mainly in occupations such as maintainance of the home, cooking, care for children which were considered as their gender-specific roles. However, women constituting 43 percent of the agriculture labour force globally including developing countries (FAO, 2011). Almost in the all rural societies women constitute the integral part of the agricultural related activities. Besides that, women suffer from wage gaps, although data documenting this in rural settings is limited. Evidence from a sample of 14 countries shows that on average women are paid 28 percent less than males in rural areas (Hertz et al., 2009). Therefore, there is need to upgrade the earnings of women appropriately by introducing the horticulture based farming systems.

Farm women involvement in horticultural activities may vary with regions, farming systems, castes, classes and stages in the family cycle yet there is hardly any activity except ploughing, in which she is not contributing. In North India, women mostly participate in fruit and vegetable processing, flower gardening, ornamental nursery, fruit and vegetable nursery kitchen gardening. However, In South India, Eastern India and North Eastern India, besides these farm activities, women are playing important role in marketing of horticultural produce too. The engagement of farm women as labour need to be enhanced as entrepreneurs and women based horticultural technology should be adopted by them. The scope and opportunities of various farming system for women in different horticultural activities is being described under following heads;

A. Fruit crops based farming system: Fruit crops based farming system are mostly perennial in nature and labour intensive. Generally women workers are not involved for farm operations which require more physical strength, heavy implements (spade, machines etc.) viz., ploughing, pit digging, spraying of chemicals, mixing of manure, diverting water for irrigation etc. and those requiring greater skill, viz., orchard layout, planting, grafting, pruning and training etc. However, there are enormous options are available where they can perform with more efficiency and may support their economic security through year round engagement in different activities viz. collection of seeds, weeding, hoeing, irrigation, harvesting of fruits, transport of the produce to short distance and processing. With the exception of a few hand tools (hand hoe, spade and knife), most of the tasks undertaken by women in horticulture are performed manually. Significant contribution of women in fruit cultivation operations *i.e.* weeding (80%), field preparation (40%), irrigation (40%), collection of harvest (40%), and sorting and grading (40%) is reported by Tripathi *et al*. (2015). In apple cultivation, more involvement of women than the involvement of men for certain specific horticultural operation such as carrying cow dung on head, digging under plants, application of fertilizer, plucking of apples and transporting of boxes have been reported by Bhat and Bhat (2014). According to a study in 1984 of the Bay Region in Somalia, women and men share crop production activities. For example, in banana production, which is the main cash crop and second largest export commodity in the country, women fertilize and transport bananas to packing centres, while men irrigate and harvest the banana crop. Women are also responsible for the marketing of mango, potato, lemon, watermelon, vegetables and firewood to supplement their family income (FAO, undated[2]).

B. Vegetable and tuber crops based farming system: Women groups and individuals who produce vegetables improved their income as well as household nutrition. Kitchen gardening (Bari) is invariably a part of every household in villages and women are contributing almost 100% for Bari activities. This kitchen gardening is sufficient to meet the requirement of household however, selling of excess produce may also contribute to some extent for income generation. This excess produce may be sent to nearby market through air conditioned van operated by co-operatives or self-help groups which provide the better price from same produce. The out-migration of young men from rural areas in some regions has led to permanent changes in women's responsibilities and tasks and this opportunity may be utilized by women villagers for coming upfront in marketing channel too. Other than kitchen gardening, major operations looked after by women are almost similar to fruit cultivation in short duration vegetable crops viz., selection of crops, sowing, planting, weeding, hoeing, irrigation, harvesting, digging for harvesting tuber crops and transport of produce to the short distance. Besides, they are also involved in other activities e.g. cleaning, sorting, grading and selling of produce in local markets up to some extent. Due to short duration nature of vegetable crop and intensive cultivation practices make it a more profitable venture for women. The study conducted by Tripathi *et al*., 2015 in two districts (Khurda and Ganjam) of Odisha revealed that women contribution is more in cultivation of vegetables as compared to fruits and flower crops. They are playing major role (60-80%) in field preparation, stubble collection, sowing of vegetable seeds, transplanting of seedling and weeding. The results of the study by Baba *et al.* (2010) in J &K revealed that although women dominates in some operations of vegetable cultivation but in totality male participation is found more prominent.

C. Plantation crops based farming system: The plantation sector which consists of tea, coffee, coconut, rubber and cardamom provides significant employment and income opportunities to women. The involvement of women in coir sector is as high as 80 per cent and

60 per cent in coconut processing and broom making, respectively. Involvement of women in coconut based handicrafts is up to 40 per cent. While their remarkable contribution of 47% should be appreciated in tea plantation. Women generally work as groups and hence, there is need to organise women's societies with a view to empower women socially and economically.

Study conducted in the rubber-producing villages revealed that, women are involved alongside men in all steps of rubber tapping due to inadequate labour and the seasonal nature of rubber production. In addition, like men, women often work as self-employed or hired labour (FAO, undated[1]).

D. Ornamental crops based farming system: Commercial cultivation of flower crops mainly undertaken in Southern part of India and other regions are in developing stage. Women participate in almost all activities right from preparatory tillage to harvesting, storage and marketing of the flowers. According to Mankar *et al*., (2013) in Vidarbha region of India, farm women engaged in marigold cultivation activities are performing major role in top dressing of fertilizer (40.00%), grading (30.00%), packing (25.00%) and marketing of flowers (40.00%). Besides cultivation and its marketing as a cut or loose flower, a lot of entrepreneurial opportunities are available for women viz., garland making, veni, dry flower based products, floral ornaments etc. to start as a flower based value added products in small groups.

In Dakshina Kannada, women have been entrepreneurs since ages particularly in the floriculture arena. Women from the past have been actively associated with the development of their families and this is a trend seen from a distance past. The local flower producers/ sellers in Mangalore are a classical example of need based entrepreneurship. The study reveals that these women were solely responsible for eradicating poverty in their homes. They were entrepreneurs in a social and commercial sense and took up entrepreneurship with sole aim of eradicating poverty. The study further reveals that traditional producing and selling of flowers has declined for various reasons including the modern boutique shops and flower merchants which are operating in a large scale and selling erotic flowers which have longer shelf life and have caught the fancy and aesthetic sense of the customers. In this study the authors find that nearly half a decade ago women entrepreneurship in floriculture was flourishing (Dsouza and Pakkeerappa, 2014). The flower *maala* business in south India is purely done by women as in most of the cases the customers are women only. Bonsai making is also an art of producing miniature plants of different types where women workers may take it as entrepreneurship. Indoor gardening is a good option for start-up business of skilful women.

E. Nursery and seed production based farming system: Quality planting material is the pre-requisite of any horticultural crop cultivation and henceforth its demand is increasing day by day. This is one of the option which provides better opportunities for a farm woman to earn handsome money due to ease of operation and flexibility of timing. Traditionally they have been in those nursery activities which require less skill and machinery viz., bed preparation, seed treatment, line sowing, filling of polythene, weeding, watering, fertilizer application and seedling bundle preparation. They do not contribute much in grafting and plant protection measures due to lack of technical know- how and the amount of drudgery involved. Therefore, training on grafting and use of women friendly agricultural equipments could be very helpful in empowering them in nursery related activities. Disease and pest management is very important for nursery seedling production. For this purpose regular need based application of pesticides is necessary which is generally done by knapsack sprayer. The womenfolk find it difficult to shoulder the sprayer and operate by cranking the lever. Cart based pneumatic women friendly sprayer are available to counter this constraints. These are easy to operate and use. Farm women can easily spray pesticides to seedlings with the help of long delivery pipe, without taking the sprayer to all parts of nursery.

Women can also be involved in production of quality seed both in vegetable and ornamental crops. Women can perform various seed processing operations like harvesting, threshing, cleaning, drying, sieving and packaging (weighing filling in packets, stapling, labelling, etc.) efficiently. In Vansda taluka of Valsad districts in Gujarat, group of 4-5 women are able to raise abut 5000 plants earn a net profit of Rs.6,000 - 8,000 per member every month. The larger benefits of this programme is easy availability of good quality grafts in the interior areas, almost at 50% of the price in the market. Earlier, the farmers buy mango grafts at Rs.35-45, now available at Rs.15 - 20 at their doorsteps.

F. Beekeeping based farming system: It is an ideal, economically-viable enterprise that can be taken up by farm women as a profession as it requires less labour, attention, investment and no permanent holding. Four species of honeybees are available and/or cultivated in India, three indigenous species namely *Apis dorsata*, *Apis cerana*, *Apis florea* and one exotic species *Apis mellifera* (Italian bee). Women can easily learn various operations involved in beekeeping viz., hiving of bees and bee swarms, occasional feeding, queen introduction, prevention of absconding, swarm control, honey extraction etc. from short term training courses at Central Bee Research & Training Institute, Pune. A few bee colonies (boxes) kept in a kitchen garden or backyard of the house would add to the income of the farmer woman.

G. Mushroom Cultivation based farming system: Mushroom cultivation is considered one of women friendly enterprises as it is simple, low costing and home bound. There are so many successful stories of women enterpreneurs in mushroom cultivation encompassing the profitability of this venture. It provides great opportunities of income generation to farm women in both semi-urban and rural areas. Women possess skill and patience required for important operation like- harvesting of mushrooms, which are picked at the desirable stage very skilfully without damaging bed and neighbouring pin heads; trimming mushrooms before packing for sale. Other operations like filling of compost, spawning, casing, spraying etc. can be carried out easily by women since these do not require moving out of homes. Women can also be engaged in packing processing, processing and preservation activities. Thus, women can play a vital role in mushroom cultivation without sacrificing their household responsibilities.

Undoubtedly, mushroom cultivation can go a long way in raising overall economic level of women. Therefore, there is an urgent need to impart technical know- how to women so that they can adopt mushroom production as an income generating activity. Manju *et al.*(2012) and Biswas (2014) found the significant impact of awareness and training programmes in disseminating the knowledge of mushroom cultivation .

H. Post harvest based farming system: Post-harvest management of horticultural crops comprises the various technologies and practices undergone by the farmer, farmers' groups or cooperatives and/or agribusiness companies, from the field to the plate. To handle the crop production immediately following harvest up to its final destination, such as storing, transport, cleaning, sorting, processing and packing. Though, women have been doing various important post harvest activities in horticultural crops since the time immemorial like collection of harvest, curing, drying, cleaning, sorting, storage, etc. Yet, the income generation from post harvest based industries can be made more significant with the adoption of new available technologies like hot water treatment, fungicidal dips, waxing, pre-cooling, grading, artificial fruit ripening, packaging in corrugated fibre board boxes etc. In case of plantation crops, women involved in labour intensive and drudgery driven post-harvest operations viz., de-husking of ripe and tender areca nuts, shelling, peeling and grading of cashew nut, beating and cleaning of retted coconut husks and spinning of coir yarns. Cashew processing is a highly labour intensive industry and has a long history of employing a large number of workers. One of the unique features of this industry is that an overwhelming majority (more than 90 per cent) of workers are women belonging to the economically and socially disadvantaged strata of society especially in Kerala. Dry flower handicrafts is also a lucrative business which attracts women workers. This technology need skill and patience for making products like veni and floral designs for hair decoration, greeting cards made from dry flowers, momentos, bouquets etc.

I. Processing and value addition based system: According to UN Food and Agricultural Organization (FAO) one third of all food produced for human consumption or 1.3 billion tonnes a year is lost or wasted. Food loss is more common in low-income countries with restrictions in harvesting, storage, cooling, infrastructure, packaging and marketing systems. In recognition of this, the FAO's recently unveiled reforms include a focus on both food loss and waste (FAO, 2013). Female farmers in many low-income countries are responsible for growing and processing crops that are most susceptible to postharvest loss, such as tubers, fruit and vegetables. In Africa, for example, women play an important role in processing cassava, whose high perishability means that as much as half the crop can be lost after harvest. Indian women have been traditionally doing some processing and value addition in fruits and vegetables on small scale like preparation of dehydrated products, preserves, pickles etc. Improved technologies for drying, preparation of minimally processed product (ready to cook vegetables and ready to eat fruits) and diversified processed products (Jam, jelly, murabba, pickle, candy, squash, nectar, ready to serve drinks, marmalades, etc.) from horticultural crops are now available various technologies which could be adopted by women. Selection of suitable crops and their processing varieties will make it more profitable venture and therefore women farmer should be trained on separate aspect of processing component. Many simple farm-produce-processing technologies have been developed using minimum equipment and small investments. Women should be trained for handling these equipments/gadgets also.

Women have a key role to play in reducing food loss at the production, post-harvest and processing stages, but face many barriers in doing so. There is need to design programmes which could gainfully utilise the services and skills of women in relation to their involvement in horticultural activities. This would also help in generating self employment and rural entrepreneurship. Some of the ventures would include agri-service centres' sale of quality seeds and other agricultural inputs; advisory services and consultancy; village-level marketing; multipurpose warehouses and controlled atmosphere storage; hiring of implements; micropropagation; production of bio-fertilisers; bio-control agents; beekeeping; food processing and testing units; post-harvest management units; social agro-forestry; horticulture; cultivation and management of medicinal and aromatic plants; utilisation of crop residues; mushroom cultivation; low cost household equipments and appliances etc. Entrepreneurship skills can help in building confidence and self awareness through income generation. Various activities can be taken up by rural women for income generation while being at home and by organising themselves in 'self-help groups'.

J.Integrated pond fish/ornamental fish-horticulture based farming system: Utilization of wastewater from fish tank (rich in organic matter) for integrated horticulture (Banana/Papaya/Kitchen garden) can be done at household level. As a regular practice, water in the fish tank need to be refreshed and replenished periodically (after 10-15 days average) having approx. capacity of 450 litre. More than 2000 litre of water will be utilized from a fish unit with 10-12 tanks (40ft x 15 ft) , 4ft around the unit is spared for horticulture can accommodate 16 plants of banana or 18 plants of papaya in an area of 500 sq. ft. or alternatively kitchen garden model may also be adopted.

Constraints in growth of horticulture based farming system for farm women

- Although women play an important role in horticulture production, their role in the decision making process regarding buying inputs, selection of crop, selection of variety, planting crops, planning the budget, hiring labour, disposal of produce, etc. is not significant and they play a supportive role. Study conducted in mango growing domains in Tamil Nadu, India by Sekar (2014) shows that the women's participation in farm decision making and involvement in post-harvest operations are not encouraging. Women carry out harvesting and most of the post production operations like grading, packaging etc. but men largely control them. The outcome of the study suggested that redressing the gender gap in decision making, and improving the management skills of women through institutional intervention would be the key aspect in reducing post harvest losses, improving farm productivity and subsequently the income and household food security. The results of the research in Turky by Ozkan *et al.* (2000) provide insight into the roles and activities of Turkish women farmers in key areas of their operations. It was found that women provide most of the farm labour and make some key decisions in vegetable production. Women farmers provide the majority of labour input in planting, hoeing and harvesting activities. Women participate less in other production activities such as spraying, fertilisation and irrigation.
- Most of the horticultural activities performed by them involve considerable amount of drudgery because most of them are done manually. They use very old tools and equipment which also used by the gents and are not suitable for them. They are performing tasks repetitively with very awkward static posture such as squatting, bending, sitting which is responsible for musculoskeletal disorders and leads to occupational health hazards. Pain in upper and lower limbs, injuries in finger, nail & palm, allergies & injuries in skin are the major problems one can identify easily.
- Women farmers are facing serious constraints in carrying out horticulture production activities because of inadequate technical competency. They have less access to

information, technology, inputs and credit than men. This has compelled them to follow age old practices which in turn result in poor work efficiency and drudgery.

- She is overburdened due to her multidimensional at home and at farm. Women agricultural labourers are paid much lower wages because of the belief that women have less physical strength than men.

Technology and training for horticulture based farming system for women

- Women perform multiple roles in horticulture and play a major role in labour-intensive and manual activities. In addition, women are almost exclusively responsible for post-harvesting (processing) and household activities. By comparison, men are normally responsible for horticultural work that is mechanised or associated with greater income-generating potential. Cultural traditions and gender stereotyping seriously limit the extent of assistance men provide in manual horticultural work, processing and household activities.
- Women mostly work in groups. There is need to organise women's societies for various activities involving group engagement. A strong and effective women's cooperative movement is desirable to boost economic upliftment process of rural women and families.
- Gender inequalities exist in access to resources (such as material inputs, funds, seeds, breeds and plant varieties) as well as information and knowledge (such as training courses related to horticulture farming techniques and fertilizer use).
- Women must be provided opportunities to have control over production resources that would lead to better life for their families and their children.
- Inadequate information about the role of women in horticulture and limited recognition of their contribution, coupled with the lack of sex-segregated statistics, has created a situation in which the development and dissemination of horticultural technology has virtually ignored the role and needs of rural women. In villages where technologies to reduce female drudgery are available, they are normally beyond the means of poor and average-income households.
- Technologies which are labour saving, drudgery reducing, income generating and productivity increasing should be given wide publicity and their use encouraged through pragmatic extension.
- Lack of gender awareness at all levels of society - in the family, community, and government, and among women as well as men - reinforces traditional divisions of labour based on gender, and neglects the fact that women and men have different needs, including for technology and related support.
- Infrastructural facilities like road, electricity, cool chain, etc. must be developed in rural areas for increasing entrepreneurial opportunities
- Ignorance and a lack of attention to gender among government officials, scientists and village leaders - almost all of whom are male - lead them to assume that men are the main or even only target group in agriculture and rural development. Technology and related technical information and training are targeted at men. Officials fail to recognize the value of women's contribution in horticulture and to ensure women's participation in training. Instead, women are targeted for training in traditional female task areas such as food processing and health care.
- The NARS, ICAR and SAUs have developed several technologies directed at reducing drudgery of farm women. Use of these technologies must be ensured by dissemination of

information. Women should also be freed from socio-cultural bindings. Progress towards latter can be improved by obtaining feedback and suitably modifying the procedures in this respect.

- The traditional view of men as household heads, normally upheld by government organizations, helps to preserve gender inequality and limit the role of women in decision-making processes in the household and community. For instance, state banks offering credit target men, while women - especially from poor households - have few if any opportunities to access government loans because of their lack of collateral, and are forced to rely on informal sources of credit.
- Planners, social welfare agencies and women's development organisation should provide a rightful place to women. It is necessary to expand networking of support services so that women are freed from some of their gender imposed roles.
- Women should have access to financial resources of the family. They should assume larger role in making decisions related to setting up of small cottage and agri-based enterprises.
- Women have limited access to the world outside their village. Only younger, educated women tend to look for work outside the village. Most women - especially the older generations - do not venture far from the village. Household commitments and inadequate time, objections from their husbands, fears about safety, social norms or a lack of self-confidence prevent most women from travelling outside the village, and obstruct their access to information, technology, training and other external assistance.
- Small entrepreneurial outlets involving agri-based allied professions should be created to ensure self-employment for rural women.
- Raised to obey rather than to express opinions, most village women - especially poor rural women with little education - lack the confidence to state their views, contact government officials or attend training courses held outside the village.
- Essential to empowerment is acquisition of knowledge and skills in modern technologies such as soil testing; use of high yielding varieties; scientific use of seeds bio- and chemical fertilisers, pesticides, water, etc. Compilation and documentation of relevant technologies and a network for technology dissemination is essential.
- Overwork and lack of time, intensified by the absence of suitable labour-saving technologies, limits the ability of most rural women to participate in meetings or attend training aimed at improving productivity. The research found that poorer and less-educated women, who should be the important target group in rural development, face social and economic barriers to join women's groups. Women who belong to groups are usually better off and more likely to participate in and benefit from village-level training. However, in general, village groups still have fewer women members, and the selection process for training is biased in favour of men.

Conclusion

Farm women are actively engaged in their full vigour in almost all activities of horticulture right from the cultivation to post harvest. They do the extremely tedious, time and labour intensive works like planting, sowing, weeding and interculture, harvesting, collection of produce, transport on produce as head load to home and short distance, shelling, cleaning, grading and processing, etc. these all jobs involve considerable amount of drudgery because most of them are done manually. Horticultural technologies are available and women are needed to be exposed to all of them and trained based on their requirement. Besides, horticulture with variety of low volume high value crops provides immense opportunities to the farm women to get involved in various horticultural interventions with reduced level of drudgery. Through various horticultural interventions like back yard kitchen gardening, community nursery, mushroom cultivation, bee keeping, value addition through packaging, minimal processing and preservation she can secure not only the household nutritional but also the economic security of the family.

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Duck Rearing: Potential Livelihood Option for Farmwomen

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The importance of water for the mankind in 21st century, is beyond ordinary debate, for a multitude of reasons. It is increasingly being essential to conserve every drop of ground water for sustaining the survival of humanity, as threat of its wastage/loss could portend a disaster for everybody. Therefore, scientific community has a responsibility to ensure judicious use of all non-saline available water, so that: unit food-production per unit- water consumption is enhanced and optimized. Accordingly, all scientific-agricultural technologies employing water should invariably employ novelties, aimed at enhancing output of crops and animal husbandry and fishes.

Fitting to the above theme, come the integrated Duck-fish or the Duck-fish-horticulture; Duck-fish-agriculture concepts, which have become very popular across many parts of world. Especially, in the Asian and South east Asian nations, the Duck cum Fish integration is catching up with most farmers, who are increasingly convinced now that these systems not only offer efficient usage of water, but also enhanced productivity in terms of quality and quantity. The latter system: Duck-Fish-horticulture system, is even more appropriate for adoption in Indian conditions, particularly in the coastal states like Orissa, West Bengal, Kerala, Andhrapradesh etc.. Its rationale is simple, which shows how from unit land, unit use of water, and from unit investment the output gets significantly larger in size. Let us then look at the merit of all the available models of integrated farming which can be offered for adoption to fish and duck entrepreneurs. As such, the public also needs to be educated, how from the same traditional water body, more output can be harvested with a simple scientific intervention, by using the Ducks as an efficient layer poultry, so that the productivity of the pond could be near double interms of profit and quality protein output.

Why consider Ducks in an water based integrated agricultural system?

The Ducks (*Anas platyrhynchos*) which constitute nearly 4 to 5% of the total domesticated poultry of India (Animal Husbandry Census, 2012) are endowed with equal or better in production abilities compared to chickens. In our country, in many ways, duck production emerges as a better alternate to chicken production which can contribute substantially to food, income, employment and livelihood security of the masses. However, duck production in India, is still in unorganized form which is carried out in limited scale. Marshy lands and adverse climatic conditions of coastal areas which are not suitable for chicken production and animal husbandry, as a whole, can be effectively utilized for duck production. Ducks usually grow well with locally-available feedstuff and less manpower is needed to raise them using meagrely-equipped facilities. In rural areas, the women folk (including elderly women) and aged people (in age group of 50 to 70 too) can easily be persuaded to manage production of ducks. Small-scale farms remain enormously important because of large number of rural households they support. They also make a useful contribution to food-supply chain of urban populations using recycled resources effectively. While the global Duck population is around 1242 million (1185.74), India's duck population is just 26 million in number (FAOSTAT, 2013). With this germplasm-base, India produces around 38 million tonnes of duck meat and 1.5 billion numbers of duck-eggs annually. In India, ducks are concentrated in coastal regions, especially southern and north-eastern states.

Duck production systems suiting to various farming communities

There are many prevalent Duck farming systems which can be adopted in our country, whose merits can be briefly discussed below.

A. Foraging or free range System

It is a one of the oldest known system for duck-rearing which utilizes the natural resources through foraging mainly in paddy or crop (grain)-fields after harvest. This system of management, however, is a low input technology. As such, foraging the ducks in various possible ecosystems e.g. ponds, rivers, reservoirs, canals, lakes, back-water, miscellanious water-bodies and post-harvest paddy fields is advantageous in many ways.

B. Backyard Rearing System

This backyard duck husbandry system is primarily meant for small and rural farmers. Here, the ducks get mingled with chickens and other avian species, throughout the area. They are mainly confined to the farm premises, but may roam around the village. Under this, Duck needs little care and small supplementary feedings, where they are usually kept enclosed near to farmer's house, at night. Flock-size under this system could range from 5 to 20 ducks. While, during day-time, the ducks are free to roam outside in search of feed, they are brought inside at night, by putting some extra feed in the night-shelters and nests (usually of earthen pots or wooded partitions) for laying eggs. An advantage of this system is that: ducks go out to harvest their feed themselves. Although the performance under this backyard-system is generally lower than that of intensive systems, its hallmark of low or no-cost feed can compensate the disadvantage of lower performances.

Figure: *Ducks besides a fish pond in traditional Duck-fish integration system.*

As such, the native ducks propagated by CARI, RC are considered best for such a system, as these are hardy in nature and can manage their own nutritional needs, with minimal supplemental feeding.

C. Duck-Rice Integrated System

The duck-rice integrated system has been practised in our country since long. Although this duck-raising method accounts for a relatively limited volume of the duck industry, it has attracted more attention in recent years, owing to its connection to organic farming. The rice-duck system provides a measure to benefit both the paddy fields and ducks. Insects, snails, tadpoles, earthworms and weeds constitute the major food sources for ducks, and in turn, the duck's excreta become the manure for the rice/paddy. Water stirring caused by the ducks' activities inhibits the growth of weeds through photosynthesis reduction when the water becomes turbid. Their activities also enhance the rice root, stalk and leaf development, thereby accelerating rice's growth. In addition, duck's active grazing in such a system can directly lead to reduced need for pesticides and fertilizers, thereby benefitting the ecological system. In usual practice, an optimum population of 200-300 ducks/ hectare of paddy field can be recommended to obtain a good rice and duck harvest, in combination. This number can be adjusted based on the input feed-sources (weeds, insect and snails) which are available in paddy fields. The other points that need consideration in this practice could be as follows. (a). Ducklings at 3-4 weeks of age are introduced into the field after transplanted seedlings become rooted, and before introduction they must be trained to get into the habit of flocking and oiling their feathers. (b) A protective fence is however, required to protect ducks from predators such as dogs, wild-cats and foxes and also to prevent them from escaping. (c) Water, by planning, should be kept at a level in which ducks can both swim and walk.

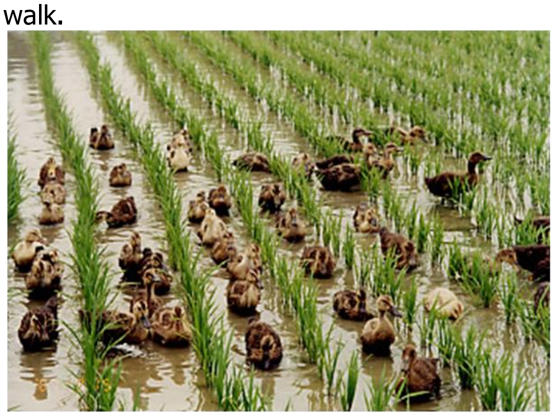


Figure: *Ducks in growing-paddy field in Duck-rice integration system.*

Along with laying ducks, the table ducks (ducks for meat) can be reared in the rice fields post-harvest. Generally farmers purchase ducklings from the hatcheries, 3 to 4 weeks before the rice harvest. The ducks usually selected for this system, are of native meat type, local meat type and or crossbred local x exotic varieties. After 3 weeks of age when the ducklings can consume whole rice grains, they are permitted to enter the newly harvested rice fields. Here, they forage the whole day on leftover or fallen rice grains, insects, shellfishes, small-frog, fish, and water plants. In the late afternoon, they can be moved back to pens or sheds near the household until next morning. The ducks raised in this system, are usually finished at 2.5-3 months of age, when they achieve live weights of 1.6-2.0kg, especially for crossbred varieties. Now-a-days, since mainly high yielding varieties of rice are planted and harvested within a short period, only a limited time can be available for the duck-flocks to scavenge. As the result, this traditional system of post-harvest duck rearing has limited feasibility and is less in vogue.

D. Duck-Fish Integrated System

This system of duck rearing is rather straight-forward system of mixed farming, which happens to be the most popular of the integration systems.

Benefits of fish- cum- duck farming

The duck-fish integration system is usually employed by many farmers, in such areas, where the underground water-table is usually good and standing water is available in the water-body, during most parts of the year. In this, the ducks have access to water for drinking and heat-stress alleviation. Ducks, in this system, only need shelter for resting. Generally speaking, a minimum area of 0.5 square meter per duck is required. Ducks can be housed in a variety of ways. A pen can either be built which floats on the water, or resting on stilts above the water or even can be fixed on bank of the pond.

Regarding the advantages of this system, unlike other domesticated poultry, ducks can alone be considered for this system as an active entity, since the ducks are basically waterfowls, which can enter into water-bodies and utilize the system symbiotically. Here, introduction of layer or dual-type Ducks are usually made into the water surface, say a fish-pond in a multi-carping project, for using it as a duck- grazing area. Ducks can then ensure a full utilization of the pond's water in complimentary terms to the fish production. Fish ponds then work as an excellent environment where ducks help prevent them from parasitic infection. Ducks can feed on predators and can help fingerlings to grow better. As a result, it can reduce the demand for protein to 2 - 3% in duck feeds. Duck droppings go directly into water providing essential nutrients to increase the biomass of natural food organisms. The daily waste of duck feed (~ 20 - 30 gm/duck) serves as fish feed in ponds or as manure, resulting in higher fish yield.

Manuring from the ducks get homogeneously distributed without any heaping of duck droppings. Further, by virtue of the digging action of ducks in search of benthos, the nutritional elements of soil get diffused in water and promote plankton production. Ducks also serve as bio aerators, as they swim, play and chase in the pond. This manoeuvring of the surface of pond greatly facilitates aeration. The feed efficiency and body weight of ducks too increase and the spilt feeds could be effectively utilised by fishes. As such, the survival of ducks raised in fish ponds increases by 3.5 % due to clean and healthier environments of fish ponds. As a conservative estimate, duck droppings and left over feeds of each duck can increase the output of fish to 37.5 Kg/ha. Ducks aid to keep aquatic plants in check. As a major advantage of this system, no additional land is required for duckery activities. So, from such a combined

Endeavour, It results in high production of fish, duck eggs and duck meat per unit time and water area. It ensures high profit through less unit investment.

In order to ensure that manure supply remains constant, it is best to keep different (duck) age groups at the same time. Once the fish has been harvested the pond will be empty of fish. When one can think of growing a batch of small fish before the old stock is harvested. As a long term policy, after 4 to 5 years of rearing, the ponds need cleaning. The manure remaining in the pond can be taken out and be used for crops or added to compost. Alternatively, the manure in the pond can be utilized by growing some crops in the dry ponds. From the fish production angles, it is however, difficult to prescribe the exact numbers of fish and ducks because the numbers are dependent on many other factors. Most fish species under this system take about 6 months to reach market weight. In such system, the stocking rates could vary from 6000 fingerlings/ha and a species ratio of 40 % surface feeders, 20% of column feeders, 30% bottom feeders and 10-20% weedy feeders are preferred for high fish yields. Mixed culture of only Indian major carps can be taken up with a species ratio of 40% surface, 30% column and 30% bottom feeders.


Figure: Ducks in the most popular Fish based integration system
Left: A Duck-Fish-horticulture integration system.(Courtesy, ICAR-CIFA, Bhubaneswar).
Right: Duck cum fish integration system in backwater of Kerala (Alappuzha)

As a major advantage of the Integrated Duck - fish farming, not only it increases fish production but also cuts down the cost of fish culture operations considerably. Where average cost of production in conventional poly-culture with supplemental feeding and inorganic fertilization was Rs. 2.93/kg in Eastern India (Anon, 1976), researchers have recorded the cost of production nearing Rs. 1.61/kg from a duck-fish integrated farming system.

Conclusion

The 21st century's agriculture has got to be a high-tech and resource efficient venture, for the sustenance of the mankind. Envisaging the increasing scarcity of water, in the coming decades, the input-output auditing of water based agriculture vis a vis the efficiency and importance of every agri output has to be ascertained. In this backdrop, the Duck cum Fish and Duck cum water-based enterprises are considered important. This system not only is investment efficient but also, ensures maximum agricultural output per unit water investment. In this system, inter alia, many benefits accruable from raising of ducks on fish ponds, it promotes fish growth, increases fish yields and eliminates pollution problems that might otherwise be caused from excreta, in a duck pen. Fish-duck integration also promotes the recycling of nutrients in the pond ecosystem. In shallow pond areas, a duck usually dips its head to the pond bottom and turns the silt to search for benthos. Due to this digging action, nutritional elements deposited in the pond humus gets released. Further, the ducks also act as pond aerators through their swimming, playing and chasing by disturbing the surface of pond and thereby contribute to the natural oxygenation of water bodies, and making them conducive for higher fish production. Therefore, in summary, the duck-fish integration system has great potential for water-efficient animal husbandry and agriculture/pisciculture.

Apiculture: A Viable Enterprise to Support Farm Women

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Women are vital and most productive work force in the Indian Economy. Their involvement and role played in agriculture is well realized. Women first domesticated the crop plants and their by initiated the art of farming. In Asia 50-90 per cent of labour from rice cultivation is comprised by women folk. Still then the women are treated as the neglected group and are deprived of their basic right. A bird's eye view to the global scenario reveals that "Women play a significant role in agriculture, the world over. About 70 per cent of the agricultural workers, 80% of food producers, and 10% of those who process basic foodstuffs are women and they also undertake 60 to 90% of the rural marketing; thus making up more than two-third of the workforce in agricultural production (FAO, 1985). In West Africa, up to 80% of the labour force in all trade is female. Yet, the role of women in these activities, so important economically, has remained obscure for long because women seldom played any major roles in political activities or decision making processes".

According to our former Prime Minister, Pandit Jawaharlal Nehru," Freedom depends upon economic conditions even more than the political. If women are not economically free and self-earning they will have to depend on their husband or some one else, and the dependant are never free". Women's contributions in agriculture have become the subject of global consideration. Technology exposure for empowering women in an integrated manner through active participation and learning is a major means to it. According to Jacques Diouf (Ex : DG, FAO)"If women are to be empowered to act as full and equal partners in development, we must realistically evaluate the conditions under which they fulfil their role as providers. We must act concertedly to free women from drudgery and remove the obstacles that limit their access to resources and their active participation in planning and decision making structures and institutions. An environment must be created and nurtured that will ensure not only that woman is listened to attentively but, what is most important, that sincere and tangible commitments are made to address their needs and concern". Education can play a major role in raising the status of women and significantly improving household, health and nutrition, reducing infant and child mortality and reinforcing environmental conservation.

An estimated 52-75% of Indian women engaged in agriculture are illiterate. Currently, the situation has been changed in gender issue and many rural women not only themselves been able to stand on their own by being successful entrepreneur in various field including the agriculture(Agri-entrepreneur) rather become exemplary for others

Avenues for empowerment of rural women

There are many avenues and ample of scope to support women for improving their entrepreneurial skill and confidence to earn money to increase their family income. Home Scientists in KVK with his/her team of fellow scientists take a vital role for women empowerment. The farm women rural youths through self help groups are trained for self employment and improving their socio-economic on any of the avenue/enterprise viz.,mushroom cultivation, wonders out of mushroom in households, kitchen gardening, use of handy tools, ***apiculture,*** nursery raising,seed treatment,soil testing,organic manure,post harvest technology, processing of fruits & vegetables,development of nutritional garden, dietary management for normal and therapeutic diseases conditions,preparation of low cost recipes from under exploited minor millets,processing of spices,preparation of milk products,tomato preservation,promoting family health through nutrition, vermicomposting and use of agricultural waste for vermicompost,household remedies for common ailments,solar cooking at house hold level,wealth from waste,crafts from agricultural wastes,items from palm,farm scale storage of fruits and vegetable storage techniques for sale at farmers market,extraction of pappain, paper making out of banana waste,use of traditional medicines,preserving coconut scrapping,soak pit making, compost pit,safe drinking water,preparation of home care products (phenyl, liquid, blue, washing powder, soap),preparation of low cost products for income generation (chalk, agarbati & candle), organization & management of crèches/day care centers & nursery schools, use of non-conventional sources of energy and bakery technique etc. Out of these **Apiculture ,** popularly known as "**BEEKEEPING"** is an excellent eco friendly and viable enterprise to support women particularly the farm women.

Apiculture

Honey - a gift of God and Mother Nature is known to mankind since ancient vedic times. The ancient Greeks, Romans, Chinese and Egyptians used honey to heal wounds and cure disease of the gut. In India, honey as a carrier of Ayurvedic medicines is in vogue since time immemorial and it can cure a host of ailments like cold, fever, piles, anemia, and infections in the throat, eye, skin and intestine. Therefore, our ancient civilization was quite aware of the medicinal properties of honey and recent scientific studies have also shown that honey has valid medical use because of its antibacterial activity. Further, honey improves digestive and nervous system. Basically, because of the therapeutic values of honey, efforts were made in the past to get this precious natural food and after the development of the concept of 'bee space' by Lorenzo Lorraine Langstroth in 1851 beekeeping came into existence. However, the potential importance of honey in modern day medicine has restricted its use as a small medicinal dose despite the fact that it can be utilized as an item for food and nutritional security. (Table-1). Moreover, the calorific value of 1 kg of honey is very high as compared to other products as may be seen in Table-2. Because of its pre-digested form an infant can get direct benefit from honey and it also provides replenishment of energy losses instantly. Therefore, honey is treated as most complete natural food and its use in our daily diet needs attention.

Table-1 Constituents of Honey

Constituent	Percentage
Total dissolved solids	70-80
Sugars Fructose Glucose Sucrose Other higher sugars	 38 37 02 0.5
Water	20
Minerals(Potassium,Calcium,Magnesium,Iron,Copper Manganese, Phosphorus, Sulphur, Chlorine,and traces of Chromium, Nickel, Tin, Silver, Gold etc.)	0.5
Acids	0.2
Proteins and Amino Acids	0.25
Enzymes and Vitamins	Traces

Table- 2. Caloric value of honey *vis-à-vis* other food products

Sl.No	Product	Calories/kg	Sl.No	Product	Calories/kg
1	Cheese	3480	6	Milk	670
2	Peas	3150	7	Fish	620
3	Honey	3000	8	Mushroom	270
4	Egg	1272	9	Orange	230
5	Potato	970	10	Cucumber	140

In addition to honey, we also get remunerative benefits from other hive products like bee wax, bee venom, royal jelly and propolis. Technologies are now available for collection and processing of these hive products. The utility of bee products further widens the scope of beekeeping as a remunerative enterprise to support farm women.

Apiculture or beekeeping is a traditional practice intimately associated with our cultural heritage. Though honeybees and multifarious use of honey was known to the people from time immemorial, but the ancient practice related to honeybee was **honey hunting** rather than **beekeeping**. Apiculture or the scientific beekeeping in our country is only about a century old practice. Realizing the immense importance of honey bees , apiculture is presently flourishing as a novel enterprise not only as an integral part of our farming system but also as an ideal enterprise especially for landless and very illiterate tribal people for improving their livelihood.Now a day's bee keeping has been the integral part of the Integrated Farming System (IFS) because of the free ecosystem service rendered by these bees through pollination of agricultural and horticultural crops. Though honey production will remain as the prime objective of a bee keeper but beekeeping is currently emphasized and practiced in **Pollination mode** rather than **Honey mode**. Honeybees play vital role in pollinating 60-70% agricultural and horticultural crops. Research studies have revealed that in oilseed crops like sunflower, mustard, safflower, niger and sesame, the seed yield increases from 33.0 to 69.0 % through installing three to five bee colonies per hectare.

Potential areas for beekeeping with the Indian hive bee, *Apis cerana indica or Apis mellifera* in India are wide spread and adoption of such entrepreneurship will not only boost up the honey production of the state but, also enhance crop yields by several fold through cross pollination. Therefore, it can be taken up as an agricultural practice especially in areas where oil seed crops (niger, mustard, sesamum, and sunflower) and horticultural crops (guava, citrus, litchi, coconut, ber etc.) are extensively grown. Further, establishment of apiculture based floriculture (calendula, cosmos, marigold, gladioli, aster, chrysanthemum rose, dahalia, zinnia, etc.) will make beekeeping enterprise more rewarding. An apiculture based farming system should include bee foraging plants.

Besides, the income from beekeeping can be generated in various ways as follows to support farm women

- Through the sales of honey,
- Through the sale of bee products like bee wax, bee venom, and royal jelly.
- Preparing and selling the comb foundation sheets.
- Renting the bee colonies to farmers for effecting the cross pollination in field
- Renting the honey extractor.
- Trading bee equipments in potential areas.
- Establishing apiculture based floriculture (calendula, cosmos, marigold, gladioli, aster, chrysanthemum, rose, dahalia, zinnia, etc.) or apiculture based farming system.

(B) Further, the promotion and sustenance of beekeeping can be ensured through;

- Mass queen production for sustaining beekeeping.
- Regulated marketing of raw honey / processed honey.
- Establishing the honey processing unit.
- Establishing apiculture based social forestry with plants like bael, kadamba, golab jamun, jamun, cinnamon, amla, eucalyptus, gambari, silver oak, soobabul, litchi, drumstick, karanj, soapnut etc.
-

Apiculture is a very skillful enterprise but can be handled with ease by even a very illiterate person. Numbers of farmers across the country as well as our states have been trained and many of them have taken up this avocation as a mean either to improve their livelihood or for employment generation. As an enterprise, apiculture can be taken up by any person irrespective of age, sex, caste, creeds, qualification, profession, have and have not's etc. It is also a well suited or women friendly enterprise. Women are the vital and productive work force in the Indian economy and their involvement and role in agriculture has been well realized. Women empowerment is also possible through apicultural interventions. Besides, the other attractive features of bee keeping for a person is that,

- It is can be practiced by landless people to people with small land holdings.
- It does not compete with any branch of agriculture.
- It does not require continuous labour.
- Does not require heavy investments. One time investment will give return for over a period of one decades
- Some equipments are required.
- It provides multi source income.

Apiculture or the Scientific Beekeeping is having lot of goodness and values, but then, it is not picking up well to the expected height in many states. Some of the important reasons for this are furnished below.

1. **Fear of bee stinging:**

   Stinging by wild bees, *Apis dorsata* leading to casualty has created havoc in mind of many people. But normally the hived bees do not sting to the extent so as to create panic. Honeybees normally sting under the following situations.

   - When adverse weather prevails,
   - Queen cells are formed,
   - Colony remains queen less for long time,
   - While shaking bees off the frame,
   - When any bee is injured while inspecting the box.
   - Creating situations that irritate the bees.

But the fact is that, mild bee stinging is good for health and it can easily be prevented by smoking gently by help of a smoker or avoided by careful handling of bee colonies, wearing a bee veil & protective dresses. The LD_{50} value of the apitoxin is 2.8mg /kg body weight.

2. **Non availability of bee colonies:**

Bee colony is the most critical input of bee keeping .Production of bee colonies is totally depend upon the nature. In the breeding season only, some more colonies in compared to natural process may be produced through technological intervention like colony division in *A.c.indica* or mass queen rearing in *A.mellifera* which will remain far behind the requirement. As per the minimum recommendation of 2-3 bee colonies /ha for effecting proper pollination of crops, India requires about 150-200 million colonies as against the present availability of about 1 million colonies. Documented authentic statistics is however not available to estimate the growth rate of apiculture in the country as well as State.

3. **Lack of awareness :**

Honeys bees are the most fascinating, most studied social insects that has attracted attention of many people. Many people wish and many other start beekeeping without understanding the basic behavior or languages of the honeybees. Keeping bee is a very skillful activity and can be performed easily if the minimum knowledge of bee behavior and their body language is understood. This enterprise is unending as the honey bees have overlapping generations. The population of the bees in a colony only dwindles in accordance to the climatic conditions and availability of bee flora.

4. **Non availability of support systems :**

The essential inputs like bee colony, bee equipments are not within the reasonable reach of the people. There is neither any open market for these items nor regulatory system for trading apicultural products which creates imbalance in marketing. Further, the government has started extending financial supports through various schemes, but then the financial support remains as a constraint for many of the aspirants.

Scientific Beekeeping:

Apiculture or the scientific beekeeping is an art and science of collecting/procuring colonies of desired honey bee species, hiving them in the standard and specified bee boxes, installing in appropriate sites, managing optimum number of colonies scientifically round the year and harnessing both direct and indirect benefits of the activities.

In addition, the other important facts of scientific bee keeping are:

- Beekeeping does not give immediate direct return to the bee keepers,
- It requires maintenance round the year but yields honey only in honey flow season lasting for more or less 4 - 5 months in a year
- After realization of the total investment towards cost of bee box, colony and hive stand the actual direct benefit to bee keeper starts from honey flow season of second year.
- From third year onwards it gives return with nominal to no investment and continues as long as it is managed carefully and scientifically.

The practice of scientific beekeeping is very simple and easy but it essentially necessitates i) Interest ii) Patience iii) Some preliminary knowledge on bee behaviour as pre requisites and iv) utilization of gained knowledge for achieving success. But unlike other enterprise, it can't be practiced by reading, hearing or seeing the activity without practical involvement. Confucius, 450BC, rightly said that ***"Tell me and I will forget; show me and I may remember; involve me and I will understand".*** Hence, for practicing scientific bee keeping successfully **Training is a must**, in which preliminary theoretical and practical knowledge on the following points must be acquired.

1. ACQUAINTANCE WITH TYPES OF HONEYBEES

Beekeeping can be done by using two species of honey bees viz. *Apis cerana* and *Apis mellifera* as per suitability. Success in both the cases depends on quality of bees, management practices and the support of natural condition, particularly availability of the bee flora. Indigenous species, *Apis cerana indica* is amenable for beekeeping in many parts of the country and suitable for stationary bee keeping. The Italian honey bees, *Apis mellifera* in the other hand is a better honey gatherer and docile species with many other desirable traits suitable for commercial bee keeping and performs well if migratory bee keeping is practiced. It gives more return when under condition of migratory bee keeping with diversification.

A honeybee colony consists of single queen, few hundred drones (About 150 in case of *A. cerana* and 750 in *A. mellifera*) and few thousand (About 20-25 thousand in case of *A. cerana* and 50-60 thousand in *A. mellifera*) workers (sterile females).

QUEEN BEE:

- Queen is the perfectly developed female in the colony.
- Queen cells are formed on the lower portion of the comb during honey flow season. They are much bigger and can be well distinguished from other cells.
- Larva excessively fed on royal jelly becomes the queen.
- Queen survives for 2-3 years but lays more eggs during first 12-18 months.
- Queen lays about 800 eggs per day in case of *A. cerana indica* and 1000-1500 eggs per day in *A. mellifera* as per the requirement.

- Queen regulates the colony size in the hive depending upon the food availability and weather conditions and acts as the leader of the colony.
- It is fed on royal jelly and is guarded by a few worker bees.
- Young prolific queen is preferred over the old ones to maintain healthy colony.
- Young queen has the abdomen straight and shining while, in old queen it is bent and dull coloured. Old queen show rat tailed movements.
- From egg laying to emergence of adult queen takes 16 days time.

WORKER BEE:

- Worker bees are sterile females and constitute the real work force of the colony.
- They live for 6 weeks to 6 months, longevity being more in the off season.
- Practically they perform all the duties of the colony excepting reproduction.
- Immediately after emergence as adult they engage themselves for first three days to clean the cells and prime it with royal jelly and make ready for further egg laying by queen.
- Bees of 4-5 days age act as nurse bees and feed the developing larvae in the honey comb.
- Bees of 6-13 days age produce royal jelly mixing the secretions of their salivary and mandibular glands. This royal jelly is used for feeding the young ones for few days and the queen bees for entire life.
- At the age of 10-13 days, they come out of the hive during afternoon hours for play fight and acquaint them with the surroundings.
- At 14-17 days stage ,workers secretes wax from four pairs of wax gland by consuming the honey and deposit the wax scales on the ventral surface of the abdomen which is subsequently used for building ob new hexagonal combs.
- Bees of 18-21 days age act as guard bees and protect their colony from intruders.
- After serving for 3 weeks within the colony, rest of their life they spent for foraging nectar, pollen and water.
- Comb construction, thermoregulation of colony, Colony cleaning, honey drying, storing and capping of honey cells, pollen storing in cells etc all the jobs are very decently performed by the workers of the colony.
- Compared to patchy worker cells, presence of compact worker cells or worker cells in concentric ring is an indication of good colony.
- From egg laying to emergence of worker adult takes 21 days time.

DRONE BEE:

- Drones are the male member of the colony found normally in the breeding season. In other times they are absent or found in very negligible numbers.
- The only work of the drones is to mate with the queen and help in reproduction activity of the colony.
- Drones that contribute to make the queen fertile die soon after the mating.
- Drones have underdeveloped mouth parts and consume much more honey compared to workers
- So drones are tolerated by workers till queen is mated and thereafter they are driven out of the colony after tearing their wings.
- Drone trap can be used to remove drones to keep the colony stronger. Drone cells remain bulged above the surface of the comb.

- From egg laying to emergence of adult drone takes 24 days time.

2. SITE SELECTION

- Site should have ample of bee foraging plants within 1km radius.

Bee foraging plants- Over 750 bee friendly plants either as source of nectar or pollen or both are available in our country.Some of the important are cited below.

i. Forest plants:-Sal, Neem, Karanja, Sisoo, Mahul, Acacia, Bael, Tamarind,Eucalyptus, Silk cotton etc
ii. Horticultural plants:-Mango, Litchi, Coconut, Jamun, Citrus, Guava, Banana, Ber, Apple, vegetable and flowering plants
iii. Field crops: Sunflower, Mustard, Sesamum, Pulses, Maize etc.
iv. Weeds, fodder plants and medicinal plants.

- Location specific floral calendar should be prepared as an indicator of suitability of the site. Ideal sites provide flower resources for at least 6-8 month.
- Site should be well ventilated, dry, neat and clean and have source of fresh water.
- It should be well communicated but away from main road as natural as possible.
- While installing the hives it should be at about 2.0-2.5 ft height from the ground level **in** case of *A.c.indica* and about 1 ft in case of *A.mellifera.*
- Between two colonies the isolation gap should be 6-8 ft in case of *A.c.indica* while in case of *A.mellifera* boxes can be kept in close proximity.

3. BEE EQUIPMENTS

The essential bee keeping tools includes standard and specified wooden bee box , hive stand, honey extractor Besides, the other tools required are ant well, nucleus box, capturing hive, smoker, bee veil, queen gate, queen excluder sheets, hive tool etc befitting to the species of bee should be used for beekeeping. The native *A. cerana* is kept in ISI. Standard "A" & "B" type boxes while Langstroth hive is required for exotic species, *A.mellifera*.

4. PROCUREMENT OF COLONY

Bee colony is the most precious and critical input of bee keeping. It cannot be purchased or procured as and when desired. In honey flow season only, the colonies are multiplied by the bee keepers for trading. The selection and procurement of good bee colony is very vital for initial establishment of a colony in new area. In case of *A. mellifera* normally divided colony is purchased or procured from the bee keepers while bee keeping with *A.c.indica* may be started by collecting natural colonies or swarm colonies or divided colonies. The person having fair knowledge about quality of bee colony should purchase/procure the bee colony either from any recognized organization or from bee keepers. Proper understanding of science, technique and skill is prerequisite for capturing the swarm or natural colonies of the Indian hive bee and so also for dividing the colony successfully for colony multiplication.

Desirable characteristics of bee colonies

- Better adoption to floral resources

- High reproductive efficiency of queen bee.
- Easily managed bees.
- No or little Swarming and absconding instinct.
- Good honey gathering efficiency.
- Less prone to disease and natural enemies attack.
- Capable of over wintering well(In case of *A.mellifera*)

5. COLONY MANAGEMENT

Success of bee keeping depends upon the support of nature and good management practices. Best output is obtained when proper seasonal management is done under favourable natural conditions. Fair practical idea should be acquired on management on the following aspects of scientific bee keeping.

1. Seasonal management
2. Colony division
3. Colony union
4. Robbing management
5. Artificial feeding
6. Swarm control
7. Need based requeening
8. Laying worker management

6. MANAGEMENT OF ENEMIES

This honey bee species is attacked directly or affected indirectly by number of natural enemies both in hives as well as in crop foraging sites. Other than the disease, over 2 dozen species of fauna found to be associated with the honeybees either in foraging sites or inhabited the bee hives. Among the species, the greater wax moth, *Galleria mellonella* was the most dominant inimical species. The *Coelioxys sp. , Vespa orientalis,* and three common species of spiders were observed predating on honeybees. The ecoparasitic mite, *Varroa jacobsoni* was also noticed on *A.c. indica*. Many mites and diseases like thai sac brood, foul brood, chalk brood, nosema etc sometimes affect the apiculture adversely.

Wax moth

Among the natural enemies, Wax moth is the most common one; it normally attacks the weaker colonies during rainy season. But fresh combs are seldom attacked by wax moths.

- Regular and periodic cleaning of the bottom board during rainy season, removal and destruction of old combs, manipulating the bees to construct new comb and maintaining populous colony keeps the wax moth infestation under control.
- Old combs can be preserved with PDB (20g) or Phostoxin (0.6g) in enclosed container.

Wasp

Wasps are problematic in hilly areas and during summer season. Their menace can be mitigated through the following practices

- Locating the wasp nest and their destruction.
- Covering the hive entrance partially with coconut leaf.
- Use of sticky traps with bait.
- Physical collection and destruction.

7. HONEY HARVESTING

- The honey is the prime hive product and the main attraction of most of the new bee keepers. The surplus honey stored in the hive by the honey bees during the honey flow season is normally extracted by the bee keepers using the honey extractor.
- Honey should be extracted when 70-80% combs in the super chamber is filled with honey and are capped.
- The extraction should be done preferably in the afternoon hour and in a protected area following scientific instructions. Honey should not be kept exposed to air for a longer period. However, the honey extracted should be processed and stored in glass bottles.

Conclusively, beekeeping is a fascinating enterprise benefiting the poor or landless for their livelihood to rich farmers for its commercial exploitation.It can be taken up by farm women to support and enhance their family income. It helps in maintaining healthy environment for sustenance of human society and conservation of biodiversity. It helps in both food and nutritional security by its high valued products. It is estimated that ,at present cost structure of beekeeping, one time capital investment results in a gains of Rs.2500/hive /annum in case of *Apis cerana indica* and it's three times in case of *Apis mellifera* . A commercial bee keeper can also generate sizeable employment opportunities for rural youths.

IFS Model for Livelihood Improvement of Farm Families

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Livelihood comprises abilities, assets(stores, resources, claims and access) and activities required for a means of living. Goods and services are essential for sustenance of individuals in the society. Income/cash is required to get goods and services. Enterprises generate income. Income generating activities are known as livelihood. Livelihood is sustainable if it copes up with and recovers from stress and shocks, maintains or enhances its capabilities and assets and provides livelihood opportunities to the next generation and contributes net benefits to other livelihoods at the local and global level in the short and long term basis. Livelihood security refers to meeting the expenses of family on food, clothing, shelter, health, education for children, ceremonies, recreations, aesthetic needs of members so as to maintain a decent standard of living in the society.

Livelihood options and classification

Various means of livelihood are included under three sectors viz. production, service and trade. The livelihoods producing goods viz. agriculture, animal husbandry and handicraft come under production sector. Tailoring, black smithy, gold smithy are included under service sector. People engaged in trade sector generate income through marketing of produce/goods. Livelihoods may be on-farm or off – farm, depending on whether it is based on land or not. Livelihood options in rural areas in disadvantaged districts of Odisha include agriculture, animal husbandry, handicraft, employment in public and private sector, collection and sale of minor forest products, daily wage earning and business.

Categorization of farmers as per size of landholdings

As per the recommendation of FAO Programme for the World Census of Agriculture, the holdings have been classified into 18 size classes in terms of the 'operated area'. The classification is given in Table 1.

Table 1. Recommendations of FAO on size classes for tabulation of data from agriculture census and their application in India

FAO recommendations	Classifications used in India	
Size of holdings	For statistical purposes	For policy purposes
Holdings without land		
Holdings with land		
Less than 0.1 ha	Less than 0.02 ha	Marginal Farmers (below 1 Ha)
0.1– 0.19ha	0.02- 0.5	

0.2– 0.49ha		
0.5 –0.99ha		
1 – 1.99 ha	1-2 ha	Small Farmers (1-2 ha)
2 – 2.99 ha	2-3 ha	Semi-medium Farmers (2-4 ha)
3 – 3.99 ha	2-4 ha	
4 – 4.99 ha	4-5 ha	Médium Farmers (4-10 Ha)
5 – 9.99 ha	5-7.5 ha	
	7.5-10 .0 ha	
10 – 19.99 ha	10-20.0 ha	Large Farmers (over 10 ha)
20 – 49.99 ha	20.0 ha and above	
50 – 99 ha		
100 – 199 ha		
200 – 499 ha		
500 – 999 ha		
1,000 – 2,499ha		
2,500 ha and over		

Livelihood options for the landless farmers

Mushroom

Rice is the staple food crop in Odisha. Enough straw is available for mushroom production. The climate is also congenial for raising paddy straw mushroom during *kharif*(8 months) and oyster(*dhingri)* mushroom during *winter*(4 months). A shed of size 7.5 m x3.6 m (25'x12') with three tier system can accommodate 120 paddy straw mushroom beds and 225 oyster bags. Production from 120 paddy straw mushroom beds will be 180 kg @1.5 kg/ bed/month. Production from 225 oyster bags will be 450 kg per 2 months.

Poultry

Poultry units of size 4.5m x3.0 m (15'x10'are adequate for rearing 100 broiler birds per batch/shed. Poultry sheds and connecting roads to the shed accounted for an area of 45 m^2. The height of the two side walls of the shed should be 2.4 m (8 ft), out of which 0.6 m (2 ft) from the ground should be made up of concrete and above 1.8 m (6 ft) should be covered with iron wire nets. Before rearing of the chicks, the floor of the poultry house should be washed with phenyl and walls should be white washed with lime. The dried saw dust of one inch should be spread over the floor. Feed and water containers should be cleaned and dried properly.

Under NAIP Component 3 sub project, broiler farming was taken up in three disadvantaged districts viz. Kandhamal, Dhenkanal and Kalahandi of Odisha. In each batch, one-day old chicks numbering 100 of improved breed 'Vencobb' were reared with recommended feeding, health care and management. The average weight of the birds at the age selling (35-42 days) ranged between 1.68 to 2.01 kg. The food conversion ratio (FCR) varied from 1.54 to 1.82. The mortality of the birds upto marketing varied from 2 to 5%.

Goatary

Animal productivity is low in Odisha due to rearing of indigenous breeds, inadequate and imbalanced feed, disease incidence and mortality, inadequate health care facilities, uncongenial environment and faulty management and decrease in area of pasture land and shortage of green fodder. Strategies for enhancing animal productivity include breeding, feeding, health care and management. Rearing of 'Black Bengal' breed of goat in districts with appreciable area under forests in Odisha under semi-intensive management system is profitable.

Bee keeping

Bee keeping is a low cost, eco-friendly non-land based enterprise of immense importance for income generation. Bee pollination increases production and productivity of more than 80% of cross pollinated crop plants. Honey bee is the best pollinator among all the bio-agents available in the globe.

Forest based enterprises

Forest based enterprises viz. leaf plate and cup-making, bamboo craft and incense – stick(*agarbathi* making) can provide gainful employment to the under-employed in the vicinity of forest area.

Livelihood options for the small holder farmers

Small holder farmers constitute 85 % of farming community in India. Small and marginal farmers constitute 19.7 and 72.2 % in Odisha with average holding of 1.63 and 0.57 ha, respectively. Rice is the staple crop of the state. Rice based cropping system alone can not ensure sustainable livelihood security to a 6 member farm family in rural Odisha. Productivity enhancement through holistic integration of crops and allied enterprises is essential to ensure a decent livelihood for rural households in the state. The need for farming system approach is being felt due to the reasons mentioned below.

a) **Shrinkage in area under cropping**

Area under cropping is decreasing day by day due to urbanization, industrialization, construction of buildings and highways. The situation is further aggravated due to population explosion leading to sharp decline in per capita availability in cultivable land. There is growing pressure of human population on the carrying capacity of the land.

b**) Small, scattered and fragmented holdings**

The average holding of a farm in India has been declining and over 80% of operational holdings are below the size of 1.0 hectare. In Odisha, 82% of the farmers are considered small and marginal with an average holding size of 0.8 hectare. There is low or no scope for horizontal expansion of land area. The option left for us is to follow vertical approach which aims at increasing productivity per unit area and time. It is possible by integrating appropriate farming components fitting to available space and time and ensuring periodic income to the farmer.

c) Seasonal nature of income and employment and out-migration

The farmers, particularly, small and marginal farmers are unable to satisfy their domestic need from cropping alone. Cropping activities in rainfed areas are restricted to 4 months in rainy season. Employment opportunities are scarce in other seasons. This leads to large-scale migration of male farmers to cities in search of work. Round the year employment opportunities should be there to check out-migration from rural areas.

d)Deterioration of resource base

The agricultural systems have met with various kinds of ecological and environmental constraints. The natural resources viz. land, soil, water and forests are being degraded day by day.

e) Household requirement

A country or state is said to achieve complete food and nutritional security if each and every person is able to consume a minimum quantum and quality of various food ingredients i.e adequate and balanced diet on a regular basis. Availability and affordability of such diet, backed by health and educational services in our environmentally sustainable scenario will enable each member of the society to live a healthy life, each individual personality getting an opportunity to develop to one's full potentiality. Per capita production of food should be 490 g for cereals, 53 g for pulses, 72 g for leafy vegetables, 55 g for other vegetables, 248 g for milk, 38 g for fats and oils and 38 g for sugar/ jaggery. A six member farm family (2 old persons, 2 adults and 2 children) will require 894 kg cereals, 97 kg pulses, 69 kg fats and oils, 131 kg leafy vegetables, 100 kg other vegetables, 453 kg milk, 69 kg sugar/jaggery. Besides a 6 member family will need 6 tons of fuel wood per annum. One large ruminant requires 1 ton grass and 1 ton legume fodder per annum. Other requirements include timber for furniture and house construction, fruits, fish, egg and meat. An Integrated farming system approach is essential for meeting all these diverse needs from limited land holdings of small and marginal farmers.

Farming system approach

Marginal and small farmers depend mainly on production of agricultural crops for livelihood. This enterprise is usually subjected to high degree of risk and uncertainty and provides only seasonal, irregular, uncertain and low income and employment. Rice is the staple food crop in the state and rice-based cropping systems are predominant. In different rice growing ecologies, productivity is declining due to several bio-physical, edaphological, socio-economic, technological and institutional constraints. Average land holding and present level of productivity from rice based cropping systems cannot sustain a 6-member rural farm family in the state. Besides, decline in crop productivity has led to food and nutritional insecurity. It is the need of the hour to integrate crop and other allied enterprises in a harmonious manner to obtain appreciable net return (Behera *et al.*, 2010). Various enterprises, viz. crops, tree, livestock and ancillary enterprises are to be integrated in Integrated Farming System (IFS) for better and sustainable livelihood. Harvesting of surplus rain water during rainy season by constructing farm ponds in 10% area of the farm enhances opportunity for diversification in space and time dimension. Ghosh *et al.* (2009) observed enhancement in cropping intensity, employment generation and farm income due to rain water harvesting and its efficient recycling.

A farming system is defined as the population of individual farm units that have broadly similar, resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate.

Field experiments were conducted at five cluster of villages located in five different blocks viz. Khajuripada of Kandhamal district, Dhenkanal Sadar and Odapada of Dhenkanal district, Golamunda and Narla of Kalahandi district of Odisha under rainfed medium land situations during 01 April 2010 to 31 March 2013. The experiments aimed at comparing performance of pond based integrated farming system model comprising rice-onion sequence cropping system, multilayer pisciculture, poultry and mushroom with conventional cropping system of rice-green gram in 0.8and 1.6 ha size farm. The following four enterprises were integrated in IFS models.

Components of IFS

An integrated farming system model**, in general, comprises** a water source (pond/ditch/well), fence (low cost live fencing), field crops, agri-horti system/ multi storied cropping, olericulture, animals and shed , farm house and miscellaneous activities as apiary, pisciculture,poultry, vermiculture, mushroom production etc.

Factors governing choice and size of enterprises

1. Climatic conditions
2. Soil type
3. Farmers preferences
4. Size of the farm
5. Knowledge, skill and technology
6. Storage, transport and marketing
7. Resource mobilizing power
8. Credit facilities available
9. Socio-economic status
10. Customs, sentiments and beliefs
11. Associated risks and uncertainties and mitigation measures
12. Time lag between investment and returns - yield and income should be regular and evenly distributed throughout the year.
13. Interaction among the enterprises - should be complementary with least competitiveness
14. Availability of inputs

Principles of integrating enterprises in IFS

1. Maximization of productivity of component enterprises and system as a whole
2. Decrease in cost of cultivation and increase in net return with continuous spread/flow of cash round the year.
3. Creating opportunities for gainful employment round the year for ensuring higher standard of living and checking migration
4. Farm household self sufficiency with focus on food and nutritional security
5. Efficient management of resources with due emphasis on *in-situ* recycling of organic residues. Primary/secondary produces/wastes of one component should be utilized as input for other component.
6. Crop and livestock integration for better resource recycling
7. The components should be interlinked and interacting with complementarity
8. Enterprise dimension is decided by size of holding
9. Enhancement of factor productivity i.e. soil, water, fertilizer, energy, labour and time
10. Maintaining/enhancing quality of environment with due emphasis on biological diversity and ecological stability.

Research findings on IFS model

Field experiments were conducted at five cluster of villages located in five different blocks viz. Khajuripada of Kandhamal district, Dhenkanal Sadar and Odapada of Dhenkanal district, Golamunda and Narla of Kalahandi district of Odisha under rainfed medium land situations during April 2010 to March 2013. The experiments aimed at comparing performance of pond-based integrated farming system models comprising rice (*Oryza sativa*)-onion (*Allium cepa)* cropping system, pisciculture, on dyke plantation(papaya, banana and drumstick) , poultry(broiler farming) and mushroom(paddy straw and oyster) with conventional cropping system of rice-greengram(*Vigna radiata)* under rainfed condition. The details of enterprises have been described below.

a) Cropping

Rice cv. Lalat in *kharif was* followed by onion in *rabi* in an area of 0.7110 ha and 1.4310 ha under 0.8 and 1.6 ha models, respectively under pond conditions. Performance of the IFS models was compared with rice- greengram cropping grown under rainfed conditions.

b). Pisciculture

Composite fish culture was followed with *catla, rohu* and *mrigal* @ 5000 fingerlings/ha in 3:4:3 ratio. Pond dykes were utilised for planting horticultural crops viz. papaya, banana and drumstick.

c). Poultry

Most of the farmers reared local birds. For high return, broiler farming was introduced.

d). Mushroom

Three tier system mushroom unit of size 7.5 m X 3.6 m to produce paddy straw mushroom during March- October(8 batches) and oyster from November- February(2 batches) were integrated with cropping to utilize rice straw.

Model performance

Productivity

The 0.8 ha IFS model gave 3.0 t grain of rice, 15.3 t onion, 213 kg fish, 1570 kg fruit of papaya, 843 kg banana, 525 kg drumstick, 852 kg poultry meat, 901 kg paddy straw and 714 kg oyster mushroom and recyclable wastes of 3.3 t paddy straw, 0.9 t onion leaves, 3 t pond silt, 2 t poultry excreta and 13 t mushroom spent for recycling in the system.

The 1.6 ha IFS model gave 5.5 t of grain, 29.8 t of onion, 444 kg fish, 1983 kg papaya, 1083 kg banana, 642 kg drumstick, 852 kg poultry meat, 901 kg paddy straw mushroom and 714 kg oyster mushroom and 5.9 t paddy straw, 1.7 t onion leaves, 5t pond silt, 2 t poultry excreta and 13 t mushroom spent for recycling in the system.

Model size of 0.8 ha gave rice equivalent yield of 31.92 t as compared to 3.78 t from Conventional Cropping System(CCS) of rice-green gram and 1.6 ha IFS model gave rice equivalent yield of 44.93 t compared to 6.70 t in conventional cropping.

Profitability from IFS model

The mean gross return and net return from 0.8 ha IFS model (Table 2) was ₹ 3,56,196 and ₹ 1,61,148 with B: C 1.83 as compared to ₹ 41,952 and ₹ 11,631 with B:C 1.38 in conventional rice-greengram cropping system. The mean gross and net return was ₹ 5,01,523 and ₹ 2,27,521 with B:C 1.83 for 1.6 ha IFS model (Table 2) as compared to ₹ 74,429 and ₹ 15,235 with B:C 1.26 in conventional rice-greengram cropping system. Rangasamy *et al.*(1995)

demonstrated superiority of the integration of crops with fish, poultry and mushroom in low lands of Tamil Nadu over conventional system of cropping.

Employment opportunities

Labour requirement for conventional rice-greengram cropping system was 204 and 400 in 0.8 and 1.6 ha models. The IFS model with 0.8 ha size required a total labour of 588 human days per annum constituting 60.0, 24.0, 9.9 and 6.1 percent in crop, mushroom, poultry and fish, respectively. In case of 1.6 ha model the total employment opportunities was 942 human days with share of 71.8, 15.0, 6.1 and 7.1 percent for respective enterprises. Shekinah and Sankaran(2007) also reported higher employment opportunity for family labour compared with conventional cropping alone in integrated farming systems provided.

Sustainability

Sustainable yield index(SYI) and sustainable value index(SVI) increased to 0.80 and 0.65, respectively, in 0.8 ha model from 0.10 and 0.08, in rice-greengram conventional cropping system with equal farm size. The respective SYI and SVI values in 1.6 ha farm were 0.82 and 0.64 with integration of enterprises and 0.13 and 0.10 with conventional cropping(Sahoo *et al.*, 2015a) .

Nutritional security

The models ensured production of rice, vegetables, fish, mushroom and meat and ensured food and nutritional security of farm family.

Resource recycling

Table 2. Yield, economics and labour employment in small holder IFS models and Conventional cropping system

Productivity and economic indicators	0.8 ha farm	1.6 ha farm
Farming system approach(IFS models)		
Rice equivalent yield (t)	31.92	44.93
Cost of cultivation (₹)	195048	274000
Gross return (₹)	356196	501523
Net return(₹)	161148	227521
B: C	1.83	1.83
Labour employment (man days)	588	942
Conventional cropping system(Rice-green gram)		
Rice equivalent yield (t)	3.78	6.70
Cost of cultivation (₹)	30321	59194
Gross return (₹)	41952	74429
Net return (₹)	11631	15235
B: C	1.38	1.26

Labour employment (man days)	204	400

Resource recycling

The 0.8 ha IFS model gave 3.0 t grain of rice, 15.3 t of onion, 213.2 kg fish, 1570 kg papaya, 843 kg banana, 525 kg drumstick, 857.0 kg poultry meat, 901.2 kg paddy straw mushroom and 714.4 kg oyster mushroom for use by the farm family and recyclable wastes of 3.3 t paddy straw, 3000 kg pond silt, 2129.0 kg poultry excreta and 13.0 t mushroom spent for recycling in the system and use as input by other units. The conventional cropping provided rice and greengram for consumption. Due to efficient recycling of resources, the productivity and profitability of IFS models were higher compared to conventional cropping system. In integrated farming system, it is possible to reach the same level of yield with proportionately less input and yield would be more sustainable because of waste of one enterprise become the input of another, leaving almost no waste to pollute the environment or to degrade the resource base. In integrated farming system, the farm is considered as independent unit, although several external factors influence the system. Recycling of resources between biotic and abiotic components through various bio-geo-chemical processes occurs in independent IFS units similarly as in larger ecosystems. The farming system through smaller unit, care is taken for recycling of the by-products from different enterprises. In the present experiment, the cropping enterprise generated by-products like straw. Straw was utilized for mushroom production. The spent mushroom subsequently converted to compost and nutrient and carbonaceous materials were returned back to the crop field. Paddy straw was an ideal substrate for growth of mushroom. The poultry excreta amounting to 768 kg was utilized in the fish pond for feeding to 400 poly culture fingerlings of IFS pond and surplus amount was utilized in the crop field. Application of this excreta favoured the growth of phytoplankton, the primary producer in this recycling process. The nutrients recycled from poultry and duckery were more in terms of plankton (256/litre) development in the ponds for fish growth. Phytoplankton subsequently boosted the growth of zooplankton which served as food for fishes. Tank silt from the IFS model pond was desilted during summer after drying the pond and utilized in the crop field. The tank silt boosted the organic carbon and content of N, P and K of the soil and improved soil health. The surplus quantity of poultry droppings was converted to manure. The nutrient content of the compost was enhanced by this conversion process. Application of poultry compost improved soil health and gave higher yield.

Some external inputs like poultry feed and part of straw requirement of mushroom unit were procured from sources outside the system. The system ensured food and nutritional security of the farm families. The paddy straw was utilized for mushroom production. As the straw obtained from the IFS unit was not sufficient for year round production of mushroom, the extra straw was purchased from outside. The water from the well was utilized for family consumption, mushroom unit, poultry unit and for recharging the farm pond at the time of need. The broken grains and rice bran were fed to poultry birds and fishes. In conventional cropping system, the crop residues, by-products and other wastes were not efficiently utilized.

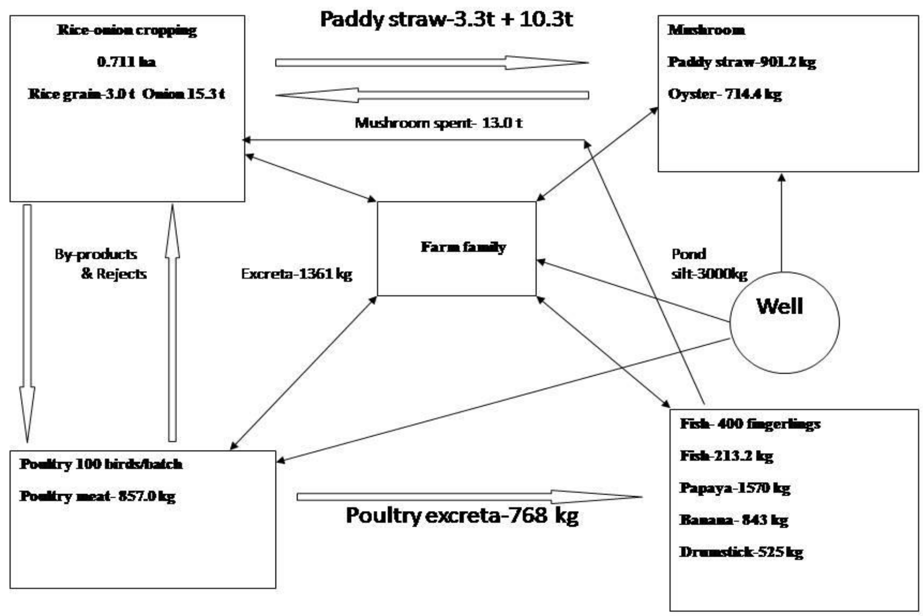

Fig. 1 Resource recycling in 0.8 ha IFS model with crop+fish+poultry+mushroom integration

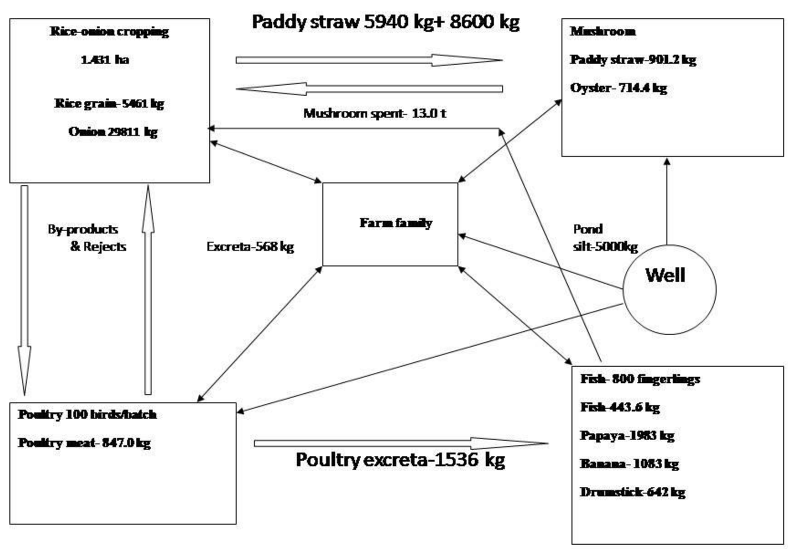

Fig. 2 Resource recycling in 1.6 ha IFS model with crop+fish+poultry+mushroom integration

Sustainability of IFS models

Rainfed agriculture is complex, diverse and risk prone. The Sustainable Yield Index(SYI) and Sustainable Value Index (SVI) values were lower in rainfed systems as compared to pond based systems. Sustainable yield index(SYI) and sustainable value index(SVI) increased to 0.80 and 0.65, respectively, in 0.8 ha model from 0.10 and 0.08, in rice-greengram conventional cropping system with equal farm size. The respective SYI and SVI values in 1.6 ha farm were 0.82 and 0.64 with integration of enterprises and 0.13 and 0.10 with conventional cropping(Sahoo *et al*., 2015a). There was decrease in bulk density, increase in soil pH, organic carbon, soil N, P and K status and increase in the population of heterotrophic bacteria, actinomycetes and *Azotobacter* compared to initial values(Sahoo *et al*., 2015b) .

Constraints in implementation in Odisha

1. The land holdings in villages are small, fragmented and scattered. A continuous patch of land of economic size(1.0 or 2.0 ha) required for establishing IFS models is not available. Consolidation of land has not been possible due to social reasons.
2. The crop fields are located far away from residential houses in the villages. Family labour, particularly, women labour, is not utilized well. Additional labour is needed for watching, as farm family resides in the village located at considerable distance from the farm.
3. A boundary wall is required. The literacy level of farmers is very low. The farmers growing rice alone are unable to execute several activities in models.
4. A multi-disciplinary specialists should be available to give technical know-hows to solve the emerging problems.
5. Initial investment for establishing IFS models is very high.

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Freshwater Aquaculture for Food and Nutrition Security

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Fish forms an important component of the animal protein supplement of Indian food. Being the cheapest and the safest animal protein source, popularity of fish has increased in the country. Fish is consumed by 55-60% of Indians. Increase in popularity of fish has prompted enormous growth of the aquaculture Industry in the country. As per the available data of 2013-14. India produced 6.58 MMT of fish of which the inland sector produced around 6.14 MMT. While inland production includes both inland capture and aquaculture production, the later contributes 80-85%. Over the years, the changes have been brought in the methods of fish farming. Species spectrum in the culture system has been increased. Culture of fast growing native fish species has been promoted. The aquaculture industry has come up with varied fish farming methods suiting to the need of industrial aquaculture as well as rural fish farming. Today, aquaculture has also been recognised as an important avenue for rural food and nutritional security.

Freshwater aquaculture in India mostly involves polyculture of three Indian major carps, viz., catla (*Catla catla* Hamilton), rohu (*Labeo rohita* Hamilton) and mrigal (*Cirrhinus mrigala* Hamilton), or sometimes with the three exotic carps, viz., silver carp (*Hypophthalmichthys molitrix*), grass carp, (*Ctenopharyngodon idella*) and common carp (*Cyprinus carpio*). More than 83% of the total freshwater aquaculture production (≈ 5.1 million tonnes/yr) in the country is contributed by the carp groups for which carp culture is considered almost synonymous with the freshwater aquaculture. Of late, the necessity to include more species of promise into the freshwater aquaculture systems in the country has been emphasized time and again. Fortunately, our country is blessed with wide species diversity including many promising cultivable species. Attempts on species diversification in recent years have shown enough possibilities for incorporation of some medium and minor carps *viz*., *Labeo calbasu*, *L. fimbriatus, L. gonius, L. bata, Puntius gonionotus, P. sarana* etc. in the major carp based polyculture systems due to their reasonable growth, consumer preference and price they command in the market. The country also has a rich resource of many small indigenous fish species (SIFS) which are available in almost all types of water bodies and are important for nutritional security. The SIFS are popular among the fish eaters because of their taste and richness in the nutrients. Culture of such species in carp ponds and rice fields has proven its potential in contributing to the nutritional security of the poor people in Bangladesh. Such species are gradually becoming popular among the fish farmers of India. Besides carps, there are many other species such as freshwater prawn (*Macrobrachium rosenbergii* and *M. malcolmsonii*), air-breathing catfishes (*Clarias batrachus, Heteropneustes fossilis, Pangasionodon hypophthalmus, Pangasius pangasius, Ompok spp.*), snakeheads or murrels (Channa striatus, Channa marulius) and freshwater pearls mussel (*Lamellidens marginalis*) have also attracted considerable attention of the aquaculturist, offering scope for diversifying their culture system into more rewarding farming systems.

Freshwater aquaculture in general offers three types of opportunities:- (i) Induced breeding and seed production of important species, (ii) Seed rearing activity and (iii) Grow-out fish farming, with sub-division of each activity as per species and different life stages of the fish. Unlike earlier years, each of the activity has been able to provide scope of round the year activity which has ensured adopting each specialised activity as full time profession. For example, successful off season breeding and extension of breeding season has stretched the hatchery activity throughout the year. Similarly demand for fish seed throughout the year has helped in making seed rearing a full time profession. Further, the wide range of input dependent fish production (2-15 t/ha) through fish farming offers scope to adopt the activity by marginal to commercial farmers depending on their investment capacity as well the kind of water body.

In the following pages, information has been provided on the above activities for carps, since this group form the mainstay of aquaculture in the country. For other species like catfish, prawn and murrel, though pond management and broodstock management and feeding etc, are more or less similar, certain species specific activities are essential for induced breeding and seed production. However, discussed here the details of activity for carps and barbs.

1. Induced breeding and seed production of carps in hatchery

The technology of induced breeding aimed at producing quality seed starts with the broodstock management till the production of spawn in the hatchery. For performing these activities, a hatchery should have the facilities of broodstock raising pond and the hatchery proper with its components like spawning pool, hatching pool, overhead tank, and water supply and drainage systems.

The induced breeding activity for the Indian major carps, minor carps and barbs is almost similar with certain modification for the barb species which are also discussed. Two to three years of healthy fishes are collected and maintained in the broodstock ponds at least 3-4 months before breeding season at the density 1500-2000 kg/ha. They are provided with balanced diet @ 1-2% of the body weight daily. Water replenishment of 20-25% is advisable in the pond in every month. The matured males at oozing condition and females with buldged abdomen and protruding vent are collected from the broodstock pond for breeding. The males and females are kept in the breeding pool under shower separately in two previously fixed breeding hapas, at male and female ratio of 1:1 by number and approximately 1:1 by weight. When pituitary extract is used as inducing agent, females are given two injections, first dose @ 3-6 mg/kg followed by the second @ 8-12 mg/kg at 6 hours intervals, while males are given single injection of 3-6 mg/kg at the time of second injection to the female. However, in case of using synthetic hormones like Ovaprim, Ovatide or Wova-FH, the injection is given only once to both males (0.2-0.3 ml/kg) and females (0.3-0.5 ml/kg). The injected brooders are released in the pool for spawning. In case of breeding *Puntius gonionotus* (silver barb) in eco-hatchery condition, since the hatchlings are extremely small measuring only 3 mm in length, a finer mesh cloth is required for the central screen of the incubation tank to prevent escape of hatchling. Similarly, *P. sarana* was observed to be a batch spawner releasing eggs in weed mass. While provision of aquatic weed in bunches in the breeding tank facilitates its spawning, the strands and leaf surface of weed such as *Hydrilla* acts as a substratum for attaching the typical egg of the species which is provided with a stalk for attachment.

The broods are kept in the pool under shower before and after hormone injection. Water current is allowed in the pool before one hour of estimated spawning time, which triggers the spawning activity. The response time in all these species varies between 8-11 hours at water temperature 27-28°C. Once spawning starts, effective spawning occurs within 1-1.5 hours from the spawning initiation. Fertilised eggs collected from the breeding tank are incubated in the circular incubation tank. Larvae hatch out after an incubation period of 15 hours at 27-30°C temperature. The hatched larva called hatchlings are kept in the incubation tank for another 60-62 hours during which yolk absorption completes and the larvae develop to the tiny fish called spawn. The spawn from the incubation chamber can be collected by cotton hapa or through the outlet of the pool on a water cushion in the spawn collection chamber. The pool is cleaned with 5 ppm $KMnO_4$ for the next operation.

The carp spawn can be transported to long distance in oxygen filled polythene bags. The density of spawn depends on the duration of transport which generally range between 25,000-50,000/bag with 6 litre of water. Short distance transfer, however, may be done by aluminium containers.

2. Seed rearing of carps

Seed of carp generally refers to two life stages such as fry and fingerling. The spawn collected from hatchery are further reared in well prepared nursery pond for 15-20 days to raise them to 1 inch size which is called fry. The fry is further reared in the rearing pond for a period of two and half to three months when it reached about 4 inch size which is called fingerlings. The details of the procedures are discussed below.

2.1 Production of carp fry

Generally small ponds of 0.01-0.1 ha size were considered ideal for spawn rearing of carp fry. However, higher growth and survival of the fry have been observed in relatively bigger ponds up to 0.4 ha size. Rearing of spawn of carps is carried out mostly with monoculture. Availability of suitable natural feed in the nursery pond is the most critical factor for the delicate transition phase of yolk nourishment to commencement of natural feeding. Suitable ecological conditions also play a great role for the survival of these spawn. Such environmental condition is ensured following a series of activities of pre-stocking pond preparation prior to seed stocking that includes aquatic weed clearance, Eradication of predatory and weed fishes, manure application, liming, inorganic fertilisation, aquatic insect control, etc.

Ponds that dry up in summer or could be easily and economically drained present least problems. But perennial ponds if not managed properly, often gets infested with several types of aquatic weeds, which are floating, submerged, emergent and marginal in nature. These aquatic weeds poses several problems as they absorb nutrients arresting pond productivity, harbouring predatory and weed fishes/insects, hindering free movement of fish and netting operations. Although a wide range of manual, mechanical, chemical and biological methods available for control of these weeds, generally the manual method is commonly advocated for weed clearance because of their smaller size and no time requirement for detoxification as in herbicide use.

Presence of predatory and weed-fishes in the ponds severely affect the seed survival through devouring on the stocked seed as well as competing with them for space and oxygen. While the commonly found predatory fishes in fish ponds are murrels, gobi, magur, singhi, pabda, *Wallago*, etc., the weed-fishes include *Puntius*, *Barbus, Oxygaster, Anabas,* *Amblypharyngodon, Colisa*, etc. Dewatering followed by sun drying the pond is the most effective methods adopted for eradication of these fishes. Other methods used includes

(i) application of mahua oil cake @ 2,500 kg/ha-m three weeks before seed stocking: besides acting as pesticide, it also serves as organic manure after decomposition.
(ii) application of commercial bleaching powder (30% chlorine) @350 kg/ha-m of water (approximately 10 mg/l chlorine)
(iii) Alternatively, application of urea @100 kg/ha-m followed by commercial bleaching powder @175 kg/ha-m after 18-24 hours is also effectively controls these fishes.

Generally soil with slightly acidic to neutral pH (6.5-7.0) is considered productive, while low pH is always associated with low productivity. Therefore, amendment of pond bottom soil is a prime requirement for fish culture. Acidic soils are treated with lime for increasing the soil pH. High dose of organic manures are sometimes used for amending slightly alkaline soil, while alums are used for pH correction in alkaline soil. The characteristic soil pH in most part of the country falls in the acidic range and is amended through application of different types of lime. Lime also helps as a disinfecting agent in pond with a neutral soil pH, corrects water pH and controls of turbidity in subsequent period of culture operation.

Over the years, several phased manuring practices advocated for nursery rearing have shown encouraging results. However, most of these could not be adopted in large scale due to their complex application schedule. Phased manuring with a mixture of groundnut oil cake at 750 kg, cow dung 200 kg and single super phosphate 50 kg/ha have shown to be effective in production of desired plankton. A thick paste of half of the above amounts are prepared by addition of sufficient water and applied as basal dose 2-3 days prior to stocking and the remaining amount is applied later in 2-3 split doses depending on the plankton levels of the ponds.

Varied stocking densities 1.0-10.0 million spawn/ha have been tried in earthen nursery ponds for rearing of carp spawn to fry with application of manures and fertilizers alone and along with other inputs such as supplementary feed, aeration etc. Study conducted at CIFA has shown density of 5.0 million/ha to be ideal for such earthen nursery pond. Use of bigger concrete tanks for seed rearing of carps at high density has also proven to be effective. Nursery rearing of carp spawn at 10-20 million densities (1000-2000/m^2) in the concrete tanks (10 m x 5 m x 1.2 m) system developed at CIFA has shown higher fry survival to the tune of 40-50%. Use of aeration and water exchange in such system has further proven to enhance the seed survival up to 60%. Use of such concrete seed rearing system has made it possible for a farmer to use high density seed rearing in smaller area and harvest 3-4 crops of fry with higher survival level in a season i.e., during June-September.

The spawn are transferred from the hatchery and stocked in nurseries during cool hours, preferably in morning, after due acclimatization to the new environment. The stocked seeds are provided with mixture of finely powdered groundnut oil cake and rice bran at equal proportion by weight as supplementary feed @ 600 g/lakh for the first 5 days and 1200 g/lakh spawn per day for the subsequent days in two equal instalments during morning and evening hours. During 15 days of rearing period the fry attain the size of about 25 mm which is the ideal size for transferring to rearing pond. Harvesting is done by repeated netting with dragnet of 1/8″ mesh. Survival levels of 40-50% are normally achieved in well-managed ponds. During a season from June to September at least 2-3 crops of fry can be raised in earthen ponds and 4-5 crops in cements tanks.

2.2 Production of carp fingerlings

Fry are raised for two to three months to fingerling size in a relatively larger rearing ponds of 0.05-0.1 ha area with 1.2 to 1.5 m water depth. Like nursery ponds, the rearing ones also need specialized management for good survival and production of healthy fingerlings. However, some of the basic operation such as clearance of aquatic weeds, soil correction, and control of predatory and weed fishes are similar to the ones discussed for the nursery pond. The aspect of aquatic insect control in this case is not required. Further, the aspects of management involved in manuring, fertilization and water quality management of the rearing ponds are discussed below.

Pond fertilisation includes application of raw cowdung at the rate of 5-10 tonnes/ha depending on the organic carbon load of the soil. While one third of the above amount is applied 8-10 days before stocking, the remaining amount is applied in equal split doses at fortnightly intervals. Application of biogas slurry at 30-45 tonnes/ha in bimonthly split doses is also found to be effective as improvement over raw cowdung application. In case of use of poultry droppings, the dose may be reduced to one third to half of the amount of cowdung. In addition to the organic manures, inorganic fertilisers such as urea and single super phosphate are applied depending on the nutrient status.

While single species culture is practiced in nursery ponds, rearing pond involve culture of mixed species of carp due to their divergent feeding habit and food preference. Usually fry are stocked at 2-3 lakh/ha density. In ponds with facilities for water circulation/exchange or aeration, the density can be further increased to a considerably high level.

Feed requirements of the growing fingerlings are met through the available natural fish food and provision of supplementary feed commonly in the form of mixture of groundnut/mustard oil cake and rice bran/wheat bran at 1.1 ratio by weight. Other ingredients such as fish meal, soybean flour, vitamin-mineral mixture, etc. are also suggested to be incorporated for improving the feed quality. Periodical samplings of the fry at fortnightly interval are done to assess the growth and biomass. Feed is provided at the rate of 8-10% of biomass of fry stocked per day during the first month, which are reduced to 6-8% of the standing biomass during the subsequent two months. Feeding is usually done in moist dough form in equal installments during morning and evening hours. Crumbled pellets may be used for reducing the feed wastage.

Harvesting of fingerlings is done when they attain 80-100 mm length. Fingerlings are effectively harvested by using a closed-meshed drag net. Rearing period can be further extended when bigger size fingerlings or stunted fingerlings are required.

If the fingerlings are to be transported, feeding is usually stopped one day prior to harvesting so as to improve their conditioning. Morning hours with low water temperature is the most preferred time for harvesting. Long distance transportation of fry and fingerlings can be done in polythene bags filled with oxygen. The number of seeds to be packed in each bag would depend on the size of fry/fingerling, duration of transport, quality of water and environmental temperature.

3. Grow-out carp production

Usually ponds of 0.1 to 1 ha size with an average water depth of 1-5-2.5 m is preferred for polyculture of the major and minor carps. However, seasonal ponds with 5 to 6 months holding of 1-1.5 m water depth can also suitably used for culture of the minor carps and the barbs. Essentially, the management practices in carp polyculture involve environmental and biological manipulations for obtaining higher levels of fish production, which can be broadly classified as pre-stocking, stocking and post-stocking operations.

3.1 Pre-stocking pond preparation

The details of the pre-stocking pond preparation have been discussed in seed rearing section. Manipulation of the species ratio in grow-out pond is important for minimizing the inter-specific and intra-specific competition for food available at various trophic levels and zones in a pond. Either single species or more than one species occupying different niches could be utilized in a pond for exploiting the food available at various zones. A proportion of 30-40% surface feeders, 30-35% coloumn feeders and 30-40% bottom feeders is commonly adopted depending on the productivity of the pond. Accordingly, suitable species combination of major and minor carps/barbs may be adopted.

3.2 Stocking density

Decision on the stocking density is an important aspect in the management which depends on pond productivity and the type of rearing protocol to be used. Generally in major carp polyculture, a density of 6000-8000 fingerlings is followed as standard stocking rate per ha for a production target of 4-5 tonnes/ha/yr. In seasonal ponds or where water level becomes limiting during summers it is reduced to 3000 fingerlings/ha to obtain higher growth rate. Stocking densities of 8000-10000 fingerlings/ha has been used for production levels of 5-8 tonnes/ha/yr. Although the major carps are expected to reach an average of a kilogram in the first year, the growth rate is invariably reduced in higher stocking densities. Higher targeted levels of fish production levels of 10-15 tonnes/ha/yr are achieved by resorting to stocking the ponds at a density of 15,000-25,000/ha.

Ponds are stocked with seed after proper acclimatization. If mohua oil cake or bleaching powder is used as piscicide during pond preparation, it must be ensured that toxicity is reduced and oxygen balance is established in the pond prior to seed release. Fingerlings of 10-15 cm size are considered as suitable stocking material of the major carps while size of the fingerlings in minor carps may vary from 4 to 6 cm.

In the single stocking–single harvest cropping pattern, when fingerlings of major carp are used for stocking the grow-out ponds, there remains a large gap between the carrying capacity and standing crop of the pond during the initial months leading to underutilization of the pond productivity. Pond productivity can be effectively utilized with use of the single stocking-multi-harvest cropping pattern where the stocking density can be increased 1.5-2.0 times. In this method, almost one third to half of crop is harvested at the end of six culture months and the leftover stock is reared further with periodic planned harvesting. However, the initial growth of the species hampers in such culture method due to the increase in the intra-specific competition apart from the crowding effect. Therefore, .instead of increasing the number of individuals of the same species (catla, rohu and mrigal) in the pond, different species of minor carps can suitably be incorporated considering their habitat preference and food habit, which would not only reduce the intra-specific competition, but also would increase the utilization of micro niches in the pond. Considering this fact, the concept of intercropping of the minor carps has been advocated in the conventional major carp polyculture system to increase the fish yield. In the intercropping methods, while major carps are stocked at the recommended density (8000-10000 fingerlings/ha), an equal density of minor carps/barbs are released in the pond as additional stock. These minor carps are harvested from the pond after approximately six months of culture letting the major carp to grow further. As mentioned earlier, such intercropping has proven a 30% increase in the fish yield.

3.3 Post-stocking pond management

The post-stocking pond management primarily involves the aspects of intermittent liming and fertilisation, supplementary feeding, water management and health care. In an average productive pond, the post-stocking fertilization measures includes fortnightly application of cowdung @ 0.5 tonne/ha, urea @10 kg/ha and SSP @15 kg/ha. The organic manure and inorganic fertilizers are applied in alternative weeks to maintain the natural productivity status. However, the time of application and dosage can be deferred depending on the water quality and plankton content of the pond. Poultry dropping may suitably be applied in place of cowdung, but at one third of its dose. n intensive carp culture pond, application of *Azolla* as a biofertilizer @ 40 t/ha/yr, supplied at weekly split doses, has proven to supply the full complement of nutrients i.e. 100 kg nitrogen, 25 kg phosphorus, 90 kg potassium and 1,500 kg organic matter. Use of biogas slurry @ 30-45 t/ha/yr or 80-100 litre/day/ha) is advantageous due to its lower oxygen consumption and faster rate of nutrient liberation.

3.4 Supplementary feeding

Supplementary feeding enhances fish production, permitting higher stocking density. While several ingredients of both plant and animal origin have been evaluated on Indian major carps and exotic carp species, the supplementary feed in Indian carp polyculture is mostly restricted to mixture of groundnut/mustard oil cake and rice bran at 1:1 by weight. This combination is often fortified with vitamins and minerals and are used by some fish farmers. Carps require at least 50% natural food, which normally take care of the vitamins and minerals requirements. But in situations where they have to be brought up on artificial diet alone or where supplementary feeding forms a major part, such fortification becomes necessary. With the shift towards intensive fish culture, a qualitative change has been effected by incorporation of different plant and animal protein sources. Further, the formulations of balanced feed have received considerable attention in recent years for making up the deficient essential amino acids and incorporating vitamins and minerals. To hold these components in the feed together, pelletization has been done and their merits in terms of water stability, consumption and utilization by fish have been proven. Extruded floating pellets are now available for carps.

Feed is usually provided at 5% of the stocked biomass in the first month of culture and gradually reduced to 1% within 6 to seven months of culture. The biomass of fish is estimated through monthly sampling and the daily feed ration is calculated as follows:

Feed requirement/day = Estimated fish biomass in the pond x % feeding rate

where, biomass = Average weight of fish X total number of fish stocked x %survival

Survival percentage of 80% is usually considered for estimation of biomass. The daily ration may be divided into two splits and provided in dough form preferably in feed trays or gunny bags hung at uniform distance inside the pond.

Feed intake of fish often reduces following cloudy weather and also in the winter months. Therefore, the daily ration should be modified as per the consumption pattern of the previous meal. In terms of dispensation of the dough feed, the feed mixture is to be provided in the form to dough in trays or gunny bags hung at different places in the pond. Quantitative requirements of feed is important since underfeeding depresses growth while overfeeding results in wastage of feed, the costliest input, leading to deterioration of water quality.

3.5 Aeration and water exchange

Dissolved oxygen is probably the most important single variable regulating production of fish in intensive culture. Aeration may be used mechanically to increase the concentration of dissolved oxygen in ponds. There are several types of aeration. Emergency aeration is employed to prevent fish death during periods of oxygen depletion. Oxygen depletion may occur during prolonged period of cloudy weather. Aeration is also sometimes applied to prevent thermal and oxygen stratification in ponds. Of the three major types of pond aerators available *viz.,* the paddle wheel aerators, the aspirator aerators and the submersible pond aerators, while the first one is a surface aerator which may be ideal for water depth of 1.0 to 1.5 m, the other two type of aerators is considered to be more effective in fish ponds due to their high injection capacity of air into the water, even in deeper ponds.

Water exchange is another important activity, considered to be crucial in aquaculture operations. Due to continuous accumulation of metabolites and decayed unutilized feed, besides heavy organic manuring, the water environments get deteriorated, leading to slow growth of fish species and often leading to outbreak of diseases. Thus, it is necessary to replace certain amount of water at regular intervals, especially during later part of the culture period in case of intensive culture practices.

3.6 Health management

It is said that prevention is better than cure. So prior to stocking, the fish seed should be given a bath of 3-5% potassium permanganate for 15 seconds. Incidence of disease is quite common in high stocking densities. Though mortality is rearely observed in well-managed ponds fish growth is severely affected due to parasitic infection to some extent. Repeated infection is effectively controlled by applying a dose of 0.1 ppm at monthly intervals.

3.7 Harvesting and marketing

Harvesting of fishes is usually done after a culture period of 12 months to one year. However, fishes attaining the marketable size can be harvested periodically to reduce the pressure of density on the pond and thereby providing sufficient space for the growth of other fishes. Replenishment of the harvested species ensures maintenance of ecological balance that the particular species exhibit. Such periodic harvesting with and without replenishment, facilitating stock manipulation, are biological means of increasing fish production.

Usually fresh fish fetches about one and half times higher market price in the local market than those of iced-fish transported from long distance. Further, fishes sold in live condition commands around 30% higher market price than the fresh ones. Thus, the marketing strategy forms an important aspect for higher profit realisation that the fish growers should take advantage.

4. Conclusion

Freshwater aquaculture has been identified as the key areas for meeting the growing demand for fish in the country. Carp culture being the principal component of the sector has tremendous potential for growth in coming years. Higher fish production from this sector can be realised through bringing more area under culture and increasing the production per unit area. Further, carp culture involves easily adaptable technology and offers greater flexibility in use of local resources, which makes it farmers' friendly. The availability of a host of carp culture technologies with varied production levels further provides enough option to the farmers as per their investment capacity.

Role of Women in Biodiversity Conservation

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Biodiversity may be the basis of human well-being but human habits threaten to deplete it.

Bio diversity definition is broad, spanning diversity between ecosystems and species, and also within species (genetic diversity). Agro-biodiversity encompasses all components of biological diversity of relevance to food, agriculture and the sustainability of agro-ecosystems.

Loss of biodiversity

The two great ecological challenges of our times are biodiversity erosion and climate change. And both are interconnected, in their causes and their solutions. Industrial agiculture is the biggest contributor to biodiversity erosion, as well as to climate change. According to the United Nations, 93 percent of all plant variety has disappeared over the last 80 years. Monocultures based on chemical inputs do not merely destroy plant biodiversity, they have destroyed soil biodiversity, which leads to the emergence of pathogens, new diseases, and more chemical use.

Unfortunately, the loss of biodiversity is accelerating at an unprecedented rate. According to the World Conservation Union's 2002 Red List of Threatened Species, over 11,167 species face extinction. The most important drivers of biodiversity loss are unsustainable production and consumption, inequities in distribution of wealth and resources, demographic developments, international conflict, and international trade and agricultural policies. These result in land conversion, climate change, pollution, atmospheric nitrogen deposition and unsustainable harvesting of natural resources. As ecosystems falter, threats to food and water security, health care and economies grow.

Role of women

The Convention on Biological Diversity in its preamble recognizes "the vital role that women play in the conservation and sustainable use of biological diversity" and affirms "the need for the full participation of women at all levels of policymaking and implementation for biological diversity conservation".

A specific framework for the participation of indigenous women is found in the programme of work on the implementation of article 8 (j) and related provisions of the Convention on Biological Diversity regarding participatory mechanisms for indigenous and local communities. In this regard, task of the first phase of the programme of work urged:

> Parties to develop, as appropriate, mechanisms for promoting the full and effective participation of indigenous and local communities with specific provisions for the full, active

and effective participation of women in all elements of the programme of work, taking into account the need to:

- ✓ Build on the basis of their knowledge
- ✓ Strengthen their access to biological diversity
- ✓ Strengthen their capacity on matters pertaining to the conservation, maintenance and protection of biological diversity
- ✓ Promote the exchange of experiences and knowledge
- ✓ Promote culturally appropriate and gender-specific ways in which to document and preserve women's knowledge of biological diversity

In order to ensure the full involvement and participation of indigenous women in the work being carried out under the Convention on Biological Diversity with regard to traditional knowledge, the Secretariat takes into account gender considerations when selecting participants for meetings, when undertaking research work, when creating experts groups and, in general, when engaging in all activities related to policy-creation and implementation of the provisions of the Convention. In addition, given that traditional knowledge is a cross-cutting issue within the Convention, the promotion of the participation of indigenous women is applicable to meetings regarding each work programme and decision of the Conference of the Parties to the Convention.

In light of the recognition of the role of women in the Convention of Biological Diversity and, in particular, in the work programme on the implementation of article 8 (j), the Secretariat is pleased to participate in events related to indigenous women and biodiversity. In this regard, for instance, the Secretariat delivered a presentation at a workshop for indigenous women on biodiversity and traditional knowledge held in New York, on 6 May 2004. The workshop was organized by the Indigenous Women's Biodiversity Network (IWBN), an open network of indigenous women interested in environmental issues, initiated in May 1998 at the fourth meeting of the Conference of the Parties, held in Bratislava. Finally, the Secretariat of the Convention on Biological Diversity continues to cooperate with the secretariat of the Permanent Forum on Indigenous Issues, among other relevant organizations, and with women representatives of indigenous and local communities, to ensure that the perspectives and strategies of indigenous women in biodiversity-related issues are taken into account in the work being done under the Convention with regard to traditional knowledge.

Gender makes the difference

Across the globe, women predominate as wild plant gatherers, home gardeners and plant domesticators, herbalists and seed custodians. Research on 60 home gardens in Thailand revealed 230 different species, many of which had been rescued by women from neighboring forests before being cleared. Women in different regions of Latin America, Asia and Africa manage the interface between wild and domesticated species of edible plants. This role dates back to 15,000-19,000 B.C.

Women and men often have different knowledge about, and preferences for, plants and animals. For example, women's criteria for choosing certain food crop seeds may include cooking time, meal quality, taste, resistance to bird damage and ease of collection, processing, preservation and storage. Men are more likely to consider yield, suitability for a range of soil types and ease of storage. Both are essential for human welfare. In a study in Sierra Leone, women could name 31 uses of trees on fallow land and in the forest, while men named eight different uses. This shows how men and women have distinct realms of knowledge and application for natural resource management, both of which are necessary for sustainable use and conservation.

Women provide close to 80% of the total wild vegetable food collected in 135 different subsistence-based societies. Women often have specialized knowledge about "neglected" species. The majority of plant biodiversity research is not gender sensitive. This has led to incomplete or erroneous scientific results with respect to the diversity, characteristics and uses of plants, and the causes and potential responses to genetic erosion. Integrating women's traditional knowledge into botanical and ethno-botanical research, and protecting all informants' rights, are critical for improved knowledge and management. The language used by the Convention on Biological Diversity and the Bonn Guidelines to address subjects related to indigenous and local communities is not gender-sensitive. In spite of the fact that an increasing number of experiences are highlighting the sustainable manner in which women use biological diversity, it is often true that women do so without equitable participation in the access and control of such resources. There is a tendency to ignore the natural spaces predominantly used by women in favor of those used by men, and to undervalue non-commercial (mostly female) production spaces in favor of commercial (mostly male) production spaces.

Therefore, it is necessary to make visible the gender-differentiated practices and knowledge of women and men in their relations with biodiversity resources. Despite considerable efforts over the past fifteen years at national and international fora, such as the Convention on Biological Diversity, very little progress has been made in understanding the fundamental roles that women play in managing and conserving biodiversity. It is essential to recognize that women and men have particular needs, interests and aspirations, and that they make different contributions to the conservation and sustainable management of biodiversity. Making visible the various roles women play in biodiversity conservation, sustainable use of resources and survival of the human species is only the beginning.

How to address gender and agro-biodiversity (FAO initiative)

According to the FAO, the promotion of a long-term strategy of conservation, utilization, improvement and management of genetic resources diversity for food and agriculture requires:

- ✓ Recognition and consideration of the gender-differentiated roles, responsibilities and contributions of different socio-economic groups
- ✓ Recognition and valuing of men and women farmers' knowledge, skills and practices and farmers'rights
- ✓ Sound and equitable agricultural policies to provide incentives for the sustainable use of genetic resources, especially through "in-situ" conservation and improved linkages with "ex-situ"conservation
- ✓ Appropriate national legislation to protect "threatened" genetic resources for food and agriculture, guarantee their continued use and management by local communities, indigenous peoples, men and women, and ensure the fair and equitable sharing of benefits from their use
- ✓ Enhanced access of women farmers to land and water resources, to education, extension, training, credit and appropriate technology
- ✓ The active participation by women, as partners, decision-makers and beneficiaries

Adherence to the above points will facilitate the provision of appropriate support to the different actors, protect local men and women's interests, enhance food security and enable the development and implementation of sustainable, effective and equitable agro-biodiversity programmes. The challenge for the next generation is the safeguarding of agro-biodiversity by paying greater attention to diverse and integrated agricultural systems, especially those managed by women that provide food and livelihood security. The maintenance of plant and animal diversity will protect the ability of men and women farmers to respond to changing conditions, to alleviate risk and to maintain and enhance crop and livestock production, productivity and sustainable agriculture.

Aquacultural Potential of Derelict Waterbodies

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Introduction

Fish constitutes an important component of diet of a significant part of country's population. The aggregate fish demand at the national level has been projected at 6.7-7.7 million tonnes by 2015 and aquaculture would hold the key for meeting the future demand challenges (Kumar *et al.*, 2005). Therefore, expansion of area under aquaculture has to become an important option to boost fish production. In this context, derelict waterbodies could be immensely useful. Coastal Orissa is endowed with large areas of unutilized waterbodies like derelict canals and drains. According to the Department of Water Resources, Govt. of Orissa (2002), huge water areas occur in the form of drainage in-between different river systems. They are termed as 'doabs' area (water area between rivers). There are 17 'doabs' in the nine coastal districts of Orissa. These drainage systems have secondary and tertiary branches also. While the main drainages have flowing water, the secondary and tertiary drainages have stagnant waters for most part of the year, and are usually infested with aquatic weeds, mainly, water hyacinth. These drainage systems allow draining of excess water during rainy season and serve no major purpose in the remaining part of the year, except meeting irrigation requirements to a limited extent despite maintaining good water depth. Can these systems be put to any productive uses? The most immediate feasible option seems to be using such waterbodies for aquaculture. But, before committing resources to bring derelict waterbodies into culture system, it is important to assess their yield potential. In this context, an attempt was made to bring some patches of derelict waterbodies in the Nimapara block of Puri district of Orissa under aquaculture through technological and institutional interventions and study the economics of these waterbodies. The results of this study have been reported in this paper.

Integrated Fish Farming

Integrated fish farming refers to a combination of practices, incorporating the recycling of wastes and resources from one farming system to the other, with a view to optimizing production efficiencies and achieving maximal biomass harvest from a unit area, with due environmental considerations (Ayyappan *et al.,* 1998). To harness the benefits of integrated fish farming, fish-duck integration was introduced in 0.67ha water area in the first year and in 1.04ha area in the second year. Twenty-day old ducklings of 'Khaki Campbell' variety were introduced @ 400 per ha during the first week of December, i.e. after three and a half months of fry release. Fish-duck production system can play a crucial role in improving food security and nutrition among the labour households (Rajasekaran, 2001). After the introduction of ducklings, the feed rate was decreased slowly to two per cent of bodyweight. Fish was cultured for 8-10 months, depending on water depth.

Method of Analysis

Production data from the experiment were analyzed to find out fish yield in different waterbodies. Gross income vis-à-vis the cost involved is an indicator of economic feasibility of an activity. Therefore, income and B-C analysis were carried out following standard procedure to assess economic feasibility of the activity. Gross income from the derelict waterbodies was estimated by taking quantity of fish produced, number of live birds sold, number of eggs produced, and unit sale prices of components at different points of time during the project period. Cost involved in the activity was estimated by taking into account all the direct costs, i.e. expenditure incurred on developing pen materials, sheds and inputs like bleaching powder, fry, groundnut oilcake, fish feed, duck, duck feed, labour, medicine, etc., and imputed value of the family labour as applicable to different waterbodies. Gross income from the waterbodies was taken as the benefit.

Results and Discussion

SWOT Analysis

The SWOT analysis conducted involving different stakeholders revealed that derelict waterbodies have high natural productivity and maintain good waterdepth for most part of the year; hence, are favourable for aquaculture. Further, their close proximity to human settlement offers advantages like easy supervision. On the other hand, many such waterbodies, including drainage systems, do not have developed dykes, and rainwater flows into them, raising the water level. In the case of drainage systems, the fluctuation in water level is more frequent. Such waterbodies with stagnant water are also prone to weed infestation. Therefore, controlled management may be difficult.

The derelict waterbodies offer immense opportunities for sustaining livelihood of rural people through enhanced fish production and consumption. Moreover, a prudent leasing policy for the use of derelict waterbodies can generate a good revenue for the government also. There are some potential threats too in using waterbodies for aquaculture. These include poaching and nuisance by the unscrupulous persons, spilling over of chemicals and pesticide-residues from the nearby fields into the water bodies, gush of rainwater into the waterbodies etc. These could cause heavy economic losses.

Fish Production and Yield

Fish culture was carried out for two years, i.e. during the year 2004-2005 and 2005-2006. Before implementation of the project, derelict waterbodies were mostly inhabited by weed and predatory fishes. The mean fish yield of these waterbodies was estimated to be 0.17t/ha. It was worked out based on the quantity of fish harvested after the repeated netting before putting the waterbodies into culture. Analysis of fish production data from these waterbodies indicated that in the first year the mean yield of fish was 2.24 t/ha, with maximum and minimum yields being 4.33t/ha and 1.37t/ha, respectively. In the second year, the mean fish yield increased to 2.95t/ha, with maximum yield being 4.66t/ha and minimum 2.0 t/ha. Incidentally, during both the years, the highest yield was obtained from the smallest waterbody of about 0.06 ha area (Table 2). A perusal of Table 2 reveals that fish yield of more than 4.5t/ha is achievable through proper management of derelict waterbodies (Case 6).

Table 1. Production and Yield of fish from different waterbodies : 2005 and 2006

SL No. of Water-bodies	Water area (ha)	No. of farmers involved	Production in 2005 (t)					Yield in 2005 (t/ ha)	Production in 2006 (t)					Yield in 2006 (t/ ha)
			C	R	M	S	Total		C	R	M	S	Total	
1	0.15	17	0.26	0.15	0.10	-		3.4	0.28	0.16	0.10	-	0.54	3.6
2	0.20	16	0.18	0.11	0.09	-	0.38*	1.9	0.17	0.12	0.11	-	0.40*	2.0
3	0.32	17	0.13	0.12	0.10	0.09	0.44	1.37	0.42	0.31	0.19	-	0.92	2.88
4	0.22	30	0.25	0.15	0.11	-	0.51*	2.3	0.33	0.20	0.15	-	0.68	3.1
5	0.15	30	0.15	0.09	0.05	-	0.29*	1.9	0.21	0.12	0.09	-	0.42	2.8
6	0.06	4	0.073	0.064	0.068	0.055	0.26	4.33	0.11	0.09	0.08	-	0.28	4.66
7	0.14	10	0.15	0.10	0.075	0.065	0.39	2.78	0.18	0.125	0.115	-	0.42	3.0
Overall under the project	**1.24**	**94**	**1.193**	**0.784**	**0.593**	**0.21**	**2.78**	**2.24**	**1.70**	**1.125**	**0.835**	-	**3.66**	**2.95**

Notes : *Without fish-duck integration, C – Catla, R – Rohu, M – Mrigal, S – Silver barb
In the second year, silver barb was not stocked due to non-availability of fish seeds.

Table 3. Net income from different waterbodies and B-C ratio

SL No. of water-bodies	Area of water-bodies (ha)	First year (2005)						Second Year (2006)					
		Gross income (Rs)	Cost of inputs involved (Rs)	B-C ratio	Net income (Rs)			Gross income (Rs)	Cost of inputs involved (Rs)	B-C ratio	Net income (Rs)		
					Total	Per capita	Per ha				Total	Per capita	Per ha
1	0.15	32,610	10,480	3.11	22130	1301	147533	32,800	8620	3.8	24,180	1422	161200
2	0.20	17,100	5520	3.09	11580	724	57900	18000	1680	10.7	16320	1020	81600
3	0.32	29,280	19,955	1.46	9325	549	29140	36700	11,200	3.27	25,500	1500	79688
4	0.22	21930	6305	3.47	15625	521	71023	30950	6970	4.4	23,980	799	109000
5	0.15	13450	3930	3.42	9520	317	63467	17100	7495	2.28	9,605	320	64033
6	0.06	15,420	6630	2.32	8790	2198	146500	15,830	3385	4.6	12,445	3111	207416
7	0.14	24,150	5150	4.68	19000	1900	135714	23,940	6460	3.7	17,480	1748	124857
Overall	**1.24**	**153,940**	**57,970**	**2.65**	**95970**	**1021**	**77395**	**175,320**	**45,810**	**3.82**	**129,510**	1378	**104443**

Fish-duck integration was introduced in four out of the seven waterbodies in the first year, and six waterbodies in the second year. The production data from these waterbodies indicated that fish yield was higher in the fish-duck integrated than non-integrated waterbodies, except in one case that was affected by intrusion of water from outside. In the first year, the average fish yield was 2.38t/ha from the integrated systems and 2.07t/ha from non-integrated systems. In the second year, the average fish yield of integrated systems increased to 3.13t/ha while that of the lone non-integrated waterbody remained lower at 2.0t/ha. Some of the waterbodies that did not have integration in the first year, recorded a sharp increase in fish yield after introduction of fish-duck integration (Cases 4&5). Therefore, it could be inferred that fish-duck integration is a useful option for the management of derelict waterbodies.

Income and B-C Ratio

The appropriate management of derelict waterbodies could provide a good income to the farmers by augmenting fish production in the rural areas. In addition, the sale of live birds and eggs from fish-duck integration added to the income of rural poor.

Table 2. Income from different components during 2005 & 2006

(in Rs)

SL No. of water-bodies	Water-body area (ha)	First year (2005)			Second year (2006)		
		Income from fish production	Addl. income from fish-duck integration	Gross income	Income from fish production	Addl. income from fish-duck integration	Gross income
1	0.15	21,930	10,680	32,610	24,300	8,500	32,800
2	0.20	17,100	-	17,100	18,000	0.0	18000
3	0.32	22,000	7,280	29,280	31,500	5,200	36700
4	0.22	21930	-	21930	29200	1,750	30950
5	0.15	13450	-	13450	14900	2200	17100
6	0.06	10500	4920	15,420	12,880	2,950	15,830
7	0.14	17,550	66 00	24,150	19,740	4,200	23,940
Total	**1.24**	**124,460**	**29480**	**153,940**	**150,520**	**24,800**	**175,320**

The average gross income in the second year was about 14 per cent higher at Rs1,75,320 than in the first year (Rs1,53,940) (Table 3). It was largely due to the integration of duck in the system. It was also observed that while income from fish production in the second year showed a marked improvement over the first year, there was a decline in the income from duck component. It was largely due to the killing of ducks by predators and poor management of duck sheds. Out of the six cases, only in two (Cases 1 & 6) income from duck component was more than the cost involved therein.

A considerable variation was observed in the performance of waterbodies as measured by per-hectare income (Table 5). It could largely be attributed to the management practices adopted by the farmers. A perusal of Table 5 reveals that both gross income and net income were higher in the second than first year. The per capita income was higher by 13.5 per cent at Rs1378 in the second year than in the first year (Rs1021). The increase in per-ha income was of 28.5 per cent in the second year over first year.

Benefit-Cost Analysis

The overall B-C ratio for the project and B-C ratios for the individual waterbodies indicated that aquaculture in the derelict waterbodies could be an economically viable option. In the first year, the overall B-C ratio was estimated to be 2.65, with maximum and minimum B-C ratios being 4.68 and 1.46, respectively. In the second year, the overall B-C ratio of the project increased to 3.82, and the maximum and minimum B-C ratios of waterbodies were found to be 10.7 and 2.28, respectively. In five out of the seven cases, the B-C ratio increased in the second year, indicating good returns and better prospect of aquaculture in the derelict waterbodies. It was largely due to increase in income from fish production and partly due to reduction in cost. The cost of inputs (Table 4) was higher in the first year than second year. It was largely due to expenditure on labour for cleaning of waterbodies and on bleaching powder for eradication of weed and predatory fishes. For example: in the first year, more labour was required to clean the derelict waterbodies infested with weeds and therefore, cost on labour was high. In the second year, cost on labour was reduced considerably. Similarly, bleaching powder accounted for a good part of total cost in the first year, but in the second year, it was not applied. Similarly, groundnut oilcake was not applied in the second year due to high organic load in the water bodies. All these contributed to overall cost reduction under the project.

A perusal of Table 3 indicates that high B-C ratio may not always be associated with high level of net income. Even waterbodies with similar B-C ratios had different levels of net income per hectare. In the first year, some of the waterbodies with high B-C ratio (B-C ratio more than 3) yielded lesser per-hectare net income than other waterbodies with high B-C ratios. In the second year, the waterbody with highest B-C ratio had lower level of net income per hectare as compared to other waterbodies with a similar B-C ratio. It was due to poor management of duck unit and waterbodies. On the other hand, there were cases where despite reduction in total cost, income increased (Case 6). In such cases, farmers could capitalize on first year's investment on pond management. However, overall increase in B-C ratio was accompanied by increase in gross and net incomes from waterbodies.

The per-capita income is also an indicator to assess distributive aspect of benefits of the project. As evident from Table 3, in the first year, the lowest per capita income of Rs317 was obtained in Case 5, while the highest per capita income was Rs2198 (Case 6). In the second year, there was virtually no improvement in the lowest per capita income, while the highest per capita income level increased to Rs3111. Incidentally, the same waterbodies yielded the lowest per capita income (Case 5) and the highest per capita income (Case 6) in both the years. The overall per capita income under the project increased from Rs1021 to Rs1378.
Some of the important points that emerged from the study are:

- Even very low level of investment in the derelict waterbodies could yield good income (Case 2)
- Medium level of investment coupled with good management could provide in fairly high income (Case 6)
- High investment may not always bring expectedly high income (Cases 3 &5)
- In all the cases, the potential of fish-duck integration could not be harnessed due to poor performance of duck units. Assessment of the situation revealed that even though women were given necessary orientation and training to manage the units, absence of an agreed mechanism to equitably share the responsibilities of management among women themselves led to poor supervision of duck units and neglect of birds.

Constraints

The most common problem in the management of derelict waterbodies was inflow of derelict water and entry of predators and weed fishes into the culture system following damage to the pen materials (bamboo linings and nets) caused due to either heavy rain or anthropogenic activities. As a result, there was a surge in the weed fish population in the culture system which affected the growth of cultured fishes adversely. At times, such developments were not easily noticeable as damage often occurred to the under-water portion of pen materials. Secondly, some people also reported poaching by unscrupulous persons. As a result desired benefits did not accrue to the farmers.

Conclusions and Implications

The study has shown that derelict waterbodies can be productively and profitably utilized for aquaculture. These waterbodies could yield good income even from low level of investment. Such an activity can provide enormous income and employment opportunities in the rural areas. To encourage large - scale utilization of available derelict waterbodies for aquaculture, a prudent and well conceived policy for leasing out derelict waterbodies and transfer of relevant technologies to the needy and interested farmers should be evolved. These steps would not only boost fish production in the rural areas, but would also give much needed impetus to the growth and diversification of rural economy.

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Fodder based Integrated Farming System for Supporting Livelihood of Farm Women

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Livelihood security refers to the ability to continuously maintain or enhance a healthy and secure life which encompasses a range of on-farm and off-farm activities and togetherly provide a variety of procurement strategies for food and cash. Livestock farming has been considered as a potential means of providing large scale employment as a part or full time job especially in rural areas. Women form the backbone of agriculture and play a significant role in animal, farm and home management. Successful livestock farming not only improves the socio-economic status of rural women, but also assures a sustained and assured means of income to supplement their income from the main enterprise. The major activities involved in animal farming include collection of fodder/cultivation of fodder, grazing the animals, feeding and marketing of milk produce. Livestock rearing especially dairy and sheep/goat farming not only provide employment and income but also supply farmyard manure and biogas through utilization of agricultural by-products which ensures an excellent nutrient recycling which is an eco-friendly practice. Biogas reduces the dependence on wood for household fuel. Animal dung is utilised for biogas and manure and conserve our forest and pasture resources. Within this framework, an integrated crop-livestock farming system represents a key solution for enhancing livestock production and safeguarding the environment through prudent and efficient resource use.

Diversified versus integrated farming system

Diversified systems consist of components such as crops and livestock that coexist independently from each other. In this case, integrating crops and livestock serves primarily to minimize risk and not to recycle resources. In an integrated system, crops and livestock interact to create a synergy, with recycling allowing the maximum use of available resources. Crop residues can be used for animal feed, while livestock and livestock by-product production and processing can enhance agricultural productivity by intensifying nutrients that improve soil fertility, reducing the use of chemical fertilizers. A high integration of crops and livestock is often considered as a step forward, but small farmers need to have sufficient access to knowledge, assets and inputs to manage this system in a way that is economically and environmentally sustainable over the long term. An integrated farming system consists of a range of resource-saving practices with integrated resource management that aim to achieve acceptable profits and high and sustained production levels, while minimizing the negative effects of intensive farming and preserving the environment. However, technologies and management schemes that can enhance productivity need to be developed to upgrade conventional agriculture along with preserving the natural resource need to be strengthened.

Fodder resource management in integrated farming system

Fodder production is a major component of the integrated farming system and efforts need to be made for increasing the forage production in a holistic approach of integrated resource management. Legumes enriching the soil can be grown in mixtures with grasses in grasslands. Indigenous legumes such as clovers (*Trifolium pratens*, *T. repens*), *Medicago denticulata, Melilotus alba*, white clover, red clover have proved successful apart from Lucerne and Berseem. The grass rangelands exhibited enormous gain in forage production through multi-tier silvipasture and hortipastoral techniques amalgamated with planting of multipurpose trees in wastelands followed by sowing/planting of grasses or legumes in inter-spaces of trees. Under alley cropping system, *Leucaena leucocephala* provide leaf fodder to get better crop production. Foliage of fodder trees could be fed mixed with crop residues and hay which improved their palatability and nutritive value. Further, with a steady increase in the growth of goat population, there is an increasing pressure on forage supply intensifying their dependence on community resources for free grazing. Farmers continue to expand their herd and exploit community pastures and forest resources to feed their livestock.

The shortage of feed and fodder resources could be attributed to the growing livestock population, low productivity and less emphasis on forage cultivation by the livestock owners. It can be observed that 54% of the total fodder is met from crop residues, while 18% fodder is met from grasslands and only 28% fodder is met from cultivated fodder crops (Hegde, 2006). Prominent among the crop residues were paddy straw, wheat straw, stalks of sorghum, maize, pearl millet, groundnut, beans and grams. Although these crop reduces were considered as very valuable by the livestock keepers, there have been a lot of wastage in different parts of the country.

Forage production for improving the Profitability of livestock farming

Agriculture and animal husbandry are the primary occupations of the rural inhabitants. The economic viability of animal husbandry is dependent on the genetic potential for production, good health care, balanced feeding of animals and efficient marketing of the produce. The profitability is directly dependent on the sources of feed and fodder, as about 65-70% of the total cost of livestock farming is attributed to feeding. Any saving in feed and fodder cost would directly contribute to increase in profitability. The animals depend predominantly on open grazing or stall feeding on the byproducts of agricultural produce like wheat straw, paddy straw, hay and green or dry grass collected from forest. The livestock population greatly exceeds the carrying capacity of the land and thus a situation of acute shortage of feed and fodder arises. This results imbalanced or underfeeding of animals which adversely affects the health and productivity of the animals. During the rainy season, green fodder may be in excess of need which can be effectively conserved for lean period. It has been estimated that 66% of total dry matter of available fodder comes from forests as tree leaves and forest floor litter and only 34% is contributed from cultivable land (Singh, 2003). Besides this, huge amount of poor quality roughages and agro industrial byproducts are left or burnt in the field which can be effectively preserved for the scarcity period. The quantitative and qualitative deterioration in common grazing lands by indiscriminate grazing pressure and the lack of adoption of fodder production technologies and its preservation further deteriorates the bioavailability of forage resources for animals.

The economics of dairy animals is heavily dependent on the quantity of nutritious forage fed. With feeding of good quality forage, particularly leguminous fodder, feeding of concentrate can be reduced significantly. Animals yielding upto 5-8 kg milk per day can be maintained exclusively on 48-55 kg lucerne or berseem greens, as a substitute for 4.5 to 5.0 kg concentrate. However, there are not many dairy animals, having genetic potential to produce high milk yield, by efficiently converting the fodder. With regard to inferior quality animals, inspite of feeding good quality fodder, the milk yield remains low and the farmers find it uneconomical to feed such animals. As there are no opportunities to sell surplus fodder in local markets, farmers are reluctant to cultivate fodder exclusively on fertile agricultural lands, without owning high yielding animals. Although the promotion of forage production is a critical factor, which has a direct influence on the livestock industry, forage cultivation is closely linked to the productivity of livestock.

Strategy for increasing forage Production

While improving the forage resources, it is necessary to address the opportunities related to increasing the fodder yield of cultivated fodder crops on agricultural lands as well as on wastelands and community pastures and efficient use crop residues,. The strategy should cover selection and breeding of high yielding and stress tolerant fodder crops and varieties, improving the yields through sustainable production practices, efficient conservation and strengthening the value chain of dairy and meat producers to provide various critical services required to optimise the income.

Intensive forage production: Intensive forage cropping is the only alternative to boost forage yield from irrigated lands and overall productivity of forage cultivable land.Some of the intensive cropping systems have been suggested for different regions.

North zone

- Maize+Cowpea - Sorghum+Cowpea (two cuts) - Berseem+Mustard
- Sudan grass+Cowpea -Maize+Cowpea-Turnip-Oats (two cuts)
- Hybrid napier or *Setaria* inter planted with cowpea in summer and Berseem in Winter (9-10 cuts/year)
- Teosinite+ Cowpea (two cuts) - Carrot - Oats+ Mustard/Senji (two cuts)

Western and Central Zone

- *Bajra*+ *Guar* (Clusterbean) (two cuts) - Annual Lucerne (6 cuts)
- MP Chari+ Cowpea(2 cuts) - Maize+Cowpea - Teosinite+ Cowpea(2 cuts)
- Hybrid napier/*Guinea* or *Setaria* inter planted with cowpea in summer + Berseem in Winter (8-9 cuts/year)
- Hybrid napier or Guinea or Setaria inter planted with Lucerne (8-9 cuts/year)

Southern zone

- Sorghum+Cowpea (3 cuts) - Maize+Cowpea - Maize+Cowpea
- Hybrid napier or *Guinea* grass inter planted with Lucerne (8 cuts/year)/Hybrid napier+ *Subabool/Sesbania* (9-11 cuts/year)
- Sudan grass+Cowpea (3 cuts) - MP Chari+ Cowpea(3 cuts)
- Para grass + Centro (*Centrosema pubescens*) (9-11 cuts/year)

Eastern zone

- Maize+Cowpea - Teosinite+ Rice bean (2 cuts) - Berseem+Mustard (3 cuts)

- MP Chari+ Cowpea - *Dinanath* grass(2 cuts) - Berseem+Mustard (3 cuts)
- Para grass + Centro (*Centrosema pubescens*) (8-9 cuts/year)
- Hybrid napier or Setaria grass inter planted with *Subabool/Sesbania* (9-10 cuts/year)

Efficient Use of Crop Residues: Although about 54% of the fodder needs are met from various crop residues, no serious efforts are presently made to either increase the yield or quality of this fodder. Farmers in many regions have been wasting the crop residues, either by feeding the stalk without processing or by burning. Timely harvesting of crop residues, proper processing and storage can also enhance the quality of the forage and prevent wastage. Harvesting of stalk before it turns fibrous f**or** direct feeding or converting into silage, can keep the nutritive value high while reducing methane generation by the ruminants. Chaffing of stalk before feeding, can reduce the emission of methane by 10% while saving the wastage by 25-30%. Establishment of fodder banks in fodder surplus areas and transportation of compact feed blocks to fodder deficient areas can mitigate fodder crisis.

Fodder Crops for Wastelands: Considering the limitations of traditionally cultivated fodder crops, it is necessary to introduce various non-traditional fodder crops for growing on marginally productive farms and denuded community lands. Hardy grasses and legumes like stylo, seratro, hedge lucerne, etc. can be grown on wastelands. Fast growing shrubs and trees can be lopped regularly as fodder and can be established on field bunds, home gardens and along farm boundaries. In the agri-horti-forestry projects promoted by BAIF in South Gujarat, Rajasthan and Karnataka, the fertility of the lands was extremely poor. Such lands were developed for cultivating hardy, drought tolerant horticultural species such as mango, cashew, custard apple, tamarind, Indian gooseberry, etc. The bunds and borders of these plots were used for growing fodder and fuel tree species like subabul, gliricidia, acacia, sesbania, etc. Most of the farmers found these species to be reliable sources of fodder, particularly during summer and monsoon, when other sources of green fodder were absent. The interspace between fruit plants was used for either food crop production or forage production, depending on soil productivity and moisture supply. In case the soil productivity was low, farmers preferred to grow fodder instead of growing agricultural crops and maintain some cows or buffaloes to boost their income further (Hegde, 2006).

Community-based fodder production : Community pastures is another excellent opportunity. Generally, about 5% to 10% of the land area in every village is reserved for community pastures. In the absence of controlled grazing and care, the productivity of these community pastures has been severely eroded. Such lands can be brought under silvipasture development involving local people. The major activities included the establishment of live hedges, gully plugging, contour bunding, sowing of forage seeds such as *Cenchrus setigirus* (Dhaman grass) and *Stylosanthus hemata* (Stylo) before the onset of monsoon. Saplings of Acacia and *Prosopis cinereria* (*Khejdi*) were also planted and stray grazing was prohibited.

In order to provide green forage, year-round alternate land use (Agroforestry) systems need to be developed on private or community lands in the vicinity of villages. The community lands, civil and panchayat lands, serve as potent source for grazing and hay production but do suffer from lack of management. "Every body's property is no one's responsibility", applies well to these areas. Legume and fodder tree/ shrub species and access to fodder minikits programmes need to be prioritised for production of good biomass. Management of natural forest by the community could be improved substantially, ensuring ecological stability and reducing biotic pressure on existing resources.

Now a days a special focus on feeding of small ruminants is given as most of the sheep/goats are let out for free grazing or taken out to community pastures and village woodlots by one of the members of the family and are not provided supplementary feed. In areas where tree population on common lands is dense, goat keepers bring lopped branches for supplementary feeding. To overcome the problem of fodder scarcity faced by pregnant goats, goats are preferred to bred during April-May to facilitate kidding in September-October when adequate fodder is available for the lactating goats. During summer, when availability of forage is at the lowest level on community lands, the rate of conception is also lower, due to nutritional deficiency. Pods of *Acacia, Prosopis, Sesbania, Bahunia, Samania* and *Albizia* are very nutritious and palatable which are crushed before feeding or possibly mixed with locally available biomass to process into complete feed.

Conservation of conventional forage resources

Conservation of forage resources with the principle of judicious utilization of existing conventional and unconventional resources to augment productive performance of animals is essential. Green fodders of conventional source can be conserved as silage and hay making.

Silage is the preserved green fodder in succulent form under air tight conditions where acids produced by controlled anaerobic fermentation of carbohydrates. The objectives of ensiling are achievement of anaerobic conditions and to discourage the activities of undesirable micro organisms i.e. *Clostridia* and *Enterobacteria* allowing proliferation of desired spp. of *Lactobacilli* which stabilize the acidic pH (<4.2) and restricts the growth of spore forming anaerobes and *Clostridia* producing objectionable fermentation products (amines, ammonia, CO_2, butyric acid, acetic acid etc.). Good silage is yellowish-green in colour with a pleasant vinegar smell. Silage can be effectively made from maize, sorghum, bajra and barely. Among the perennial grasses, hybrid napier grass, guinea grass, para grass, sudan grass and rhode grass are commonly used for silage making. Legumes like berseem, lucerne and cowpea are not suitable for silage making. However, when mixed with non-legume crops in the right proportion, the mixture yields a well balanced silage. The fodder crop should be harvested at a stage when nutrient content is at peak stage. The crop must have sufficient sugars to permit the quick production of preservative acids of which lactic acid is the most important one. Flowering to milk stage is recommended for making silage from maize, Jowar and oats crops having dry matter of 30-35 per cent. Pit silo is best for ensiling under village areas of hills out of many types of silos i.e. pit silo, tower silo, trench silo, bunker silo and bag silo etc. Pit silo may be of circular or rectangular pit of desirable dimension on a site located at the higher elevation and near the animal shed. It may be roughly calculated on the basis that one cubic meter of the silo can have 650 to 700kg settled silage. A silo pit of 3.0X2.5X2.0 meter (LxWxD) dimension is a convenient size for making silage for feeding five dairy animals at the rate of 20 kg silage per head per day for three months. Silage should be ready for feeding in about 45 days. Good silage has higher vitamin A content and better palatability than hay and other dry roughages. Cattle prefer silage to coarse, mature and less palatable green fodder. During ensiling the concentration of toxic constituents such as hydrocyanic acid, nitrate and oxalic acid is reduced drastically thus, the fodder having very high concentrations can be safely fed to animals after ensiling. The animals may take 4-5 days adoption period to accept the silage.

Hay making is the traditional method of drying and storing of high quality forage by reducing the moisture content to the level at which plant tissues are dead or dormant. It reduces the moisture content of green crop to a level low enough to inhibit the action of plant and microbial enzymes so that it can be safely stored without any deterioration. The moisture level in well cured hay should be below 15%. In most of the crops, early flowering stage having maximum nutrient contents is considered to be the best stage to harvest crop for hay making. Thin stemmed crops like berseem, lucerne, cowpea, soybean, oat and natural grasses are suitable for hay making. The crops should be preferably harvested in the morning when sunrises and allowed for field curing until it is wilted sufficiently. Then it is rolled into small loose bundles followed by collection at one place into big heap in tripod system or baled for storing. Good quality hay should be leafy, green colour with typical aroma of forage from which it was prepared and should be soft, pliable, free from dust, moulds, weeds and foreign materials. It reduces the labour involved in handling and transport green forage due to less moisture content. The labour and botheration of cutting green forage daily is eliminated. Even the intensity of cropping can be increased and more cuttings can be taken from the multicut crops. In hay making from high-quality forage, the biggest drawback is the loss of valuable leaves in handling. With the loss of leaves, a large fraction of proteins in the crop is lost particularly in case of legumes such as berseem, Lucerne, cowpeas, rice bean and guar.

Conservation of non-conventional forage resources

Forage resources which do not form the part of normal diet of animal are generally termed as non-conventional forage like crop residues and agro industrial byproducts and tree leaves.

The poor quality roughages, crop residues and agro industrial byproducts are used as a staple diet for ruminants in our country. The crop residues having relevance in ruminant feeding are jowar, bajra, maize stovers, wheat and paddy straw. These are highly fibrous in nature with low crude protein content. Most of the crop residues have more than 60% of DM in the form of cellulose and hemicellulose which are good source of energy (Jakhmola and Misra, 2000) for ruminants. But, their association with lignin form lingo cellulose complex which is more resistant for action by hydrolytic enzymes and rumen microbial enzymes and reduce the bioavailability of energy source (cellulose and hemicellulose) to animals. The products of digestion from such roughages are also considered to be poorly balanced for all productive purposes. Physical (chaffing, chopping, soaking, grinding, pelleting etc.) alkali treatment (sodium hydroxide, calcium hydroxide, urea etc.) and supplementation of trace minerals improve the rumen fermentation pattern, digestibility and nutritive value of crop residues. Urea (4% level) is generally the most practical and often cheapest chemical available for treating crop residues which changes its physical nature and improve digestibility (ICAR, 1985). Further, maintenance of animals on all roughages diet utilizing urea treated straw in combination with tree leaves in 25 : 75 ratio is a viable alternative (Misra *et al.,* 1998). However, urea ammoniation technology is not accepted to the desired extent due to wastage of 75-85% added nitrogen, labour intensive, problems of environmental pollution and lack of awareness among the people.

Most of the agro industrial by products are invariably moderate source of energy and protein with high levels of acid insoluble ash, erratic levels of minerals. The presence of toxic principles may not show apparent toxicity but may cause cumulative toxicity over a period of time and may adversely affect the health and production of animals. Besides physical and chemical treatment, biotechnological tools through use of white rot and brown rot fungi also improve the nutritive value of crop residues and agro industrial byproducts. They solubilize the lignocellulosic complex by secreting enzymes and synthesize amino acids resulting improvement in quality.

The feeding value of crop residues and agro industrial byproducts can be improved if they are blended into complete feeds. Complete feeds with desired ratio of roughages, concentrate, molasses and other agro forest based non-conventional feeds including top feeds improve the feed palatability, voluntary DM intake, avoids refusal of unpalatable portion, reduces wastage, increase bulk density thereby reducing transportation cost. This feeding system not only ensures improved utilization of nutrient from non-conventional feed stuffs but also helps in developing low cost balanced feeds for ruminants especially the dairy animals in hills suffering from chronic shortage of conventional feed and fodder. Compact feed blocks are found to be very nutritious, easily digestible, handy to transport in remote areas of the hills and require comparatively lesser space for storage and are considered as readymade balanced ration for ruminants for the benefit of landless labourers, small and marginal farmers. The common formulation of standard compact feed block is wheat straw / cellulosic waste/ tree leaves – 55-60 %, concentrate mixture - 30-35 %, molasses - 10%, mineral mixture - 1% and salt - 0.5% (Singh and Singh, 2007)

Supplementation of tree leaves rich in protein such as *Leucaena, gliricidia* etc. could act as a replacer of feed concentrates for livestock with reduced feed cost and nutritive value of cereal forages (Mojumdar and Mahanta, 2006). The tree leaves contain about 12-15 % of crude protein and as high as 23% protein in *Subabool* and *Bhimal* has been are reported in tree leaves, but the fibre is complex and highly lignified at the mature stage and as fibre level increases, protein content decreases. Wide Ca: P ratio of tree leaves and high tannin (CT >5%) content limits bioavailability of nutrient in animals (Fernandes, 2004). Therefore, the tree leaves of higher nutritive value can be judiciously used as part of diet with concentrate mixture and green grasses (2:1:1) even after detoxification of anti nutritional factors (Min *et al.,* 2003). Further, tree leaves should be conserved through effective lopping management for supply of these precious fodder to the animals round the year.

Feeding of fodder based balanced ration to animals

Rural women farmers usually feed homemade concentrate devoid of mineral mixture imbalanced with energy, protein, mineral and vitamins which adversely affect the health and productivity of the animals and hence the economic return. Preparation of balanced ration by incorporating locally available feed and fodder resources ensure optimum proportion of macro and micronutrients certainly ameliorate the malnutrition problems of animals. The concentrate and roughage ratio is usually recommended at 40: 60 for milch animals and 1kg concentrate for every 2.5 kg milk production along with 1.5-2 kg of concentrate as maintenance ration is usually followed for dairy animals. Besides concentrate mixture, provision of 30-40kg of good quality green fodder along with 2-3 kg of dry roughage (straw/hay) is normally recommended for a cow yielding 5kg milk per day.

Need for forage-based development research

A fresh look at the policy to establish a vibrant communication between scientists and the target communities through the following initiatives is required :

- ✓ Establishment of field research units to promote on-farm studies and test the technologies under field conditions.
- ✓ Carrying out joint research studies in association with farmers' organisations, voluntary agencies, State Agriculture and Animal Husbandry Developments and Krishi Vigyan Kendras.
- ✓ Establishment of an Extension Division to collaborate with various farmers' organisations, veterinary officers and Agricultural Training centres and participation in Kisan Melas and seminars to disseminate fodder based technologies along with receiving their feedback regularly.
- ✓ Encourage forage scientists to participate in the value chain of dairy husbandry and meat production to promote forage production for increasing the profitability.

Integrated farming system enhances productivity, profitability and nutrition security of the farmer and sustains productivity through recycling of organic source of nutrients from the enterprises involved reducing the production cost and ultimately improve the farm income considerably satisfying the ever-increasing population of the country, and create confidence among farmers through higher profitability.

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Utilisation of Fish Waste for Generating Income by Farm Women

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Fishery is an important sector of food production in India. Its contribution to the countries' development is through enabling nutritional security, earning foreign exchange through exports and providing employment to almost 14 million people of the country directly or indirectly. India produces around 6.3% of global fish production with an average annual growth rate of around 4.5%. Indian fishery contributes to 1.1% of the country's GDP and 5.15% of its agricultural GDP. With a total fish production of more than 10 million metric tones, India stands second only to China in the world fish production. Fish and fish products have emerged as the largest exported agricultural products in the country to the tune of 10.51 lakhs tones amounting to almost 34000 crores.

Similar to most food industries, fish processing operations also produce waste in the solid form like fish carcasses, viscera, skin and heads and liquid form like washing and cleaning water. India is home to more than 60 minor fishing harbours, around 1500 fish landing centres, 350 seafood processing factories and innumerable number of fish markets where a huge amount of processing waste is being generated. Waste generated through fish processing varies from 10% to 80% of the weight of the fish according to the processing activities. Presently in India, around 960 million tonnes of solid waste is being generated. By 2050, our country would need 9 times the area of land for dumping of wastes which we all know is not feasible taking into account the exponential population growth. The organic components of the waste have a high biological oxygen demand and if not managed properly, can pose serious environmental problems. The decomposition of fish waste attracts pests, flies and animals can create serious health implications for humans. In India, with its tropical and subtropical climate, the problem of decomposition process becomes more severe as heat and moisture promote decomposition. There are several alternative uses of fish processing waste, like utilization of fish mince for the preparation of battered and breaded products, production of fish gelatin, nutraceutical ingredients, fishmeal, fish protein hydrolysate etc. Chitosan, produced from shrimp and crab shell, has shown a wide range of applications from food to cosmetic to pharmaceutical industries.

Fish silage is a liquid product which can be made from waste of fish or whole fish, which are liquefied by the action of natural enzymes present in the fish. There are two processes by which silage can be made. One is acidification where the natural enzymes in the fish are activated by addition of organic or inorganic acid or a mixture of both. The second process is fermentation, where the enzyme activity is catalysed hy the acids produced by the fermentation of added sugar with or without the presence of lactic acid bacteria. The technology of fish silage production has the following advantages: Simple technology, less capital investment and low skill requirement, hence women friendly, nutrient composition similar to that of raw material

(Fish waste), no offensive odour, Fast ensiling under tropical climate (2-3 days), shelf life of more than 6 months for chemical silage and 2 months for fermented silage and alleviates environmental pollution and Low cost of production

Preparation of acid treated and fermented silage from freshwater fish dressing waste

Acid treated silage

Mince the gut and gills of fish after washing.

↓

For each kg of minced waste, add 15 ml formic acid and fifteen ml hydrochloric acid or 30 ml formic

↓

Add 200mg of Butyl hydroxyl toluene (BHT) (to prevent rancidity development) and 1gm of Potassium sorbate (to prevent fungus and mould attack)

↓

Mix well and keep in air tight in plastic containers at 28-30 degree celcius

↓

Stir twice daily for 2-3 days or till the product attains semiliquid form

Fermented silage

Mince the gut and gills of fish after washing.

↓

To each kg of minced waste, add300 ml water and 200gm

↓

Add 200mg of Butyl hydroxyl toluene (BHT) (to prevent rancidity development) and 1gm of Potassium sorbate (to prevent fungus and mould attack)

↓

Mix well and keep in air tight plastic containers at 28-30 degree celcius.

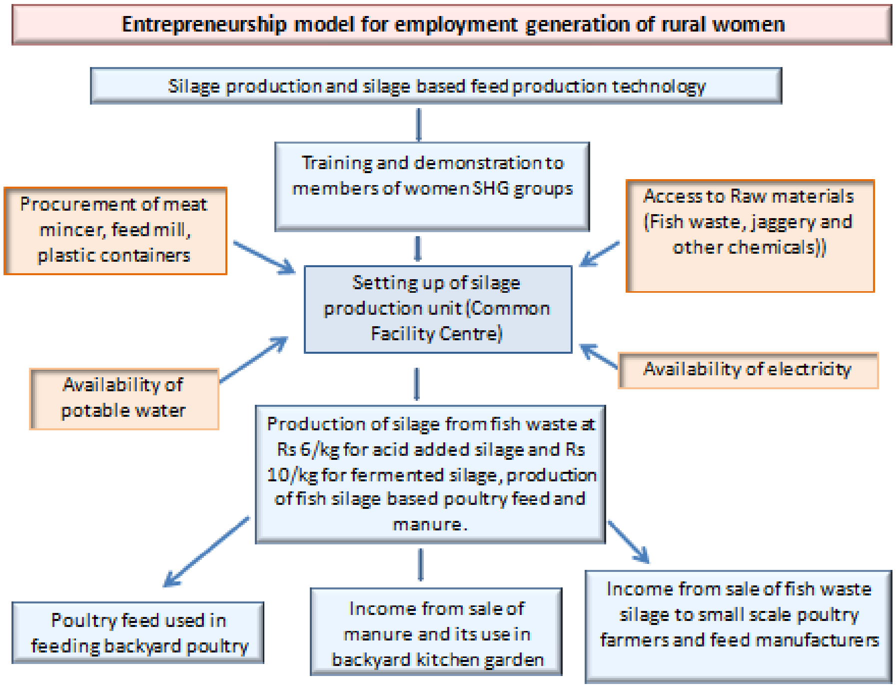
↓

Stirred twice daily for 4-5 days or till the product attains semiliquid form.

Utilisation of fish silage

Fish silage finds its major use in the area of animal nutrition, where it is mainly used as a source of protein. In poultry and aquaculture production, feed accounts for over 50- 70 % of the production cost. Protein of high quality with adequate amino acid balance is one of the most important nutrients for fishes and poultry birds. Through out the world, fish meal and meat meal are the animal protein sources most widely used in poultry and fish feeds. The high cost of good quality fish meal compels the poultry farmers to opt for fish meal of a lower grade. But the threat of salmonella and aflatoxin contamination always accompanies the use of low quality fish meal in poultry feeds. Hence the use of fish silage as a replacement to fish meal could be a better option for poultry farmers. Another probable use of fish silage is as organic fertiliser as it contains the nutrients suitable for plant growth, soil microbes and earthworms and is free from off odour. Organic farming is gaining momentum in the recent years as the farmers are getting more and more aware of the need to sustain the fertility of their soils which has been tampered because of the excessive application of inorganic fertilizers, insecticides or pesticides. The use of fish silage or fish emulsion as organic fertiliser has gained much momentum in countries outside India. There are several products available in the international markets made from fish by-products which is utilized as fertilizers or manures like Biomarinus from NewZealand. But such kind of initiative are yet to get a start up in India. The production of organic manure from fish silage could be an innovative livelihood option for rural women.

Fish silage has been described as having good nutritional quality and its biological nitrogen value is comparable to that of skimmed milk powder or fish meal (Raa and Gildberg, 1982). Rahmi et al. (2008) has reported the potential of fish silage to be used in sheep feed. As per Green et al. (1988), pigs fed on silage based diets grew faster owing to improved food conversion ratio. Smitha et al. (2006) has reported that that 9.7% fish waste silage could be added replacing unsalted dried fish in the ration of broilers with economic benefits. Dried cuttle fish waste silage has also been tried as an economical substitute for dried fish in the rations of growing and finishing pigs with considerable reduction in cost of feed (Sakthivel et al., 2005). Several research studies have been conducted at the Central Institute for Women in Agriculture, Bhubaneswar, to validate the potential use of fish silage as poultry feed ingredient. 10% fish silage in broiler poultry diets reduced the feed cost by Rs 5/kg. Apoultry farmer could increase his profit margin considerably by using the technology. In Japanese quails, the consumption of fish silage resulted in an increase of 8% in egg production. Vanaraja, a most popular dual purpose poultry breed, popular in the rural areas of the India, also showed positive growth performance when fed with fish silage. Thus, the protein to the tune of 35-39% in acid treated silage and 15-19% in fermented silage which could otherwise go as waste can be converted to alternative feed ingredient through this low cost technology



Managing trash is a nightmare for every local self government and the land suitable for disposing of solid waste in our country is fast diminishing. Strategies like production of silage from fish waste will not only help in turning waste to money but will also provide the much needed alternative livelihood options for fisherwomen who are being displaced from their occupation because of the mechanization in the sector. Rural women could use the fish silage for utilization at home for feeding their backyard poultry or manuring their kitchen gardens or agricultural field. For earning money, they could convert it into an enterprise wherein they could sell the silage based organic manure in attractive packages which will lure their customers which can necessarily be established organic farmers, plant nurseries etc. converted to alternative feed ingredient through this low cost technology.

Nutrient Management in Tuber Crops based Integrated Farming System

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Introduction

India harbours 17% of global population in only 2.3 % land mass supported by 4 % of fresh water resources (Sen, 2009). The advent of high yielding, fertilizer responsive and photo-insensitive crops and crop varieties led to a record food grain production of 211 Mt in 2001-02 with a sizeable buffer stock of about 60 Mt (Yadav, 2003) and the production increased to 255.36 Mt in 2012-13. The quantum jump in food grain production is not matching the proportionate increase in fertilizer consumption from 0.07 Mt to 19.3 Mt (about 275 times), in net irrigated area from 18 Mha to 59 Mha (about 3.3 times), in cultivated area under food grains from 97 Mha to 122 Mha (< 1.3 times), and in gross area under high yielding varieties from none to 76.4 Mha during 1951-52 to 2001-02. The per capita arable land in India decreased from 0.34 ha in 1950-51 to 0.15 ha in 2000-01 and is expected to shrink to 0.08 ha in 2025. No possibility of further horizontal expansion in the cultivated area besides the galloping population from 361 million in 1951 to over 1.28 billions at present, with further projections of 1.4 and 1.8 billions by 2025 and 2050, respectively, the scarce soil resources are under heavy pressure.

Fertilizer scenario

Even though India is the second largest fertilizer user followed by China, the average rate of nutrient application in India is 128.34 kg ha^{-1} (84.54 + 33.44 + 10.36 kg N, P_2O_5 & K_2O/ha), highest in Punjab 250.19 kg ha^{-1} (188.47 + 58.67 + 3.05 kg N, P_2O_5 & K_2O/ha) (2012-13). The National Academy of Agricultural Sciences projected that 30 to 35 Mt of fertilizer nutrients would be required to meet the food grain demand by 2020. Therefore, demand will stretch by almost 15 Mt if requirements of horticultural, plantation, sugarcane, potato, cotton, etc are included, thus making a total requirement of 45 Mt. Emphasis on application of major nutrients has triggered widespread deficiencies of secondary and micronutrients like Sulphur (41%), Zinc (49%), Boron (33%), Fe (12%), Mn (5%) and Cu (3%) (Singh, 2009). It has been estimated that hardly 270-300 Mt of organic manures of different kinds contributing around 4 to 6 Mt of NPK are available in the country.

Fertilizer consumption in India (Mt)

Year	N	P_2O_5	K_2O	Total
2009-10	15.58	7.27	3.63	26.49
2010-11	16.56	8.05	3.51	28.12
2011-12	17.30	7.91	2.68	27.79
2012-13	18.04	5.96	1.81	25.80
2013-14	16.53	5.46	1.98	23.96

All India demand forecast of fertilizer products (thousand tonnes)

Year	Urea	DAP	NP/NPKs	SSP	MOP
2014-15	32029	12002	10861	5091	4492
2015-16	32858	12212	11142	5513	4643

2016-17	33677	12413	11420	5948	4793
2017-18	33754	12764	11841	6476	4934

The area under food grains in Odisha has declined from 5.428 M ha in 2008-09 to 5.03 M ha in 2012-13. The food grain production in Odisha was 8.36 Mt in 2013-14 as compared to 10.21 Mt in 2012-13 and 6.32 Mt in 2011-12. Cropping intensity in the state was 167% in 2013-14. The red, laterite and lateritic group soils constituting more than 75% of the total land area in the state having the productivity constraints like low pH & cation exchange capacity, deficiencies of Ca, Mg, S, Zn, B & Mo, toxicity of Fe, Al & Mn, low organic matter and low status of available N, P & K. Average Fertilizer consumption in Odisha was 90.29 kg/ha (58.03 + 22.88 + 9.39 kg N, P_2O_5 and K_2O/ha) (2012-13). Fertilizer consumption in Odisha reduced from 0.490 Mt in 2012-13 to 0.487 Mt during 2013-14 with a NPK ratio changed from 6.2:2.4:1 (2012-13) to 5.5:2.1:1 (2013-14). More than 50% of soils are deficient in Zn, and 33% in B.

Integrated nutrient management

The integrated nutrient supply includes the conjunctive use of chemical fertilizers with organic sources like green manure, Farmyard manure (FYM), crop residues, biofertilizers etc. helps not only in bridging the existing wide gap between the nutrient removal and addition but also in ensuring balanced nutrient proportion, in enhancing nutrient response efficiency, and in maximizing crop productivity of desired quality. Balanced fertilization ensures that fertilizers are applied in adequate amounts, and correct ratios for optimum plant growth and sustenance of soil and crop productivity. It should take into account the crop removal of nutrients, the economics of fertilizers and profitability, farmer's investment ability, agro techniques, soil moisture regime, weed control, plant protection, seed rate, sowing/planting time, soil salinity/alkalinity, physical environment, microbiological condition of the soils, soil status of available nutrients, cropping sequence, etc. The ultimate objective is to facilitate the development of nutrient efficient, stress tolerant and high quality crop varieties that will contribute to the agricultural sustainability, food security and environmental safety. Knowledge on nutrient removal under intensive cropping systems is important for developing future nutrient management strategies.

Essential plant nutrients

Essential plant nutrients are inorganic or mineral elements which are needed for crop growth and cannot be synthesized by the plant during the normal metabolic processes. There are 19 elements needed for crop growth and classified as macro and micro nutrients depending upon the quantity required. Of these 19, all except carbon, hydrogen, and oxygen are derived from the soil. When the soil cannot supply the level of nutrient required for adequate growth, supplemental fertilizer applications become necessary.

The macro nutrients are again classified as primary {Nitrogen (N), Phosphorus (P) & Potassium (K)} and secondary {Calcium (Ca), Magnesium (Mg) & Sulphur (S)} nutrients depending upon their importance. The micronutrients are equally important but their requirement is comparatively low in quantity and they include Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B), Molybdenum (Mo), Chlorine (Cl), Sodium (Na), Nickel (Ni) and Silicon (Si).

Nitrogen

Functions: Nitrogen conc. in healthy plants varies from 1 - 5 %. It is an essential component of amino acids, proteins, nucleic acids, flavins, enzymes, alkaloids and chlorophyll. N is responsible for the transfer of genetic code to the off-springs as being a constituent of RNA and DNA. N fertilization improves protein quality by enhancing the proportion of different amino acids.

Deficiency symptoms: Plants having < 1.0 % N content are usually deficient in N. Symptoms first appear on older leaves due to its high mobility. Stunted growth, chlorosis of leaves, reduction in flowering, and low protein content associated with N deficiency. Chlorotic tissues later become necrotic resulting in drying and death of the plant. Increased anthocyanin pigmentation of the young leaves especially the leaf veins is a noticeable symptom. Excessive consumption makes succulence of the plant and more susceptible to insect pests and diseases.

Phosphorus

Functions: In healthy plants, P varies from 0.1 to 0.4% by weight. It is a constituent of nucleic acids (RNA & DNA), phospho-proteins, phospholipids, sugar phosphates, enzymes and energy rich adenosine triphosphate (ATP) and Adenosine diphosphate (ADP). Major processes involving ATP are generation of membrane electric potentials, respiration, biosynthesis of cellulose, hemicellulose, pectins, lignins, proteins, lipids, phospholipids and nucleic acids. P is involved in energy transfer, photosysnthesis, transformation of sugars and starch, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next.

Deficiency symptoms: In general, plants having < 0.1% or 1000 mg kg^{-1} P are designated as P-deficient. Due to its faster mobility in plants, P gets easily translocated from older leaves to the meristematic tissues and deficiency symptoms appear first on the older leaves. Under severe P deficiency, plants develop dark yellow or orange coloured lower leaves, which later become necrotic and shed. Premature senescence of older leaves with purple discolouration due to the production of anthocyanin pigments. Young to mature leaves remain dark green at all levels of severity. Symptoms on older leaves are associated with severe stunting. When necrosis is not preceded by yellowing, the symptoms resemble K deficiency.

Potassium

Functions: Potassium concentration in healthy plant tissues varies from 1-5 %. It regulates the opening and closing of stomata, which are essential for photosynthesis. It plays major role in transport of water and nutrients throughout the plant in xylem. It increases root growth and improves drought tolerance. It activates a large number of enzymes (> 60). K is responsible for activation and synthesis of protein forming nitrate reductase enzyme. Reduces lodging of crops and enhances their winter hardiness. It imparts disease resistance to crops.

Deficiency symptoms: Deficiency symptoms develop first on older leaves gradually progressing to the upper leaves. The leaf margins turn yellow towards the midrib and the leaf tip and margins become dry and necrotic. Necrotic leaves are dark in colour and the necrotic areas become dry and brittle. Potassium deficient crops tend to produce small, thin storage roots of poor quality. Symptoms of water stress are indicative of poor K nutrition.

Calcium

Functions: Calcium in plants ranges from 0.2 - 1.0 %. It is a constituent of calcium pectate in the cell wall. It is important for the growth of meristems and functioning of the root tips. Plays a role in mitosis and helps to maintain the chromosome structure. It activates phospholipase, arginine kinase, amylase and adenosine triphosphatase enzymes.

Deficiency symptoms: Plants having < 0.1% Ca considered as deficient. It is immobile in the plant and cannot be readily translocated from older to the new leaves and hence deficiency symptoms appear on younger leaves. Leaves become cup shaped and crinkled, desiccation of terminal buds and weakening of the stem structure. Deficiency of Ca affects the root system. Excess lime in the field may lead to induction of deficiency of Fe, K, Mg, Mn or Cu. Upward cupping or incomplete unrolling or a puckered or corrugated leaf surface. Interveinal tissue is initially necrotic, petiole tends to curve downward, new leaves do not uncurl or expand. Root growth is reduced and necrosis of root tip occurs in severe cases.

Magnesium

Functions: Magnesium concentration in healthy plants varies from 0.1 - 0.4 %. Mg is a constituent of chlorophyll as Mg-porphyrin with one atom of Mg bound to four pyrrole rings. Mg being a constituent of chlorophyll, is indispensable in the reaction of photosynthesis. It is an activator of many enzymes involved in carbohydrate metabolism and synthesis of nucleic acids.

Deficiency symptoms: Deficient plants usually had < 0.1 % Mg. It is a mobile element and deficiency symptoms appear on older leaves. Interveinal chlorosis with marginal necrosis is the characteristic symptom. Chlorosis appears on older leaves accompanied by upward or downward curling of leaf margins or a wilty drooping of leaf lamina. In severe cases of Mg deficiency, root growth will be inhibited and root tips may die back. The interveinal areas dry up towards the tip.

Sulphur

Functions: The conc. of S in healthy plants ranges from 0.1-0.4 %. It is an essential constituent of S containing amino acids, viz., cysteine, cystine and methionine. It is a constituent of ferrodoxin-containing nitrogenase, which takes part in biological N fixation and other electron transfer reactions. It is involved in the metabolic activities of vitamins, biotin, thiamine and coenzyme A.

Deficiency Symptoms: Plants having < 0.1 - 0.2 % sulphur suffer from its deficiency. Deficiency symptoms first appear on younger leaves as it is immobile in the plants. Crops having N : S ratios more than 16:1 also can be suspected to be deficient in S. Pale green to yellow symptoms are similar to N deficient leaves except that they appear on upper leaves, but later extend over the whole plant and leaves remain small. Purple or red brown pigmentation may develop on both young and old leaves.

Iron

Functions: Fe conc. in matured leaf tissue ranged from 100 - 500 mg kg^{-1}. It is a transition metal, exhibits two oxidation states – Fe (II) and Fe (III) in plants and forms complexes with organic ligands. It is a constituent of 2 groups of proteins, a) Heme proteins containing Fe porphyrin complex as cytochrome oxidase, catalase, peroxidase, leghaemoglobin, and b) Fe-S proteins like cysteine, Ferrodoxin. It activates a number of enzymes. It plays an essential role in the nucleic acid metabolism. It is necessary for synthesis and maintenance of chlorophyll in plants.

Deficiency Symptoms: Plants having < 50 mg kg^{-1} of Fe usually considered as deficient. Interveinal chlorosis appears first on younger leaves with leaf margins and veins remain green. Initially yellow interveinal chlorosis develops which is characterized by a sharply contrasting green network of veins. Under severe deficiency, the chlorotic areas turn white, veins may loose their green colour and growth cessation occurs with the whole plant turning necrotic. Necrosis usually spreads from the tip and margins to the interveinal zones.

Manganese

Functions: Healthy mature plants contain 20-300 mg kg^{-1} of Mn. It is an integral component with photosystem II. It is a constituent of superoxide dismutase (present in mitochondria, peroxisomes & glyoxisomes) protects cells against deleterious effect of superoxide free radicals.

Deficiency Symptoms: Mn deficient plants contain < 25 mg kg^{-1} Mn. Deficiency symptoms are more severe on middle leaves than younger ones. Distinct interveinal chlorosis symptoms are usually seen on fully expanded leaves throughout the plant. Chlorosis accompanied by drooping of the leaves, slight puckering of the upper leaf surface or downward curling of the leaf margins. Mn deficient plants produce small thin tubers which have brownish streaks in the flesh.

Zinc

Functions: Zinc sufficient plants contain 27-150 mg kg^{-1} Zn in mature tissues. It is a constituent of enzymes *viz.*, Carbonic anhydrase (localized in cytoplasm and chloroplasts for photosynthetic CO_2 fixation), Alcoholic dehydrogenase (plays imp. role in anaerobic root respiration in waterlogged cond.), Superoxide dismutase (protects lipids and proteins of the membranes against oxidation). Zn plays important role in the stabilization and structural orientation of the membrane proteins.

Deficiency Symptoms: Plants containing < 15 mg kg^{-1} are regarded as deficient in Zn. Interveinal chlorosis first appear on younger leaves, reduction in leaf size, clustered or borne very closely, bronzing, and purple, violet reddish brown coloration of foliage. The leaves are thickened but not distorted. Shortening of inter nodes (rosetting) in dicotyledons. Leaf tips turn necrotic under severe cond. Internodes get shortened. Interveinal chlorosis of young leaves, narrow leaf lamina, brown discolouration of flesh of the tubers.

Copper

Functions: Conc. of Cu in healthy plants varies from 5-30 mg kg^{-1} and its toxicity occurs at 20-100 mg kg^{-1}. Cu is a constituent of various enzymes, *viz.*, Plastocyanin (component of electron system of photosystem II), Diamine oxidase (located in apoplasts of epidermis and xylem for peroxidase activity in lignification), Ascorbic oxidase (Occurring in cell walls & cytoplasm, catalyses the oxidation of ascorbic acid to dehydroascorbic acid), Polyphenol oxidase (involved in lignin biosynthesis), Superoxide dismutase (located in cytoplasm, mitochondria and chloroplasts, involved in detoxification of superoxide radicals generated during photosynthesis).

Deficiency Symptoms: Plants having < 5 mg kg^{-1} Cu are regarded as Cu deficient. Chlorosis, wilting and drooping of mature leaves is the first visible symptom of Cu deficiency. Young leaves turn to yellow and show a stunted and cup shaped appearance. The chlorosis is interveinal with a gradual fading of green colour. Leaf tip become necrotic, leaves are either cupped upwards or curled downwards. Plants die back from stem apices and bushy appearance. Reduced root development causes susceptible to water stress.

Boron

Functions: Boron sufficient plants contain 10 - 200 mg kg^{-1} of B. It is responsible for cell wall formation and stabilization, lignification and xylem differentiation. It imparts drought tolerance. It plays a role in pollen germination and pollen tube growth. It facilitates ion uptake and transport of K in guard cells and stomatal opening.

Deficiency Symptoms: Plants having 5 - 30 mg kg^{-1} are suspected to be B-deficient. The typical deficiency symptom is cessation of growth of terminal bud which becomes short and bunchy in appearance. In acute deficiency, plant growth ceases and the tips start wilting and drying. B deficiency affects growing tissues, both the shoots and roots. Plants become shorter with few roots. Internodes may be shortened, producing a compact habit around the apex. In severe deficiency of B, death of the growing points occurs. There was no tuber formation and only roots are noticed. The tuber skin may be rough and wrinkle towards the ends. The flesh may be mottled or corky in some places.

Management of nutrient deficiencies

The nutrient requirement of the crop mostly depends on soil test values, prevailing agro-climatic conditions of the region, nutrient response efficiency of the cultivar and time and method of application. Integrated use of *Azospirillum* and Arbuscular Mycorrhizal fungi and reduced doses of N and P fertilizers (75% and 50% of the recommended doses, respectively) could maintain soil health and high crop productivity. Deficiency of micro and secondary nutrients is being reported due to intensive cultivation of various agricultural crops and non replenishment of these nutrients showed drastic reduction in crop yields as well as occurrence of various diseases to human beings and therefore, it is essential to apply recommended doses of secondary and micro nutrients besides balanced doses of NPK. Incorporation of lime is customary in acid soils and high rainfall areas for not only to enhance the crop productivity and quality but also to improve the soil fertility. Incorporation of green manure has contributed to significant improvement of soil organic matter as well as retention and availability of essential plant nutrients to the crop and hence application of crop residues and locally available green manure crops is much advantageous to sustain the soil quality. The decomposition of organic manures is accompanied by the release of appreciable quantities of CO_2, which dissolved in water forms carbonic acid, which is capable of decomposition of certain primary minerals and release of appreciable amount of plant nutrients to the soil, which could contribute higher crop yields (Naphade *et al*., 1993). The difference in release of nutrients from the organics is also related to the amount and composition of manure, C/N ratio, lignin content of plants and management practices (Mubarik Ali, 1999). Use of VAM has shown promise in solubilization and transport of immobile micronutrient cations *viz*., Fe, Zn, Cu and Mn besides P and hence, it can be effectively utilized for enhancing crop productivity and to maintain soil health. Fungal inoculation with *Glomus microcarpum* enhanced the root volume and release of organic acids facilitates mineralization of organic P and solubilization of insoluble inorganic P fractions which ultimately contributed higher absorption of P including Fe, Cu, Mn & Zn. These results are in concurrent with the findings of Pushpakumari and Geethakumari (1999).

The measures to be followed for rectifying the secondary and micronutrient deficiencies encountered in sweet potato are presented below:

Nutrient	**Control measures**
1. Calcium	Addition of lime, single and triple super phosphate
2. Magnesium	Incorporation of dolomitic lime or Magnesium oxide in acid soils (Mg @ 20-50 kg ha^{-1}) or Magnesium sulphate (Mg @ 10-40 kg ha^{-1}).
3. Sulphur	Application of S containing fertilizers, gypsum or elemental S or Ammonium sulphate or Single super phosphate
4. Zinc	Soil application of $ZnSO_4$ @ 10 kg ha^{-1} or foliar spray of 1-2% $ZnSO_4$ $7H_2O$.
5. Iron	Foliar spray of chelated Fe or 1-2% Ammonium ferric sulphate solution
6. Manganese	Foliar spray of 0.1% $MnSO_4$ or Chelate or Mn @ 2-4 kg ha^{-1}.
7. Copper	Foliar spray of 0.1% $CuSO_4$.
8. Boron	Soil application of Borax or other borates @ 1.0-2.0 kg ha^{-1} before planting in sandy soils or up to 4.0-5.0 kg ha^{-1} in clayey, alkaline soils.
9. Molybdenum	Application of sodium molybdate or Ammonium molybdate @ 0.2-0.3 kg ha^{-1}, liming the soil to raise the soil pH above 5.5 can also alleviate Mo deficiency.

Nutrient Toxicity Disorders

Boron: Boron toxicity causes conspicuous necrotic lesions in the interveinal areas of older leaves leading to premature senescence and shedding of the leaves. B toxicity also causes root damage with severe stunting and poor survival of the plants. Boron toxicity symptoms resemble salinity induced symptoms. Interveinal chlorosis may develop well in advance of necrotic lesions. Early symptoms of B toxicity resemble Mg deficiency, but the appearance of discrete necrotic spots on older leaves distinguish B toxicity from Mg deficiency. Root tips appear to be curled, laterals are very short, and necrosis of tips and lateral roots.

Aluminium: High concentration of Al affects roots development, height and vigour of plants thereby affecting nutrient and water absorption. Roots appear short and thickened, with short laterals, and may be discoloured to yellow or brown colour. Downward extension of the roots may be restricted, resulting in a very shallow root system and poor root development. Plants show yellow lower leaves with brown or black spots along the veins and these leaves may later fall off. Al in the soil solution inhibits the uptake of Ca & Mg by roots, symptoms of Ca and Mg deficiency may develop. In addition, the solubility of P is reduced in the high concentration of Al, so that P deficiency is often associated with Al toxicity. Tubers become narrow but more tubers produced.

Manganese: Manganese toxicity also causes necrotic spots which appear on the older leaves due to accumulation of Mn in the tissue over a period of time. Mn toxicity also causes chlorosis, most severe on the younger leaves due to an induced Fe deficiency. Mn toxicity causes chlorosis on younger leaves due to an induced Fe deficiency. Unlike B toxicity or salinity these spots do not usually form a regular alignment but remain scattered within the interveinal tissue. In severe cases, root growth is severely inhibited. It can be corrected by improving soil drainage and lime application.

Zinc: Zinc toxicity in sweet potato causes severe growth reduction, even prevent the establishment of transplanted vine cuttings. Dark pigmented spots or blotches appear on older leaves, or red pigmentation was observed throughout the vine in severe cases of Zn toxicity. Severe damage to the roots at high Zn concentration in soil can cause general chlorosis and wilting. High levels of Zn inhibit the uptake of Fe, causes severe Fe deficiency.

Conclusions

There is a wide gap between the actual and potential yields of tropical tuber crops at national and state level. In most of the integrated farming systems, tuber crops are being grown as a sole crop or inter crop or relay crop or mixed crop and managed with low inputs of fertilizers and non adoption of improved technologies resulting very low crop yields. Due to lack of awareness in diagnosing the nutrient deficiency/ toxicity syndromes and diseases caused by plant pathogens and insects, the farming community is not advocating proper remedial measures for their control and to produce sustainable crop yields. Adoption of site specific nutrient management practices and nutrient recommendations based on soil test values plays very vital role to boost up the production of tuber crops. Sustainable crop production, including environmental safety and economic feasibility depends on sound nutrient management programmes. This involves both nutrient conservation and judicious application of fertilizers and organic manures, which ensures high yield and good quality. Enrichment of soil with macro and micronutrients assumes special relevance as it only enhances crop productivity but also increases the mineral content in plant foods which may ultimately contribute to nutritional quality of plant produce, thereby improving human nutrition and health.

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Mushroom Production: A Viable Enterprise for Farm Integration

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Agriculture continues to be the main strength of Indian economy. With the variety of agricultural crops grown today, the country has achieved food security by producing about 260 million tonnes of food grains. However, the struggle to achieve nutritional security is still on. In future, the ever increasing population, depleting agricultural land, climate changes, water shortage and need for quality food products at competitive rates are going to be the vital issues. It is imperative to diversify the agricultural activities in areas like horticulture to meet these challenges and to provide food and nutritional security to our people. Mushrooms are one such component that not only uses vertical space but also help in addressing the issues of quality food, health and environmental sustainability. There is need to promote both mushroom production as well as consumption for meeting the changing needs of food items. Fortunately, mushroom trade has gained importance in recent years possibly for the global shift towards vegetarian food and recognition of mushroom as a functional food. Mushroom cultivation offers an added advantage to recycle agro-waste as carbon pool into good quality protein, much of which otherwise is wasted in the field. This hi-tech horticulture venture has a promising scope to meet the food shortages without undue pressure on land.

Mushroom : The overall scenario

Mushroom farming today is being practiced in more than 100 countries and the production is increasing at an annual rate of 6-7 per cent. Present world production of mushrooms is around 3.5 million tonnes as per FAO statistics. China alone is reported to grow more than 20 different types of mushroom at commercial scale and mushroom cultivation has become China's sixth largest industry. In India, mushroom production shot-up from mere 5000 tonnes in 1990 to over 1,20,000 tonnes in 2013. Today commercially grown species are button and oyster mushrooms, followed by other tropical mushrooms like paddy straw mushroom, milky mushroom, etc. However, the production of white button mushroom is about 70 per cent of the total production of mushrooms in the country.

The research on edible mushroom in Odisha made its humble beginning in the Department of Plant Pathology, College of Agriculture, OUAT, Bhubaneswar in 1972 with a view to generate profitable and sustainable production technology. Having achieved success in developing mushroom cultivation and spawn production technology, research efforts were further strengthened and transfer of technology was initiated with the establishment of 'Centre of Tropical Mushroom Research and Training' in the University with the financial support of Government of Odisha in 1991-92. This research organization paved the way for initiation of commercial mushroom cultivation in the state within two years of its establishment.

In depth study on production of spawn and mushroom cultivation particularly paddy straw mushroom, oyster mushroom, milky mushroom and button mushroom were undertaken. Farmers training programmes and demonstrations on spawn production and mushroom cultivation were then extended to all over the state. Technical assistance was provided for development of individual/group/private sectors in establishing spawn production units and mushroom production centres.

The overall activities of the centre further gained momentum with the establishment of All India Coordinated Research Project on Mushroom in the University during 2009-10 with the financial assistance from Indian Council of Agricultural Research, New Delhi. At present, the total mushroom production of the state has reached an all time high of 12,622 tonnes/annum contributing to over 10 per cent of the country's production.

Paddy straw mushroom (*Volvariella volvacea*), commonly known as the straw mushroom or the Chinese mushroom is considered as one of the easiest mushrooms to cultivate. It is the 6th largest mushroom of the world in terms of production. The flavor is excellent and the cropping cycle is short (21 days). However, this variety has low biological efficiency (15 per cent) and poor keeping quality (12 hours). The production of straw mushroom is very popular in Odisha. Odisha is the only state where straw mushroom is grown commercially for 10 months a year (February-November) involving poor farmers. The cultivation has spread rampantly as a cottage industry involving spawn production in low cost units in villages and outdoor cultivation under the plantations. The rice farmers of the coastal agro-ecological situation in particular have demonstrated a practical way to transform the lingo-cellulosic wastes directly into a highly acceptable, nutritious and delicious food for the people. Odisha produces 8,417 tonnes of straw mushroom per annum contributing to 66 per cent of the total mushroom production of the state.

Oyster mushroom (*Pleurotus* spp.) has species suitable for both temperate and sub-tropical regions. It is the 3rd largest cultivated mushroom of the world. The production figure for the country is 15,000 tonnes/annum. In Odisha, cultivation is restricted to winter months (November-February) and the production stands at 4095 tonnes/annum contributing to 33 per cent of total mushroom production of the state. *Pleurotus sajor-caju, P. florida* and *Hypsizygous ulmarius* are the ruling species of the state. However, for small scale semi-urban and urban units, *P. eous* (pink mushroom) is gaining popularity owing to its attractive colour along with good taste and flavour. The biological efficiency is very high (100 per cent) and the shelf life is better (24 hours) than straw mushroom. Production cost is low with little longer cropping cycle (45 days). Further, it is suitable for post-harvest processing. However, the consumer demand is limited in the state.

Milky mushroom (*Calocybe indica*) is indigenous tropical mushroom of the country. However, the commercial cultivation is restricted to south Indian states only. The mushroom is attractive white with excellent keeping quality (3-4 days). Its biological efficiency is also very high (about 100 per cent). The mushroom is not being grown commercially in Odisha probably because the cropping time for both straw and milky mushrooms is same.

The button mushroom (*Agaricus bisporus*) is most popular variety of the country. At global level it ranks first in terms of production. Punjab is the leading state contributing to 60 per cent of the total production of the country. Being a temperate mushroom, production can be taken up year round in controlled environment or seasonally during winter months. Odisha has just started the commercial production with 110 tonnes/annum at present and it is likely to grow further in future.

Mushroom cultivation is a profitable enterprise. The cost for raising one bed of straw mushroom of 1.5′ x 1.5′ x 1.5′ size comes to Rs.50/- with a production of one kilogram mushroom within a crop cycle of 21 days. The net return is Rs.50/- per bed assuming the market rate at Rs.100/- per kilogram. Likewise, the cost for raising one bag of oyster mushroom is Rs.30/- with a production of 1.5 kilogram mushroom within a crop cycle of 45 days. The net return is Rs.30/- per bag assuming the market rate at Rs.40/- per kilogram. A model small mushroom production unit (300 sq.ft.) with the investment of Rs.25,000/- accommodating 120 beds of paddy straw mushroom per month during summer and rainy season and 225 bags of oyster mushroom per 1.5 month during winter season, gives an estimated net income of Rs.6,000/- per month.

Mushroom cultivation under protected condition: The need of the day

It is imperative to say that mushrooms cannot be grown year after year with full commercial access, unless proper growing conditions are provided and adequate facilities are available for the control of diseases and insect pests. Possibly, such conditions can be fulfilled in shelf growing, by the construction of properly insulated and ventilated mushroom houses accommodating store room, spawn running room, cropping room as well as packing and preservation room.

In Odisha, raising of simplified and low cost thatched mushroom houses are being encouraged for round the year cultivation of mushrooms with greater precision. The houses are appropriately designed to maintain required temperature and humidity inside, besides having access to ventilation. The vertical space in the mushroom house can be utilized effectively by raising three-tiered structures (shelves), mandatory for indoor cultivation. Experiments have shown that these low cost houses perform better than outdoor cultivation in terms of productivity. A small low cost house of dimension, 25′ x 12′ can well accommodate 180 beds of paddy straw mushroom or 125 bags of oyster mushroom in a three-tired structure within a crop period of two months. Such a house can be a livelihood option for a small farmer with a monthly net income of Rs.6,000/-. Various modifications of the thatched houses are being designed now-a-days in order to make it more permanent and mushroom friendly. Shade net houses and houses having asbestos roof are therefore, viable alternatives to the thatched sheds. In view of the higher sale price of the produce, off season or winter cultivation of straw mushroom is gaining popularity in the state. Hence, poly house cultivation is being popularized during winter season wherever growers are interested.

Value addition: An inevitable segment

Mushrooms being highly perishable because of their high moisture content and delicate texture, the produce remains acceptable for few hours only at the high ambient temperature of the tropics and sub-tropics. Thus, understanding of post-harvest handling practices plays a significant role in enhancing the availability of quality mushrooms either in fresh or processed form to the consumers and at the same time ensuring remunerative prices to the producers, low cost preservation methods like drying needs to be popularized among the growers to minimize post-harvest losses of mushrooms. Further, development and introduction of new products with wider acceptability and comparatively at low price will increase the demand and consumption of mushroom products. This will in a big way sustain the increasing trend of mushroom production in the country in the years to come.

The road ahead

Odisha leads the country in terms of production of straw and oyster mushrooms. Indoor cultivation of button mushroom has been initiated successfully in the recent past and it is expected to grow further. Moreover, the cultivation method of the low temperature tolerant variety of straw mushroom (*Volvariella bombycina*) for winter season it being worked out in the research centre. Possible introduction of the shiitake mushroom (*Lentinus edodes*) in the state is being explored. Cultivation of straw mushroom in controlled environment with higher biological efficiency (30-45 per cent) has already been initiated in the state with profound success. Preservation of straw mushroom through canning has been done successfully in Odisha for the first time in the country. The state is having the highest number (210) of spawn production units in the country. In spite of the phenomenal growth rate of the mushroom industry in the state, constraints do exist, that need addressal for the benefit of growers.

Mushroom crop needs to be recognized as a horticultural crop in the state. An appropriate mechanism should be developed for effective monitoring of the spawn production units for ensuring spawn quality, as production gets deteriorated owing to use of spawn bottles having inferior quality. Like other horticultural commodities, mushroom marketing ought to be streamlined in order to avoid distress sale. Above all, establishment of processing units with FPO license requires to be encouraged in order to facilitate the export potential of mushroom products.

The Centre of Tropical Mushroom Research and Training along with All India Coordinated Research Project on Mushroom are making concerted efforts in pushing Odisha ahead of other states in mushroom production. This would probably be the appropriate way to search for alternative nutritional sources for our huge population and help achieve non-green revolution.

Mushrooms are truly health foods and promising neutraceuticals. Odisha has tremendous potential for mushroom production owing to the availability of agricultural wastes in abundance, manpower and suitable climate. Further, there is increasing demand for quality products in domestic and export market. Mushroom being a women friendly crop, could be facilitated well with a strong Mission Shakti existing in the state. To be successful in both domestic and export market, it is essential to produce quality fresh mushrooms and processed products devoid of pesticide residues at competitive rates. It is also important to commercially utilize the spent mushroom substrate left after cultivation for making manure or vermin-compost for additional income and total recycling of agro-wastes. It is worthwhile to mention here that few of our entrepreneurs have got recognition at the national and international levels owing to their excellent endeavor in mushroom production. With the untiring efforts of all concerned, possibly Odisha mushroom industry will see a new dawn in the near future.

Integrated Farming System Models for Optimizing Water Productivity

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The International Organisation of Biological Control (IOBC) describes Integrated Farming as a farming system where high quality food, feed, fibre and renewable energy are produced by using resources such as soil, water, air and nature as well as regulating factors to farm sustainably and with as little polluting inputs as possible.The integrated farming system approach introduces a change in the farming techniques for maximum production in the cropping pattern and takes care of optimal utilization of resources. The farm wastes are better recycled for productive purposes in the integrated system. A judicious mix of agricultural enterprises like dairy, poultry, piggery, fishery, sericulture etc. suited to the given agro-climatic conditions and socio-economic status of the farmers would bring prosperity in the farming.

Components of Integrated Farming System

- Crops, livestock, birds and trees are the major components of any IFS.
- Crop may have subsystem like monocrop, mixed/intercrop, multi-tier crops of cereals, legumes (pulses), oilseeds, forage etc.
- Livestock components may be milch cow, goat, sheep, poultry, bees.
- Tree components may include timer, fuel, fodder and fruit trees.

What is water productivity?

It is the physical mass of production or the economic value of production measured against gross inflows, net inflow, depleted water, process depleted water, or available water.

WP= Agricultural benefit/ water use

It is normal to represent WP in units of kg/m^3. If production is measured in kg/ha, water use is estimated as mm of water applied or received as rainfall, convertible simply to m^3/ha (1mm = 10m^3/ha). Alternative notations include food (kcal/m^3) or monetary value (Rupees/m^3).

Crop water productivity is defined in either physical or monetary terms as the ratio of the product (usually measured in kg) over the amount of water depleted (usually limited to crop evapotranspiration, measured in m^3).

In case of **irrigation water productivity** the denominator refers to irrigation water only, not to rainfall. Obviously, values of irrigation-water productivity cannot be compared with water productivity with depleted water in the denominator.

Economic productivity is the gross or net present value of the product divided by the value of the water diverted or depleted, which can be defined in terms of its opportunity cost in the highest alternative use.

In an agro-ecosystem context, **fisheries water productivity (FWP)** may be defined as the ratio of beneficial fisheries goods and services produced in an agricultural system to the amount of water depleted in producing them.

We define **livestock-water productivity** (LWP) as the amount of water depleted to produce livestock and livestock products and services, including farm power or as the ratio of beneficial livestock goods and services generated in an agricultural system to the amount of water depleted in producing them.

Basin water productivity takes into consideration beneficial depletion for multiple uses of water, including not only crop production but also uses by the non-agricultural sector, including the environment.

Water productivity definition is scale-dependent. For a farmer, it means getting more crop per drop of irrigation water. But, for society as a whole, concerned with a basin or country's water resource, this means getting more value per unit of water resource used. Increasing water productivity is then the business of several actors working in harmony at plant, field, irrigation-system and river-basin levels.

Why integrated farming system for optimizing water productivity?

The agriculture is of fundamental importance in India's economy contributes about 20-21% of gross domestic product (GDP) and generates two third of employment. Total food grain production, which was only about 51 million tons at the time of 1st five year plan, has gone up to 213.45 million tons in 2003-04. But in spite of all these impressive achievements, net sown area in the country remained at about 141.1 M ha and per capita availability of land is decreasing. Water sustains life and is primarily used for growing crops, household uses, as input to industries, power generation, recreations and for sustaining earth's ecosystems. Presently, this essential natural resource is under threat as evident from the following facts. India covers 2.42% of the total land area of the world and supports 16.8% population of world with only 4.2% of water resources. Though India gets about 400 M ha m of water due to an average annual rainfall of 1194 mm, but it varies from 150 mm at Jaisalmer to 11690 mm at Mawsynram near Cherrapunji. About 60% of the area is rainfed and we are also unable to store desirable quantity of water in uplands of the country for agricultural use. Also per capita water availability is continuously declining from 5176 m^3 in 1951 to 2209 m^3 in 1991, 1820 m^3 in 2001 and 1703.6 m^3 in 2005. In order to meet the challenge of feeding ever increasing population of our country, there is an urgent need to produce more food from less water. This could be only possible by enhancing the water productivity through integrated farming systems.

In recent years, country is frequently experiencing natural calamities like floods, droughts, cyclone, etc. In India, by the year 2025, high rate of population growth is likely to result in about 1333 millions people while the low growth projections place the number at nearly 1286 millions. The projected food grain demand for 2025 would be 320 M tones (high demand scenario) and 308 M tones (low demand scenario). The quantum of water used for irrigation by the last century was of the order of 31.8 M ha of surface water and 20.6 M ha of groundwater, total 52.4 M ha. The estimates indicate that by the year 2025, the water requirement for irrigation (both surface and groundwater) would be 56.1 M ha for low demand scenario and 61.1 M ha for high demand scenario. A reduction in share of water for agriculture from present level of 83% to 72% by 2025 is expected due to competing demand of water for industries, municipalities and environmental needs. A large coastal tract of India has either saline water ingress or at many places a thin layer of fresh water floats over saline water. Also poor and degraded quality waters pose a challenge for effective utilization in non-consumptive domestic and production system through IFS technology. In order to meet the challenge of feeding ever increasing population of our country, there is an urgent need to produce more food from less water. This could be only possible by enhancing the water productivity through IFS.

Principles for improving water productivity

The key principles for improving water productivity are:

(i) to increase the marketable yield of the crop per each unit of water transpired;

(ii) to reduce all out flows (e.g.: drainage, seepage and percolation, including evaporation outflows, other than the crop stomatal transpiration), and

(iii) to increase the effective use of rainfall, stored water and water of marginal quality.

The three principles apply at all scales, from plant to field and agro-ecological levels. However, option and practices associated with these principles require approaches and technologies at different spatial scales.

IFS for enhancing water productivity

Integrated farming system for waterlogged area management

A study was conducted for development of pond based integrated farming system for management of waterlogged area in Khurda district. There was a patch of 3 ha area under severe waterlogging. Continuous waterlogging has converted that land to wasteland. No crop was possible to be grown in those fields and it was remaining fallow in almost all years. The soil pH observed ranged from 3.5 to 6.5; soil texture is sandy clay loam; soil organic carbon was low (< 0.5%); soil available nitrogen was low (< 280 kg ha^{-1}); soil available potassium was medium (50-170 mg/kg of soil); soil available phosphorous was medium (5-10 mg/kg of soil); iron toxicity was present. Depth of groundwater table was ranging from 20-40 cm as minimum and 50-150 cm as maximum from ground surface during December to June. During monsoon it is above ground surface. The yield of shallow aquifer is low. The land was unsuitable for ploughing except during the months of May and early June, and was left fallow in almost all years.

For determining the design and dimensions of the ponds, collection and analysis of climatic data (rainfall, pan evaporation etc.) for the period 1975-2003 for Bhubaneswar was done. The climatic parameter analysis and water balance study resulted the design dimensions of the experimental ponds which were 27 m x 27 m, 30 m x 30 m, and 34 m x 34 m at the top with 2 m depth and side slope 1:1 in experimental plot 1, 2 and 3 respectively. The excavated soils were spread around the pond to elevate the surrounding area so as to keep the water table below 2 m from ground surface. Hume pipes of 30 cm diameter and 4 m length were used as inlet and emergency outlet of the pond. Since the objective of the study was to store excess water for reclamation of waterlogged area, the area of the ponds are kept within 20 to 25% of the total area considering the water balance component of the study area.

Design and construction of three micro water resources covering water surface area of 625 (P_1), 785 (P_2) and 1025m^2 (P_3) was completed by March 2006. Treatment implementation and stocking of fish fingerling (*Magur*, 12.2g MBW) was done as the first crop. Population density was maintained at 1200, 2100 and 1700 for P_1, P_2 and P_3 respectively. The recorded mean minimum and maximum values of various water quality parameters were: water temperature 27.9 - 32.3 ^{0}C; water pH 6.7 - 8.7; dissolved oxygen 3.6 - 9.1 ppm; total alkalinity 78 - 127 ppm; dissolved organic matter 1.4 - 6.4 ppm; nitrite –N 0.006 - 0.077 ppm; nitrate-N

0.06 - 0.57 ppm; ammonia 0.01 - 0.34 ppm; transparency 39$\pm$3 – 52$\pm$4; total suspended solid 169 - 367 ppm and total plankton count 14.9x 10^3 to 19.8 x 10^4nos/liter. Average primary production in the first month of rearing ranged between 121.4-149 mg C m^{-3} h^{-1}, which improved further (533$\pm$41.3 mg C m^{-3} h^{-1}) with the advancement of rearing period. TSS and DO concentration showed a decreasing trend with the advancement of rearing period while, gradual increase in nitrite, nitrate, ammonia were attributed by intermittent fertilization, increased level of metabolites and decomposition of unutilized feed. At any given point of time, other water quality parameters did not register any specific trend. In this experiment, average growth performance of *Magur*was highest inpond-1 (P_1)(163.5g) followed by pond-3, (P_3) (141.0g) and pond-2 (P_2)(130.5g). In this experiment, reductions in growth did not appear to be due to poor water quality, as water quality did not differ significantly among various treatments, may be due to behavioral interaction or physiological response to density itself. Relatively moderate survival rate (61-64.75%) was mainly due to cannibalism at the initial stage of rearing. In this, crop yield of fish ranged between 1632-1710kg/ha/ 200days, survival rate (SR%- 61-64.75), feed conversion ratio (FCR)- 1.39-1.47, per day increment (PDI) was 0.595-0.623 g/day.

Indian major carps (IMC) were taken as subsequent crops in coming years and were released during 4th week of August. All growth parameters were undertaken regularly. The catla has recorded a maximum growth in comparison to rohu and mrigal. As age of the pond increased the quality of water improved as the sides of the bunds have been stabilized, hence IMC was undertaken in place of magur to reduce the input cost and preference in market.

Under on-dyke horticulture activities, there were 114 papaya, 89 banana, and 16 coconut plants around 1st pond, 69 banana, 9 papaya and 4 coconut plants around 2nd pond and 70 banana plants were planted around the 3rd pond (Plate 1). Besides another 90 banana plants were planted in adjacent area. The different varieties of tissue culture banana planted are *G-9, Bantal, and Robosta*. Papaya variety was *"farm selection"*.

In the first year under on-dyke horticulture activities vegetable such as bottle gourd in 386 m^2 area (7.8 t/ha), tomato in 252 m^2 area (2 t/ha) and brinjal on 66 m^2 (1.52 t/ha) were taken up. Different varieties of paddy such as *Khandagiri, Swarna, CR-1009 and Surendra* were grown in four different plots showed average yield of 2.72 t/ha.

In subsequent years on an average 220 bunches of banana were harvested. Different varieties of paddy such as *Khandagiri, Swarna, CR-1009 and Surendra* were grown in four different plots. During *kharif* the yield of Khandagiri was 2.1 t/ha, Surendra gave 3.2 t/ha and Swarna showed average yield of 2.7 t/ha. During *rabi*Khandagiri paddy gave a yield of 2.3 t/ha. Different vegetable were taken as on-dyke horticultural activities as well as intercrops such as brinjal (6.25 t/ha), cowpea (1.5 t/ha), Bean (2 t/ha), ladies finger (4.9 t/ha) and 200 kg of bottle gourd was also obtained.

Integrated farming system with aquaculture in the pond such rearing magur in the first year followed by Indian major carps in subsequent years is highly profitable and helps in improving the livelihood options of poor farmers. On-dyke horticulture such as banana, papaya and other vegetables as intercrop is possible in the system and helps in crop diversification and rural livelihood option.

Plate 1. Integrated farming system in a waterlogged area

Integrated farming system in Mahanadi delta

Where nothing is feasible i.e. drainage measures/alternate waterlogged resistant paddy crop, etc., there pond drainage with integrated farming system is recommended. The entire waterlogged area is converted into an integrated resource management unit where fishery, duck rearing, poultry or birds go together with horticulture, forest and other economic crops in bunds and vegetables in between.

One such unit was developed in Khentalo village of Barmania Pat (waterlogged area) where water logging was up to 2 m depth. Out of 2.47 ha waterlogged area of the farmer, 1.64 ha was converted into grow-out pond for fish and prawn culture while vegetable, flower and fruits were grown on 0.83 ha of raised embankment all around the pond since 1989. Poultry sheds were also constructed for rearing 4000 birds in such a way that their droppings could fall into pond as organic manure and feed for fish. The average productivity of low land high yielding paddy was 3.5 t ha^{-1} as compared to 9.4 t ha^{-1} per annum fish equivalent (fish + prawn). Gross and net returns from fish and prawn culture alone during 2002 were Rs. 6,17,160 (Rs. 3,76,317 per ha) and Rs. 3,31,065 (Rs. 2,01,868 per ha) respectively. This accounted to Rs. 14.00 per m^3 of water productivity in the pond system alone. Whereas the gross and net returns from the whole system of 2.47 ha during the year 2002 were Rs. 6,51,110 (Rs. 2,63,607 per ha) and Rs. 3,62,515 (Rs. 1,46, 767 per ha) respectively. The farmer initially invested Rs. 1,23,910 in 1988 towards construction of the pond plus infrastructure and earned a net return of Rs. 40,554 per ha of whole system in 1989, which gradually increased up to Rs. 1,32,894 per ha in 1997. He again invested Rs. 1,30,000 towards stone pitching in 1998 and Rs. 3,20,000 towards poultry shed and the net return (after adjusting investment) was Rs. 2,17,600 (Rs. 88,097 per ha) during 1998 and a net loss of Rs. 1,16,900 during super cyclone year in 1999. The net returns per ha again increased steadily after cyclone from Rs. 27,465 in 2000 to Rs. 1,37,894 in 2001 reaching up to Rs. 1,46,767 (35 times higher of the paddy cropping) in 2002.

Adjacent to the developed integrated farming system, the farmer is cultivating 2.4 ha waterlogged paddy field giving net return of Rs. 4,166 per ha only (2.8% of the integrated farming system). IIWM has designed a deep water high density rice-fish integrated system of 1.2 ha out of the 2.4 ha waterlogged paddy field system and it is estimated that it will give net return of Rs. 1.5 to 1.6 lakh per ha per year. Revival of poultry component and addition of milch cattle in the system is going to make it more profitable and more sustainable utilizing surface and ground water of the waterlogged area. This is going to be a replicable integrated farming model for the coastal Orissa. It may also be replicated in irrigated alluvial land of other regions.

IFS in cyclone affected coastal Odisha

IFS around sub surface water harvesting structure was implemented in participatory basis for 22 locations in coastal waterlogged ecosystem devastated by 1999 super cyclone where saline aquifer exists beyond 3-7 m below ground level, and fresh water aquifer floats over it. This fresh water was harvested by constructing sub surface water harvesting structures up to a depth of 3 m and the stored water was utilized for aquaculture and irrigation of the crops grown on the bund and in surrounding area. Introduction of integrated farming system approach (aquaculture, water chest nut, on dyke horticulture and vegetables in the pond command area) in those structures resulted in gross water productivity of Rs. 12.93 to Rs. 47.20 per m^3 of water used. The impact of this technology resulted in construction of 135 such new structures (SSWHS) by farmers in the coastal tract of Erasama. Consequently, significant increase in crop production (3-4 fold), water productivity (Rs. 12.93-Rs. 47.20 per m^3) and cropping intensity (103-230%) has led to the socio-economic upliftment of the resource-poor farmers with diversified livelihood options. The findings can be replicable in different waterlogged eco-systems of India.

Integrated farming system in deep water condition

In a farmer's field at Khentalo of Cuttack district, 2 ha waterlogged area was converted into two units of deep water rice-fish system with another 1 ha land exclusively for deep-water rice. Periodic observation of water quality, soil quality, fish and prawn growth parameters, yield and yield components, hydrological and water balance related studies were carried out at regular intervals at the experimental site. In the first year the water level went up to as high as 65 cm above ground surface in 34th standard week and remained above the surface during 25th to 48th week. During driest period the water table went down to 167 cm below ground level. This was a precarious water logging condition prohibiting growing of any other crop than paddy with very low return. Under this scenario, construction of refuge that acts as a drainage system and helps in lowering the water table was adopted for rice-fish culture in reclaiming waterlogged degraded area. Comparison of weekly rainfall and evaporation revealed that the rainfall is higher than the evaporation during 24th to 43rd week causing water congestion. Hence excess water was stored in the rice-fish culture field for aquaculture and for irrigating rabi crop. During 3rd year of the study the water level went up to as high as 32 cm above ground surface in the 1st week of October. There was no visible difference in water table from mid-October till

December. However during summer, water table went as deep as 3.3 m below ground level indicating lowering of water table.

The yield of deep water paddy was 2.97 and 2.42 t/ha in rice-fish system and control respectively. Average post paddy second crop (black gram) yield was 0.75 t/ha, yield from on-dyke horticulture was 463 and 495 kg for brinjal and ladies finger respectively. Net water productivity for only deep water rice was Rs. 0.46/m^3 where as it was Rs. 7.46/m^3 for only fish & prawn culture.

Conclusions/ Recommendations

Integrated farming system with aquaculture in the pond such as rearing magur in the first year followed by Indian major carps in subsequent years was highly profitable and helps in improving the livelihood options of poor farmers. On-dyke horticulture such as banana, papaya and other vegetables as intercrop was possible in the system and helps in crop diversification and rural livelihood option. IFS around sub surface water harvesting structure are very advantageous and profitable in cyclone affected areas of coastal area.Deep water rice-fish system in deep waterlogged area is very much profitable.

The different advantages of Integrated Farming System are

- Higher food production to equate the demand of the exploding population of our nation
- Increased farm income through proper residue recycling and allied components
- Sustainable soil fertility and productivity through organic waste recycling
- Integration of allied activities will result in the availability of nutritious food enriched with protein, carbohydrate, fat, minerals and vitamins
- Integrated farming will help in environmental protection through effective recycling of waste from animal activities like piggery, poultry and pigeon rearing
- Reduced production cost of components through input recycling from the byproducts of allied enterprises
- Regular stable income through the products like egg, milk, mushroom, vegetables, honey and silkworm cocoons from the linked activities in integrated farming
- Inclusion of biogas & agro forestry in integrated farming system will solve the prognosticated energy crisis
- Cultivation of fodder crops as intercropping and as border cropping will result in the availability of adequate nutritious fodder for animal components like milch cow, goat / sheep, pig and rabbit
- Firewood and construction wood requirements could be met from the agroforestry system without affecting the natural forest
- Avoidance of soil loss through erosion by agro-forestry and proper cultivation of each part of land by integrated farming
- Generation of regular employment for the farm family members of small and marginal farmers.

Integrated Pest Management and Natural Resource Conservation Practices

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Uses of capital intensive technologies are least beneficial for the poor, including women and children. Recent research in India shows that small scale and marginal farmers take loans from private finance corporations to purchase inputs and then, unable to pay their debts, become answerable to moneylenders, moreover marginal farmers have a 10 times greater risk of severe pesticide poisoning then large scale farmers.Women in small and medium scale farming suffer the worst health problems from pesticide use because they spray the fields themselves, usually without safety precautions.The rapid physiological changes experienced by women during pregnancy, lactation, and menopause render them more vulnerable to toxins. Exposure to pesticides can cause miscarriage, pre mature birth, birth defects, and low birth weight. A substantial portion (up to 33 percent) of a woman's chemical burden can be passed on to an unborn child during gestation and to a baby through breastfeeding. Use of such pesticides is prohibited or severely restricted in OECD (Organization of Economic Cooperation and Development) countries, and in line with the International Code of Conduct.

Women are the major decision-makers in ensuring nutrition to the next generation as they provide primary nutrition to the young children. A study conducted by FAO, WHO, and UNEP broadly estimates that between 1 million to 5 million cases of pesticide poisoning occur each year, resulting in several thousands fatalities. Pesticide fatalities are overwhelmingly a developing country phenomenon. About 1/3 of the pesticide poisoning cases in world are reported from India only. Some of the vegetables like ladies finger, cauliflower, pointed gourd and brinjal are dipped directly in the pesticide solution to improve their appearance.Although developing countries use just 25 percent of all pesticides produced, 99 percent of deaths from pesticide poisoning occur in developing counties. Children and women are specially at risk. So, there is an urgent need to empower women in Gender friendly plant protection practices for quality food production.

Pesticide fatalities are overwhelmingly a developing country phenomenon. Although developing countries use just 25 percent of all pesticides produced, 99 percent of deaths from pesticide poisoning occur in developing counties. Many farmers in developing countries overuse pesticides and do not take proper safety precautions because they do not understand the risks and fear smaller harvests. Making matters worse because pesticides banned or restricted in industrialized countries are used widely in developing countries. Farmers' perceptions of appropriate pesticide use vary by setting and culture. Additional negative environmental effects and socioeconomic costs include the debt incurred by farmers to purchase these inputs, the loss of local knowledge and practices once used to protect crops, and dependence on external sources of inputs. As with so many capital intensive technologies, the poor, including women and children, are the ones least able to benefit from their use. Recent research in India, for example, shows that small scale and marginal farmers take loans from private finance corporations to purchase inputs and then, unable to pay their debts, become answerable to moneylenders (Mancini and others 2005). The same study also found marginal farmers to have a 10 times greater risk of severe pesticide poisoning then large scale farmers.

People have started realizing the present state of continuous ill health is due to the increasing quantity of poison accumulating in their bones and tissues. Mrs Sunita Narain, Director, Centre for science and environment, reported traces of 6 to 13 pesticides mainly monocrotophos, chlorpyriphos and cocktail of phosphamidon and malathion in blood samples of Punjab farmers (June, 2005), which causes infertility and cancer. Certain organo-chlorine pesticides in blood samples from Punjab were found to be 15 to 60 times higher than those of US population. We are living in an age, where neither the water we drink nor the food we eat can be guaranteed free from pollution. The whole food chain is contaminated. However, the increasing consciousness of safe, healthy and quality food is increasing not alone at global front but India too. While performing different plant protection operations at household level specially for storage of food items, storage of pesticides brought for field crops, pest management of kitchen garden in homestead lands, reuse of pesticide containers, preparation of spray solution for spraying without personnel protective equipments (PPE) and weeding in field crops sprayed with pesticides; farm women get exposed to a variety of chemical pesticides and suffer with various adverse health effects due to lack of information and technological empowerment.

At present a big questions how to achieve the quality food with out environment disturbance. This is just possible. The ways to do are:

a) Judicious use of pesticide.
b) Development of safer, effective, target oriented molecules.
c) Use of IPM (Integrated Pest management) and IRM (Insecticide Resistance Management)
d) Stricter control on spurious pesticide use
e) Precision pesticide application, Enhanced use of seed treatment and newer pesticide application techniques.
f) Pesticides monitoring mechanisms for Phyto Sanitary issues.
g) Enhanced use of ICT and forecasting and forewarning.

Pesticides and toxic waste alter DNA

A two year study commissioned by the Punjab pollution control board (PPCB) in November, 2007 and conducted by Chandigarh, s postgraduate institute of medical education and research (PGIMER) in 25 Punjab villages located near 5 open drains in Jalandhar, Ludhiana and Amritsar districts, has some of the following alarming situation:

1. Significantly high rate of miscarriages among women and slow growth in children.
2. Pesticides have also been detected in vegetables, blood as well as human and cattle milk samples.
3. Evidence of genotoxicity in some cases.
4. DNA mutations in 65 percent of the blood samples.

5. Drinking water has turned toxic due to high concentration of heavy metals such as mercury, copper, cadmium, chromium, and lead. These chemicals have seeped in to the village's groundwater from the polluted drain water. Evidence of these metals entering the food chain.
6. Gastrointestinal, skin, eye, dental and bone problems significantly higher in these areas compared with villages not in proximity of drains.
7. Early symptoms of neurotoxicity.
8. Children complain of rashes and boils.
9. Old men insist their hands and fingers are turning numb.

In the Andean regions of Bolivia, Colombia and Peru, women develop and maintain the seed banks on which food production depends. In Philippines women are affected by the misuse and mishandling of pesticide containers. This, of course, also affects their children's health. Thus women friendly IPM technologies to increase safety with reduced drudgery are the need of hour at country level as well as at global level. Integrated pest management technologies with the use of multiple approaches to control pests, is becoming widespread and has been used with success in countries such as Indonesia, China, Bangladesh, United States, Australia, India and Mexico.

The word *integrated* is derived from the Latin word "*integrare*" which means to make whole, to complete by addition of parts or to combine parts into whole. The following major components may be included for integrated pest management .

1. Ecology based Pest Management

Various eco-friendly tactics of pest management have to be integrated to avoid the use of chemical pesticides. The knowledge of interaction among plant, pest, natural enemies and environment is essential for effective pest management. When man disturbs balance of nature, nature strikes back in the form of pest outbreaks. Some examples of pest outbreaks are as follows:

- White flies in cotton
- *Helicoverpa armigera* in cotton
- Slug caterpillar in coconut
- Eriophyid mite on coconut

Moreover, the pest status changes over the years due to interaction of various biotic and abiotic factors. One has to thoroughly understand the reasons for outbreak of pests and their changing status and plan the management practices accordingly so as to prevent further outbreaks.

2. Habitat Diversification

Habitat diversification makes the agricultural environment unfavourable for insect pest population growth multiplication and establishment. The following are some approaches by which the pest population can be brought down.

2.1 Ploughing, hoeing and basin preparation

Cultural practices like ploughing, hoeing and basin preparation influence directly, the survival of soil inhabiting pests. These routine agricultural operations expose soil inhabiting insect, pests and other arthropods and nematodes to harsh weather and to natural predators. Insects are most vulnerable when in the pupal stage and most insect-pests pupate in the soil, which furnishes a protective habitat. Birds like the king crow, the myna, the starling, etc. pick up the exposed pupae following these cultural operations. Some insects e.g. grasshoppers, crickets, mole crickets and borers lay their eggs in the upper layers of the soil. These eggs exposed during soil preparation and desiccated subsequently. Many insects like cutworms; grubs of the root borer and white grubs, which feed on the root system of plants, are also exposed to the vagaries of the elements during basin preparation and hoeing. Ploughing the field after summer showers, removing the crop debris from the field, exposing the different stages of insects viz., egg, larvae and pupae to sunlight greatly reduce the pest abundance and prevent the pest population buildup. Deep ploughing carried out during winter helps in reducing the over wintering populations of several pests. Afore- mentioned cultural operations are performed manually using locally made tools and implements. Beside dislodging the pests from their protective habitat and subjecting them to unfavorable conditions for survival, these scientifically tempered cultural practices also improve aeration of the soil and facilitate proper percolation of water into the soil. However, the degree of success of these operations is related directly to the presence of natural predators in adequate numbers and the synchronization of these operations with the vulnerable stages of the pest's life cycle.

2.2 Intercropping system

Intercropping system has been found favourable in reducing the population and damage caused by many insect pests due to one or more of the following reasons:

- Pest outbreak less in mixed stands due to crop diversity than in sole stands.
- Availability of alternate host.
- Decreased colonization and reproduction in pests
- Chemical repellency, masking, feeding inhibition by odours from non-host plants.
- Act as physical barrier to plants.

Few examples like Interplanting maize in cotton fields increased the bio control agents population of Araneae, coccinellidae and chrysopidae compared with control fields. Maize also acted as a trap crop for *H.armigera* reducing the second generation damage to cotton . Intercropping pulses in cotton reduced the population of leafhopper and Lablab bean in sorghum reduced the sorghum stem borer incidence. Hence, appropriate intercropping systems have to be evolved where reduction in pest level occurs.

Intercropping sorghum with other crops has been shown to reduce *C.partellus* damage on sorghum, urdbean, pigeon pea, cowpea and lablab bean. The incidence of groundnut leaf miner, *Aproaerema modicella* was highly reduced when groundnut was intercropped with cowpea of blackgram at the ratio of 3:1 and with pearl millet at a 4:1 ratio. The latter case increased natural enemy activity and reduced the requirement for one round of insecticide spraying and increased yield. Sowing cowpea (1:4) as intercrop with groundnut minimizes leaf miner infestation. Growing cowpea as intercrop also helped in attracting the female moths to lay more eggs on it and for early detection of occurrence. Intercropping system of groundnut and Bajra at 6:1 ratio had lowest leaflet damage by leaf miner (41.23%) and larval numbers (2.57) per plant followed by groundnut + cowpea, which had 49.26 percent and 3.10 larval number as compared to 64.56 and 4.13, respectively in groundnut pure crop. Greengram var.Co2 intercropped with sugarcane recorded 77 percent decrease in sugarcane early shoot borer incidence over control. Intercrop of soya bean, green gram, black gram etc. has been reported to reduce weeds as well. Sunhemp has been interplanted with potatoes to deter the potato blight fungus, *Phytophthora infestans*. Intercropping with onion and garlic is recommended for nematode control. The damage of cotton ash weevil was more pronounced when eggplant was grown as intercrop cotton or as preceding crop, since both are preferred hosts for it.

2.3 Trap Cropping

Plantings of the susceptible or preferred crop of a pest grown near the main crop to attract insects or other organisms like nematodes to protect target crops from pest attack. Beneficial effect of trap cropping is achieved by

- Either preventing the pests from reaching the crop or
- Concentrating them in a certain part of the field where they can be economically destroyed.
- Growing trap crops like marigold which attract pests like American bollworm by lay eggs, barrier crops like maize/jowar to prevent migration of sucking pests like aphids and guard crops like castor which attracts *Spodoptera litura* in cotton fields. Growing mustard as trap crop, 2 rows per 25 cabbage rows for the management of diamond back moth. First mustard crop is sown 15 days prior to cabbage planting or 20 days old mustard seedlings are planted. Growing castor along the border of cotton field and irrigation channels act as indicator or trap crop for *Spodoptera litura*. Planting of 40-day-old yellow African tall marigold and 25-day-old tomato seedlings (1:16 rows) or *Bidil rustica* tobacco around tomato (1:5) simultaneously reduces *Helicoverpa* damage. All the eggs of *Heliothis armigera* deposited on yellow *Tagetes* flowerbuds could be destroyed by the inundation of *Helicoverpa* adapted strain of egg parasitoid (*Trichogramma chilonis*). The main crop of tomatoes is also sprayed with either HaNPV or Bt, both of which are compatible with*Trichogramma.*

2.4 Companion plants

Companion plants constitute a form of biological control - the use of living organisms to manage unwanted pests and disease organisms. *Cannabis* plants have been grown as companion plants alongside crops, which require this protection. *Cannabis sativa* growing near cotton exerted a "protective influence" against cotton worms *(Alabama argillacea,* then called *Aletia xylin*a). Similarly,sunhemp grown around vegetable fields safeguarded the fields from attack by a cabbage caterpillar, *Pieris brassicae*; potato fields were protected against the potato beetle, *Leptinotarsa decemlineata* ; wheat suffered less damage by the root maggot, *Delia coarctata* ; and root exudates of *Cannabis* repelled underground larvae of the European chafer *Melolontha melolontha* . *Cannabis* suppresses the growth of neighboring plants, whether they are noxious chickweed, *Stellaria media* or valuable crops such as lupine, beets, brassicas and maize . For the control of nematode *Chamanthi* (*Chrysanthemum coronarium*) , a flowering plant is raised on the borders of tomato fields.

2.5 Crop rotation

Crop rotation breaks pest life cycles, often improves tilth and fertility. Sustainable systems of agricultural production are seen in areas where proper mixtures of crops and varieties are adopted in a given agro-ecosystem. Monocultures and overlapping crop seasons are more prone to sever outbreak of pests and diseases. For example, growing rice after groundnut in garden land in puddle condition eliminates white grub. Crop rotation with non-host crop e.g. Sorghum, sesamum, wheat and barley reduced the incidence of root knot nematode. Crop rotation with French beans reduces the bacterial wilt disease. Sorghum bicolor (Johnson grass) is grown as fodder crop in April –May. After harvesting the crop, brinjal is planted by keeping roots of Johnson grass in the field. This results in zero incidence of wilt disease in moderately infested plots.

3. Host plant resistance

Use varieties that are resistant to common pest species. Host plant resistance forms an important component of IPM . Several resistant varieties of crops have been evolved against major pests, through intensive breeding programmes. Development of varieties with multiple resistances to several pests and diseases is essential. Uses of resistant varieties reduce the cotton ash weevil damage. In rice, resistant varieties viz., MDU 3 (Gall midge), PY 3, CO42 (Brown plant hopper) should be used. To resist sorghum shoot fly incidence CSH 15 R can be used. Groundnut resistant varieties like Robut 33-1, Kadiri 3, ICGS 806031 should be grown in endemic areas to reduce the risk of thrips damage and bud necrosis disease in case of cotton, whitefly tolerant varieties like JGJ 14545, LK 861, Supriya and Kanchana should be grown in endemic areas (Regupathy et.al., 1997). Use less susceptible varieties of brinjal like SB 17-4, PBR-129-5, Punjab Barsati, Arka Kasumkar, Pusa purple round, Punjab Meetam, Pusa Purple Long and Surti Gota against shoot and fruit borer.

4. Physical method of pest control

Physical, (devices and procedures used to change physical environment of pest populations), methods of pest control are the oldest of all such insect control methods. These are rooted in simple practices that man, as a farmer, has leant from his long and close association with pests. These aid him in reducing pest populations to low levels. These include both direct and/or indirect measures which may be preventive or corrective in nature but are essentially slow acting, often ecofriendly, cost effective and compatible with other methods of pest control.

5. Mechanical methods of pest management

Mechanical methods of pest control are essentially slow acting, often ecofriendly, cost effective and compatible with other methods of pest control. These characteristics make them amenable to blend better with other methods of pest control even though they do not bring about an immediate or drastic reduction in pest populations. Modern concept of pest control does not emphasize the outright eradication of pests but focuses on maintaining their populations at levels, which do not cause economic losses. Some of the mechanical methods of pest management include:

5.1 Light traps in pest management

Nocturnal insects responding positively to light, e.g. defoliating beetles, moths of Bihar, hairy caterpillar, tomato fruit borer, tobacco caterpillar, and *cerambycid* beetles etc. are collected, using light source or by trapping them in a light-trap and are subsequently destroyed. The light traps could be used both for monitoring and as a means of control. Rice stem borer and the brown plant hopper responded more towards yellow light source, while the rice leaf folder and green leaf hoppers *Nephotettix virescens* and *N.nigropictus* responded to green light source.

5.2 Yellow sticky trap

White coloured traps are most effective in attracting the pigeon pea fly, *Melanagromyza obtuse* yellow colour attract cotton whitefly, *Bemesia tabaci*, cotton aphids, *Aphis gossypi* G. and green house white fly. *Trialeurodes vaporarioru* .. Models combining the sticky trap with water pan have also been developed in increase the insect catch. Sticky traps are generally used with pheromones .

6. Use of Hormone

The basic studies of insect physiology have evolved the successful use of insect hormones in minimizing the pest population. The prime candidate for developing hormonal pesticides is the Juvenile hormone that all insects secrete at certain stages in their lives. It is one of the three internal secretions used by insects to regulate growth and metamorphosis from larva to pupa and pupa to adult. The Juvenile hormone is secreted by *corpora allata*, which is in the form of two tiny glands in the head. Besides, Ecdysone is secreted from thoracic gland, which causes pupation and maturation in insects. These hormones have been shown to alter the course of development in insects abruptly when applied at appropriate time and in turn it may be used as pesticides. Carroll M. Williams was first to synthesize cecropia crude juvenile hormone.

7. Use of insect pheromones

Pheromones are chemical substances released by insects, which attract other individuals of the same species. Pheromone trap catches are highest when wind is from the East. Sex pheromones have been used in pest management in the following ways:

a. Monitoring
b. Mating disruption
c. Mass trapping

Pheromones are naturally produced chemicals used by animals to communicate to each other. There are three basic types of pheromones. Aggregation pheromones attract many individuals together, for example, a site where food may be plentiful. Sex pheromones are used by one sex of a species to attract a male. Trail pheromones are deposited by walking insects, such as ants, so that others can follow. Synthetic pheromones produced in laboratories mimic these natural chemicals. They are used to attract pest insects into traps, disrupt mating, and monitor populations of insects. Because they do not leave any residual effect they are considered gender friendly tools in order to reduce health hazards of farmwomen. In some cases women have had to walk long distances to fetch water to prepare pesticides for cotton production, and switching to pheromone trap based pest control lightened women's labour.

8.Using farmers wisdom ITKs.

The knowledge that indigenous people have regarding ecology, biodiversity and land use management is embedded in their belief system, their culture and religion. They have evolved ecologically sound technologies to deal with issues related to eco-friendly pest management. Traditional knowledge was perceived as a social responsibility albeit a paid one.

Growing commercialization and industrialization over the last two decade has eroded this commitment adversely affecting the quality of care. In the context of global change, scientific validation of traditional knowledge and blending with scientific recommendations has assumed greater significance. Around the world, there is growing interest in finding alternatives to the industrial farming methods that have emerged during the 20th century. One approach is to build upon traditional methods, which evolved over the first 10,000 years of agriculture.

9.Use of plant products/botanicals as Novel pesticides

Recent studies have also indicated the presence of photo-activated Secondary Phyto Chemicals (SPCs) (Photosensitizers/phototoxins), i.e they become toxic to insects in the presence of light . These SPCs are involved in the plant defence mechanisms against insects. Such naturally occurring solar powered toxins are an attractive alternative to chemical pesticides because they are biodegradable .

10. Biological control

Suppression of harmful pest organisms by introduction, augmentation and conservation of their natural enemies is known as biological control. Natural enemies include parasitoids, predators, and microorganisms of pests.Recent efforts to reduce broad spectrum toxins added to the environment have brought biological insecticides into vogue. Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides. An example is the development and increase in use of *Bacillus thuringiensis*, a bacterial disease of *Lepidopterous* and some other insects. It is used as a larvicide against a wide variety of caterpillars. Because it has little effect on other organisms, it is considered more environment friendly as well as gender friendly. The toxin from *Bacillus thuringiensis* (Bt toxin) has been incorporated directly into plants through the use of genetic engineering. Other biological insecticides include products based on entomopathogenic fungi (*Metarrhizium anisopliae*), nematodes (*Steinernema feltiae*) and viruses (*Cydia pomonella* granulovirus).According to an estimate 26 billion dollars are spent on synthetic pesticides worldwide per year while only 300 million is spent on biological pesticides. Biological pesticides are far less potent over the long term. As the market for biological pesticides increases, we will also see more and more farmwomen use these biopesticides, which are ultimately better for the environment and beneficial to reduce pesticidal hazards.

Natural Resource Conservation Practices

Lands, forests and biodiversity are at the heart of the cultures and ways of life of indigenous peoples. Nearly 70 million indigenous women and men worldwide depend on forests for their livelihoods, while numerous other indigenous women and men depend on activities such as cultivation, hunting-gathering or pastoralism. Such forms of livelihood are increasingly under threat from deforestation, desertification, land degradation and biodiversity loss. In a number of countries, indigenous peoples also face restrictions on access to their traditional lands and territories arising from the exclusionary policies adopted for forests and biodiversity conservation. This often results in poor conservation outcomes while further exacerbating their livelihoods and food insecurity.

Indigenous peoples possess a wealth of traditional knowledge and practices relating to the sustainable management of natural resources . For instance, forests managed by indigenous peoples tend to have lower carbon dioxide emissions and deforestation rates. In many countries, however, the exclusion of indigenous peoples from the management of forests and other natural resources remains a major challenge that must be surmounted.

India is rich in Natural resources and there are plenty of Natural Resource Conservation Practices. Therefore, there is a need to enmesh these practices along with other conventional measures for Natural Resource management and promoting sustainable development of agriculture. Some of the successful examples are summarised below:

The theory of ecological prevention and cure in controlling the insect pest of terrestrial higher-grade animals and plants has been in practice in long time and has achieved remarkable success. The recent commercial patenting of the active principle Margo son-O, derived from neem (*Azadirachta indica*) tree, has been successfully extracted, chemically stabilized and patented by the industries for its pesticidal properties, is an example of the attempts to commercially exploit traditional knowledge for Agro Eco-System Management.

Neem (*Azadirachta indica*) has had a long history of use primarily against household and storage pests and to some extent against crop pests in the Indian sub-continent. It was a common practice in rural India to mix dried neem leaves with grains meant for storage. Mixing of neem leave (2-5%) with rice, wheat and other grains is even now practiced in some parts of India and Pakistan. Also as early as 1930, neem cake was applied to rice and sugar cane fields against stem borers and white ants. Some innovative farmers in Karnataka and Tamil Nadu States in India even today "puddle" green twigs and leaves in plant hoppers and whorl maggots. Environmentally, neem has a reputation as a natural air purifier, exhaling out oxygen for atmospheric balance. Mudar (*Calotropis procera*) root-bark is very largely used in India for the treatment of elephantiasis, leprosy, chronic eczema, diarrhoea and dysenty. The acrid juice hardens into a substance like gutta-percha. It has long been used in India for abortive and suicidal purposes.

The use of numerous plant species for food, medicine, fuel, timber and various other purposes by mankind has been well documented in ancient Hindu literature.The Indian system of Medicine and Homoeopathy consist of *Ayurveda, Siddha,Unani* and Homoeopathy and therapies such as yoga and Naturopathy. Some of these systems are indigenous and other such as Homoeopathy have over the years become a part of Indian tradition . Prior to the advent of modern medicine ,these systems had, for centuries, catered to the health care needs of the people; these systems are widely used even today because their practitioners are acceptable both geographically and culturally, are accessible and their services and drugs are affordable as well as free from any side effects which are available in the modern system of medicine and for prevention and management of lifestyle related chronic diseases. Traditional knowledge on medicine since the time of Great sage *Charak* has led to the discovery of many important drugs of modern era (e.g. Reserpine from *Rauvolfa serpentina,* Quinine from *Cincona pubescens)* (Uniyal *et.al.*2002).

Mahua *Madhuca longifolia* (Koen), family Sapotaceae plays an important role in medicinal uses. Almost all parts of the plant are used by tribal communities of Madhya Pradesh in various ailments and disease. The root paste is given to treat stomach ulcer. It is applied on scorpion sting. The bark decoction is gargled in case of gum swelling. The decoction with that of *Ficus racemosa* L. is used for leucorrhoea. The bark is astringent and tonic. Its decoction is given in diabetes and rheumatic diseases. The flowers are given bronchitis and cough. The flower paste is applied to take out the pierced thorn. The fruit paste is applied on toothache. The seed oil is massaged over the chest in the treatment of pneumonia. The seed cake is used in snakebite; few drops of its decoction are put in nostrils, which results into vomiting and relief. Two to three leaves of Mahua with common salt are given to livestock to kill the worms of wound. The smoke of the cake is believed to keep snake away.

Local people of Bhagirathi Valley (Western Himalaya) used many plant species to supplement their diet. These wild plants, which once formed a part of their daily menu, are now occasionally consumed. Some of the commonly used plant species in the villages were *Urtica parviflora, Paeonia emodi* (dhandra), *Fagopyrum esculentum* (Kanlai), *Phytolacca acinosa* (Jarkya) and *Diplazium esculentum* (lingra). Local people, during their stay at temporary huts, also collect *Allium stracheyi* (jimbu) and *Angelica glauca* (Chora), for use as condiments in various dishes. Besides these, leaves of C*innamomum tamala* (tejpat) were also collected from the forest. A delicious salad locally known as "Athana" prepared by mixing flowers of *Rhododendroh arboreum*, leaves of *Rumex hastatus* (almoda), coriander and spices is much relished by village women especially when they go for fuelwood collection in the forest. Local people also consumed ripe fruits of *Berberis* spp., *Rubus spp., Pyracantha crenulata* (ghingaru), *Prunus cerasoides* (chuli), V*iburnum mullaha* (mayon), *Ribes orientale* (kirmola), *Pyrus pashia* (mol) and *Myrica esculenta* (Kaphal). *Prunus cerasoides* and *Myrica esculenta* were also sold in the local market besides self-consumption. Fruits of *viburnum mullaha, Prunus cerasoides*, Ribes and *Rosa brunonii* (rangeela) were used in preparing jams and pickles.

Local people also used few plant species to treat different diseases of livestock, four were used for healing bone fractures. Bark of *Boehmeria platyphylla, Debregeasia salicifolia, Ulmus wallichiana* and *Prunus cerasoides* were applied on fractured bones after making paste. Leaf and root extracts of *Anaphalis triplinervis* (bach) and *Rumex hastatus* respectively, were applied to cure the laceration of foot (khurya). Seeds of *Rhus punjabensis* were fed to combat poisoning caused due to intake of *Rhododendron arboreum* leaves, where as roots of *Rheum australe* (dolu) were applied on the cuts and wounds of animal. Few decades ago, *Aconitum heterophyllum* (atis) and *Swertia chirayita* (chirata) were most frequently used for curing fever. Leaves of *Quercus leucotrichophora* were also used for curing a fever locally called "Ghichak". For cuts and burns *Rheum australe and Eupatorium adenophorum* (basing) were the most preferred species. *Bergenia ciliata* (gheepati) and *Mentha longifolia*, once commonly used for stomach disorders have now given way to allopathic medicines. Species such as *Angelica glauca*, *Adhotoda vasica* (basak) and *Picrorhiza kurrooa* (kutki) were used for the treatment of cough and cold. For body pain, headache and toothache S*wertia chirayita, Berberis ciliata, Rheum australe, bark of Zanthoxylum armatum* and J*uglans regia* were commonly used. Oil of *Cedrus deodara* and *Daphne papyracea* (Satpura) is still used for rheumatic pains. For skin diseases, fruits and seeds of *Melia azedarach* (daikan) and *Daphne papyracea* were used. For urinary and related problems decoction of roots of *Valeriana hardwickii* and *V. jatamansi* were taken and the bark and root paste of *C. deodara* and T*halictrum foliolosum* (mamira) were externally applied for piles. Peoples of Bhagirathi valley were also associated with several plants which are used in religious rites, festivals and superstitious beliefs. Nineteen plant species were considered sacred by the local people, of which, *Aesculus indica*, *Quercus floribunda* (moru) and *Taxus baccata* were the most revered trees species. These were used for making palanquins (Devta doli) for the local deity. Bark of *Betula utilis* was used to make charms whereas stem of *Zanthoxylum armatum* was kept in houses to ward off evil spirits. Flowers of *Primula macrophylla* (jayan) and *Saussurea obvallata* (brahmkamal) were specially collected for local festival known as Fulal in the month of August. *Jurinea macrocephala* (dhoop), *Juniperus* spp. (dhoop-lakkad), *Tanacetum longifolium* (Guggal), S*kimmia laureola* (Kedarpati) and V*aleriana* spp. were used as incense.

Reddy and Rao (2002) reported 59 plant species belonging to 37 different families used as herbal remedies in primary health care by the village folk of Andhra Pradesh, India. The herbal remedies mentioned are against post-delivery infections, lumbago, white and red discharges in women, body pains and swellings, tooth and gum affections, muscle catch and sprains, bone fractures, fevers, stomach ache, eye infections and cataract, snake bite, scorpion sting, cough and asthma, ear aches, head ache and migraine, boils and abscesses, dysentery, rheumatic pains, liver disorders, diabetes, piles as aphrodisiac for improvement of general strength.

Karuppusamy *et.al*. (2002) reported that the powder leaf of *Andrographis paniculata*; plant of *Evolvulus alsinoides* and root of *Aristolochia indica, Cryptolepis buchananii, Jchnocarpus frutescens, Rauvolfia serpentina* and *Rhinacanthus nasutus* are being used in Tamilnadu @ 50g/day for 3 days (orally administered) as Antidote for snake bite and scorpion sting.

Plants have provided an important source of pigments and tannins for millennia. While tannins have been used in preserving animal skins, plant pigments have been used in dying textiles, wool and fibres in different societies across the world. Bark, fruit and root of *Juglans regia* were used for drying the wool while only root of *Berberis asiatica* (kilmora), *Rheum emodi* (Dolu), *Rumex nepalensis* (Sayama) and Rheum spp. (Tatori) were used for dyeing the wool in yellow and pink colour in the higher Kumaun Himalaya.

The old villagers and herbal practitioners known as "Vaidyas" of U.P. have very good knowledge of the indigenous herbal preparations from common plants of their surroundings. *Agave americana, Angelica glauca, Betula utilis, Carthamus tinctorius, Eleusine coracana, Fagopyrum esculentum, Ficus auriculata, Glycine max, Grewia optiva, Jnglans regia, Macrotyloma uniflorum, Pinus roxburghii, Pyracantha crenulata, Pyrus pashia, Quercus lucotrichophora, Ricinus communis, Rubus effipticus, Solanum incanum,* have been famed for the treatment of various disorders of human beings. Leaves of *Toona hexandra* (Wallich ex Roxb) are used as natural insecticide. Fresh leaves are used to protect food grains from insects; their paste is used while storing the grains for long duration. About 50 ml. decoctions of the leaves twice a day for 15-30 days is given to the patients suffering from diabetes. The mature wood of the tree is used for making doors and frames.

The history of water conservation techniques in dry zone of Maharashtra goes back to 400 years, when grandfather of Chhatrapati Shivaji Maharaja ; Malhojeeraje Bhosale introduced Kastalov in Satara district. The rain water runoff flowing in watershed commands were obstructed by small weirs. People were educated specially during the droughts; Phad system was well known in Kolhapur . Bhudaki : as a special character of irrigation was specific feature in Kolhapur region. Percolation tanks were designed for the water conservation vis-à-vis agriculture development in the drought area of Maharashtra. It was a local water harvesting technology adopted not only for irrigation purposes but also for developing agro-forestry and social forestry alongwith watershed development programme'.

Vegetative fencing with Kiluvai (*Blasmo dendron verii*) to reduce water run off and its velocity , vegetative barrier with Agave to reduce run off velocity and to increase infiltration opportunity time, conservation furrows with traditional plough (*Oodu ulavu*) for *in situ* moisture conservation. Use of indigenous plough (Kodai ulavu) for formation of broad bed and furrows to harvest rain water and dispose of excess water, inter cropping coriander with Bengal gram and cotton with black gram for protective irrigation and Nala check with soil filled in cement bags for water harvesting for irrigation have been reported from different parts of Karnataka. Traditional compartmental bunding for soil conservation, peripheral bunding with *Agave* spp. for gully control, peripheral stone bunding for soil conservation and run off management, application of groundnut shells for moisture conservation by mulching and incorporation, sand mulching for soil and moisture conservation, mixed intercropping of groundnut, pigeon pea and pulses as vegetative barrier for run off management, cultivation and sowing across the shape for soil and moisture conservation, stone and bags as gully check for gully control and run off management have been reported from Andhra Pradesh. Ipomea as vegetative barrier across gullies to act as gully check, stone bunding, murram bunding and conservation of bench terrace have been reported from Karnataka for soil and moisture conservation. Deep ploughing and gravel sand mulching for moisture conservation, retention of pebbles on the soil surface and retention of sun flower stalks for soil and moisture conservation, inter cropping of groundnut + pigeon pea and wider row spacing and deep interculturing for in situ rain water harvesting, ploughing across the slopes for moisture conservation, relay cropping of onion–rabi sorghum or chick pea and mixed cropping of onion+chilli+cotton (Mishrabele paddati) for reduction in run off and better utilization of soil moisture, cover cropping of cucurbits for soil and moisture conservation, clear over fall waster weir to safe run off disposal, drop in let spillway for run off disposal and surplus waste weir at the outlet of the field for soil and water conservation have been reported from Karnataka.

Loose stone surplus bund to prevent loss of fertile soil and rilling of cultivated land, stone and soil bunding with an opening to reduce the speed of run off and safe disposal of run off water, loose boulder checks to check soil erosion and arrest the velocity of water, tank silt application to increase the fertility and moisture holding capacity of soil, cris cross ploughing to control of soil erosion and improvement in soil moisture, rain water management using Role to predict the rain fall amount for ploughing the field, and farm pond to store water in the pond for ground water recharge and/or supplemental irrigation are the various traditional wisdoms reported from Andhra Pradesh.

Field bunding for soil conservation and run off harvesting, stabilization of field boundary bund with *Vitex negundo* (Nirgudi) and plantation of grasses on field bound, and stabilization of field boundary bund with *Agave* spp. and to reduce run off and soil loss. Ploughing/deep ploughing to harvest early showers, to loosen soil which conserve moisture and to reduce run off, land preparation with harrow (Kulav) to loosen the soil which ultimately conserve rain water and to remove stubbles, weeds and crushing of clod, hoeing with local hoes in Kharif and Rabi crops for moisture conservation, weed control and providing support to the crop by earthening, stone waste weir for safe disposal of surplus water from the field and to arrest the sediment, waste weir (stone/sorghum stubbles) at the outlet of the field from safe disposal of runoff and furrow opening in standing crops with local implement hoe (Dawara) for moisture conservation are the common practices of traditional wisdom in different parts of Maharashtra.

Strengthening bunds by growing local grasses for soil and water conservation is the common practice in Krandimaska village in Kandhamal district of Orissa. Similarly, bund farming of pulse crops (Pigeon pea, black gram) in Kharif under rain fed situation at Nayagarh district for enhancement of income per unit area and strengthening of bund, leveling the plots by local leveler for moisture conservation in Kandhamal district, mulching with sal leaf in turmeric for conserving moisture in Kandhamal district, collecting the silt from the foot hills and reusing in the fields for moisture conservation by way of soil amendment, line sowing behind the plough for soil and water conservation and better utilization of soil moisture and reduction in cost of inter cultural operation. Planting of potato across the slope to conserve the moisture, planting of sweet potato along the ridges for soil and water conservation. Brush wood structure across the bund to check soil loss are the various traditional wisdom reported from Kandhamal district of Orissa.

Earthen bunds (kuchha pala) to reduce soil erosion and conserve soil moisture, inter culturing operation (Aantar khed) to conserve soil moisture and removal of weeds, percolation pond/tank (Khet Talawadi) to harvest the run-off water of individual field, ground water recharging through ditches and percolation pits to increase the ground water level, small check dams for harvesting run off water to harvest the run off water for drinking and irrigation purpose. Small Masonry irrigation tank to store the run off water for irrigation, recharging of wells through farm pond to harvest the run off water and to recharge the ground water, bunds protected with vegetal cover for protection and strengthening of earthen bunds and to reduce soil erosion and run off losses, deep ploughing to break down the hard pan and improve water infiltration, opening up set furrow for harvesting rain water, inter culturing (Hoeing) and earthening in standing crop for harvesting rain water and to provide soil mulch and for easy penetration of pegs of groundnut in the soil, application of tank bed silt for soil moisture conservation by soil amendments. Crop residue in the field to prevent sheet erosion and increase in-situ moisture conservation, wider row spacing to sustain crop production during deficit rain fall by moisture conservation and to control weed and to increase aeration by inter culturing, sowing across the slope to harvest more water in soil profile, application of manure (FYM) and murrum in set furrow system to increase supply of available plant nutrition and for soil moisture conservation by soil amendments, stone water way to control soil erosion and well recharging through run off collection pits for augmentation of ground water are various traditional wisdom in practice in Gujarat.

Conclusion

Ensuring the production of quality foods, free from potentially harmful contaminants, is of enormous significance throughout the world. India has achieved self sufficiency in the production of food grains, but still we are not in a position to meet the quality dietary requirement of the increasing population. Food security is important throughout all aspects of day to day living. There is an urgent need to empower women on integrated pest management practices for safe food production. This can be achieved by enhanced use of ICT, forecasting , forewarning, development of safer, effective, target oriented molecules, use of IRM (Insecticide Resistance Management), IPM, stricter control on spurious pesticide use, precision pesticide application and enhanced use of seed treatment and newer pesticide application techniques. In this era of globalization, India with its excellent and abundant natural resources can become a key player in agro-eco-system management. Documentation and dissemination of natural resources management practices can transform India into a major centre in its utilization globally .

Participatory Methods for Prioritizing the Components of IFS Models

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Introduction

A participatory approach advocates actively involving 'the stakeholders' in decision-making processes, whereby the relevant 'stakeholders' depends upon the topic being addressed. In general, policy processes can be seen as a three-step cycle of planning, implementation and evaluation, whereby a participatory approach may be used in some or all of these steps. However, it should be noted that the level of participation is a continuum and methods vary in the degree to which they engage participants in framing the questions/ indicators and issues and in designing the procedures.

Why use a participatory approach?

Demands for increased public participation in policy-making have been founded upon both pragmatic and normative lines of argumentation. From a pragmatic perspective, participation is considered to improve the quality of decisions, while from a normative point of view participation is necessary to render the decision-making process more democratic. It is normatively desirable to enable a process that is as democratic as possible in order to ensure that all values and opinions can be represented in a policy debate. Involvement in participatory processes also builds capacity among the stakeholders. It does so by educating the public as well as creating networks of relevant persons who can continue to address policy issues as they develop. However, not only the public needs to learn. All decision-makers can best learn how to improve their services and products by receiving direct feedback from the 'users'. Rather than first making and then fixing, it is most efficient to involve the end-users in the initial design and planning. Furthermore, a participatory approach to policy-making is seen as a way of building social cohesion. It is a useful process to achieve consensus when differences in opinion and even conflicts need to be resolved. When this approach is taken up early in the process, participants can share their perspectives, values and reasoning on an emerging issue as these develop and mature.

In sum, effective and meaningful participatory approach is seen as essential to:

- enable high quality and democratic governance
- strengthen capacity
- develop and deliver programmes effectively and efficiently
- build public confidence and trust in decisions
- generate a greater understanding of public issues, concerns, priorities and solutions
- build broader support for programmes and initiatives
- increase mutual learning through the sharing of information, data and experiences
- ensure that decisions and policies incorporate knowledge and expertise that otherwise might be overlooked

- reflect a wider range of public concerns and values in decision-making
- rapidly identify issues
- help bring together different points of view to achieve consensus in a collaborative manner.

Impact Monitoring/ Impact Assessment

Despite the increasing number and sophistication of management tools and methodologies, monitoring the impacts of development efforts continues to be a complex and neglected task. Management focus is generally concentrated more on planning than on other aspects of project administration. Results are usually measured in terms of outputs……... and sometimes in terms of outcomes. But almost never in terms of impacts

Impacts are often difficult to measure for several reasons…..

- They do not have always happen as per plans and schedules
- Impacts that are intangible or qualitative are difficult to measure and document credibly and comprehensively
- Unintended, unplanned, unexpected impacts get overlooked unless they are somehow discovered and captured
- The extent to which project activities alone are responsible for impacts is not always clear since there may also be other external factors influencing impacts
- Practical methodologies to assess and document impacts are inadequate

On the other hand, development agencies are increasingly exposed to public pressure and are expected to justify how and to what extent expenditures have benefited the intended populations. They are called upon to demonstrate that their projects are creating the expected benefits for their target groups.

Participatory Impact Monitoring/ Assessment (PIM/A)

A process in which development interveners and local communities jointly observe, document and critically reflect on the effects and changes caused by project interventions

The objectives of PIM/A are threefold

Promoting Learning Process
Improving Communication between stakeholders
Improving Project Steering

PIM/A is not simply a methodology but even more, it represents a philosophy. It is not a one-time event, it has to be periodically undertaken so that programmes and intervention strategies are constantly reviewed and improved.

Indicators for Impact Monitoring, Assessment and Prioritization

Indicators are quantitative or qualitative variables that can be measured or described and, when observed periodically, demonstrate trends; they help to communicate complex phenomena. They represent the abstraction of a phenomenon or a variable. In other words, an indicator is just an indicator. It is not the same as the phenomenon of interest, but only an indicator of that phenomenon (Patton, 1997).

Classification of Indicators

Scientific indicators tend to be measurable in quantitative terms; they are global within a given discipline and are meant to be comparable across space and time.

Grassroots (indigenous/local) indicators are signals used by local people (individuals, groups, communities) based on their own observations, perceptions and local knowledge, applied within specific cultural, ecological and spiritual contexts; they tend to be more descriptive.

Another, classification of indicators says that, they can be broadly classified into two categories, namely; ***final and intermediate***.

Final indicator: when an indicator measures the effect of an intervention on individuals' say ` well-being', we call it a "final" indicator.
For example, literacy may be considered one of the dimensions of `wellbeing', so an indicator measuring it—say, the proportion of people of a certain age who can read a simple text and write their name—would be a final indicator. Sometimes final indicators are divided into ***"outcome"*** and ***"impact"*** indicators.

Impact indicators measure key dimensions of `well-being' such as freedom from hunger, literacy, good health, empowerment, and security.

Outcome indicators capture access to, use of, and satisfaction with public services, such as use of health clinics and satisfaction with the services received; access to credit; representation in political institutions and so on. These are not dimensions of
`well-being 'in themselves, but are closely related. They may be contextual. Thus, both the ***impact*** and ***outcome*** indicators should constitute the final indicators of impact assessment and monitoring impact.

Intermediate indicator: when an indicator measures a factor that determines an outcome or contributes to the process of achieving an outcome, we call it an ***"input"*** or "***output"*** indicator, depending on the stage of the process—in other words, an "intermediate" indicator.

For example, many things may be needed to raise literacy levels: more schools and teachers, better textbooks, and so on. A measure of public expenditures on classrooms and teachers would be" input" indicators, while measures of classrooms built and teachers trained would be "output" indicators. What is important is that inputs and outputs are not goals in themselves; rather, they help to achieve the chosen goals.

Features of Good Indicators

A good indicator:
• Is a direct and unambiguous measure of progress/change—more (or less) it is unmistakably better.
• Is relevant— it measures factors that reflect the objectives.
• Varies across areas, groups, over time, and is sensitive to changes in policies, programs, institutions.
• Is not easily blown off course by unrelated developments and cannot be easily manipulated to show achievement where none exists.
• Can be tracked (better if already available), is available frequently, and is not too costly to track.

Identification and Selection of Indicators for Prioritization, Impact Monitoring and Assessment

Once a set of goals/objectives of the project have been agreed upon through a participatory analysis processes, the next step is to identify indicators—also in a participatory way—to measure progress toward those goals as a result of an intervention or a development project. The impact monitoring and assessment depend critically on the choice of appropriate indicators. Preferably, they should be derived from the identification and descriptions of relevant variables being given by the clients, with appropriate indicators of them being based on discussion of all the stakeholders.

Basis for Indicators

Indicators should comprise comprehensive information about the program outcomes:

- Indicators of the program impact based on the program objectives are needed to guide policies and decisions at all levels of society- village, town, city, district, state, region, nation, continent and world.
- These indicators must represent all important concerns of all the stakeholders in the program: An ad- hoc collection of indicators that just seem relevant is not adequate. A more systematic approach must look at the interaction of the program components with the environment.
- The number of indicators should be as small as possible, but not smaller than necessary. That is, the indicator set must be comprehensive and compact, covering all relevant aspects.
- The process of finding an indicator set must be participatory to ensure that the set encompasses the visions and values of the community or region for which it is developed.
- Indicators must be clearly defined, reproducible, unambiguous, understandable and practical. They must reflect the interests and views of different stakeholders.
- From a look at these indicators, it must be possible to deduce the viability and sustainability of change due to a project program and current developments, and to compare with alternative change/development paths.

- A framework, a process and criteria for finding an adequate set of indicators to assess all aspects of the impact of the program are needed.

These facts must be borne in mind when defining indicator sets.

Participatory Method for Prioritization- Appropriate Participatory Tools

Participatory Rural Appraisal (PRA) tools are often only seen as appropriate for gathering information at the beginning of an intervention, as part of a process of appraisal and planning. Development workers may talk about having 'done' a PRA, sometimes seeing it as just a step towards getting funding. However, PRA tools have a much wider range of potential uses, and can often be readily adapted and used for participatory prioritization, participatory monitoring, and for participatory evaluation.

1. Transect walk: is a means of involving the community in both prioritization, monitoring and evaluating of changes that have taken place over the period of programme intervention. This method entails direct observation whilst incorporating the views of community members.

2. Spider web diagram: in this case is used as a means for participants to prioritize, monitor and evaluate key areas of a programme. The spider web is a simple diagrammatic tool for use in discussions; it does not entail any direct field observations.

3. Participatory mapping: is perhaps the most easy and popular of participatory tools, used to prioritize and evaluate project interventions.

4. Matrix ranking: can be used to prioritize/ evaluate the impact of skill training.

5. Preference/ Problem Ranking: Preference/ Problem Ranking is a participatory technique based on analysing and identifying problems or preferences *stakeholders* share. In order to implement improvements and solutions for water and *sanitation* problems communities face, you first have to analyse and identify the problems and priorities *stakeholders* share. Several different techniques can be used to obtain the local people's perceptions of the most important problems they face regarding a particular issue. One simple participatory method is to ask participants to list the main problems their community are confronted with. Afterwards, ask them to rank these problems in order of importance.

A more systematic technique is called "pairwise ranking" and uses cards to represent the different problems. The facilitator shows the "problem cards", two at a time, each time asking, "Which is the bigger problem?" As the participants make the comparisons, the results are recorded in a matrix. The final result is obtained by counting the number of times that each problem was judged to be the larger problem over the others and arranging them in appropriate order.

6. The H-form: the method : H-form is a simple monitoring and evaluation tool, that can widely be used as a prioritization tool also. This method is particularly designed for monitoring and evaluation of programmes. It was developed in Somalia for assisting local people to monitor and evaluate local environmental management. The method can be used for developing indicators, evaluating activities, prioritizing the activities and to facilitate and record interviews with individuals.

Steps in using a H-form

1. Take a large paper and fold it in half length-wise and then fold it in half width-wise, and then half again width-wise. Unfold the paper and darken the 'H' lines with a pen. Exclude the centre vertical line.
2. Write the question in the top centre of the H-form. This should be simple and lucid. If you have a complicated issue, break it up into many small questions. On the left of the horizontal line of 'H' write 0 representing 'not well' and at the right side 10 representing 'extremely well'.
3. If you are working with a group, ask each individual to place their score along the line between 0–10. Give them each many cards or 'post its' (pieces of paper with a sticky backing) and ask them to write/draw out as many reasons for their score. Only one reason should be written on one card.
4. The participants have to write both positive and negative reasons for their score, which are then collected and pasted on to the respective side.
5. The participants are then encouraged to read each other's comments or each participant is made to read out the comments they have written. This is a process of sharing and also to encourage discussion.
6. The next step can be to encourage the group to come out with a consensus group score. Once this is achieved, the group discussion can focus on 'steps ahead', ideas of how to make things better, etc.
7. The results of the exercise can be recorded and analysed further as a step towards prioritizing, monitoring and evaluation and documented in a report.

Potential Indicators for Prioritizing IFS Components

- ✓ Increased productivity
- ✓ Increased profitability
- ✓ Sustainability
- ✓ Balanced nutrition
- ✓ Efficient resource recycling
- ✓ Money round the year
- ✓ Solve fodder & energy crises
- ✓ Employment generation
- ✓ Improves skill of the farmers
- ✓ Improves standard of living of farmers
- ✓ Sustain soil health
- ✓ Provides opportunity for agri-oriented industries

Be flexible in the use of participatory tools : It is best to conduct participatory exercises in a spirit of flexibility, whilst keeping sight of the information that is required for effective prioritization, monitoring and/or evaluation.

Gender: A deliberate effort has to be made to seek out the views of women and men separately. Generally, however, the outcomes may be quite similar, the overall findings will be pooled as one. Sometimes differences of perspective can appear relatively minor, but it is nevertheless important that they are discussed to ensure that any underlying differences are fully explored.

A participatory approach to prioritization, monitoring and evaluation requires not only knowledge of tools, but an overall understanding of community dynamics, and aspects such as facilitating the representation of all groups in discussions and decision-making. It also requires, of course, a clear conceptual understanding of what prioritization, monitoring and evaluation entail.

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Farmstead Planning and Formulation of Women Friendly Agricultural Tool Packages

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Farmstead is defined as "farm and its buildings" or "the buildings and adjacent service areas of a farm". Planning is the first and most important step in designing a farmstead. The modern farmstead layout should provide efficiency, security, and safety. The overall goal of the enterprise should be evaluated carefully at the onset of farmstead planning. The planning process should clearly define the relationship of each structure, or farmstead feature, to the overall goal.

Following points are to be considered before establishment of a farmstead:

1. **Selection of site** : proximity to field, efficient travel system, etc should be taken in to consideration.
2. **Drainage**: This is the most important consideration in selecting a site for a farmstead. Adequate surface and subsurface drainage will ensure all-weather driveways and dry foundations and will prevent local flooding.
3. **Water** : An adequate supply of good quality water is nearly as important as the possibility for good manure management. While water may reasonably be piped for some distance, it is advisable to ensure a satisfactory water source early in the site selection process.
4. **Soil**: soil fertility test should be made prior to site selection.
5. **Orientation** : Site orientation should be studied w. r. t. slope, winds natural barriers etc.
6. **Expansion**: Growth in the enterprise should be anticipated and the current layout should facilitate the future expansion of buildings and services.
7. **Utilities and services** : Proximity to market place, hospitals, schools etc should be kept in the mind.
8. **Manure management**: If livestock is the major enterprise, then state and local environmental regulations should be adhered. The topography should be satisfactory for the required storage and drainage of manure and effluent produced at the farmstead. The prevailing wind directions, air drainage, and distances should be such that the farm home and neighbouring homes will not be bothered by odours.
9. **Building arrangement**: It is generally convenient to consider that a farmstead layout has four basic areas: (1) a house or operation center, (2) machinery storage/farm shop, (3) feed and grain storage and processing, and (4) the livestock areas. The operation center, which is likely to be the farm home with an office and perhaps a communications center, should be located first as a starting point and focal point
10. **Slope**: proper studying of the slope and careful placement of the structures to ensure minimum cutting and filling of the soil.

11. **Prevailing winds**: Summer and winter wind currents, localized weather patters should be studied. Winds carry odors, dust, microorganisms, and noise, and prudent arrangement of buildings will use the wind to carry these away from the living center. Tree barriers should be put up to ensure reduced soil erosion.
12. **Solar**: Proper design allows utilization of solar effects in the winter and minimizes solar heating in the summer. The general rule is to locate the long dimension east-west and allowing maximum solar penetration on the south.
13. **Distances**: Labour efficiency is improved by reducing travel to a minimum. Buildings between which the most travel will occur should be located close together. The distance between buildings usually is determined by a compromise involving efficiency, fire safety, odour control, disease control, and available space.
14. **Miscellaneous** : lighting, legal paper works, environmental regulations, etc.

Need for adoption of farm mechanization by women

Studies show that 37.2 % agricultural labour force in India is female (AICRP on ESA). And it is predicted that this value is going to increase. Major reason behind this is the male rural-to-urban migration. Male members of the family are leaving the agriculture profession and migrating to cities in search of higher paying jobs. This leaves the females incharge of the house and the farm. Hence, women face increasing workload and wider scope of agricultural task, decision making etc., but the degree to which they have access to improved agricultural technologies needs a special consideration.

As men leave there is unavailability of labour during critical time period of farm operation. Thus, there is a need for skilled agricultural labour along with improved work efficiency to complete the operations timely operations.

Hence it can be concluded that women are playing the dual role of labour and also that of a decision maker. There is a rapid feminization of agriculture. So, it is essential that we equip the women with the agricultural advances for enhancing productivity and reducing the drudgery.

Women friendly tools and implements by DRWA

There are several researches carried out in DRWA related to ergonomic evaluation and refinement/ modification of different farm technologies with women perspective. Certain equipments such as manually operated cleaner-grader, fertilizer broadcaster, seed drill, ridger, hand operated maize dehusker sheller for farmwomen, rice drum seeders, rice transplanters, cono-weeder, improved sickles, pedal operated thresher and winnower were ergonomically evaluated and also modified. But limited work was done on horticultural crops related to women friendly farm equipment and drudgery.

The women friendly farm tools and equipment were refined/ modified/ assessed/ developed by different research organizations. Of which, twenty one manual operated improved farm tools and implements have been found suitable for operation by farm women based on ergonomical (Singh et al, 2007 and Srinath and Singh, 2009). The improved tools and implements are given below with brief description.

<table>
<tr><th colspan="4">Improved Equipment</th><th rowspan="2">Benefits of Improved Equipment</th></tr>
<tr><td>S.</td><td colspan="3">Summary of Data</td></tr>
<tr><td rowspan="6">1</td><td colspan="3">Commercial available seed treatment drum was ergonomically evaluated with farm women.</td><td rowspan="6">Equipment provides safety to worker as direct contact with chemical is avoided in addition to avoiding bending posture & uniform mixing.
The equipment can also be used on custom hiring also to generate income.</td></tr>
<tr><td>Weight</td><td>:</td><td>26.0 kg</td></tr>
<tr><td>Output</td><td>:</td><td>200 kg/h</td></tr>
<tr><td>Mean heart rate</td><td>:</td><td>115 beats per min</td></tr>
<tr><td>Mean work pulse</td><td>:</td><td>27 beats per min</td></tr>
<tr><td>Cost (approx)</td><td>:</td><td>Rs. 2000.00</td></tr>
<tr><td rowspan="6">2</td><td colspan="3">DRWA Hand ridger was modified and ergonomically evaluated with farm women</td><td rowspan="6">About 67% saving in physiological cost with equipment in addition to avoiding bending posture that is adopted in traditional practice.
Productivity of worker doubles with the equipment than traditional practice.</td></tr>
<tr><td>Weight</td><td>:</td><td>3.0 kg</td></tr>
<tr><td>Area covered</td><td>:</td><td>333 m2/h</td></tr>
<tr><td>Mean heart rate
Pulling
Guiding</td><td>
:
:</td><td>
127 beats per min
115 beats/min</td></tr>
<tr><td>Mean work pulse
Pulling
Guiding</td><td>
:
:</td><td>
44 beats per min
30 beats per min</td></tr>
<tr><td>Cost (approx)</td><td>:</td><td>Rs. 500.00</td></tr>
<tr><td rowspan="6">3</td><td colspan="3">Commercial unit of fertilizer broadcaster was refined/modified for farm women and evaluated ergonomically with farm women</td><td rowspan="6">About 6% saving in physiological cost with equipment in addition to uniform application of fertilizer apart from their occupational safety.
The equipment can also be used on custom hiring also to generate income.</td></tr>
<tr><td>Weight</td><td>:</td><td>3.0 kg</td></tr>
<tr><td>Area covered</td><td>:</td><td>1.15 ha/h</td></tr>
<tr><td>Mean heart rate</td><td>:</td><td>134 beats per min</td></tr>
<tr><td>Mean work pulse</td><td>:</td><td>49 beats per min</td></tr>
<tr><td>Cost (approx)</td><td>:</td><td>Rs. 1500.00</td></tr>
<tr><td rowspan="6">4</td><td colspan="3">CIAE seed drill was refined/modified for farm women and evaluated ergonomically with farm women.</td><td rowspan="7">About 87% saving in physiological cost with both the equipment than traditional practice in addition to avoiding bending posture that is adopted in traditional practice.</td></tr>
<tr><td>Weight</td><td>:</td><td>11.0 kg</td></tr>
<tr><td>Area covered</td><td>:</td><td>430 m2/h</td></tr>
<tr><td>Mean heart rate
Pulling
Guiding</td><td>
:
:</td><td>
135 beats per min
119 beats per min</td></tr>
<tr><td>Mean work pulse
Pulling
Guiding</td><td>
:
:</td><td>
46 beats per min
28 beats per min</td></tr>
<tr><td>Cost (approx)</td><td>:</td><td>Rs. 2000.00</td></tr>
<tr><td>5</td><td colspan="3">PAU seed drill was refined/modified for farm women and evaluated ergonomically with farm women.</td></tr>
</table>

	Weight	:	13.0 kg	
	Area covered	:	460 m2/h	
	Mean heart rate Pulling Guiding	 : :	 122 beats per min 127 beats per min	
	Mean work pulse Pulling Guiding	 : :	 37 beats per min 41 beats per min	
	Cost (approx)	:	Rs. 2000.00	
6	TNAU four row paddy drum seeder was ergonomically evaluated with farm women			Being light in weight, easy to transport and handle. Line sowing is done with the equipment that promotes use of mechanical weeders thereby reducing drudgery and cost during weeding operation. The equipment can also be used on custom hiring also to generate income
	Weight	:	8.0 kg	
	Area covered	:	917 m2/h	
	Mean heart rate	:	144 beats per min	
	Mean work pulse	:	61 beats per min	
	Cost (approx)	:	Rs. 5000.00	
7	CIAE naveen dibbler was ergonomically evaluated with farm women.			About 13% saving in physiological cost with equipment in addition to avoiding bending posture that is adopted in traditional practice.
	Weight	:	4.0 kg	
	Area covered	:	150 m2/h	
	Mean heart rate	:	104 beats per min	
	Mean work pulse	:	17 beats per min	
	Cost (approx)	:	Rs. 400.00	
8	CRRI two row rice transplanter was ergonomically evaluated with farm women			In addition to avoiding bending posture that is adopted in traditional practice, CRRI two and four row rice transplanters save 39 % and 55% cardiac cost/ m2, respectively. But there is need to refine the float to reduce the frictional load.
	Weight	:	14.0 kg	
	Area covered	:	95 m2/h	
	Mean heart rate	:	138 beats per min	
	Mean work pulse	:	64 beats per min	
9	CRRI four row rice transplanter was ergonomically evaluated with farm women			
	Weight	:	23.0 kg	
	Area covered	:	245 m2/h	
	Mean heart rate	:	148 beats per min	
	Mean work pulse	:	62 beats per min	
	Cost (approx)	:	Rs. 7000.00	
10	CIAE twin wheel hoe was ergonomically evaluated with farm women.			About 43% saving in physiological cost of worker per unit of output in addition to avoiding bending/ squatting postures.
	Weight	:	5.0 kg	
	Area covered	:	150 m2/h	
	Mean heart rate	:	127 beats per min	
	Mean work pulse	:	41 beats per min	
	Cost (approx)	:	Rs. 500.00	

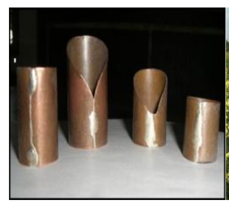
11	CIAE IEP cono-weeder was ergonomically evaluated with farm women.			It avoids bending posture as it is operated in standing posture.
	Weight	:	9.0 kg	
	Area covered	:	165 m2/h	
	Mean heart rate	:	153 beats per min	
	Cost (approx)	:	Rs. 2000.00	
12	Improved serrated sickles (Vaibhav, Naveen and Gujarat Agro) were ergonomically evaluated with farm women for harvesting wheat, paddy and soybean.			About 15% saving in physiological cost of worker per unit of output during wheat harvesting in addition to the advantage of safety to workers as it does not slip.
	Weight	:	0.2 kg	
	Area covered	:	151 m2/h in wheat	
	Mean heart rate	:	120 beats per min	
	Mean work pulse	:	27 beats per min	
	Cost (approx)	:	Rs. 60.00	
13	OUAT pedal operated paddy thresher was ergonomically evaluated with farm women.			It helps to reduce the drudgery involved in paddy threshing as bending posture is avoided and arms are not raised above shoulder height. The equipment can also be used on custom hiring also to generate income.
	Weight	:	39 kg	
	Output	:	77 kg crop/h	
	Mean heart rate	:	136 beats per min	
	Mean work pulse	:	53 beats per min	
	Cost (approx)	:	Rs. 5000.00	
14	Octagonal tubular maize sheller was ergonomically evaluated with farm women			About 15% saving in physiological cost of worker per unit of output in addition to eliminating the chances of injury to fingers of worker with this.
	Weight	:	0.22 kg	
	Output	:	27 kg cobs/h	
	Mean heart rate	:	93 beats per min	
	Mean work pulse	:	16 beats per min	
	Cost (approx)	:	Rs. 60.00	
15	Commercial available rotary maize sheller was ergonomically evaluated with farm women.			About 32% saving in physiological cost of worker per unit of output in addition to eliminating the chances of injury to fingers of worker with this.
	Weight	:	80 kg	
	Output	:	73 kg cobs/h	
	Mean heart rate	:	114 beats per min	
	Mean work pulse	:	36 beats per min	
	Cost (approx)	:	Rs.5000.00	
16	DRWA Gender friendly hand operated maize dehusker-sheller was developed using ergonomics and mechanical considerations.			About 39 per cent saving in physiological cost of worker per unit output as compared to traditional method of dehusking and shelling. About 22 per cent saving in physiological cost of worker per unit output as compared to traditional
	Weight	:	85 kg	
	Output	:	60 kg grain/h	
	Mean heart rate	:	142 beats per min	
	Mean work pulse	:	42 beats per min	

	Cost (approx)	:	Rs.18000.00	method of dehusking and shelling with tubular maize sheller. Equipment is gender-friendly. The equipment can also be used on custom hiring also to generate income.
17	DRWA refined sitting type groundnut decorticator was refined/modified for women and ergonomical evaluated with farm women.			About 79% saving in physiological cost of worker per unit of output with equipment in addition to eliminating the chances of injury to fingers of worker. The equipment can also be used on custom hiring also to generate income.
	Weight	:	10 kg	
	Output	:	30 kg pods/h	
	Mean heart rate	:	111 beats per min	
	Mean work pulse	:	27 beats per min	
	Cost (approx)	:	Rs.1200.00	
18	CIAE Standing type groundnut decorticator was also ergonomically evaluated with farm women.			About 74% saving in physiological cost of worker per unit of output with equipment in addition to eliminating the chances of injury to fingers of worker. The equipment can also be used on custom hiring also to generate income.
	Weight	:	15 kg	
	Output	:	33.1 kg pods/h	
	Mean heart rate	:	122 beats per min	
	Mean work pulse	:	42 beats per min	
	Cost (approx)	:	Rs.1500.00	
19	Commercial available Jaw type cotton stalk puller was ergonomically evaluated with farm women.			Bending posture is avoided thus reducing drudgery and chances of backache to workers in cotton stalk pulling operation.
	Weight	:	5.0 kg	
	Area covered	:	46 m2/h	
	Mean work pulse	:	25 beats per min	
	Cost (approx)	:	Rs. 500.00	
20	CRRI hand operated paddy winnower was ergonomically evaluated with farm women			Winnowing can be done at any time in enclosed area, which avoided the environment problems. The equipment can also be used on custom hiring also to generate income.
	Weight	:	36 kg	
	Output	:	242 kg /h	
	Mean heart rate	:	112 beats per min	
	Mean work pulse	:	31 beats per min	
	Cost (approx)	:	Rs.7500.00	
21.	CIAE hanging type grain cleaner was ergonomically evaluated with farm women			In addition to 63% saving in physiological cost, the productivity of worker increased more than four times with equipment as compared to traditional practice. The equipment can also be used on custom hiring also to generate income.
	Weight	:	17 kg	
	Output	:	225 kg /h	
	Mean heart rate	:	103 beats per min	
	Mean work pulse	:	22 beats per min	
	Cost (approx)	:	Rs.3500.00	

The above women friendly equipment are found suitable for various farm operations like, ridge/ furrow making, seed treatment, granular fertilizer broadcasting, sowing in lines, weeding in lines, rice transplanting in line, crop harvesting, fruit harvesting, paddy threshing, paddy winnowing, cleaning/ grading the grains, maize dehusking-shelling, maize shelling, groundnut pods stripping, groundnut decortications, stripping of sugarcane leaves, uprooting of cotton stalks, etc. These farm equipment need to be assessed amongst users (farm women) under their limitations and management. Of this, there are about seven women friendly farm equipment (Seed treatment drum, Belly mounted Fertilizer broadcaster, four row-paddy drum seeder, Groundnut stripper, Groundnut decorticator, Maize dehusker-sheller and Paddy winnower) which are suitable for custom hiring purpose and introduction of such farm equipment will increase their income and ultimately improvement in livelihood.

Technology developed by the scientists of AICRP on Home Science:

1) Finger Guard : For picking flower and vegetables ANGRAU, Hyderabad developed Finger guard to reduce drudgery.




Advantages :
- Reduces palm and finger injury
- Increase the work efficiency
- Protection of fingers from burning sensation and skin ruptures as drudgery factor
- Gender friendly technology

Cost : Rs. 150/-

2) Ring Cutter : For plucking of vegetables PAU, Ludhiana developed ring cutter for farm men and women


Advantages :
- Saves labor, time and cost of preparation.
- Reduces finger injury, as finger does not come in direct contact with the vegetable
- Reduces physiological and muscular stresses while working with improved technology
- It is easily available in market

Cost : Rs.30/-

3) Face protector: To reduce occupational health hazards GBPUA&T, Pantnagar developed a Face protector use during harvesting and weeding for farmwomen.

Advantages : Its use protect the worker from the risk of direct facial contact with sharp leaf edges and insects hence, in less of time, pace of work can be increased.

4) Cotton Picking bag : To reduce drudgery and increased efficiency CCSHAU, Hisar developed Cotton picking bag for cotton picking.

Advantages :
- Good quality cotton cloth is used for making the bag which helps in absorbing perspiration of the women.

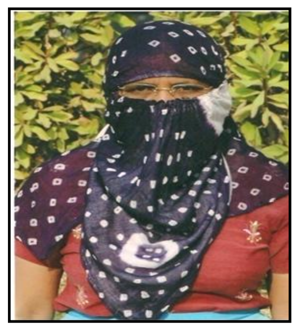
- Length of the bag is above the knees which make the women comfortable while walking.
- Provision of shaped pockets make the bag more friendly and reduce the drudgery while putting cotton in the bag

Cost : Rs 25/-

5) Protective clothing: To reduce occupational health hazards CCSHAU, Hisar developed Protective clothing for male and female pesticide applicators in thrashing period. Protective clothing were assessed to be highly suitable and acceptable by the earm workers

Cost :

- Rs.2000-/ per kit (inclusive of dress and accessories)
- Protective clothing for Threshing period Rs.1300-/ per kit (inclusive of dress and accessories)



6) Fertilizer Trolley : To reduce drudgery UAS, Dharwad centre developed Fertilizer trolley for carrying the fertilizer in the field

Advantages :

- Reduces the distance traveled from the source of fertilizer to the field.
- Reduces the load of carrying fertilizer on the body.

It has been realized that the needs of men and women with respect to technologies differ because of the differences in preference, priorities and working environment. Although women are involved in all the agricultural activities but have been using traditional methods/ tools. In agriculture, both men and women perform the farm operations but still the women workers do not use machines as mostly theses have been developed male anthropometry in mind. As a result these equipment are not suitable for women as the ergonomical characteristics (aerobic capacity, strength, anthropometry, physiological workload, work preference, wearing of loose clothes/dupatta and safety issues) of farm women differ from that of men. Above all women friendly ergonomically designed farm tools or implements should be designed to reduce drudgery and health hazards. This also leads in the direction of women empowerment. Therefore these tools and equipments can be modified or refined suitable to the workplace and to help the farm women in maximizing their activities. Safety aspects can be considered while providing improved tools and equipments.

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