

Diversification of Tribal Farming Systems

(Technological impacts on tropical islands)



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Preface

The farming in the tropical islands largely depends on the limited resources of the islands and evolved a unique way of practicing farming within the island ecosystem. The tropical islands of Nicobar are part of the union territory of Andaman and Nicobar Islands, India which is home to two most important aborigines viz. Nicobarese and Shompens. The agricultural economy is still underdeveloped and limited to meeting the food requirements of the tribes. It lacks diversification due to which it is highly vulnerable to the climate change as well. In recent years the tribes face a host of diverse challenges and new constraints due to the degradation of natural resources, and increasing demand for food. These challenges can be addressed by diversification of tribal farming.

In the fragile island environment in which the agricultural development has to take place, it is particularly important that it addresses the environmental concern and inculcate stability to the tribal system. It should also take into account the tribal customs and availability of resources. In the last few years increased interaction with the local people, capacity building, characterization of the resources of these islands at larger scale and research efforts to understand and enhance the farm production in Nicobar Islands have helped to generate lot of information pertaining to the tribal farming. We have also engaged in implementation of several programmes aimed at diversification of tribal farming system. This experience is translated into information and documented. These are very vital information required by several stakeholders for successful implementation of any developmental plan.

In this book we have made an attempt to bring together our experiences and past work carried out on diversification of tribal farming system. We have also endeavored to analyze and comprehend the information on the tribal farming practiced in the tropical islands. We believe that this book will address the needs of different stakeholders in providing information on diversification of tribal farming in the tropical islands and Nicobar Islands in particular.

Authors

AGRICULTURAL DIVERSIFICATION

IN LOWLANDS



IN TRIBAL AREAS OF CAR NICOBAR



Homestead IFS at Car Nicobar

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1. The nature of tribal farming systems

1.1 The prologue

The primitive societies referred as tribes have passed through several stages of economic development everywhere in the world at different time period. Even today, we can find different stages such as food gathering, hunting and fishing, mixed farming specialized crops, etc. among the tribes though their society has passed through ages. Thus, the history of agriculture dates back thousands of years, and its development has been driven and defined by greatly different climates, cultures, and technologies. Agriculture also called farming, is the cultivation of animals, plants and other life forms for food, fiber, biofuel, drugs and other products used to sustain and enhance human life. Agriculture was the key development in the rise of sedentary human civilization, whereby farming of domesticated species created food surpluses that nurtured the development of civilization. However, all farming generally relies on techniques or adequate knowledge of farming to expand and maintain the lands that are suitable for raising domesticated species. Some of the tribal society might have reached to the level of commercial production and some may still in the primitive stage of agriculture. Both require specific transformation through technological interventions to reach the required level of diversification so that the stability and sustainability of farming is ensured.

1.2 General characteristics

In general, the tribal economic organization is mainly concerned with producing such things as are necessary for their daily needs and consuming them. These activities are very much determined by the geographical environment of the tribe. Usually, the tribals have to struggle very hard to meet their economic needs. The following are some of the important characteristics of tribal economic organization.

i) Production without technological aids

As the tribals are illiterate and cut off from the civilized world, they generally carry out production without adequate technological aids with the

result that there is much loss of material with very little production. The tribals are, therefore, generally very poor inspite of working very hard.

ii) Mixing economic activities with religion and magic

It may not be wrong to state that the tribals live in a natural environment where there is no distinction of economic, religious and magical activities. There is, therefore, a tendency to mix all these. In the economic activities also religious and magical activities are utilized to attain economic ends.

iii) Production for consumption

In the absence of sufficient technological aids and scientific knowledge regarding agricultural and other production, the tribals generally produce only to consume. Hardly anything is left for exchange or maintain significant hoarding. In the materials of consumption, food and clothing are generally given first preference, and then there is the place for the home. In many places species already adapted to their living environment are maintained with less diversification in the production system. In some tribal societies they hardly carry out any exchange of economic goods with outside groups.

iv) Absence of regular markets

There are no regular markets found in tribal societies consequently both inputs supply and output flow is unregulated. The farm output, production is not properly linked to the market demand and, therefore, there is no competition, monopoly, business or trade in their economic organization.

v) Community basis of economic activities

Some conception of personal property is found in almost every tribal society. A person is allowed a right over the things produced by him or his family. There is, however, group ownership over the ponds, the land and the forests, etc. Thus the chief aim of economic activities in a tribal society is to fulfill the community duties. The organization of most of the economic activities is cooperative and communal. In most of the cases there is no division of labour and specialization.

vi) Economic backwardness

The above mentioned characteristics of tribal economic organization account for their economic backwardness. They are not fully aware or not able to understand the new changes and inventions in different fields of agricultural production. Their methods and implements of cultivation, hunting and fishing are mostly suitable for subsistence farming with only few exceptions. The cottage industries are carried on by means of unrefined and primitive tools and methods.

1.3 Climate change

The changes in surface air temperature and rainfall over a long period of time due to emission of greenhouse gases is known as climate change. If these parameters show year-to-year variations or cyclic trend, it is known as climate variability (IPCC, 2001). The projected temperature rise will lead to thermal expansion of the oceans and melting of glaciers and polar ice sheets resulting in the rise of mean sea level. The global mean sea level is projected to rise by 0.09 to 0.88 meter over the next century. Therefore, climate change and variability are concerns of humankind though the climate of our earth had never been static.

Small islands are among the most vulnerable to sea level rise and climate change (Mimura, 1999). Due to global warming and sea level rise, many coastal systems can experience increased levels of inundation and storm flooding, accelerated coastal erosion, seawater intrusion into groundwater and encroachment of tidal waters into estuaries and river systems (IPCC, 2007). With warmer temperatures, evapo-transpiration rates would raise, which would call for much greater efficiency of water use. Besides, land cover changes effected by human activities in the coastal areas will make agriculture more vulnerable due to salinization and erosion. This will seriously affect the tribal farming system existing in most of the tropical islands exposing them to greater risk. Climate change and global warming also affect the abundance, spawning and availability of commercially important marine fisheries (Krishnakumar et al. 2007). Increase in sea surface temperature also adversely affects coral and coral associated flora (sea grass and seaweed) and fauna. Collectively these changes are posing a

serious threat to the livelihood of coastal communities and reduce the resilient capabilities of tribal farming.

Sea level rise associated with global climate change produces greater wave attack and flooding leading to greater erosion and amplified impact of storm (Patwardhan, 2006). By mid-century, climate change is expected to reduce water resources in many small islands in the Caribbean and Pacific, to the point where they become insufficient to meet the demand during low-rainfall periods (IPCC, 2007). Rise in mean sea level causes beach erosion of 50% of all inhabited islands and 45% of tourist resorts in the Maldives to varying degrees. The island nation is particularly vulnerable to climate change owing to its heavy reliance on imported food, except for tuna and coconut. El Niño events which cause drought situations in some parts of the Pacific (e.g. Papua New Guinea, Marshall Islands, Samoa, Fiji, Tonga and Kiribati), and increased precipitation and flooding in others (e.g. Solomon Islands, and some areas in Fiji), have become more frequent in these regions (Lal et al. 2009).

The direct impact of sea level rise is that it threatens the area available for farming in the mainland which would be more pronounced for small islands like Nicobar group of islands, India. It was seen from the Indian Ocean Tsunami of 2004 that nearly 5600 ha of cultivated land in this group of islands was damaged affecting the livelihood of people. In addition, analysis of the historical climatic data indicated variation in number of rainy days and dry spell over these islands (Srivastava and Ambast, 2011). It is therefore, important to assess the vulnerability of these islands to events associated with climate change and establish response strategies. Agricultural diversification in tribal areas is one of the compelling strategies very essential to adapt to climate change and ensure livelihood security of the tribals particularly in the tropical islands.

1.4 Agricultural diversification

It is an important mechanism for economic growth of tribals. It depends, however, on available opportunities for diversification and on farmers' responsiveness to those opportunities. Traditionally, diversification

was used more in the context of a subsistence kind of farming, wherein farmers grew many crops on their farm. The household level food security as also risk was an important consideration in diversification. In the recent decade, diversification is increasingly being used to describe increase in area under high value crops (Das, 2009).

Diversification refers to a situation in which decrease in the dominance of an activity, alternately increase in the share of many activities in a system is depicted. Extending the same notion to agriculture means increase in the share of many commodities in agricultural income may be termed as income diversification in agriculture; whereas increase in the share of withdrawal of a resource by many crops may be termed as resource diversification in agriculture.

Agricultural diversification can be facilitated by technological breakthrough, by changes in consumer demand or in government policy or in trade arrangements, and by development of irrigation, roads, and other infrastructures. On the contrary, it can be impeded by risks in markets and prices and in crop-management practices, by degradation of natural resources, and by conflicting socio-economic requirements - perhaps for employment generation, or for self-sufficiency or foreign-exchange-earning capacity in particular crops or livestock or fishery or forest products (Singh et al., 2002).

Based on the level of diversification and resource endowments the farming can be divided into four groups (Fig. 1.1) viz.,

- ✓ low diversification and low per capita income
- ✓ High diversification but low per capita income
- ✓ Low diversification and high per capita income
- ✓ High diversification and high per capita income

In most of the locations the tribal farming falls under low diversification and per capita income and in some cases it has high diversification but low per capita income. As indicated earlier the major characteristics of tribal farming system is food security rather than economic gain. Agricultural diversity, which is socially acceptable, enhances sustainability of tribal farming

as well. Therefore, there is an urgent need to diversify the tribal farming so as to achieve food security and sustainability. With the introduction of technology and capacity building in long run, tribal farming may transform itself and provide high per capita income. It may also be possible to improve the existing tribal farming which are climate resilient by technological interventions in certain areas.

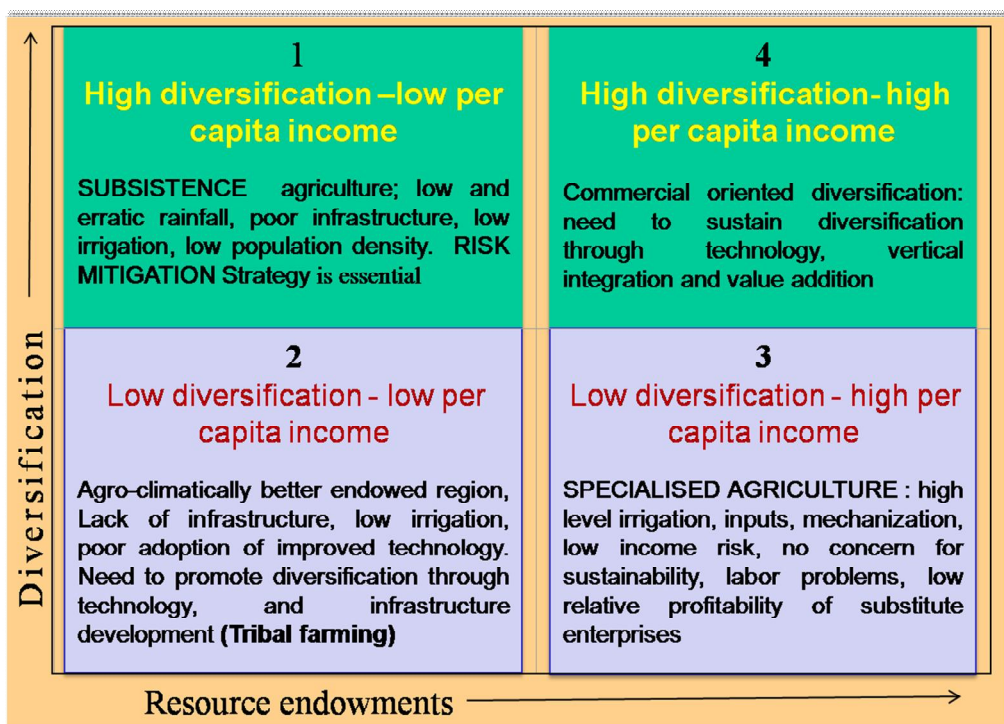


Fig. 1.1. Grouping based on diversification and resource endowments

Based on the above discussions of farming activities undertaken by the tribes their resource availability they are grouped into the following classes viz.,

- i. Hunting and food gathering tribes include Kadar, Jarawas, Sentinels, Shompens, Chenchu, Kharia and Korawa etc.
- ii. Cattle rearing tribes such as the Todas and Bhils.
- iii. Cultivating tribes such as Kumar, Vega, Birhor, Andamanese and Nicobarese.
- iv. Industrial tribes such as Kharia and Nagas.

Therefore, people's proper understanding of future threats and participation in planned counter measures is needed to implement adaptive options while ensuring livelihood security to tribals particularly through agricultural diversification.

1.5 Determinants of diversification

There are two important factors viz. supply side and demand side factors which determine the level of diversification (Fig. 1.2). The supply side factors include technology, infrastructure, market linkage, resource endowment and socio-economic factors. Unfortunately, in many of the tribal areas the level of technology adoption and infrastructure are very low. On the other hand, the demand side factors such as population, climate change and preferences impose greater pressure on tribal farming to meet the required demand. Together, these two factors shapes the nature and level of agricultural diversification in the tribal areas.

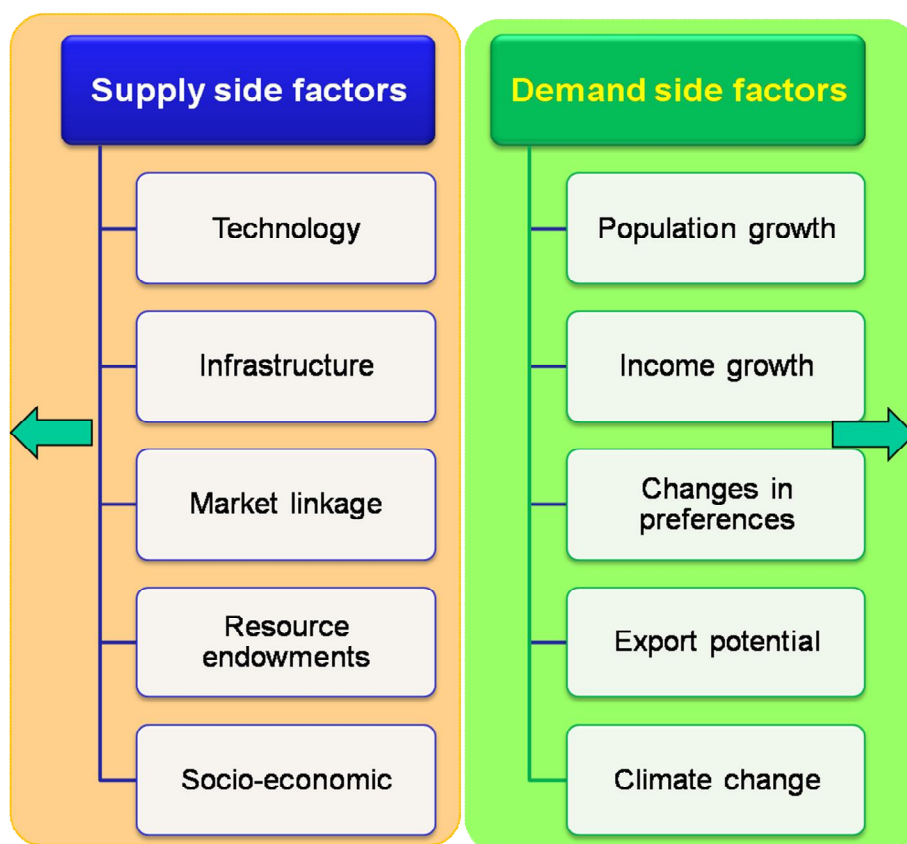


Fig. 1.2 Determinants of diversification

In view of shrinkage of agricultural land and operational holdings, changes in consumer food habits, exponential population growth rate, farmers are pressured to include or substitute additional crops in to the existing cropping system. With increasing population and the need to ensure livelihood security, it is imperative to evolve a suitable strategy for augmenting production through on farm and off farm activities. By integrating different agricultural activities based on the resource endowment and constraints of different locations, it is possible to improve the farm production as well as employment opportunities of the individual tribal households. Further, crop diversification through substitution of one crop or mixed cropping/inter-cropping may be a useful tool to mitigate problems associated with aberrant weather. This will reduce the external dependence of most of the tropical islands particularly with tribal inhabitants for livelihood.

2. Tropical Islands: Land of biodiversity and tribes

2.1 Introduction

The Andaman and Nicobar Islands is the union territory of India which is situated as a dissected chain in arcuate fashion oriented in North to South in the Bay of Bengal off the Eastern Coast of India and extended between 6° and 14° North Latitudes, and 92° and 94° East Longitudes covering a geographical area of 82 km². These islands form two major groups, popularly known as Andaman Group or the Northern Group of Islands and Nicobar Group or the Southern Group of Islands (Fig. 2.1). The Nicobar group of Islands is situated in the South-east of the Bay of Bengal which is separated from the Andaman group by 10° channel. The Nicobar group is having 22 islands of which 13 are inhabited which are divided into three subdivisions *viz.* Car Nicobar, Noncowry group and Great Nicobar.

2.2 The inhabitants

Since pre-historic times these islands have been the homes of aboriginal tribes. The areas inhabited by tribal population are notified as tribal reserve, which constitutes 34 percent of the forest area. These Islands are characterized by two distinct native cultures *viz.*, **Negroids** in Andaman Islands (the *Jarawas*, *Onges*, *Great Andamanese* and *Sentinels*) and **Mongoloids** (*Nicobarese* and *Shompens*) in Nicobar Islands. Both the native groups thrived in all difficult phases and maintained their distinct identities. Among them the Nicobarese are the largest tribal group inhabiting 12 Islands with major concentration in Car Nicobar. They were the last indigenous people to arrive on these Islands and have racial mixture with the natives of South East Asia. If we go across these islands, it can be seen that Car Nicobar is primarily inhabited by Nicobarese, the Noncowry group of islands inhabited by the Nicobarese and Sri Lankan expatriates and Great Nicobar Island inhabited by tribal Shompens and Nicobarese. Off the total population, tribal population accounts for 63% in Nicobar Islands (DES, 2011). In Andaman Island majority of them are settlers from Bangladesh and mainland India. The major tribal groups inhabiting Andaman group of Islands are

Jarawas, Sentinalese, Onges and Andamanese. Their spatial distributions in different islands are depicted in Fig. 2.1. Among them Nicobarese are the largest tribal group inhabiting the Nicobar group of islands. In certain pockets of Andaman tribes from Jharkhand and Karen community of Myanmar are also settled.

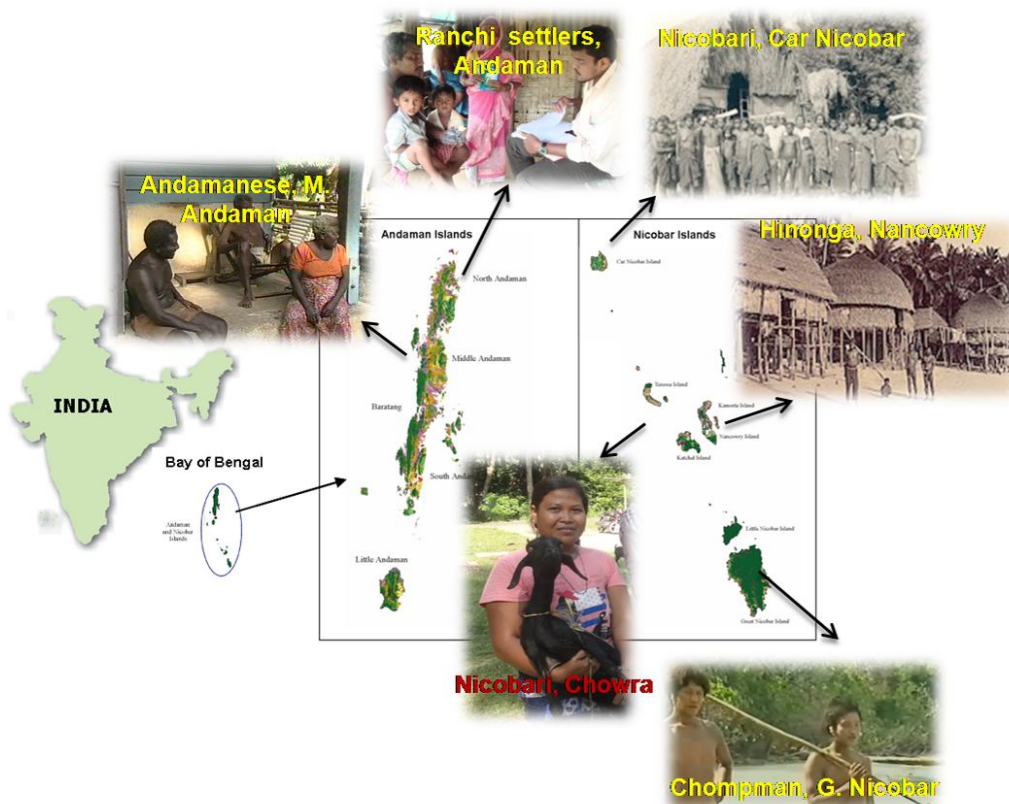


Fig. 2.1 Location and tribals of Andaman and Nicobar Islands

2.3 Climate

The Islands experience humid tropical climate with total annual rainfall ranging from 260 - 300 cm (Fig. 2.2). The mean maximum and minimum temperature are 30.2° C and 23.0° C, respectively. Major share of rainfall is received during May to December while dry period extends from January to April. The relative humidity varies from 65-90% in different period in a year. During the dry period the evapotranspiration is very high and it far exceeds the precipitations. The Islands have undulating topography, characterized by hills and longitudinal valley areas. The major land forms are longitudinal hills, hill slopes, mid hill valley and coastal plains. Agriculture, plantations,

mangroves, and forests are the major land use/cover of these islands. In general the climate and landform decides the distributions of natural vegetation and agricultural crops and other allied activities.

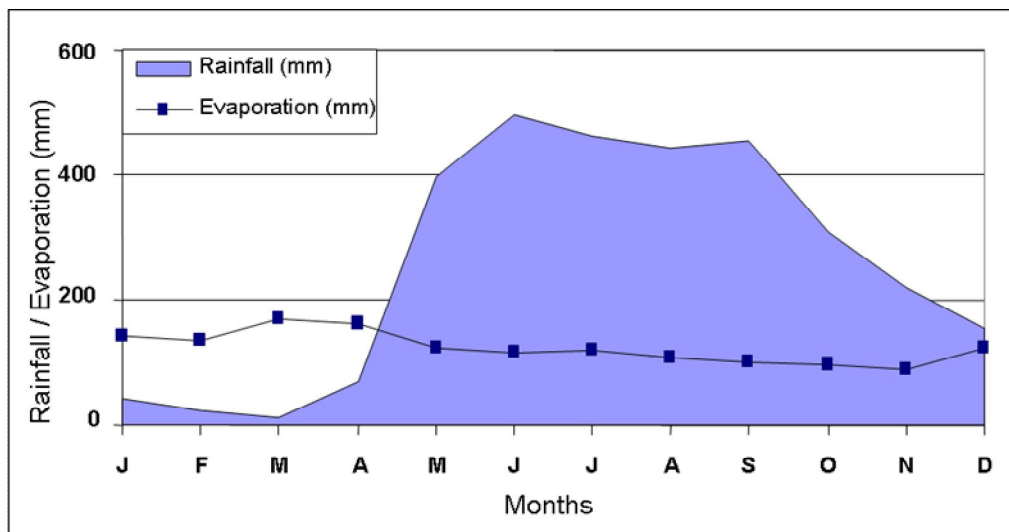


Fig. 2.2. Climatic parameters over Andaman and Nicobar Islands

2.4 Geomorphology and physiography

These islands are coral in origin having marine sediment and coralline material as base. Geomorphologically these islands can be divided into three distinct units,

- i. Low to moderately high and steep hills
- ii. Intermontane narrow valley
- iii. Limited gently sloping coastal tracts including swamps

The hill ranges are generally covered by dense forest. These islands are of coral origin and have marine sediments as base (Geological survey of India).

Only the Great Nicobar Island has an overall rugged topography with parallel ridges of folded sedimentary rocks. Other islands of Nicobar group are characterized by their remarkably flat topography except for some cliffs, and are also known for their geographical isolation and limited physical size (Fig. 2.3 A). In general, most of these islands have central elevated land surrounded by coastal plains. In terms of percent distribution nearly 30% of total geographical areas of these islands are having elevation not more than

20 m above mean sea level (Fig. 2.3 B). In Chowra and Trinket islands more than 90% of the geographical areas have elevation less than 20 m posing serious threat due to sea level rise.

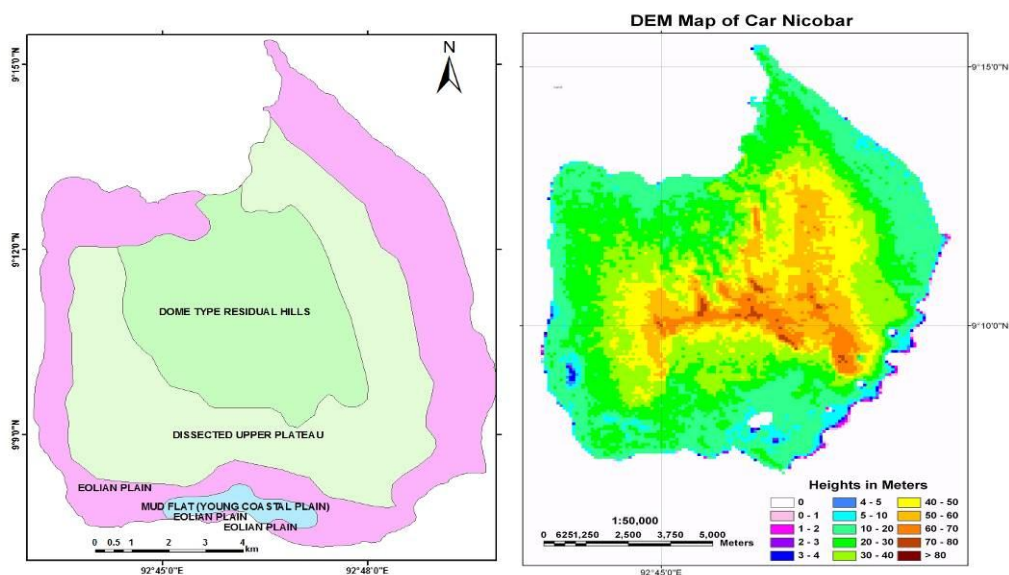


Fig. 2.3. Geomorphological (A) and Elevation (B) map of Car Nicobar

2.5 Land use

Plantation crops like coconut, arecanut and rubber are the major crops under agriculture while food crops like rice and vegetables are grown in small patches. In Car Nicobar coconut plantation is mixed with forest trees with very less management. The majority of these islands are covered with thick tropical forests in the interior and by mangroves along the coasts. The Islands are surrounded by coral reefs, which protect these Islands from the impacts of strong waves and other such effects.

2.6 Soils

The soil type of Andaman and Nicobar Islands ranges from sandy clay to sandy loam. These have developed under the dominant influence of vegetation and climate over diverse parent material. The uplands under forest cover are intensely leached, but runoff is very high, wherever forest cover has been removed completely. Parts of south and middle Andaman has low organic carbon status mainly because of severe erosion of the surface soil caused due to extensive deforestation and complete neglect of the deforested

area. In general, soil fertility analysis indicates medium in available N, low in both available P and K.

In Nicobar Islands the main agricultural soils are found in the valleys which are of alluvial and colluvial origin. The coastal areas are prone to tidal floods, soils of these islands are moderate to poor in soil fertility, and their organic matter content is on the decline in the cultivated areas. The soils of the Islands vary in depth, texture and chemical composition. They are slightly acidic to saline in nature (Fig. 2.4). These are medium textured on the surface and medium to heavy textured in the sub-soil. Humus in the forest is generally washed away due to copious rainfall and steep slopes. In general, the soils are sandy clay to clay loam in the valley and sandy in coastal areas. It is partially drained to water logged in the valley areas during rainy season. The depth of the soils is very shallow in the hill slopes to moderate in valley and coastal areas.

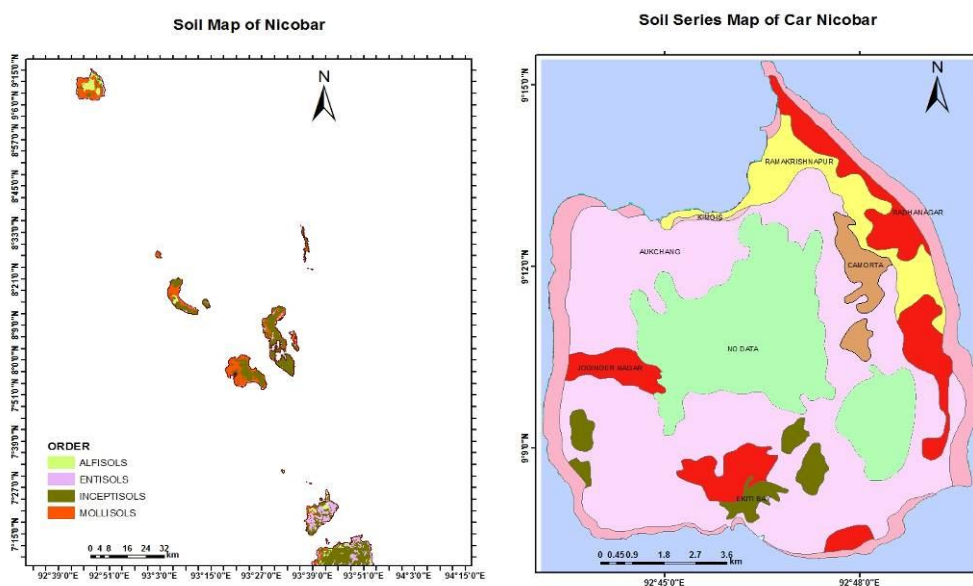


Fig. 2.4. Soil map of Nicobar Islands

The soils of Great Nicobar are acidic with high organic carbon content in surface soils. In contrast the soils of Car Nicobar shows they are shallow, coarse textured with high content of sand, calcareous and rich in organic carbon in surface layers. Apart from Inceptisols which is the majority category Alfisols and Entisols (as per USDA soil taxonomy) are also found.

2.7 The nature of farming

Only rainfed agriculture is practiced and horticultural crops are the major source of livelihood with coconut occupying an area of 80% of agricultural area in Nicobar Islands. The other crops such as banana, papaya, tapioca, sweet potato, pine apple etc. are mainly grown in home gardens. The farmers are practicing subsistence farming or natural farming as there is no application of external inputs in crop production. In Andaman Islands agriculture is confined to mid hill valley and coastal plains with less diversification and low productivity. Rice-based cropping system is predominant in the coastal valley with rice–fallow, rice–pulse, rice–vegetable, and vegetable fallows. Rice is grown during rainy season, and vegetables or pulses are mostly grown during dry season extending from December to April. Plantations of coconut and arecanut are dominant in hill slopes adjoining the valley or coastal plains (Swarnam et al., 2014).

3. Need for agricultural diversification

Population in most of the tropical world is increasing but the land area remains same in tropical Islands necessitating the production of more food from the limited area available for cultivation. Compounding with this, the agricultural systems have encountered numerous ecological and environmental constraints. The goal of ensuring food security of the tribals inhabiting these islands can be achieved by seeking the optimal use of internal production inputs. Integration of different agriculturally related enterprises with crops provides ways to recycle products and by-products of one component as input through another linked component and reduce the cost of production and thus raises the total income of the farm. In addition, multiple land use through integration of crops, livestock and aquaculture can give the best and optimum production from unit land area.

3.1 The status of natural resources

3.1.1 Soil

Soil acidity, coastal salinity and water logging are the major constraints for crop production in these Islands. The Andaman, Nancowry and Great Nicobar Islands have acid soils with pH less than 6, where as the soils are calcareous in Car Nicobar and Katchal. Because of soil acidity and calcareous nature, availability of nutrients like phosphorus (P), boron (B) and zinc (Zn) limit the crop production, while iron (Fe^{2+}) and manganese (Mn^{2+}) are found in toxic levels. Therefore, proper soil management strategies are very vital for diversification as well as improving crop production.

3.1.2 Rainfall and water

Though the Islands experience heavy rainfall during monsoon season, dry condition prevails for three months during January to March resulting in water scarcity. However, during dry period minimum of 40 mm rainfall is received in about 2 to 4 rainy days which provides scope for small scale *insitu* water harvesting to tide over the water scarcity for crop cultivation. At the same time, there is very limited scope for development of large scale reservoir, drainage system or canals in these Islands due to topographical

limitations. In addition, the impact climate change and extreme events on the agricultural production system is expected to affect the tribals particularly the coastal communities very severely.

3.1.3 Livestock

The major livestock of the tribals comprises of pig (82%) and goat (18%) which are reared in extensive open semi feral system by the tribal community. Rearing pig is considered as a traditional household activity and 76 % of the households were involved in it (Jeyakumar et al., 2014). Similarly small number of indigenous birds is reared by women in backyards (Fig. 3.1). The intensive rainfall received during monsoon season causes heavy mortality of other introduced birds like *Vanaraja* which is successful in other parts of the country. The major constraints for livestock and poultry production in these Islands are lack of improved breeds adapted to harsh conditions of the Island, low input production system, poor housing facilities / night shelters, lack of knowledge on scientific reproductive management, health care, hygiene and disease control.



Fig. 3.1 Status of livestock rearing in the tribal areas

3.1.4 Fisheries

The estimated fishery potential of the Andaman and Nicobar Islands is 2.4 lakh tons constituting 6.2% of the total fishery potential of our country. In spite of having rich fisheries potential only 13.8% of the estimated potential is exploited. In Nicobar Islands, the crafts and gears used by the fishermen are of the traditional type and of limited capacity (Fig. 3.2). Endurance for high sea fishing, exploratory and multi-day fishing, fishing for coastal tunas, oceanic tunas and other straddling stocks are not possible with the limited capacity of the craft and gear. Therefore, the development of fisheries in

these islands has been tardy. The remoteness of the islands, lack of adequate infrastructure facilities and poor knowledge of the spatial and seasonal abundance of tuna in the EEZ of these islands are the major constraints in developing a capital-intensive tuna fishing industry (Dam Roy and George, 2010).



Fig. 3.2 Traditional fishing craft of Nicobar tribes

3.2 Government policy

Besides the biophysical factors viz., climate, soil and water, government policy on land use and tribal customs also limit farm production. The land use policy of the government such as notifying the entire Nicobar Islands as Tribal reserve, Biosphere reserve and location of two national parks in these Islands limits the free movement of non-tribals and goods affecting large scale economic activity in these Islands. Off the total geographical area of Andaman and Nicobar Islands expansion of area under cultivation is not possible because of the existing laws. Moreover, in tribal areas, there is no individual land right as in other parts of the country and only usufructry rights were given to the individual households which is a major constraint for taking up any large initiatives in agriculture. It is desirable that government policy should encourage diversity and stability, particularly in island ecosystem.

3.3 Livelihood security

The livelihood security is defined as “adequate and sustainable access to income and resources to meet basic needs including adequate access to food, potable water, health facilities, educational opportunities, housing, time for community participation and social integration”. Livelihoods can be made

up of a range of on-farm and off-farm activities which together provide a variety of procurement strategies for food and cash. Therefore, diversification and improvement of agricultural production along with household based other off-farm activities should be the strategy to improve the livelihoods in these islands. Diversification in crop production can be brought about by including new enterprises supported by technological innovations, on farm processing and other farm based income generating activities.

3.4 Rationale for diversification

The Indian Ocean tsunami of December 2004 inflicted heavy damage to these islands particularly the Nicobar Islands experienced intense damage to the coastline, at places reaching several hundred meters deep inland with loss of human lives and property. This resulted in dislocation of the tribals living in the coastal areas to the central part of the Island. Besides, soil and water resources were affected due to sea water intrusion into the areas adjoining the coast in several inhabited Islands (Fig. 3.3). In addition, area under agriculture particularly of rice growing areas decreased due to permanent submergence and periodic water logging caused by the subduction of the land and earthquake.



Fig. 3.3 Impact of tsunami on land resources

Bio-physical and socio-economic constraints together with 2004 tsunami led to the degradation of natural resources especially in coastal areas and tribal inhabited islands. The economic productivity of tribal farming system has drastically decreased depriving the people of their livelihood opportunities.

In general, the following points stress the importance of agricultural diversification with a focus on food security.

- Remoteness & geographical isolation
- Limited land resources for production & their constraints – Acid & acid sulphate soils, waterlogging, water scarcity,
- Only rainfed agriculture – No irrigation systems
- Increasing population & decreasing resource base
- Dependence on supply of essential commodities such as Wheat, onion, potato, tomato, Rice, vegetables, milk & milk products from mainland
- Unemployment among educated youth
- Problems of interconnectivity – Inter Island & intra Island
- Climate change and weather variations
- Natural hazards – Earthquake, tsunami, cyclone and floods – Loss of lives, coastal degradation due to tsunami 2004

Considering the physical, socio-economic limitations and devastation caused by tsunami on these islands, an integrated approach for diversification of tribal farming system for achieving livelihood security has become very essential. This is also pertinent to several other tropical islands in the Indian Ocean region.

4. Approach for diversification

4.1 Basic concept

Information on biophysical, socio-economic and institutional factors is vital for assessing the resource availability, production, consumption pattern and employment opportunities besides economic prosperity of any region. In addition, understanding and assessing the impact of natural events such as tsunami particularly in the Indian Ocean region is indispensable to assist in restoration and rehabilitation of production system in the vulnerable and affected areas. Therefore, the basic approach should be significantly improve the livelihood security of the tribals through agricultural diversification, improvement in production, innovation in resource use and agro-ecosystem stability within the tribal social system (Fig. 4.1). This approach innovatively incorporates participatory community input and planning into each step ensuring activities is flexible and revolves around the interests and opportunities in the tribal areas. The adoption of this approach guarantees agricultural diversification and food security for the tribals.

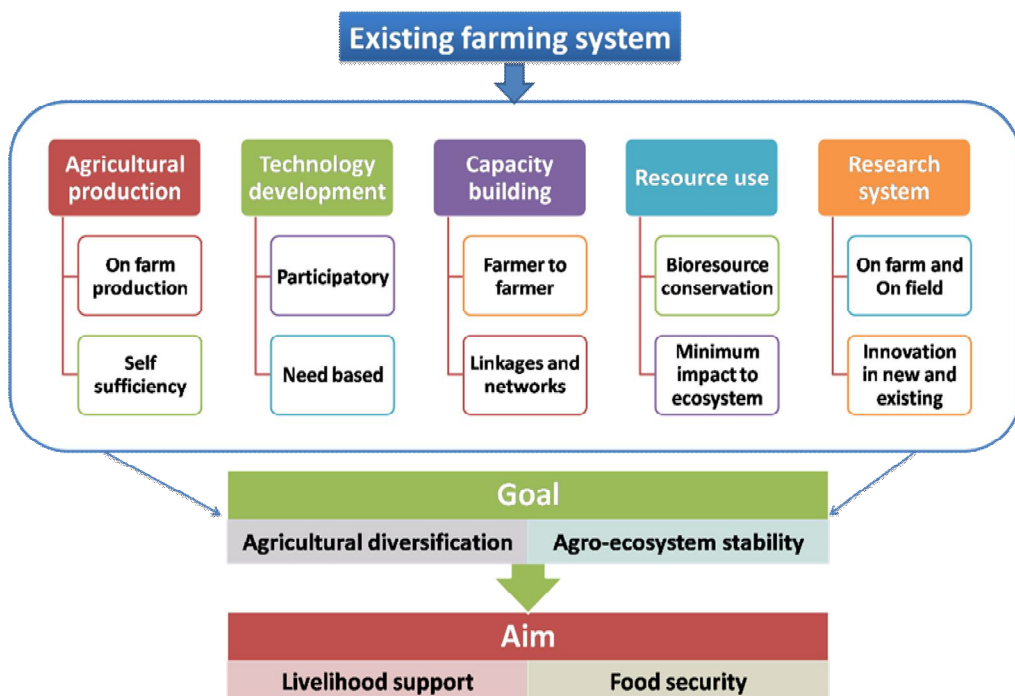


Fig. 4.1 Approach to improve the tribal farming system

The basic approach of agricultural diversification should be holistic in nature and should include the traditional skills of tribal farmers as well. Apart from crop component, livestock, fisheries and proper supporting strategies should also be essential for practicability and large scale adoption. In the tribal farming system diversification can be brought at genetic level to landscape level through a process of technological adoption (Fig. 4.2). Genetic diversity is at the core of diversification process which ensures the livelihood security and adaptation to climate change.

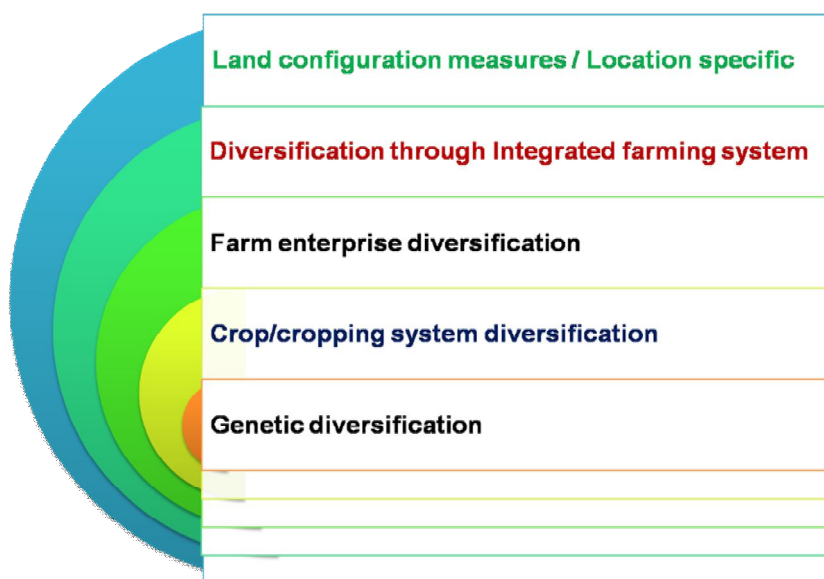


Fig. 4.2 Diversification of tribal farming system at various levels

4.2 Strategies for diversification of tribal farming

With reference to tropical islands or tribal farming areas, the basic approach for achieving agricultural diversification and livelihood security should include the followings;

- ✓ Characterization of existing farming systems to identify the problems and dissemination of suitable technologies for agricultural diversification aimed at enhancing livelihood and nutritional security
- ✓ Assessment and characterization of farm animal and fisheries resources, dissemination of suitable technologies for improving their production and integrating them with the tribal farming system

- ✓ Development of technologies and strategies for the rehabilitation of coastal degraded land to provide alternate livelihood opportunities through agricultural diversification
- ✓ Development of off farm activities through value addition and traditional handicrafts of the tribals for income diversification
- ✓ Assessing the vulnerability of tribal areas / Islands to climate change and weather extremes to develop suitable adaptation strategies and should provide value added services

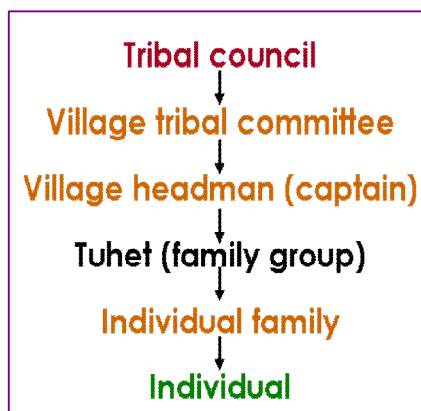
4.3 Approach for Nicobar islands

4.3.1 Characterization of biophysical and socio-economic aspects

Efforts are very much essential to characterize the biophysical and socioeconomic aspects of the tribal farming systems in an island ecosystem.

It helps to understand the constraints and identify the opportunities for development.

This forms the basis for setting priorities and devising strategies to improve the livelihood security of the inhabitants. In Nicobar Island the analysis of socio-economic status of the tribals and experiences of other agencies working in



the tribal areas suggested the importance of people's participation, group approach and small scale interventions suitable within the tribal milieu for the successful implementation of any program. As an example, homestead based integrated farming system model involving individual *tuhets* (tribal family group) was developed, for sustainable utilization of soil, water, plant and animal resources to achieve nutritional security for the tribals.

4.3.2 Land management

Land is the basic natural resource on which efforts are made to improve the farm productivity and diversify the activity to meet the demand of farmers. Land degradation has become a major concern in the tropical islands of Andaman, India and other Island nations as it directly affects the

livelihood of thousands of people. Therefore adoption of appropriate management technology is essential to manage both land and rain water as the region is also projected to suffer from sea level rise and flooding (Cruz *et al.*, 2007). The strategy for sustainable management of land resources in these islands include land shaping techniques for crop diversification in rice mono cropped areas, integration of different farm enterprises for optimum utilization of available resources, organic waste recycling through effective native microorganisms and rain water harvesting for multiple use.

4.3.3 Livestock management

Livestock forms integral part of tribal farming which adds stability to the system and greatly supports in achieving the nutritional security. In a tribal society some of the animals are domesticated since early human civilization and some find place in the vicinity of their habitat or live in the wild. Depending on the wild animal is no longer seen as a good practice to meet the livelihood security of the tribals. The livestock on which tribal rely to meet some of their basic needs are to be maintained scientifically. Therefore, the diversity and nature of different farm animals needs to be documented with the identification of major production constraints for goat, pig and dairy farming. Suitable technologies should be developed and disseminated to improve the livestock production. Apart from this, health camps for the farm animals should be organized and awareness should be created on farm animal management among the tribals inhabiting the islands.

4.3.4 Fishery resources

Many of the tropical islands have huge fisheries resources, if properly utilized which can provide sustainable livelihood to many of the tribals inhabiting these islands. Even though, Nicobar Islands have high harvestable fishery resources, it remains greatly underutilized. The fishing activity in the islands extends from 6 h to 25 days with a majority of the time being spent on scouting for fishing grounds. Potential Fishing Zone (PFZ) forecasts are highly helpful to the fisher-folk in identifying fish stocks and improve the fish harvest so as to earn better livelihood. In order to improve the fishing and processing capabilities, supports in the form of global positioning system, out

board engines, life jackets, modern fishing gears, ice box and deep freezers can be provided to the tribal fishermen with adequate training. This will greatly improve their capabilities in fishing activities. Further, to improve the local availability of freshwater fishlings nurseries based on cluster approach should be developed in the potential areas and farmers should be trained for fish breeding and nursery management to improve the employment opportunities of the rural youths.

4.3.5 Management of weather and climate change

Smaller islands are most vulnerable to climate change and extreme events therefore, it is vital to develop a reliable observational network for weather parameters. The vulnerability assessment needs to be carried out using state of art technology in observation and analysis. The task can be accomplished using freely available satellite products such as Landsat and other data pertaining to the islands, Shuttle Radar Topography Mission (SRTM) elevation data, Sea surface temperature (SST) and historic meteorological data coupled with field survey and ground observations. The data such as spatial and non-spatial data, can be integrated, by assigning uniform projection (Albers Projection) and datum (WGS 84) in a geographical information system (GIS) for geospatial analysis and prediction.

In addition to this, the tribal should be provided with weather based advisories for day to farming activities. Research organisation and development departments should join in hands to prepare and disseminate weather based integrated agromet advisories with the purpose of reducing the time and money involved in different agricultural operations, livestock production and marketing strategies by issuing weekly advisories through electronic and print media accessible to the tribals.

4.3.6 Diversification through integrated farming system

In conventional farming systems crops and livestock coexist independently from each other and serve 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. So the integrated farming system not only allows the diversification but also allows synergy between the components to increase production and productivity.

Table 4.1. Site specific IFS models for A&N Islands

System	Gross income (Rs/ha)	Expenditure (Rs/ha)	Net return (Rs/ha)	Employment generated (man days)
(a) Hilly uplands				
Plantation + buffalo + poultry	4,74,440	83,732	3,90,708	528
Existing system	3,72,560	46,152	3,26,408	365
Additional benefit	1,01,880	37,580	64,300	163
(b) Mid slope or medium uplands				
Plantation + crop + cattle + poultry + fish	5,52,017	1,57,850	3,94,167	438
Existing system	4,00,107	1,05,758	2,94,349	240
Additional benefit	1,51,910	52,092	99818	198
(c) Low lying valley or coastal plains				
Crop + cattle + poultry + fish	2,64,904	99,944	1,64,960	259
Existing	99,549	41,789	57,760	58
Additional benefit	1,65,355	58,155	1,07,200	201

Based on the principle of enhancing natural biological processes above and below the ground, the integrated system represents a winning combination that (a) reduces erosion; (b) increases crop yields, soil biological activity and nutrient recycling; (c) intensifies land use, improving profits; and (d) can therefore help reduce the negative consequences of climate change

and have the potential for providing mitigation co-benefits besides help reduce poverty and improve food security. Different IFS model have been evaluated for hilly uplands, mid slopes and low lying areas of Andaman Islands and the result showed increase in net return and employment generation (Table 4.1). This land specific IFS is more resilient to climate change and sustainable under island condition.

4.3.7 Management of natural disasters

Indian Ocean tsunami of 2006 has not only inflicted damage to agriculture in Nicobar and several islands in the Indian Ocean but also changed the coastal ecosystem. Therefore, understanding these causes and its effects are essential to devise an appropriate strategy for rehabilitation and restoration. After assessing the impact of tsunami on land and animal resources of Andaman and Nicobar islands, different rehabilitation measures such as land shaping, introduction of high yielding salinity tolerant rice varieties and drainage improvement were implemented by Central Island Agricultural Research Institute, Port Blair, by following cluster approach aimed at restoring agricultural production in the degraded areas. Besides, farm women and landless were given farm animals like goat, pig and poultry to restore their livelihood. Though the coastal and paddy fields in some parts of the Island were submerged, it provided a scope for coastal aquaculture. Hence a mangrove-based integrated aquaculture model for local coastal farmers/fishers was developed and implemented to provide alternative livelihood options in the affected areas. These measures can be fine tuned to suit to local condition of any tropical islands to manage natural disasters in the future. This is expected to reduce the vulnerability of tribals inhabiting in these islands.

4.3.8 Tools and implements

Tools and implements are very essential to reduce the drudgery in farm operations and improve the efficiency several farm implements. But, In many tropical islands tribals use traditional tools or implements which are not improved to carry out a specialized operation due to lack of scientific knowledge and facilities to manufacture. These tools are very handy and

useful and improves the efficiency of tribals while carrying out farm operations or post harvest processing. Some of the useful tools and implements are, coconut dehusker, climbers, improved axe, spade, solar dryer and biomass fired dryer. Though the designs of these tools and implements are standardized and commercially available, it needs to be suitably modified in design to suit ergonomically to the tribes, developed and should be provided to the tribal farmers. Also, seeds of salinity tolerant, high yielding varieties, seedlings should be distributed to tribal farmers as a means of new technologies.

4.3.9 Capacity building

The success of any technology and its adoption depends on the effective dissemination and its acceptance by the stakeholders. Therefore, efforts should be made to organize capacity building programs such as trainings, on farm demonstrations, visit to research farms, livestock farms of line departments and the fields of successful farmers. This will raise the awareness and knowledge level of the tribes. The approach is universally applicable but the cultural element of each tribe should be taken into account while planning for capacity building programs. There is ample scope to use the mass media such as radio, television and news papers in these activities for introduction and popularization of the technologies.

4.3.10 Bio-resource documentation and traditional knowledge

It is also vital to document the bioresources of the tribal areas so as to conserve and harness the benefit for enhancing the production of tribal farming systems. Several species of indigenous tubers, greens, multipurpose trees and microbes should be evaluated and documented for further use and suitable inclusion in the tribal farming systems. In addition, the indigenous technical knowledge of the tribes on agriculture production, livestock management and natural resource conservation needs to be evaluated and documented. The most successful and scientifically proven aspects of tribal traditional knowledge can be upscaled to other regions.

5. Targeting to enhance agricultural diversification

5.1 The basis for targeting

Many the tropical islands lie scattered surrounded by seas and oceans. As the inhabiting tribals belong to different ethnic groups and different levels in the economic development, any efforts towards technology dissemination need to be targeted. Concurrently, proper utilization of mass media becomes very handy. Here, targeting means, identification of target group, identification of their spread, method and medium of dissemination and nature of technology or intervention required for diversification and enhancing agricultural production. This assumes significance because it ensures the benefit reaches the target people living in different Islands.

5.2 A model for tribal areas

While targeting diversification of tribal farming the basic activities and requirements needs to be identified in the first step. This should be included in the planning process itself. This involves resource assessment, identification of technological gap, identification of suitable technology, identification of farmers / tribal groups, selection of medium and methods of communication and time frame for implementation. This holds good for any of the tropical islands while implementing any developmental programme aimed at improving tribal farming system.

Targeting of different islands and the inhabiting tribals through different means of communications for various activities aimed to achieve agricultural diversification are depicted in Fig. 5.1. In an effort to diversify the tribal farming system, resource assessment and characterization was carried out in all the tribal dominated Islands of Nicobar viz., Car Nicobar, Nancowry, Katchal, Kamorta and Hut Bay by stratified random sampling. Tribal farmers from different *tuhets* (extended joint family) of Kinmai, Kimios, Small Lapathy and Big Lapathy villages of Car Nicobar were adopted after consultation with the tribal council and village captains to improve the farming system through integrated farming system approach. In some other tribal villages farm tools and equipments apart from inputs were distributed to facilitate diversification.

The rehabilitation of coastal degraded areas was carried out in a cluster approach after a base line survey of North, Middle and South Andaman Islands. Farmers from tsunami affected village panchayats of Madhupur, Laxmipur, Dasratpur, Sabari, Tushnabad, Shoalbay and Chouldhari were selected for the demonstration of land shaping techniques, drainage improvement, integrated carp culture and livestock based interventions to achieve agricultural diversification and food security.

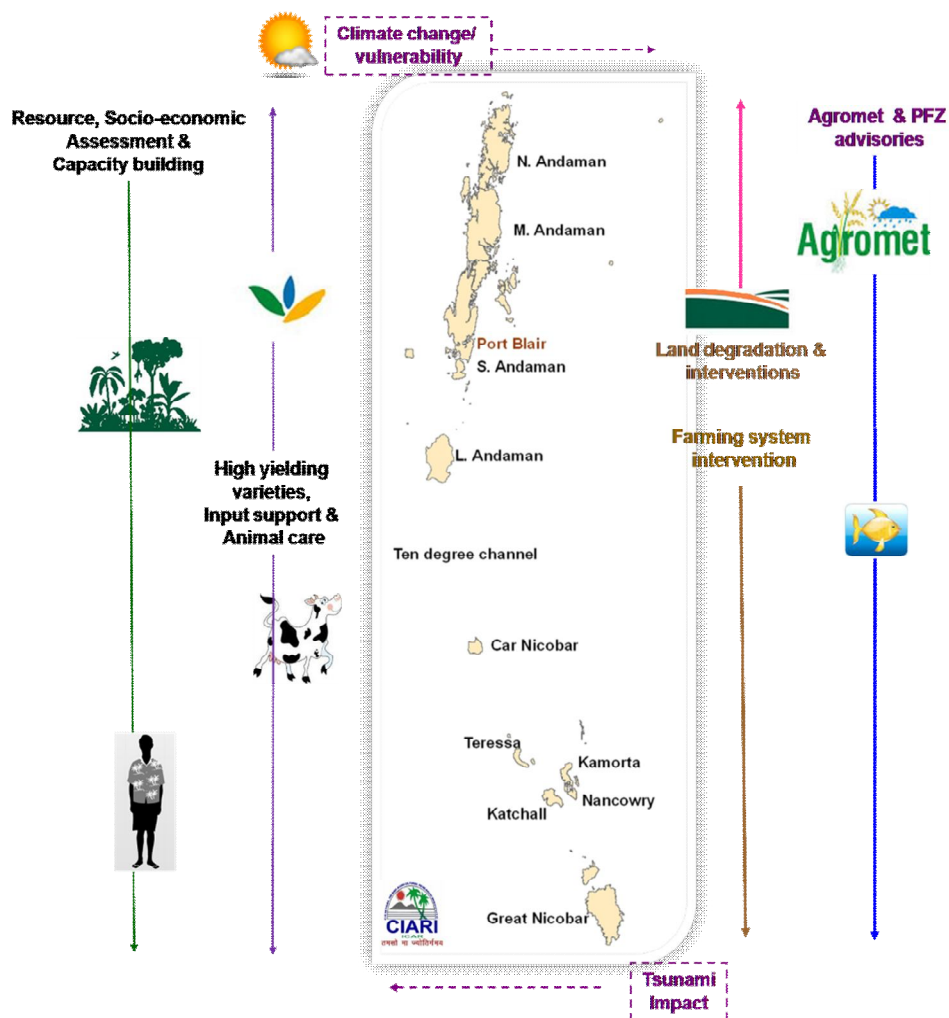


Fig. 5.1 Targets and the strategies for improving the tribal farming system

In addition, farmers from far off villages located in Neil, Havelock and little Andaman have been given special attention in respect of animal health care and livestock based input support. The Integrated Agromet and Potential Fishing Zone advisories reach all the stakeholders throughout Andaman and

Nicobar Islands twice a week through print, electronic and mobile communications.

5.3 Advantages

We found that the approach was very effective in targeting and helped to achieved desired goals in diversification efforts. This reduces time and cost involved in dissemination of technologies and more effective as the target group and activities are well defined in this approach. Similar approach of targeting of tribes for agricultural diversification elsewhere in the tropical islands also holds good. Some of the islands can only be reached effectively by electronic media or radio, which are in general, climate resilient. Further, such a targeted approach is also effective to disseminate market intelligence which helps the tribals to enhance their farm income through diversified agricultural activities.

6. Organization of activities

In order to accomplish the goal of improving the tribal farming system and achieve food and livelihood security through agricultural diversification, proper organization of the research and developmental work is very much essential. A two way information flow between the targeted population and the scientific team attempting agricultural diversification in the tribal areas with proper coordination and institutional framework was fundamental for the success. A model used in successful transfer of technology and diversification of tribal farming is depicted in Fig. 6.1. On the whole, the team should organize themselves based on their expertise to analyze the existing farming systems, identify the constraints and potentialities of target areas, and plan and execute the work with the involvement of tribal society.

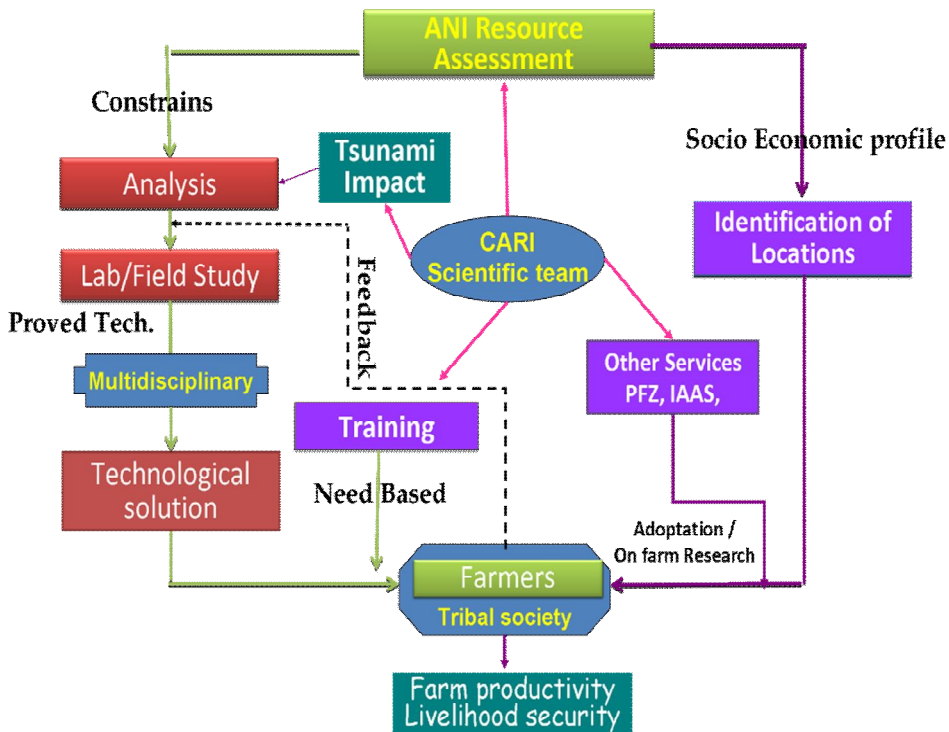


Fig. 6.1 Organization of research and extension work in the targeted areas

6.1 Characterization

Farming system and socio-economic characterization was carried out in the tribal dominated islands of Nicobar and Hut bay. In each island 3

villages in different physiographic position were selected in which 7 *tuhets* (tribal family group) from each village was selected. Tribal farmers were selected randomly with in each *tuhets* so as to constitute stratified random samples and household survey was conducted using questionnaire method. Similar approach was followed for the entire Andaman Islands. Remote sensing and GIS were used along with field survey to map and assess the natural resources of the entire Andaman and Nicobar islands. During the survey soil, water and plant samples were collected to assess the nutrient status and its potential for use in agricultural production. These data sets were pooled and statistically analyzed. Based on the constraints, capabilities and priorities expressed by the farmers, on station and on farm research were conducted and developmental strategies were formulated for the improvement and diversification of the tribal farming systems.

6.2 Livestock wealth and support

The survey also provided the status of livestock wealth in these islands which helped in identification of problems and devise strategies to address them. Periodical health camps were organized and infertility issues especially in goat and cattles were attended at farmer's door step using modern techniques such as ultrasound sonography and artificial insemination.

6.3 Baseline information for land improvement

Baseline information of the study area and target group is very much required for successful implementation of any agricultural development programme. This is also essential to evaluate the impact at the end of the project implementation. So as to achieve the diversity in farming baseline household survey was conducted in the coastal villages after tsunami in order to find out the extent of degradation, and technological options for improvement. Suitable technologies already developed in the Institute and elsewhere in India were evaluated on pilot basis before its implementation in tsunami affected coastal areas for restoring the livelihood through agricultural diversification. Besides, inputs such as seeds, seedlings of plantation crops, fish and small farm tools were distributed to individual farm families.

6.4 Capacity building

In order to impart necessary skills, several on station and on farm capacity building programs in the form of trainings, field day, expert visits, group interaction were conducted. The technology dissemination was done through print media, radio and T.V talks by the participating scientist apart from publication of folders, bulletins etc. During the training, efforts were made to develop entrepreneurship among the potential rural youths in commercial fish culture, seed production and livestock farming. The Integrated agromet and PFZ bulletins were published periodically for the benefit of farmers and fisherman of entire Andaman and Nicobar Islands through print and electronic media. To improve the efficiency of farming and fishing activities necessary inputs were distributed to the fish farmers.

6.5 Periodic review

The progress of various projects and planned developmental activities to improve the livelihood security and agricultural diversification should be periodically reviewed at the institute level by the Head of the institute /change agent. This will help to take corrective measures and bring all those involved together with a resolve to accomplish the task. This also helps to integrate the activities in the organizational work and get help from the strength of an organization. In addition, regular consultation and review of activities have to be carried out by the team members along with tribal leaders and other stakeholders. In this case, accordingly the milestones were set individually and collectively in the fields relevant and essential to achieve diversification such as soil science, agronomy, animal science and fisheries science. They are as follows,

(a) Resource assessment

- Biophysical and socio economic characterization of tribal farming systems and analysis and prioritization of constraints
- Assessing the farm animal biodiversity and characterization of indigenous germplasm for conservation and improvement
- Documentation of indigenous knowledge on farm activities

(b) Developing technologies for improving the productivity and diversification of existing farming system

- Developing technologies / evaluation of suitable methods for improving productivity of land, crop, animal and fishery resources
- Developing integrated farming system models and agricultural diversification strategies for tribal areas through on farm participatory research
- Identification of avenues for off farm activities, processing and value addition of farm products to diversify family income
- Implementation of suitable technological interventions in coastal degraded areas of the Island for rainwater harvesting and crop diversification

(c) Dissemination of technologies

- Organizing capacity building programs like training and scientist-farmers interaction meet etc.
- Conducting on farm demonstration of technologies through farmers participatory mode
- Regular radio and TV talks and live shows to reach out to every household
- Issuing integrated agromet and potential fishing zone advisories through SMS
- Field visit to research farms, successful farmers field etc.

(d) Climate change and impact studies

- Assessing the vulnerability of Nicobar group of Islands to climate change and extreme events
- Impact assessment of *tsunami* on coastal areas of the Islands and identification of technologies for rehabilitating the affected areas

This kind of division of work and organizational structure will bring greater flexibility in addressing issues, bring focus on the target to be achieved and stability to the process.

7. Assessment of pre-intervention status

It is very essential to know the conditions and opportunities before actually initiating any developmental work or technological intervention to accomplish the desirable results. While working in tribal areas it is more than required that at each stage we focus on identifying how the projects / planned activities can deliver value for money and efforts even as delivering intended benefits. An important aspect of the pre intervention assessment is that information from past projects and experience is also translated into lessons learned to improve current and future programmes.

The pre-intervention assessment can be used to assess if a project or intervention is worthwhile in a broad sense i.e. will it bring the agricultural diversification and have the social and economic benefit expected. If, so the efforts can be justified and chances of efforts and technological intervention getting diverted or diluted is minimized. In this case, diversification of tribal farming to achieve sustainability and nutritional security of the tribes should be kept in mind before designing / formulating the strategy. This is very much required because as in the case of continental India, there are wide demographic variations among the inhabitant of Andaman and Nicobar Islands in religion, language, race and socio-economic status. A detailed survey was carried out in the tribal dominated Island and tsunami affected areas of these Islands. The details are given below:

7.1 Tribal areas of Nicobar Islands

The Nicobari tribes were the last indigenous people to arrive on these Islands and have racial mixture with the natives of South East Asia. Unlike other tribal groups, they have good contact with outside the tribal society and socio-economically more developed than any other tribal groups inhabiting Andaman and Nicobar Islands (Swarnam et al., 2015). Nevertheless the technological adoption is still poor; the main crop coconut is maintained without proper management and spacing (Fig. 7.1). Majority of the tribal households were headed by men (79.1%). The average age of the household

head was 48 years and majority (73.4 %) of them was in active workforce (less than 55 years). The family size varied from 2 to 16 and 10-15 family constitutes a *tuhet* (tribal extended family).

The adoption and acceptance of technologies is still at very slow phase. Poorly developed market network seriously discourages farmers from taking up larger initiative to enhance his farm production and diversification. It was observed that less importance given to the tribal customs and practices let to the non-acceptance or partial success of several agricultural technological interventions mooted by government departments.



A. Poorly maintained coconut garden



B. Working together of extended joint family



C. Primitive way of collection of coconut



D. Primitive way of copra production

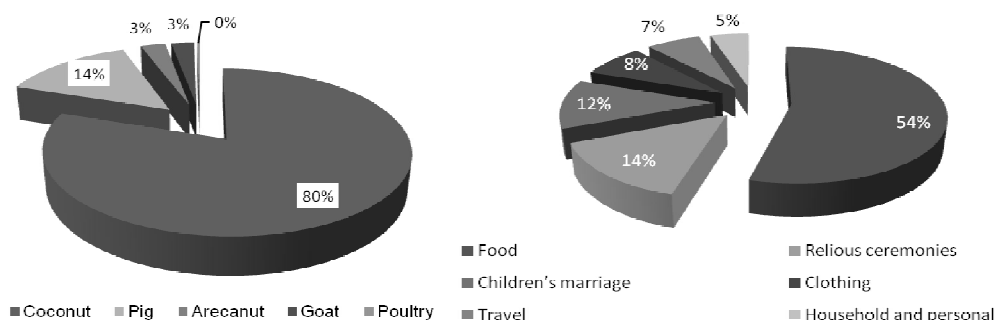
Fig. 7.1 A glimpse of status of tribal farming system

The average income of tribal household was calculated as (INR) Rs.46,000/- (at standard price) from major farm enterprises. In general, plantation crops viz., coconut and areca nut accounted for maximum returns followed by pig (14%) and goat (3%). Poultry is practiced as family poultry and

mainly used for home consumption rather than a major source of farm income (Fig. 7.2). Based on the income contribution from different farm enterprises, coconut based farming was identified as the most prevalent farming system and the farming is not diversified due to lack of knowledge and suboptimal resources use.

The average annual expenditure is (INR) Rs. 38,000/- (at constant price) for an individual household. The expenditure pattern indicated that the major expenses were on food followed by religious ceremonies, children's marriage besides household and personal maintenance including health costs which were covered mainly by selling copra. The expenditure on food grains such as rice, wheat and pulses are substantial (54%) as these crops are not grown in these Islands. In general, farm income could satisfy family expenditure of almost 85% of households while remaining 14% met from other sources.

Fig. 7.2 Certain characteristics of tribal farming system



The food consumption pattern indicates that the Nicobari diet mainly depends on food grains brought from the mainland such as rice, wheat, pulses with home grown tuber crops like greater yam, tapioca and fruits of banana, pineapple and pandanus. The consumption of meat, egg, fish and vegetable is less than the recommended level. The dietary intake of tribal's comprises mainly of carbohydrate sources with imbalance of protein, fat, fruit and vegetables. The vegetables like bhendi, amaranth, brinjal, green chilli, tomato etc. are not grown in the Islands due to lack of space, water in the dry season and other inputs. Due to shortfall in production / non-availability of vegetables and imbalanced intake of major food items limits their nutritional security.

7.2 Coastal degraded areas

The coastal areas of South and Middle Andaman was worst affected by the December 2004 Indian Ocean tsunami. Some of the small Nicobar Islands got inundated upto 40%. A total of four village clusters most affected by 2004 Indian Ocean tsunami and relatively backward viz., Chouldhari, Shoal Bay, Dashrathpur and Deshbandhugram were selected for technological intervention aimed at diversification of agriculture through demonstration, input supply and capacity building. A general nature of these soils can be seen in Fig. 7.3. A detailed socio-economic survey was carried out in the project area which indicated that low land constituted nearly 54% of the land area followed by upland 24.9% and hilly land 20.9%. Acid saline conditions followed by water logging were the major land problems besides high cost and timely non-availability of farm inputs. The average size of land holding is 2.2 ha with marginal farmers accounting 21.6% of the total households. Because of this the agricultural diversification and productivity was very low resulting in inadequate livelihood support.



A. Salt deposits on the surface

B. Waterlogged soils

Fig. 7.3 Degraded coastal land in A&N Islands

The Primary occupation of majority of the population in the project areas was agriculture (56.4%) followed by fisheries (8.2) and livestock rearing (6.3%). Besides, 20% of them involved in service sector while 9.3% in

business activities. The percent rice cultivators reduced from 71% to 59 % and vegetable growers during rabi season reduced to 44% after the 2004 tsunami. In addition, the cropping intensity of the study area was also reduced to 120%. Out of the total production of paddy nearly 71% was used for self consumption, 22% is sold in the market at an average selling price of Rs.8 kg⁻¹ and 7% was kept for seed purposes. Similarly out of the total production of vegetables only 13.7% was used for self consumption and rest of the production is sold in the market at an average rate of Rs.25 kg⁻¹. Off the farm families surveyed, 35.1% rear goat and 75.3% had back yard poultry. The survey also showed that on an average income from crop cultivation was (INR) Rs.35,000 followed by (INR) Rs.13,000 from livestock and (INR) Rs.10,000 from fisheries. In the severely affected coastal areas (Fig. 7.4) the land was left fallow and the farmers become labourers or take up other service activities. Other livelihood opportunities were very minimal due to lack of opportunities or adequate technical skills.



Acid sulphate soil & water logged



Flooding due to sea water intrusion

Fig. 7.4 Acid sulphate soil and water logging in the coastal areas

7.3 *Ex ante* impact assessment

Assessment of pre-intervention status is very important to understand the status of technological adoption, resource status, required technologies and its possible impact. This help to carry out *ex ante* impact assessment before any developmental program is initiated in the tribal areas as an aid in priority setting, based on the potential impacts of alternative research portfolios on aggregate net benefits. *Ex ante* impact studies are conducted to

estimate the expected returns from current alternative research efforts and technology generation. Assessment of future impact includes measures of productivity impacts, distribution of economic benefits, and effects on environmental quality. Assessing expected impact is a two-stage process (Pachico 2001): (1) scenarios are generated with the conditions expected in the future without the proposed research; and (2) the impact of potential research innovations is estimated. Considerable uncertainties exist in the generation of future scenarios as well as in the projections of expert knowledge of the potential payoffs from research and the probabilities of success (Alston et al. 1995). In practice, *ex ante* impact studies have been conducted for just a single technology development program based on information obtained from on-farm trials and thus have little or no priority setting motivation (e.g., Kristjanson et al. 2002). Such studies provide valuable information on the potential impact of the technology developed and help to make the case for continued efforts and investments in technology promotion.

8. Understanding the resource endowment

It is very important to assess and analyze the effectiveness of activities involved in diversification of tribal farming system aimed at livelihood and food security. This enables us to understand not only the impact but also reassess the technological gap and to work out the corrective measures. But the success depends on the resource endowment of the target region. It is important that any activity or technology aimed at agricultural development and diversification takes into account the available resources and its characters to ensure success and sustainability. In this case study, the research and extension activities were aimed at improving the farming system and livelihood security of the tribals in Andaman and Nicobar Islands. The region is endowed with several natural resources such as water, soil, fisheries while some are deficit which needs to be managed or alternate strategies are required. The resources and their characters of the tribal areas are described below:

8.1 Resource assessment

8.1.1 Water Resources

The Nicobar group of Islands is located in the tropical region due to which it experiences heavy rainfall during monsoon period from April to December with precipitation exceeding evapotranspiration (ET) resulting in water surplus situations. During the period the number of rainy days exceeds 15 in every month. But, dry condition prevails from January to March, wherein ET exceeds precipitation and rapid loss of soil moisture takes place due to intense heat. Historical data indicated that the maximum length of dry spell was 13.5 days which occurs with more than 70% probability (Velmurugan et al., 2015). Incidentally this period also accounts for highest rate of evapotranspiration and faster soil moisture depletion. As a result, water scarcity limits the cultivation of annual crops during dry period which necessitates appropriate water harvesting structures.

Table 8.1 Projected water demand in selected Islands

Name	Water availability (BCM)	Projected population		Projected water demand* (BCM)	
		2011	2021	2011	2021
S. Andaman	4.178	230893	293004	0.242	0.307
Car Nicobar	0.393	25750	32677	0.027	0.034
Chowra	0.025	1758	2230	0.002	0.002

* Includes demand of drinking water and food requirements

The present average food ingest of 2800 kcal/person/day require 1000 m³ per annum for its production which is met only from rainfall and surface soil moisture. Food crops require 0.4 BCM of water per annum and in Car Nicobar it is only 0.03 BCM for irrigation (Table 8.1). Even If we develop only 20% of the water resources it can meet the demand in the future. The surface water resources are available only during monsoon season and there is very limited scope for its development.

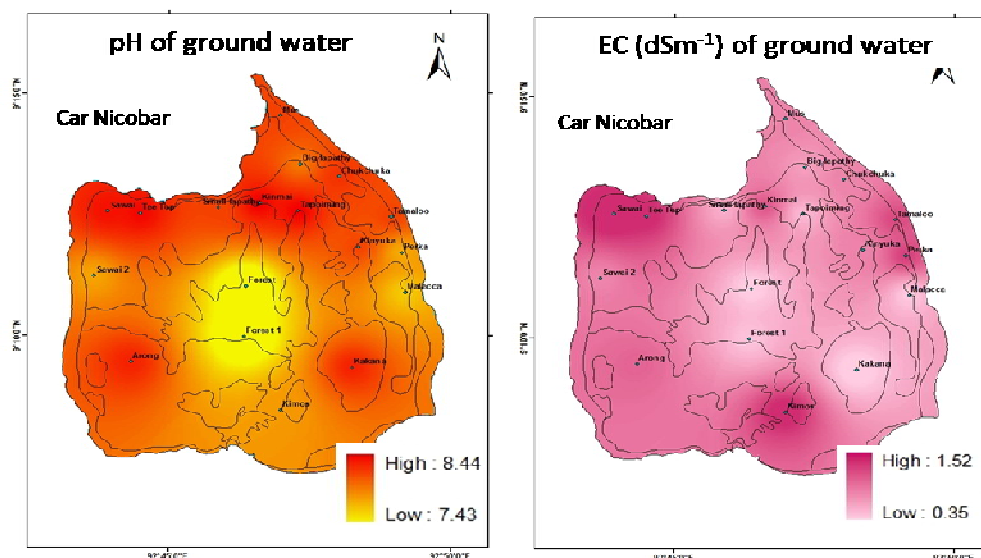


Fig. 8.1. pH and EC at Car Nicobar

The available data indicated that the overall quality of surface and ground water in Nicobar Islands are well with the acceptable limits for its multiple uses barring few locations (Fig. 8.1). However, if over exploitation continues at coastal locations it may lead to sea water intrusion into the fresh water coastal aquifers. Studies also showed that surface water can be stored

and effectively utilized if lined tanks on top of hill, tank cum well system in the mid hills and open dug well in the valley areas are developed (Swarnam et al., 2014). Hence, rain water harvesting forms a viable alternate source to support agricultural diversification particularly during the dry season.

8.1.2 Soil resources

The nature and properties of the soils determine the productivity and developmental potential of these Islands. The study indicated that soil properties (Table 8.2) vary across the Islands. The soil reaction indicates the presence of acidic, neutral, calcareous and alkaline soils in different Islands. The soils of Car Nicobar and Katchal are neutral to calcareous and non saline with higher mean organic carbon content (2.03%).

The soils are medium to high in available nutrient status viz., N, P and K. The calcareous soils affects the nutrient availability especially P. While Nancowry and Kamorta Islands acid soils are found with average pH values of 5.3 and having low P status (10.1 to 12 kg ha⁻¹). The soils of Hut bay were alkaline (pH =8.0), poor to medium in N, P and K. As the Nicobar group of Island is declared only for organic production by the government, technological interventions for sustaining soil fertility through organic means are essential.

Table 8.2 Surface (0-20cm) soil properties of different Islands

Island	Item	pH	EC (dS m ⁻¹)	% O.C.	Available macronutrients (kg ha ⁻¹)		
					N	P	K
Car Nicobar	Mean	7.1	0.06	2.03	361	22.0	230
	SD	0.7	0.05	0.39	66	7.3	82
Nancowry	Mean	5.3	0.07	2.09	349	12.0	239
	SD	0.3	0.01	1.07	32	4.6	51
Katchal	Mean	7.3	0.11	1.79	309	21.4	198
	SD	0.4	0.02	0.76	42	5.6	23
Kamorta	Mean	5.2	0.12	1.70	285	10.1	247
	SD	0.5	0.04	0.20	145	2.2	54
Hut Bay	Mean	8.1	0.2	1.10	235	12.5	238
	SD	0.5	0.17	0.45	36	3.6	78

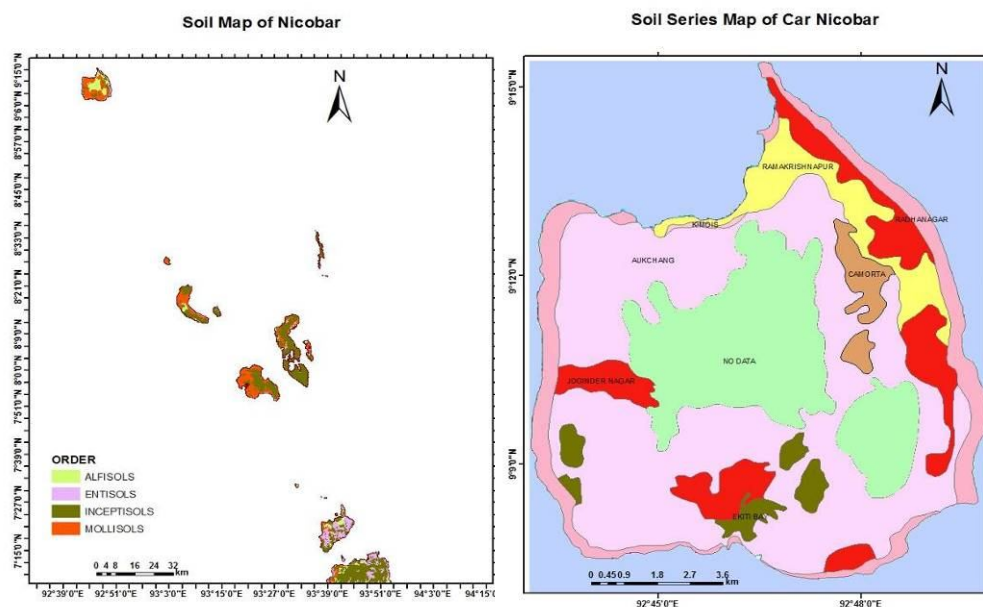


Fig. 8.2. Soil map of Nicobar islands

Taking advantage of the policy support and availability of plenty of organic residues, essential plant nutrients can be supplied by adopting to vermicomposting. Concurrently, organic waste can be enriched by adding rock phosphate and phosphorus solubilizing organisms so as to support the nutrient requirement of different crops included in diversification activities.

8.1.3 Fishery Resources

Andaman and Nicobar Islands have 20% of Exclusive Economic Zone (EEZ) and 25% of the coastline of India. The annual fish production of the islands is 33,159 tonnes of which 99% is from marine capture fisheries. The important marine fishery resources include coastal pelagic, demersal, offshore and deep sea fishes. The bulk of the catch is from pelagic and demersal fishes like sardines, mackerel, anchovies, carangids, mullets, porches, silver bellies, barracuda, tuna etc (Dam Roy and Grinson, 2010). The studies indicated that January to April is the peak fishing season while May- August is the lean season. Only 38% of demersal fishes are exploited because of non availability of suitable craft and gear. Moreover, traditional boats operate in the in-shore and part of near shore waters only. Similarly the potential of harvestable oceanic tuna is estimated at 83,000 Mt of which only 2.7% is exploited at present. The tunas are reported to occur in abundance especially

around great Nicobar, south of Car Nicobar and southern regions. Similarly, the average potential of reef fishes is about 3000 to 6000 MT from existing coral reef areas (Dam Roy et.al, 2014). Among the reef fishes, perches and perch like fishes are represented by 7 major groups are important and the peak fishing season for these fishes is August to November. The *groupers* are specially targeted group for export as live fish having annual of about 300-600 MT. The major limitations which impede mariculture development in the islands are availability of seeds and access to the potential markets. Development in fisheries sector in these island provide livelihood to tribal youth and nutritional security. The traditional skills and gears of the tribals in fishing particularly in the estuarine and nearshore areas should be evaluated and improved for greater acceptance of the interventions.

8.1.4 Production systems of Tribal farming

In Nicobar Islands plantation crops especially coconut (*Cocos nucifera*) occupies 84% of the area under agriculture followed by areca nut (*Areca catechu*) (Table 8.3). In addition, fruit crops such as banana (*Musa sp*), papaya (*Carica papaya*) and pine apple (*Ananas comosus*) covers an area of about 4%. Though the tuber crops such as greater yam (*Dioscorea alata*), colocasia (*Colocasia esculenta*), cassava (*Manihot esculenta*) and sweet potato (*Ipomoea batatas*) occupies significant place in the tribal society, it covers only 1 % of the agricultural area.

Table 8.3 Structure of crop and livestock production in tribal household

Statistic Variable	Minimum	Maximum	Std. Deviation	Mean	% household
Household size	2	16	5.9	2.3	-
Coconut	10	1000	235	179	100
Areca nut	0	1000	38	110	36
Pig (herd size)	0	30	3.3	4.2	76
Goat	0	15	1.7	3.0	38
Poultry	0	150	9	16	41

In addition, livestock also forms part of the tribal farming system which varies between 36 to 76% of households. Further, inequality analysis of the tribal farming society was also carried out. The skewness of the distribution as indicated from standard deviation showed existence of inequalities in tribal society and highest inequality was found in coconut, while lowest in goat ownership.

After a systematic questionnaire survey it was found that isolation and remoteness of the Islands were the major constraint as expressed by majority (74.1%) of the respondents (Fig. 8.3). The other issues were monopoly in copra marketing (75.5%), tuhet system (63.9%) which imposes sharing at least some part of the individual income with all members of the tuhet. Water scarcity (58.7%), lack of knowledge on new agro techniques for annual crops especially vegetables (51.4%) and lack of improved native breeds of pig, goat and poultry (30.6%) were also identified as some of the constraints for improving farm production in the tribal areas of the Islands (Swarnam et al., 2014).

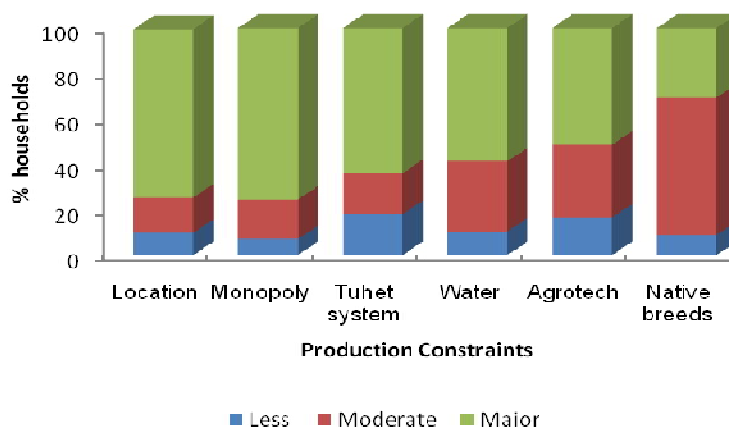


Fig. 8.3 Major constraints experienced in farm production

Due to remoteness and isolation of these islands the economic activity is very low and the production of perishable products like vegetables, fruits, and poultry cannot be taken up on a larger scale. Moreover, there is no scope for area expansion under agriculture because of existing laws. Only at Car Nicobar, there is limited market availability for these items. The purchase of copra is controlled by tribal co-operative society and no free market for this

product because of which the tribals were not getting remunerative price for their product. Besides, crude methods of copra drying affect its quality due to excessive moisture, sudden incessant rains and high humidity.

8.2 Characterization and conservation of Island bioresources

8.2.1 Native breeds of tribal areas

The Nicobar Islands are known for their indigenous animals such as Nicobari fowl, pig and Teresa goat however, after tsunami they were in danger of extinction. Efforts are made to characterize and conserve the Teresa goat and Nicobari pigs. For this extensive survey has been conducted in Teressa, Katchal and Champin islands of Nicobar district to record information about population status, physical characters, slaughter and carcass processing among the tribes of Nicobar group of Islands. This will enable to improve the native breeds which are well adapted the local conditions and accepted by the tribals.

(a) Teresa goat

The herd size of Teresa goat is higher in Teresa Island (11.9) compared to others. Majority of the goats appeared tall, brownish or dark tan or black or white in colour with white and black patches (Fig. 8.4). The goats are healthy and timid in nature. Dorsal midline is lined by black hairs up to the tail. Muzzle, eyelids and hoofs were black in colour. These breeds are sturdy and very tall compared to other local breeds. Their height ranges from 26 to 32 inches. In some goats beard and wattle are absent. Head length is 8.5 ± 0.22 and the tail is generally medium to long. Horns are large, flat at base and directed backwards with an average length of horn size 4.0 ± 0.1 inches. The average age (months) at slaughter and live weight (kg) at slaughter is 14.1 ± 0.8 and 45.7 ± 2.3 , respectively. Attempts have been made for molecular characterization and genetic improvement of these breeds. Molecular characterization indicated that these breeds are native to these Islands and



Fig. 8.4. Teresa

mode-shift test indicated the genetic bottleneck in Teresa goats, indicating greater attention towards *in situ/ex situ* conservation. Some animals are conserved in research farm as live germplasm which can be used in the future breeding programmes.

(b) Nicobari Pig

The survey indicated that the herd size for native pigs is higher in Champin Islands (23.85) followed by Teresa and Katchal. Majority of Nicobari pigs appeared short, black and brownish in colour (Fig. 8.5). The whole body length and chest girth of male are 33.42 ± 3.45 and 33.29 ± 2.38 inch, respectively. The height of male Nicobari pig is 22.84 ± 2.15 inch. The average abdominal circumference and neck girth are 35.97 ± 3.19 and 32.00 ± 3.08 inch respectively.



Fig. 8.5 Nicobari pig

Pigs are reared mainly for pork consumption among Nicobari tribes. During pig festival (Canahaun), which is celebrated after Christmas in the month of January or February, a grown up swine from their stock will be selected to slaughter and distribute to all members of *tuhet*. Due to the importance of Nicobar pigs in the tribal farming system detailed study was carried out to characterize the local pigs by molecular techniques (Jeya kumar *et al.*2014). This is very essential not only to improve the breed but also will enable to utilize certain desirable traits elsewhere. Such an approach is also pertinent to other tropical islands as well.

8.2.2 Marine resources

This is one of the resources less understood and underutilized. Exploratory surveys for marine sponge resources have been conducted at 12 sites which are frequented by the tribal to harness the marine resource

potential (Fig. 8.6). The efforts resulted in collection of 458 marine sponge specimens of which 61 species have been identified through conventional taxonomy. A total of 140 voucher specimens have been submitted and registered in ZSI, A&N Regional Centre representing 57 species. Seven such marine sponges which are fully described taxonomically have been submitted to the Global Sponge Barcoding project database under reference category. The geographical positions of all identified sponge specimens have also been documented.

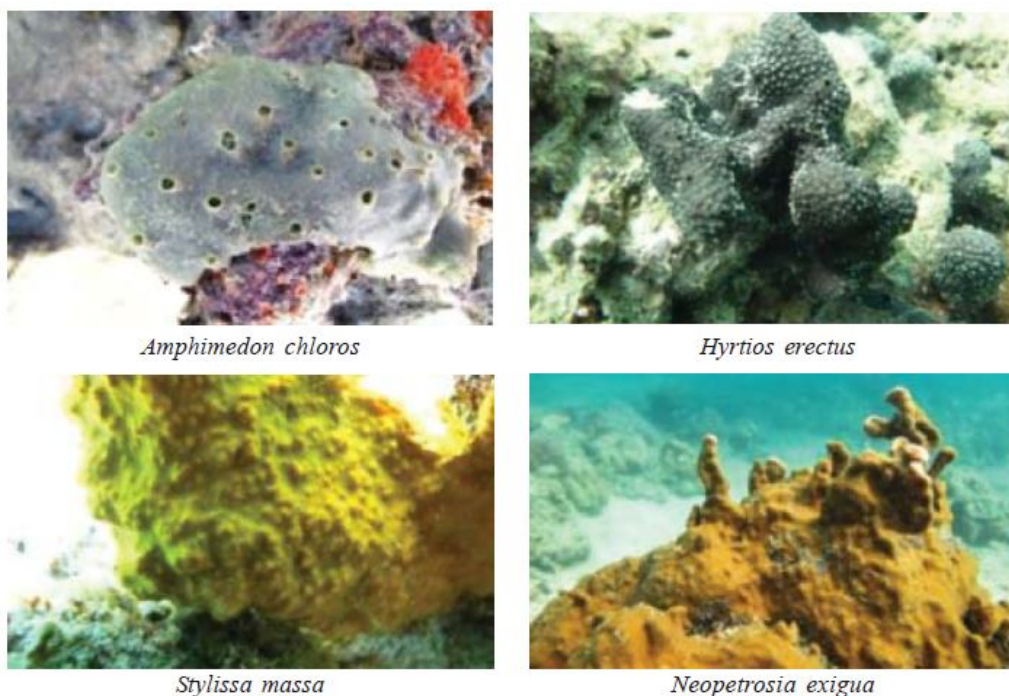


Fig. 8.6. Marine sponges recorded in the Island waters

8.2.3 Mangrove biodiversity

Mangroves are one of the sources of income and food for most of the tribes. In Andaman and Nicobar Islands 966 km² is under mangrove vegetation, of which 929 km² in Andaman islands and only 37 km² in Nicobar group of Islands. Mangroves occurring in these islands are mostly fringing the creeks, backwater and muddy shores. Along the creeks, the width ranges from 0.5 to 1 km. This salt-tolerant community is found on rocky shores exposed to tidal action and sometimes is also found growing in tidal mudflat (Fig. 8.7). Attempts have been made to document the mangrove biodiversity of the Islands and 34 true mangrove species belonging to 15 genera, 10

orders and 12 families are documented. *Sonneratia ovata* has been recorded for the first time from these Islands (Dam Roy et al., 2009).



Fig.8.7 A. *Premna obtusifolia* R.Br & B. *Barringtonia asiatica* (L.)

8.2.4 Soil microbial resources

Soil microbial population is involved in several important activities which are vital for the normal functioning of soils and maintain its productivity. Some of the microbes are involved in nutrient mobilization, growth promotion, and provide protection against harmful plant pathogens. If utilized properly, microbes can enhance the crop production and help in diversification of farming system. From the soils of Andaman and Nicobar islands more than 100 potential bacterial isolates have been isolated from the rhizosphere and non-rhizosphere soils of these islands. A total of 20 bacterial most promising isolates were identified through 16S rDNA and BLAST search and registered. Among them *Bacillus subtilis*, *Bacillus cereus* and *Bacillus megaterium* are having higher potential for phosphorus solubilization with maximum phosphate solubilization of about 46, 40 and 38 $\mu\text{g/ml}$ respectively (Fig. 8.8). In addition these isolates are adapted to low pH therefore, they can be a potential P solubilizers which can be used in acid soils for increasing P availability (Velmurugan et al., 2015).

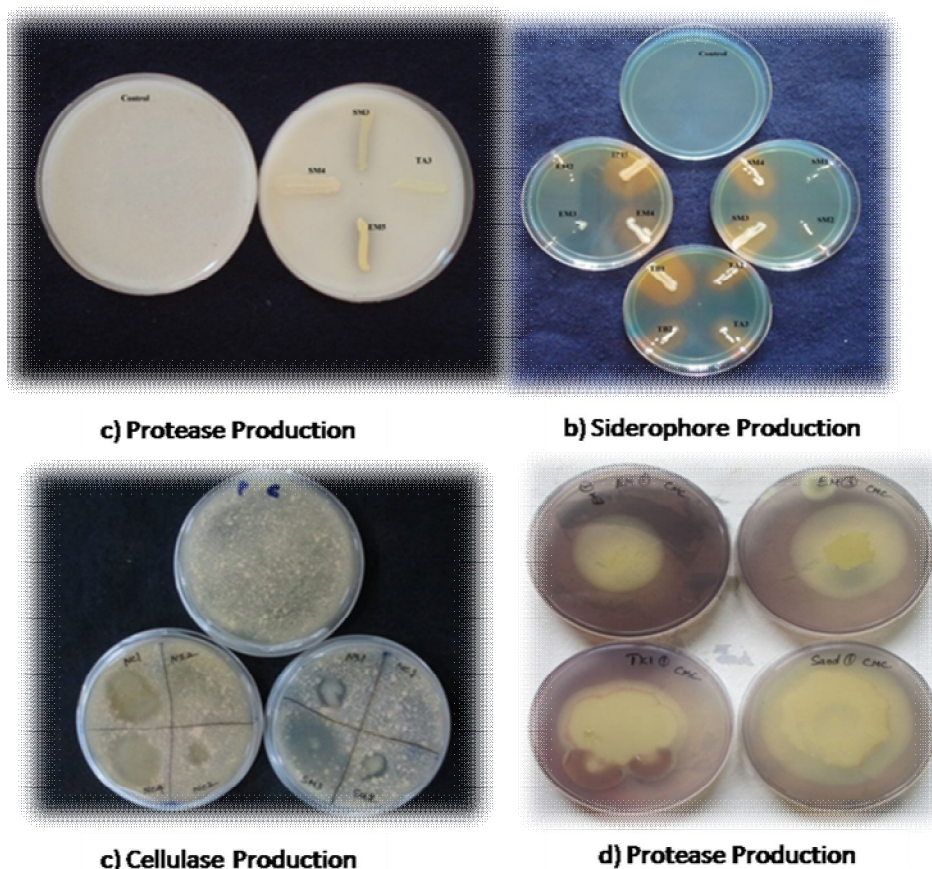



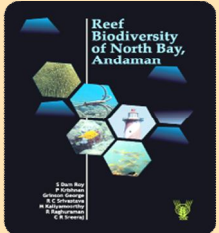
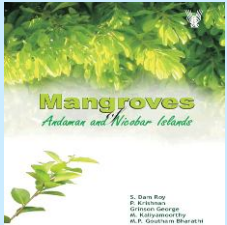

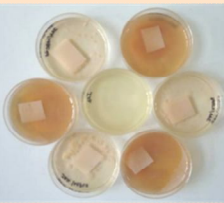
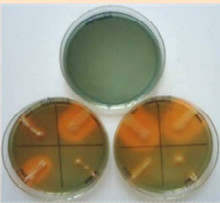


Fig.8.8. Promising microbial cultures isolated from the native soils

The details of conservation and level of utilization of biotic resources of Andaman and Nicobar islands is given in Table 8.4. Similarly, other tropical islands should also document and characterize their biotic resource which helps in diversification of tribal farming system.

Table 8.4 Conservation and utilization of biotic resources for diversification

Bioresource	Work done	Specimen/ sample
Teressa Goat	Phenotypic and molecular characterization and for conservation and propagation of this endangered breed	

Boer Goat	Cross	Upgradation of local goats with Boer goat through Artificial Insemination technology and successfully produced Boer cross goats for higher meat productivity and given to tribal farmers.	
Nicobari pig		Conserved the local Nicobar pig and involved in dietary supplementation of livestock to improve the productivity	
The coral reef biodiversity		Coral reef biodiversity of M.G.National Park, North Bay and Havelock Islands have been documented in association with other scientists.	
Mangrove biodiversity		Documented mangrove species, distribution and their contribution to fish recruitment in association with other scientists. Also worked on the economic value of mangroves for the Island.	
Effective Microorganisms		Documented effective microorganism isolated from AN Islands for faster decomposition, P mobilization and growth promotion. This will help in promoting organic farming and nutrient security in the tribal areas. These organisms (20) are registered with NCBI and accession numbers were obtained.	<p>KJ013535 : Cellulase, IAA production</p> <p>KJ013536 : High cellulase, ligninase</p> <p>TA3 KJ013537: IAA production</p> <p>KJ013540: P solubilizing</p> <p>KJ013541: Siderophore, Chitinase</p>
		  	<p>PO₄ solubilization</p> <p>IAA production</p> <p>Siderophore</p>

9. Technologies for diversification of farming system

New technologies are needed for areas with shortages of land or water, or with particular problems of soil or climate. These problems limit the expansion or diversification of agriculture, such a situation generally prevails in the tribal areas. These areas are with a high concentration of poor people, where such technology could play a key role in improving food security (FAO, 2002). Therefore, the development and dissemination of new technology which are suitable for the tribal areas is an important factor determining the future of agriculture and its diversification. The study investigated three areas that are particularly critical, viz. technologies in support of natural resource management and sustainable agriculture, improved crops and breeds and the directions that should be taken by future research. It is vital to pay attention that technologies should be developed and evaluated / refined by the multidisciplinary scientific team which is specific for improving the productivity of the farming systems of tribal areas.

9.1 Concepts and technologies for agricultural diversification

Concurrently sustainable agriculture principles should be promoted as a way of farming in the tribal areas of Nicobar Islands that can be carried out for generations to come. This long-term approach to agriculture combines efficient production with the wise stewardship of the earth's resources. By doing so, it is hoped that, over time, such sustainable agriculture technologies will do the following:

- Meet human needs with a safe, high-quality, and affordable supply of food and livelihood to the tribals
- Protect the limited and fragile natural resource base and prevent the degradation of air, soil and water quality
- Use natural biological cycles and use nonrenewable resources efficiently
- Assure the harmonious survival of farming and the well-being of farmers, their families and communities with the nature

- Creation of institutional incentives and funding that focus on research, education, and technology development on integrating agricultural productivity and profitability with environmental stewardship

It is imperative that suitable technologies for tribal areas should encompass itself agricultural diversification and sensitive to environment and tribal customs. This concept is applicable to any part of the world. The selected technologies should address the resource constraint and fully utilize the available resources while enabling agricultural diversification and increasing farm production. Some of the important technologies which are sensitive to the needs of tribes and island natural resources are as follows:

- Soil fertility management
- Rain Water harvesting
- Suitable crops and varieties
- Technologies for increasing livestock production
- Farming system diversification
- Post-harvest processing and off-farm activities
- Land shaping for diversification of low-lying and degraded areas

These technologies are disseminated to the tribal areas or demonstrated at farmers field with an aim to enhance the production and support the agricultural diversification.

9.2 Soil fertility management

Fertile soil is the foundation of a sustainable agricultural system. Without fertile soil we would have no plants. Without plants we would have no food. Therefore it is utmost important to focus attention on maintaining and improving soil fertility of islands to diversify agriculture and support agricultural production.

9.2.1 Agricultural waste recycling

Plenty of organic wastes are produced mainly from coconut and arecanut plantations apart from other vegetation in Andaman and Nicobar Islands. However, the hardy and lignified materials take several months to get composted resulting in locking of nutrients in organic form. Therefore, it is not possible to meet the annual crop nutrient requirements through organic

sources. Only by composting the wastes the nutrients are released for crop uptake. A method for fast composting of organic wastes was developed suitable for these island in which the coconut wastes was cut into small pieces, mixed with poultry manure and *gliricidia* leaves at 7: 2:1 ratio, filled in composting tanks of size 1 x 1 x 0.75 m and 60-70% moisture level was maintained (Velmurugan et al., 2013).



One month after earthworm (*Eisenia fetida*) was introduced. The compost (CHC) was ready by 130 to 140 days. Similarly, rice straw compost (RSC) was prepared from rice straw, *gliricidia* leaves and cattle manure used in the ratio 8:1:1 in addition to effective microorganisms. One month after precomposting, earthworms were introduced and the compost was ready within 110-120 days (Fig. 9.1). The composting improved the pH, total base cation content, proton consumption capacity, CaCO_3 equivalent besides increasing the total nutrient content. The total N content increased from 9.6 to 17.3 g kg^{-1} and 3.5 to 10.7 g kg^{-1} in rice straw and coconut husk composts, respectively. There was also reduction in C: N ratio as compared to the original residues used for composting. Use of compost will not only supply plant nutrients but also enhances its retention in the soil which is most important in sandy soils. Continuous use of Vermicompost slowly built up

beneficial microorganisms in soils, which in due course of time helps to grow diversified crops.

9.2.2. Value addition of composts

Farm compost is poor in phosphorus content (0.4-0.8 %) and moderate in N content. Addition of P makes the compost more balanced, and supplies nutrient to micro-organisms for their multiplication and faster decomposition. The addition of P also reduces N losses. Super phosphate, bonemeal or phosphate rock can be used to enrich the compost with phosphorus. 1 kg of super phosphate or bonemeal is applied over each layer of animal dung. Low-grade phosphate rock can also be used. The same can be used in compost pit as well. In a P-enrichment study powdered rock phosphate is used which resulted in P content of more than 4% (Table 9.1). The application of the same to acid soil significantly improved the P uptake by crops. The chemical and biochemical characteristics of vermicompost and P-enriched vermicompost are presented in table 1 (Murugan and Swarnam, 2012). This helps to supply P to crops particularly in acid soils. In such tropical acid soils P deficiency is widely prevalent.

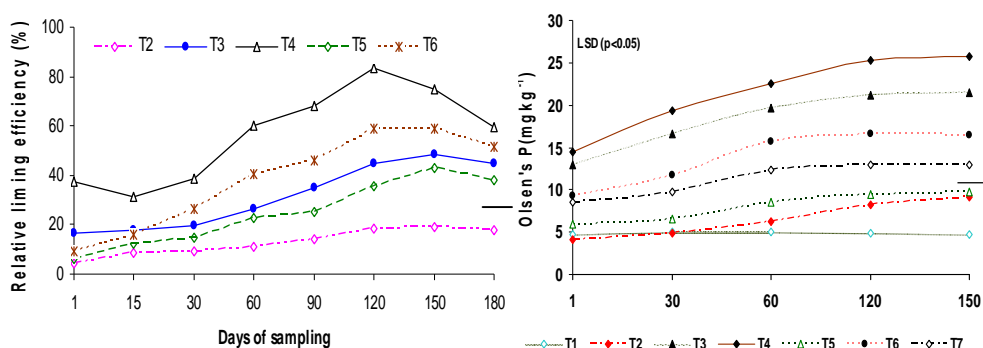
Table 9.1 Comparison of vermicompost and P-enriched vermicompost

S.No.	Parameters	Vermicompost	P-enriched vermicompost
1	Ash (%)	51.0	52.5
2	TOC (%)	27.2	26.5
3	N (%)	1.9	1.95
4	C/N ratio	14.3	13.6
5	P ₂ O ₅ (%)	0.8	4.0
6	K ₂ O (%)	0.8	0.86
7	Mn (ppm)	500.0	540
9	Zn (ppm)	100.0	100
10	Cu (ppm)	44.0	46
11	Dehydrogenase (mg TPFkg ⁻¹ compost hr ⁻¹)	40.0	39

9.2.3 Organic amendments for managing acid soils

As discussed in the previous section soil acidity due to heavy rainfall and leaching of cations is one of the major problems hindering crop production in many of the tropical islands. As these islands experience high rainfall and plenty of scope for organic production of high value crops it is wise to ameliorate the soil acidity and improve its physical conditions by suitable organic methods. The organics such as poultry manure, rice straw compost, *gliricidia* leaves, and coconut husk compost were evaluated for improving the soil pH and other soil properties.. Among the organics poultry manure shown significant increase ($p < 0.05$) in soil pH where the increase was in the order of lime > poultry manure > coconut husk compost > rice straw compost > *gliricidia*. The coconut husk compost and poultry manure recorded a relative liming efficiency of 26% indicating their potential as alternative liming sources in low input agricultural system (Fig. 9.2). Besides increase in soil pH, decrease in exchange acidity, Al^{3+} , DTPA extractable Fe^{2+} and Mn^{2+} were also observed indicating reduction of its toxicity to crop plants. The application of organics also improves biological activities of soils and crop yield. The technology was standardized and transferred to farmer's field for adoption.

Fig. 9.2 Relative liming efficiency of different organics and its effect on P



9.3. Rain Water harvesting

Water is vital for agricultural diversification and achieving higher production particularly in islands throughout the world. Therefore, focus should be given in standardization of rain water harvesting technology suitable for island conditions. In the agro-climatic conditions of these Islands a lined tank technology was standardized for hilly regions of Andaman and

roof top rainwater harvesting for Nicobar regions (Fig. 9.3). The seepage loss from earthen tank is quite high due to coarse soil texture and porous coral base at lower stratum. Hence, lining the ponds with different materials was evaluated and lining with silpaulin was found suitable. A tank of 10-15m X 7m X 2.5m size with 1:1 slope constructed at hill top, lined with silpaulin is effective for storing rain water which can be used to provide irrigation to crops. The bottom bed and side slope should be well dressed and compacted before the film is spread and anchored on sides. To prevent the lining material from exposure to the UV light from the sun, the side slopes and the bottom area are plastered with tiles of 20 mm thickness. Further, very fine soil for 2 inch thickness was placed above the tiles at the bottom.

Fig. 9.3 Rainwater harvesting in lined ponds



In Nicobar and Little Andaman Islands water is scarce during dry season and ground water is saline which necessitates harvesting and storage of rainwater for multiple use. Car Nicobar experiences 2800-3000 mm per annum of rainfall which provide lot of scope for rainwater harvesting.



Fig. 9.4 Rooftop rain water

The roof area of a group house is 300 m² and the rainwater falling on the roof is 9,00,000 liters. If we assume 70% can be collected then 6,30,000 liters of rainwater is available for collection (Fig. 9.4). This can be effectively used to provide irrigation to crops grown during dry season. Roof top

harvesting was done by collecting the rain water in plastic tanks through pipes.

9.4 Suitable crops and varieties

Sustainable crop production and diversification will use crops and varieties that are better adapted to ecologically based production practices than those currently available. Therefore, farmers need a genetically diverse portfolio of improved crop varieties, suited to a range of agro-ecosystems and farming practices prevalent in the tribal areas and resilient to climate change.

As the availability of cultivable land is limited in most of the tropical islands, it is appropriate to select suitable crops and varieties which are required to meet the food demand and hold comparative advantage to grow under the given agro-climatic conditions. In Nicobar Islands suitable varieties of plantations, tubers and rice were tested and introduced to diversify the agricultural production systems as well as meet the food requirements.

9.4.1 Salinity tolerant rice varieties for coastal degraded areas

One of the main constraints for improving rice production in the tsunami affected areas of these Islands is salinity and water logging. These conditions are also prevalent in many of the tropical islands. Therefore, it was planned to evaluate different rice varieties for these conditions and popularisation of most promising varieties among the farmers of these degraded areas (Fig. 9.5).

In order to enhance the rice production in Andaman and Nicobar Islands, Central Agricultural Research



Fig. 9.5 Evaluation of rice varieties in the coastal low lands

Institute, Port Blair has developed two Pokkali somaclones, BTS 24 and BTS 28 suitable for saline soils using biotechnological tools. Also agro-techniques for rice based systems have been developed for different situations. Multi location demonstrations were carried out at farmers' fields in South and

Middle Andamans to popularize these varieties. In addition, in recent years, the farmers from the coastal areas were provided with Salt tolerant rice varieties Viz., CSR 36, CSR 23 and CARI Dhan-5 supported by training on agro-techniques to enhance the rice productivity in tsunami affected lands in order to ensure food security. It was observed that CARI Dhan-5 is a very good variety for saline soils with short stature (95.5 cm) and long duration (150 days). It yielded 4.2 to 4.5 t/ha with high input in normal soils and 3.4 to 3.6 in saline soil conditions. It is tolerant to sheath blight, BLB, leaf spot and stem borer and non lodging. CSR-36 performed better even in saline condition and yielded 3.8 t/ha. Under normal condition it yielded 3.8 – 4.2 t/ha and best suited for low input condition but CSR-23 gave only 2.4 t/ha in saline soils. However, all of them were performed better than C-14-8 a local variety (NAIP, 2013). Seeds of these varieties were distributed to farmers after proper training on improved package of practices.

9.4.2 Horticultural crops

Coconut and arecanut being two major plantation crops occupy nearly 50% of the total cultivable are in these Islands. But their productivity was low and therefore, major emphasis was given for identification and selection of high yielding elite palms. In this context, it is very much pertinent to collect and conserve the important germplasm of tropical islands which can be used to in improvement programmes. They may have promising genes to adapt to changing climate or biotic stress.

Evaluation of exotic coconut germplasm in World Coconut Germplasm Centre at Port Blair has resulted in the identification of Niu Lekha as a promising dwarf cultivar with the highest copra content 245 g/nut. Among the dwarf coconuts (Green, Orange and Yellow dwarf), Green dwarf was found a promising cultivar for tender coconut-water (Fig. 9.6). As a logical follow up, the tribal farmers should be supplied with quality planting material of these varieties to replace the existing low yielding and senile plantation in a phased manner.

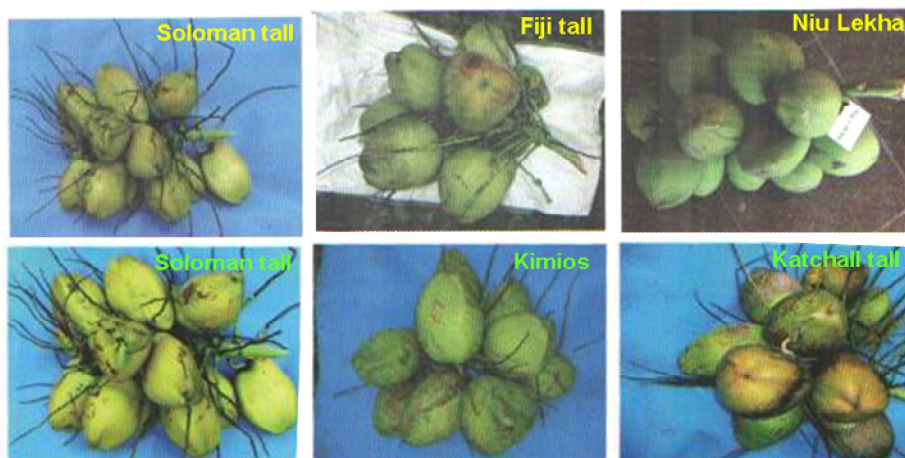


Fig. 9.6 Improved coconut varieties for Andaman and Nicobar Islands

In tropical Island situations it is possible and pertinent to develop coconut and arecanut based multistoried cropping systems with spices like clove, nutmeg, cinnamon and black pepper as intercrops to ensure diversification and enhanced farm return. Suitable grasses as intercrops of coconut plantation will go a long way in solving the fodder requirement of livestock in island conditions. Agro-techniques should be standardized and disseminated to the farmers for intercropping of elephant foot yam, tapioca and other tuber crops in coconut garden. It assumes significance due to the limited availability of land resources and necessity to diversify the agricultural production system in tropical island condition.

9.5 Technologies for increasing livestock production

Mixed farming systems which include crops and livestock are widely prevalent in the tropical world on small and medium sized farms. However, the level of technological adoption and productivity varies widely across the islands while the productivity is low under tribal farming systems owing to many reasons. Although crops and livestock are interdependent to a large extent, the latter constitute an important mechanism for coping with the risks of crop failure. In India, livestock wealth is mainly concentrated among the majority of marginal and small landholders while it is considered as a major wealth for tribals. Technology-induced growth in the livestock subsector would thus improve food and nutritional security, alleviate poverty, and reduce interregional and interpersonal economic inequities.

The technological options to improve the livestock production include genetic enhancement of indigenous breeds through crossbreeding with exotic breeds, improvement of nutritive quality of feed and fodder through biological and chemical treatments, development of vaccines against animal diseases, improved livestock management practices, and post harvest management. Additionally, processing technologies have been developed to strengthen the vertical linkages between the farm and dairy industry. However, the adoption pattern of these technologies varies among tropical islands across species, farm typologies and regions. Some of the technologies suitable and implemented in Nicobar Islands are given below:

9.5.1 Controlled breeding technology

Crossbreeding of low-yielding indigenous breeds with high-yielding exotic breeds has been widely acknowledged as a valuable strategy to improve animal productivity. Controlled breeding technology is of good practical interest to planned breeding and fixed time artificial insemination (A.I) in goat would accelerate kidding system (Fig.9.7). Controlled breeding and artificial insemination was aimed at improving the livelihood of the local farmers, agricultural diversification and meet out the local demand for chevon. The progestagen in association with PMSG (pregnant mare serum gonadotrophin) was employed in controlling estrus in goats. Use of indigenously developed intravaginal sponges found as the means of facilitating planned breeding and to reduce the kidding interval in goats. Ultrasonography based approach resulted in a non-invasive, easy and simple method for breeding soundness or clinical examination of male goats.



Fig. 9.7 Use of ultra sonography and A.I

A high performing cross breed (Boan) between Andaman local (desi) female goat X Boer male crossed through artificial insemination technology was successfully produced (Fig. 9.8). The F1 generation goats appeared similar to Boer. The body weight at birth, 3, 6, 9 and 12 months were significantly higher than the local goats. The body weight of Boer cross (F1) at 12 months is 36 kg and 45 to 50 kg at 2 years of age. The protocol was



Fig. 9.8 Cross breed production and distribution

standardized and the cross breed was distributed to the farmers and entrepreneurs. This greatly increased the meat production and diversified the agricultural activities. In addition a Barren island Feral goat, the only ruminant in nature known to survive on saline sea water, was also conserved and genetically improved. In Island ecosystem this method is promising to improve the local breed.

9.5.2 Conservation and improvement of local birds

It is very essential to conserve and improve upon the local germplasm of birds in this part of the world as it is locally well adapted. This concept was implemented in the form of production of new genetically improved strain of Nicobari poultry bird by CARI which lays 158 to 160 eggs per year even under zero management practices. These birds are comparatively more resistant to most common poultry diseases. Therefore, it is wise to make efforts to evaluate, conserve and integrate this kind of local birds in tribal farming systems which are suited to the backyard conditions.

9.5.3. Feed and fodder

Availability of feed and fodder is a major constraint for livestock production in these Islands. In Nicobar Islands pig and goat are the major

livestock components grown in an open ranch system. Coconut and kitchen wastes are used as feed materials for pig and goat which is not enough to feed the animals therefore, the animals are depend on grazing in the open and waste lands. Studies on evaluation of feed supplements for pig (Fig. 9.9) using fruits of Noni, cashew apple, tapioca and sweet potato grown in the coconut garden were indicated that these can be used as a supplementary feed for pigs to the extent of 25% of total feed requirement.



Fig. 9.9 Noni and cashew apple as alternative feed for pigs

Similarly to increase the availability of green fodder to the cattle and poultry studies were conducted to utilize the fallow lands, inter spaces of plantation (coconut, areca nut), slopes and embankment of ponds to boost the green fodder production. Cultivation of Azolla in lined small tank (2.5 x 1.5 x 0.3m) can act as a feed supplement and reduce the dependency on concentrated feed (Fig. 9.10). Fresh Azolla can be fed @ 100-300 g/day/bird and 1:1 with concentrate feed for cattle. Farmers were given seeds and cuttings of different grass species after adequate training and encouraged to cultivate them in the vacant spaces which greatly reduced the green fodder shortage problem during rainy and dry season resulting in increased milk production.



Fig. 9.10 Improving the availability of green fodder in the island

9.5.4 Disease Control

The production potential of livestock is drastically reduced due to diseases. In India many deadly diseases such as rinderpest, foot and mouth disease, hemorrhagic septicemia, and black quarter are major threats to profitable livestock production. Livestock disease control has undergone a paradigm shift in recent years. A number of biological products (vaccines) have been developed for preventive and curative disease management. It is also essential to conduct animal health camps for the benefit of tribals but, as most of the animals are reared in free ranching it is very difficult to vaccinate them. In addition, the infrastructure for disease control has also expanded considerably. The main limitations to effective livestock health management in many of the tropical islands are an inadequate focus on preventive measures, lack of medicines and equipment in the veterinary clinics, and ignorance among the farmers about the diseases and preventive measures.

9.6 Farming system diversification

Integrated Farming System promises to enhance food, nutritional, livelihood and income of farmers apart from reducing risk of total failure crops in monocropped areas due to weather vagaries and or biotic factors such as pest and diseases. In Islands, farmers mostly grow traditional photosensitive, low input requirement, lodging prone and low yielding (2 - 3 t/ha) cultivars of rice or with plantation crops having long gestation period. The unpredictable rain dependent farming leads to unstable production and financial risks. In order to meet the challenges of sustained food security and economic growth, farming system approach in rainfed environment is essential. This would also ensure the human and crop nutritional security otherwise threatened from mono-cropping. Farming system is intended to give a wider choice to cultivars in the production of crops along with complimentary enterprises such as livestock and fish culture in unit area so as to expand production related activities and also to lesson risk.

9.6.1 Homestead based IFS for nutritional security

Considering the physical, social and economic limitations of the Nicobar Islands, an integrated farming system model for homestead

cultivation was developed in a participatory mode (Fig. 9.11). The model comprises of 400m² of fenced area in the vicinity of the tribal settlement and integrated with backyard poultry (vanaraja), goat farming along with one vermicompost unit for organic waste recycling. In the fenced area seasonal vegetables viz., okra, brinjal, tomato, green amaranth, cucumber, bitter gourd and bottle gourd were grown. Besides fruit crops like banana, pine apple and papaya were also grown in the garden. To meet the fodder demand *Sesbania grandiflora* (agathi) a multipurpose legume tree was introduced for the first time into the Islands as a biofence, green fodder and green leaf manure. The model yielded 475 kg of vegetables, 250 kg of fruits and 300 kg of tubers in annual cycle of 2 cropping season. It was observed that the intake of fruits and vegetables has substantially increased. In addition the egg production has increased 7 to 8 times (1800 egg) thus, ensuring the nutritional security of a tribal family. The excess production is usually shared with the other members of the tuhet. Organic waste recycling effectively met the major nutrient requirement in an annual cycle of 2 per year.



Fig. 9.11 Homestead based IFS model for Nicobar Islands

Similar such location specific IFS model should be developed to meet nutritional security of the local through diversification. The system is most efficient and utilizes the available resources in a best possible way.

9.6.2 Mangrove-based Agro-Aqua farming

Mangroves contribute to the natural productivity and also act as a bio-shield against natural disasters protecting the island coastline from storm surges and cyclones. A mangrove-based integrated agro-aqua farming system model was developed for coastal communities (Fig. 9.12). The model has two ponds with provision for water exchange as per tide level and a mangrove nursery bordering the ponds. The ponds were stocked with mullet - *Mughil cephalus* (300 Nos), Scat - *Scatophagus argus* (150 Nos), Tilapia - *Oreochromis mossambica* (200 Nos) and Tiger Prawn - *Penaeus monodon* (200 Nos) under poly culture system. Vegetables and fruits were raised on the bunds. A duck shed (for 10 birds) was provided on the bund with a provision to wash off the duck waste directly into the ponds. Azolla cultivated in the FRP tank on the bund also served as a source of fish and duck feed. A mangrove nursery was constructed bordering the ponds where the seedlings of *Bruguiera gymnorhiza*, *Rhizophora apiculata* and *Acanthus ilicifolius* were raised. The ponds received the organic wastes from the duck shed and the nutrient rich mangrove water during high tide and no supplementary feed was provided to the fishes. The integrated farming system model provided additional income of around Rs.25,000/- per year in addition to meeting the nutritional requirement of the farmer.



Fig. 9.12 A view of the model farm with different components

9.6.3 Farming system diversification through livestock

It is well known that livestock component is very vital to support agricultural diversification in Islands. This not only supports nutritional requirements but also the waste generated in animal production system helps to recycle the other organic wastes. At the same time required fodder for livestock can be produced in IFS. This is the case with several tropical islands which provide stability to agricultural production system. In the present discussion, the Nicobari tribes depended on the natural vegetation for feed and fodder requirement of their livestock. Rearing of pig and poultry is a traditional activity with low productivity due to lack of proper housing, feed and scientific management practices. Further, there was a greater loss to the livestock population during 2004 tsunami in coastal areas of these Islands. Hence, attempts were made to promote livestock based enterprises in tribal and coastal degraded areas of the Islands by distribution of piglets, goat and poultry chicks to tribal farmers as well as landless and women through various projects like FPARP (Farmers Participatory Research), NAIP (National Agriculture Innovation Project) and Tribal Sub Plan (TSP) over the periods (Fig. 9.13). Besides distribution of animals, trainings were imparted on scientific rearing of animals, use of locally available materials for construction of housing and as feed supplements. Fodder trees like *Sesbania* sp. were introduced as a fodder for goat in home gardens of Nicobar Islands.

As noni and cashew apple are found in natural forests which can be used as feed supplement in addition to traditional foods of coconut and tubers to the pigs. Besides, periodical health camps are required to address the issues of infertility and other problems in livestock.



Fig. 9.13 Distribution of pig, chicks and goat strengthen diversification

9.6.4 Farm diversification through aquaculture activities

Andaman Islands are dotted with fresh water ponds providing scope for fresh water aquaculture and farm diversification. The composite fish culture comprising Indian Major Carps (Catla, Rohu, Mrigal) and exotic carps (Silver carp, grass carp and common carp) in various mixtures was popularized among the farmers to increase the productivity of fish ponds. By this method different layers of pond will be utilized by different kinds of fish ensuring judicious exploitation of all the niches available in the pond as well as utilizing the whole strata of the pond. To diversify the farm income land configuration techniques like rice-fish system and fish pond were implemented at farmer's field in coastal degraded areas



Fig. 9.13 Fresh water prawn

under NAIP and FPARP programs along with distribution of fingerlings and conducting capacity building programs. As the availability of fish seed is the major constraint in these Islands, interested farmers were trained for breeding programs through the concept of **satellite fish nurseries** so that the seed requirement of particular cluster will be met besides substantial income to the farmer.

Fresh water prawn *Macrobrachium rosenbergii* is known for its fast growth, stress tolerance and high market returns (Fig. 9.13). Attempts were also made to develop suitable technologies for breeding and seed production of fresh water prawns under Island condition. This can be integrated with vegetable cultivation and post harvest processing.

Another potential scope for farm diversification is the mud crab fattening in mangrove ecosystem as they widely found in these Islands (Fig. 9.14). Juvenile crabs can be collected from estuaries, lakes, back waters, creeks, mangroves and grown in grow out ponds constructed in tide fed estuaries, backwaters and creeks. The crab ponds can also be constructed by

converting one portion of existing fish ponds and providing provision for brackish water inundation into that area. A pond of 0.1 ha area can be used for mud crab culture. With 500 nos /ha stocking density of 50-60g size crab for a period of six months, about 780kg/ ha production can be achieved. It can fetch a net return of Rs. 3000 per culture from 0.1 ha pond.



Fig. 9.14 Mud crab culture by a farmer

9.7 Post harvest processing and off-farm activities

Proper postharvest processing and handling is an important part of not only modern agricultural production but also essential component to increase the farm income by reducing losses. This is very pertinent to the humid and high rainfall regions of the tropical islands. Postharvest processes include the integrated functions of harvesting, cleaning, grading, cooling, storing, packing and transport. Post-harvest losses compromise food security particularly of tribals and the market presence of small-scale farmers by disrupting supply or reducing the quality of products. Therefore, local storage and small-scale processing capacity has an impact on development similar to that of the construction of other rural infrastructure. Some of the technologies suitable for tribal areas are discussed in the following sub-sections.

9.7.1 Solar dryer

In Nicobar Islands coconut is the major crop occupying 80% of the total agricultural area. The copra production is limited to traditional methods of sun drying and biomass drying. The copra is dried by burning the coconut husk and other biomass from below for 4-5 hrs mostly in the evening. The process is repeated for 2-3 days until the moisture content is reduced to safer level (5-7%). Drying may continue during rainy season till it is ready for oil

extraction. The quality of copra produced is affected due to high relative humidity and fungal infection. To overcome these difficulties, a solar dryer was designed, evaluated and fabricated to facilitate fast drying of copra and other spices in these Islands (Fig. 9.15).



Fig. 9.15 CIARI-Solar dryer used for drying of coconut and spices

The performance evaluation of solar drier indicated that solar drying saved up to 31% of total drying time in comparison to sun drying to reduce moisture content to final safe level in spices like clove, cinnamon and black pepper. The maximum temperature inside the solar dryer reached up to 65.7°C compared to outside air temperature of 34.8°C indicating the efficiency of solar drying. The solar dryers were distributed to tribal farmers of in Car Nicobar on community basis for copra production so as to facilitate fast drying and improve the quality of copra produced to fetch higher market price.

9.7.2. Extraction of virgin coconut oil

The Nicobari tribes have the traditional knowledge on virgin coconut oil extraction directly from coconut milk. The virgin coconut oil is extracted by traditional equipment called *Kintan tavi-i* after scrapping the kernel with the petiole of *Calamus andamanicus* which has spines on it. The virgin oil is extracted by two methods viz., Sun Dry Method and Hot Water Extraction Method. In the first method the scrapped coconut kernel is pressed in *Kintan tavi-i* to get coconut milk, which is then boiled to obtain the oil. This oil is mostly used for toiletry purpose. In another method, the coconut milk obtained by pressing scrapped coconut in *Kintan tavi-i* is mixed with hot water and kept open in a vessel over sunlight for separation of oil (Fig. 9.16). However,

realization of oil in both the methods is only around 25 - 32% of the kernel content.



Fig. 9.16 a. Scrapping matured coconut, b. pressing in *kintan tavi-l* for milk
c. Sun drying for extraction of virgin oil d. Virgin coconut oil

As there is a wider scope for modernization of the virgin oil production efforts were made to distribute modern virgin oil extractor on community basis to tribal farmers of Nicobar Islands which provide an opportunity to enhance and diversify the farm income.

9.7.3 Diversification through off farm activities

Nicobari tribals were known for their skill in developing artifacts/handicrafts from local materials like pandanus, coconut and bamboo etc. The handicrafts like mat, bins, artifacts made of coconut shell were popular among the Islanders especially in Andaman Islands (Fig. 9.17).



Fig. 9.17 Making of mat from pandanus leaves and bamboo bins

As there is growing potential of tourism in these islands, there is a greater scope for increasing their income by promotion of such activities. Experienced craftsmen from adopted villages in Car Nicobar were identified

and their products were popularized through Kisan Mela and separate stalls were provided for display and sale of their products.

9.8 Land shaping for diversification of low-lying and degraded areas

The coastal areas of Andaman Islands are affected by acid saline condition and water logging, which was aggravated by 2004 tsunami. Hundreds of acres of arable land were degraded due to salt deposition, water logging and acid sulphate condition. Different land

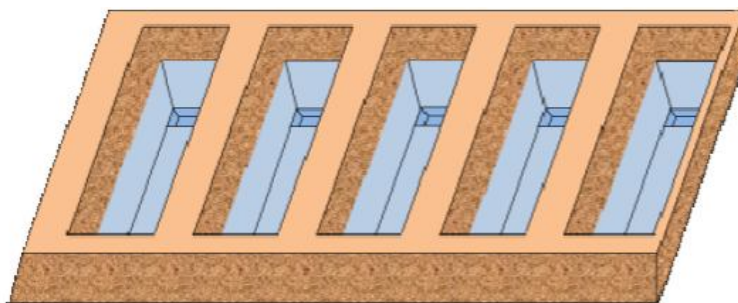
configuration techniques were implemented at farmers' field as a means of reclaiming these areas and to diversify farming system to provide livelihood



opportunities. The technological intervention was implanted in four clusters covering several villages of the affected areas. The approach got overwhelming response from farming community and so far 208 acres of land have been brought into cultivation directly benefiting 500 farm families. The land configuration techniques such as broad bed and furrow (BBF), paired bed, rice-fish and farm ponds increased the water availability by insitu harvesting of rain water and brought additional area under irrigation besides improving the drainage and productivity of degraded lands. The details are given below:

9.8.1 Broad bed and furrow system

This involves shaping of land for broad beds and furrows alternatively in low-lying lands. In broad bed & furrow system, beds of 4 - 5m width and 1 m height, and furrow of 5 - 6m width and 1m deep with a provision of (2 m x 4 m x 1 m) fish shelter at the end of the furrow has been made. Raised beds are used for cultivation of vegetables round the year and fish was cultured in the furrows. This system provided the scope for *in-situ* rainwater harvesting of about 3800 m³ ha⁻¹ and was used to cultivate crops during dry seasons. The cropping intensity increased up to 240% with increase in net income to Rs. 1,89,085 from base line value of Rs.22400 per ha.



Schematic diagram of broad bed & furrow technique



Excavation of broad bed & furrow technique at farmers' field



Crop cultivation under broad bed & furrow technique at farmers' field



Availability of water even during April in BBF at Tushnabad, South Andaman

Fig. 9.18 Broad bed and furrow system

9.8.2 Paired bed system

In paired bed technique degraded low lying land in Andaman Islands was shaped into broad furrow of 9 m width x 2 m depth and two beds of 6 m width. In this 5 m x 9 m size nursery pond was also created at one end of the furrow for fish culture (Fig. 9.19). Two dykes were created of 2 – 3 m width at both ends. Broad furrow was used for harvesting of rain water of about 3750 m³ ha⁻¹. The fish nursery of 90 m³ at one end of the furrow was used for raising finger lings and broad furrow was used for brooders. Vegetables were grown round the year in the raised beds and dikes. In this technique the inner rows of raised beds were remain in aerated condition even if the furrow was filled with rain water.



Excavation of paired bed technique at farmers' field



Crop cultivation under paired bed technique at farmers' field

Fig. 9.19 Paired Bed System

9.8.3 Farm ponds

Farm pond with broader dikes was excavated in relatively low-lying areas in the farm land with flat topography or in the undulating landscape to harvest rainwater during monsoon season. The dug out soil was used to make broader dykes of 5 m width and 1.5 m height around pond (Fig. 9.20). The pond was used to harvest rain water (about 8000 m³ ha⁻¹) which was used for composite fish culture and providing irrigation to crops on dikes during dry season. The broader dike in the farm pond was used for vegetable cultivation round the year.



Newly excavated farm pond with dyke



Crops in the dykes and fish in the pond

Fig. 9.20 Farm Ponds

9.8.4 Rice – Fish system

In rice fish system diversification was achieved by fish and vegetable cultivation in otherwise rice mono cropped area by simple land manipulation involving digging of trenches of about 5.0 m width and 29 1.5 m depth around the field and forming beds of 4 m width around the field (Fig. 9.21). The centre of the land left undisturbed was used for paddy cultivation during rainy season and vegetables/field crops during dry season and, fruit crops were planted on the outer slopes of the border beds. The rainwater harvested in the trenches (3564 m³ ha⁻¹) was used for fish culture and for irrigation for vegetables grown on border beds around the field.



Excavation of paddy-cum-fish technique at farmers' field



Crop cultivation under paddy-cum-fish technique at farmers' field

Fig. 9.21 Rice – Fish shstem

Land shpaing holds greater promise to imporve and diversify the coastal degraded areas of island ecosytem as experienced in Andaman and Nicobar Islands where farmers are directly benefited from the land shaping activities. These methods are centred around rainwater harvesting and use.

10. Climate change and vulnerability of tribal farming

Climate change is currently debated as an anthropologically enhanced phenomenon. Many scientists of today have been trying to quantify climate change and its relation with other environmental systems. Climate variability is concerned with the changeability in 'the mean state and other statistics (such as the standard deviation, extremes, or shape of frequency distribution) of climate elements on all spatial and temporal scales beyond those of individual weather events. Climate change on the other hand is variability that continues over a longer period and is statistically significant.

Arguably one of the most heavily dependent upon weather system is the monsoon season of Southeast Asia. While there are many literatures available on the interactivity of the monsoon seasons, the impact of climate change in terms of rising temperatures on monsoon rainfall intensities in Southeast Asia has received little attention. As the Island nations are more vulnerable to the perceived climate change (IPCC, 2007), it is imperative to assess the impact of climate change on Nicobar Islands. The state of art observation systems such as satellites images and efficient tools such as Geographic Information System (GIS) along with ground observation were used for the study.

10.1 Rainfall and temperature

The analysis of the historical rainfall data since 1951 indicated that there is no significant change in the average decadal rainfall in Andaman and Nicobar islands though the pattern of rainfall has changed with increases in the number of extreme rainfall events. The study of climatic pattern highlighted decreasing trend in rainfall and rainy days over the Islands in winter and post-monsoon seasons (Fig. 10.1).

It also decreases with latitude, for example Kondul Island, which is at southern latitude, gets the highest rainfall and on the other side, Maya Bandar, which is at northern latitude gets the lowest rainfall during these seasons. This may be due to fact that during winter and post-monsoon seasons, rainfall over Andaman and Nicobar Islands is mainly due to easterly

wind which is generally stronger over Nicobar Islands than over Andaman Islands. The temperature and rainfall pattern for 2025 and 2050 was projected for the Islands indicating an increase in mean temperatures and precipitation in the Islands.

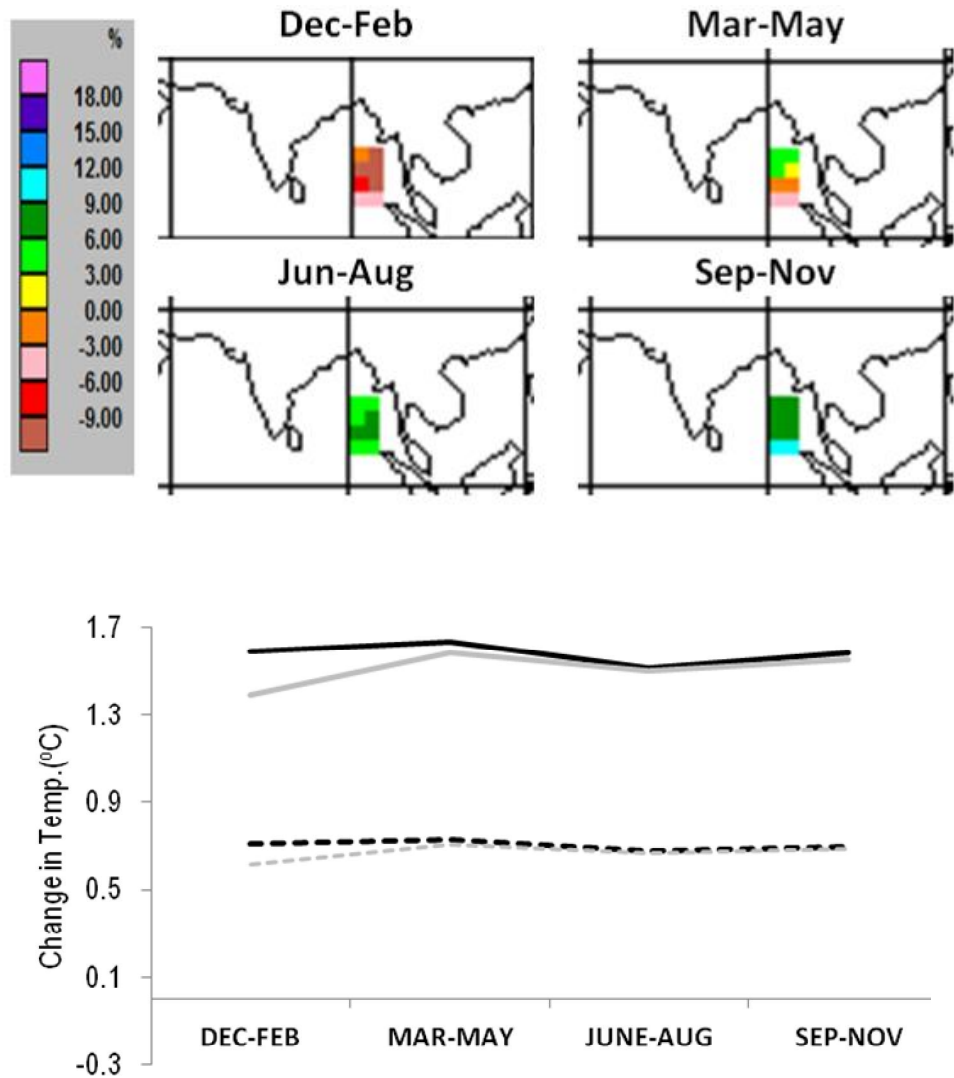


Fig. 10.1 Predicted changes in climatic parameters

10.2 Sea water inundation

The Digital Elevation Model (DEM) of the islands indicated that in Trinket and Chowra more than 15% of the total land area is less than 10 m above mean sea level (MSL) indicating their potential vulnerability to climate change events (Fig. 10.2). The DEM data taken together with the population density of different islands showed the vulnerability of Chowra Island to sea level rise as it is densely populated and has a vast expanse of land area at elevations less than 20 MSL. This may lead to loss of livelihood and displacement of large population.

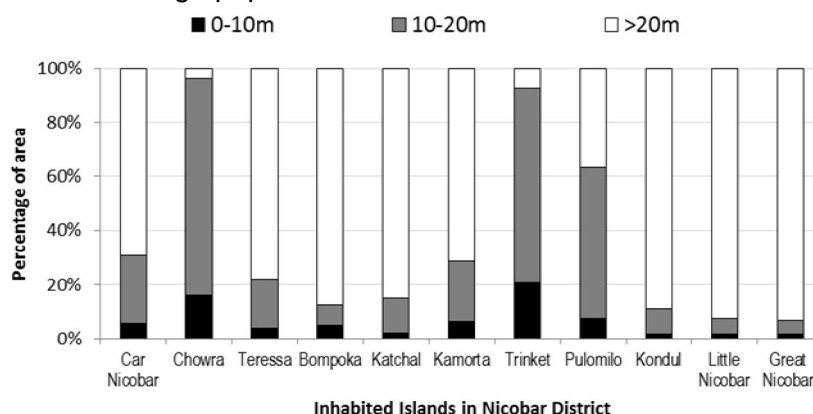


Fig. 10.2 Area under different elevation range (0–10, 10–20, > 20 m)

10.3 Agricultural Vulnerability

Vulnerability expresses the susceptibility of being harmed by external forces as a result of exposure. Joined with vulnerability are the concepts of resilience and sustainable development: the former describes the ability to cope with the exposure to vulnerabilities through a combination of withstanding damage and/or developing a propensity to recover from any damage (Briguglio *et al.*, 2008), whereas the latter refers to development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Climate change-induced increases in rainfall or seawater ingression could lead to erosion, leaching of salts, and salinization of coastal lands rendering the soil unproductive for agriculture. The effect would be more serious in the small islands. Therefore, assessment of vulnerability of these islands are of great importance in devising climate resilient strategy. A

vulnerability study of Car Nicobar was carried out which indicated that the coastal plains and hill slopes of Nicobar group of Islands are highly vulnerable to such events. It was observed that about 20% of the area in Car Nicobar has high to very high vulnerability to climate change.

10.4 Sea surface temperature and coral bleaching

The average monthly sea surface temperature (SST) extracted from different locations around the Nicobar Islands for 2010 was higher than the corresponding monthly average SST of each of the three different decadal averages (1981 – 2010, 1991 – 2010 and 2001 – 2010), during January to July (Fig. 10.3). This anomalous increase in SST in Andaman during 2010 resulted in mass bleaching of corals. Short term exposure to such SST anomalies induce bleaching and subsequent recovery, however, prolonged exposure to elevated SST causes chronic stress and frequent high temperature events and can lead to irreversible bleaching (Krishnan et al., 2010). As the SST has direct correlation with the intensity of cyclones, there is greater likelihood of frequent and more intense cyclones in the region in the near future. There is an evidence of a 5-10% increase in intensity (wind speed) which would contribute to enhanced storm surges and coastal flooding.

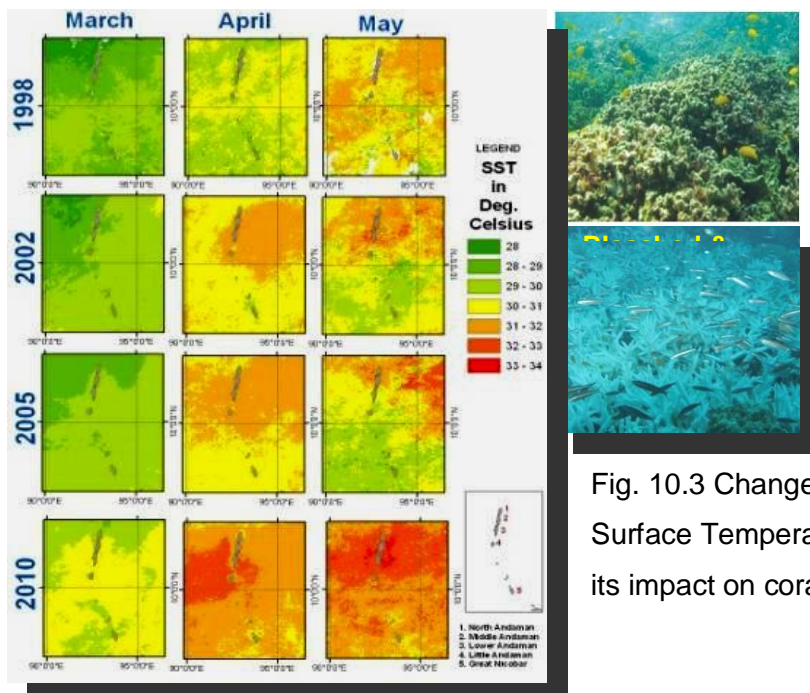


Fig. 10.3 Changes in Sea Surface Temperature (SST) and its impact on coral bleaching

10.5 Impact of tsunami on soil and water resources

The remote sensing (IRS-1D, LISS III), Geographical Information System (GIS) and ground based data were used to assess the impact of *tsunami* with reference to agriculture and soils. Normalized difference wetness index (NDWI)I of pre and post *tsunami* remote sensing data was used to delineate waterlogged areas (Fig. 10.4). The NDWI image was also used as an input with SOI toposheets to carry out ground verification and suitable corrections were made to get the final affected areas. Visual interpretation of remote sensing data of post *tsunami* was also used as an input while delineating the affected areas. It was found that major impact was felt on the eastern coast of the Islands. Off the total agricultural area of 10,466 hectares 14% of cultivated area was affected by tsunami with varying severity of damage. The soils of Dhanikari series was affected most accounted for 48 % followed by Wandoor (18 %), School line (13 %) and others. The impact was found to be higher on Dhanikari series as its spatial extent is on the eastern side of the island closer to the coast.

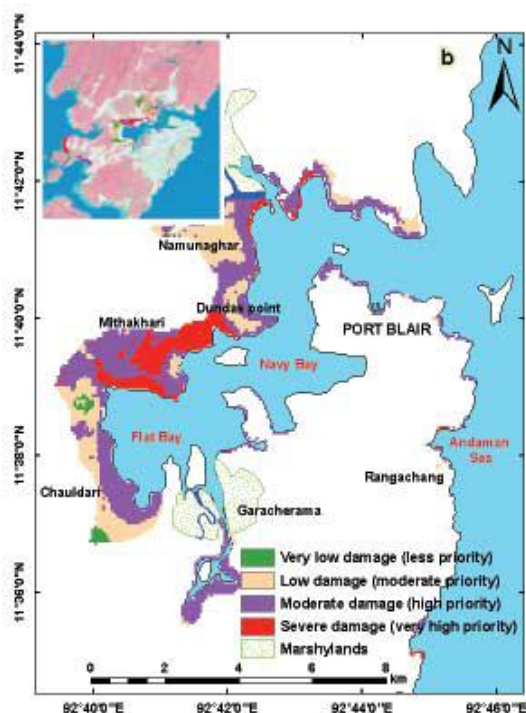


Fig. 10.4 Delineation of tsunami affected areas

Sea water intrusion into the agricultural lands resulted in salinization of soils and adversely affected all kinds of vegetation and soil (Velmurugan et al., 2006). The results revealed that in the affected areas soil pH (6.9) increased slightly as compared to the unaffected areas (6.4). The soil salinity was measured from the soil saturation paste extract and found increase in ECe in the affected areas (17.9 dS m^{-1}) as compared to the unaffected areas. Similarly, increase in SAR in affected areas (19.14) indicated huge amounts

of sodium addition from sea water into the soil. Among the three soils series, Dhanikari recorded maximum SAR value (6.48 – 48.18) followed by Wandoor and School line. However, there is no significant pattern in the spatial distribution of SAR in the affected areas. It appears that soil texture, distance from the coast and the direction of sea water intrusion might have influenced the spatial pattern of SAR. The excessive concentration of sodium ions in the soil may create sodicity problem leading to structural deterioration and poor infiltration. Apart from the soils, tsunami also inflicted greater damage to the livestock resources of these islands. Restoring the infrastructure and enable the farmers to take up their livestock farming in the integrated way, forms the basic strategy for diversification of agriculture in the tsunami affected areas.



Fig. 10. 5 Impact of tsunami on soil, crop and livestock resources

10.6 Adaptation

Apart from the El Nino effect over the Island the changing weather pattern calls for cautious approach in weather and natural resource management of our Islands. Future development of village settlements should be in clusters on elevated land away from the coastal areas. Therefore, agriculture should move towards more water efficient and climate resilient crops. But, enhanced efforts are essential for localized harvest and storage of rainwater in addition to recharge of ground water resources to gear up ourselves for any climate change effects in the future. It is also essential to preserve the corals and mangroves to enhance the ability to adapt to future climate change. The focus has to be on adaptation-centric, pro-development climate policy for the islands against the conventional approach of responding to climate change as an environmental problem.

11. Climate change adaptation and diversification

Global climate change and food insecurity are the two major challenges for humanity, with the former appearing to escalate faster than the later (FAO, 2012). The impacts of changes in climate and climate variability on agricultural production will have substantial effects on small holder farmers in many parts of the tropics and subtropics, and the resulting reduced food security potentially will increase the risk of hunger and under nutrition (HLPE, 2012). Averting this challenge requires that farmers adapt by making changes in farming and land management decisions that reduce the negative consequences associated with changing climate (Jarvis et al., 2011). The adaptation options may include increasing the resilience of existing farming systems, diversification and risk management (Thornton and Herrero 2014).

Diversification may be of on farm and off farm diversification. The on-farm diversification occurs when more species, plant varieties or animal breeds are added to a given farm or farming community. It also includes landscape diversification *i.e* different crops and cropping systems interspersed in space and time. Non-farm diversification may occur when taking up non-farm activities or processing of farm products. Both on-farm and off-farm diversification helps in adapting to climate change by smoothing the short-term household income fluctuations and providing households with a broader range of options to address future change (Thornton et al. 2013). It is important to recognize that diversity can be created temporally as well as spatially, adding even greater functional diversity and resilience to systems with sensitivity to temporal fluctuations in climate.

11.1 Rationale for Andaman and Nicobar Islands

Product/crop diversification can also lead to diet diversification because of on farm production which can have an important role to play in adapting to climate change. This can be achieved by on farm diversification of crop production and integration of other on farm activities like livestock, back yard poultry, fisheries etc. depending on the site specific conditions which is highly dependent on the geographical and socio-economic context of the

specific farming system. While diversification is an important element of climate change adaptation, there is surprisingly limited information available that can be used to guide farmers and farming communities in a particular situation. This is more pertinent to the island ecosystem of Andaman and Nicobar which is vulnerable to climate change events.

The Andaman and Nicobar group of experiences tropical humid climate because of their location in equatorial zone surrounded by Andaman Sea. Maximum rainfall is received during May to December and dry period extends only for 3 to 4 months from January to April. Agriculture in the Islands depends on rains which mostly occur during monsoon months (June-September). Due to heavy concentrated rainfall in a short span, flat topography, low infiltration rate and lack of proper drainage most of the cultivated fields are deeply waterlogged limiting the cultivation of HYVs of rice and mono cropping of tall *indica* rice varieties in *wet season*. During dry season, acute shortage of irrigation water along with increase in soil and water salinity due to presence of brackish water table at a shallow depth compelled the farmers to keep their land fallow leading to high poverty and unemployment among the rural people.

11.2 Crop Diversification

11.2.1 Genetic/Varietal diversification

The crop diversification can be achieved at two genetic level or species level. In Andaman Islands, long duration, photosensitive rice variety (C14-8) is traditionally grown during monsoon season. It is transplanted during August and harvested in December or January after withdrawal of monsoon rains. Because of which land is kept fallow during the dry period and mostly monocropping of rice is the general norm in this region. Recently number of medium duration, photo insensitive and high yielding varieties were developed or evaluated (Table 11.1) for the islands and are found to increase not only the yield but it enables growing of dry season crops. Different diversification methods are detailed by Swarnam et al., (2015).

Table 11.1 Performance of improved rice varieties

Rice variety	Average Yield (t/ha)
CSIR-36 (Medium duration)	4.2
CARI Dhan-5 (Long duration & salt tolerant)	4.0
Naveen (medium duration & salt tolerant)	3.6
Jaya (Medium duration local variety)	2.8
C 14-8 (Long duration local variety)	2.3

11.2.2 Cropping system diversification

Rotation systems have been used for millennia to maintain soil fertility and productivity and to suppress pests and diseases. Diversification through crop rotation can be an especially useful strategy in farming systems that integrate crop and livestock production. The addition of forage crops to cereal-based system enhanced nitrogen supply through fixation by legumes, and increased nutrient cycling due to greater livestock density and manure production. These changes allowed the intensification of both crop and livestock production and increased yields substantially.

Rice is the only cereal crop grown in the Islands during wet season due to water logging in valley and coastal plains. The land is kept fallow during dry season. Crop rotation with vegetables, pulses, oilseeds and maize not only increase the production and improve food and nutritional security due to increase in farm income and on farm availability. Suitable rice based cropping systems viz., rice-green gram, rice-maize, rice-vegetables (okra), rice-ground nut, and rice-fallow were evaluated for the valley areas. The results indicated that highest yield was obtained in rice-maize system (16773 kg ha⁻¹) followed by rice-okra (15630 kg ha⁻¹). Accordingly these systems also recorded highest net return and B: C ratio of more than 3.0.

11.2.3 Diversification through intercropping or mixed cropping

The practice of growing two or more crops together is widespread throughout the tropics. The benefits of nutrient exchange, reduced weed

competition and pathogen control can generate substantial increase in income and stability to the system. In Andaman Islands coconut is grown in an area of 7135 ha, which can be utilized to grow inter crops like green fodder, pulses besides spices like clove, cinnamon, black pepper etc. The cultivation of pulses in new niche areas like intercropping in coconut is promising for increasing the pulse production in these Islands because at present only 1154 tonnes of pulses are grown in the Islands from an area of 2610 ha which is not sufficient to meet the local demand of 6200t. The sole crop area after rice cultivation is limited in the Islands because of competition from vegetable cultivation. As in coconut plantation, 76 % of land is lying vacant which may be utilized for pulse cultivation.

The intercropping of red gram in coconut recorded grain yield of 459 to 544 kg/ha. The black gram varieties/lines, AN-11-19 recorded higher yield (354 kg/ha) which was at par with VBN 6 (330 kg/ha). Though the yield level of pulses under coconut plantation is low (40-60 % of sole crop yield), there is a scope to increase the pulse production in Andaman Islands through area expansion under coconut plantations.

Two varieties viz., ICGS 76 and TG 37A of table purpose ground nut were intercropped in more than 10 year old coconut plantation having the spacing of 7.5 m between rows. The result indicated that TG37A recorded significantly higher pod and kernel seed yield (1652 and 858 kg ha⁻¹ respectively) compared to ICGS 76 (1245 and 740 kg ha⁻¹). On an average, the light intensity of 42500 lux was recorded during flowering stage (45-55 DAS) in the plantations of more than 10years age which is sufficient for ground nut.

11.2.4 Diversification through integrated farming system

In conventional diversified systems crops and livestock coexist independently from each other and serve 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. So the integrated farming system not only allows the diversification but also allows synergy between the components to increase production and productivity. Based on the principle of enhancing natural biological processes above and below the ground, the integrated system represents a winning combination that (a) reduces erosion; (b) increases crop yields, soil biological activity and nutrient recycling; (c) intensifies land use, improving profits; and (d) can therefore help reduce the negative consequences of climate change and have the potential for providing mitigation co-benefits besides help reduce poverty and improve food security. Different IFS model have been evaluated for hilly uplands, mid slopes and low lying areas of Andaman Islands and the result showed increase in net return and employment generation. This land specific IFS is more resilient to climate change and sustainable under island condition.

11.3 The way forward

The challenges posed by climate change will have greater impact on small holder farms by way of erratic rainfall, persistent droughts, desertification, high temperature besides changing policy environment within which they operate. Considering the increasing population growth and degradation of land resources, the key options to tame climate change related problems rest on: agricultural diversification through the use of water and nutrient efficient cultivars, modifications in existing cropping systems and adoption of site specific integrated farming systems to diversify the farming systems and also harness the mitigation co-benefits. The land management options to reduce the impacts of waterlogging and facilitating *in-situ* water harvesting will also play a major role in ensuring food security of the small holder farmers.

12. The role of value added services

The agricultural sector is knowledge intensive and should be farmer centric. To improve and sustain farm productivity, farmers require information on new technologies, best practices, inputs, and postharvest information related to marketing and prices. The traditional information broker between the farmer and some of this information has been the public-sector agricultural extension agent. But over the past few decades public-sector extension has received much criticism due to limited reach and relevance, and high cost of operation. With the changing focus of agricultural extension and with the commercialization of agricultural technology and research, the private sector and revolution in IT is now playing a larger role in advisory services which can be made used to improve the tribal farming systems.

In this context, value added is defined as the addition of time, place, and/or form utility to a commodity in order to meet the tastes/preferences and improving the derived utility so as to benefit the tribals, otherwise of consumers. In other words, value-added is figuring out what consumers want, when they want it, and where they want it – then make it and provide it to them. In an approach to improve the diversification and technological adaption in Nicobar Islands, the technologies were disseminated to the farmers and tribals of these islands. We have organised on-farm demonstration, FLD, village adaptation and health camp for which we made use of mass media and personal contact. In addition, field days and training programmes were organised. In order to support the farm decision making integrated agro-advisories and to increase the fish catch potential fishing zone advisories were issued.

12.1 Advisories for weather based agricultural activities

Integrated agromet advisories are issued twice a week for each district based on the local condition and predicted weather pattern using advanced process models. It is disseminated through media, SMS, internet, KVK and personal contact. In the Dry season rain forecast help the farmer to postpone land shaping activities in low lying areas. This lead to saving in cost of labour

as labour cost is very high in this Island. Similarly, timely advice to the farmers based on the weather forecast help them to strengthen the field bunds and mud plastering the bunds to store rain water. Based on the advisory, farmers provide clean water with glucose and vitamin C to the poultry birds to avoid heat stress and mortality rate. In addition, seasonal advisories are also issued to help the farmer in planning agricultural activities for entire season.



12.2 Potential Fishing Zone advisories

The information derived from satellite based observation over ocean has immense potential to improve the fish catch, particularly the resource poor farmers. In Andaman and Nicobar Islands potential fishing zone advisories are based on Indian Remote Sensing Satellite P4 Ocean Colour Monitor (IRS P4 OCM) derived chlorophyll data and National Oceanographic Aerospace Administration- Advanced Very High Resolution Radiometer (NOAA AVHRR) derived Sea Surface Temperature (SST) are generated thrice a week by Indian National Centre for Ocean Information Services (INCOIS). These forecasts are disseminated with an objective to exploit the fishery resources of ANI in a sustainable manner and to bridge the gap between the estimated and harvested potential for the islands. We have

conducted capacity building programmes to help the fisher-folk in identifying fish stocks and in designing successful harvesting strategies.

12.3 Animal health camps

Improving the productivity of livestock is very vital to ensure the diversity and sustainability of agriculture. Due to harsh and humid climate the farm animals develop several health problems which need to be addressed. However, in smaller islands maintaining large cattle population may be a problem, instead tribal are concentrating well adapted animals such as pig, poultry and goat. In order to increase the production and economy of



: Infertility camp organized jointly by CARI and Dept. of AHVS at New Bimbliton village of South Andaman

livestock, infertility camps were conducted both under farm and field conditions at different locations in Andaman. In the camps 76 cattle were examined and treated. The incidence of various causes of infertility among dairy cattle were 35% for post partum anoestrus, 10.55% for repeat breeding syndrome, 1.3% for post pubertal anoestrus, 3.9% for under developed genitalia in heifers and 5.3% for reproductive disorder viz. endometritis and cystic ovary. The cows were treated periodically with deworming and deticking treatment (Deltamethrin/ Cyprimethrin and injection of Ivermectin) drugs which reduced the pest incidence rate. The infertility was treated following which highest pregnancy rate of 81.9% was observed in CIDR insert protocol followed by Ov-synch protocol (28.6%) and PGF2 α injection protocol (25.0%).

12.4 Capacity building of tribal leaders

Training and exposure visits organized for the tribal leaders providing them an opportunity to learn about different technologies and process of agricultural diversification. They are not only the decision makers in the tribal

community but also can act as a change agent and ambassadors of new technologies.

12.5 Opportunities for tribal products

Farm innovators and farmers day organized at state or regional level provide an opportunity for the tribal farmers to exhibit and find market for their products made through off-farm activities. This can be very well emulated in other tropical islands as it is location specific and even attracts traders if properly popularized.

13. Impact assessment

Agricultural diversification, intensification and development is widely seen as a pre-condition for sustainable pro-poor growth (Ligon and Sadoulet, 2007; WDR, 2007) in this case tribal farmers. An important component of agricultural development strategies is the promotion of the adoption of technologies / innovations. As public investment in development efforts has expanded, attention has focused on assessing how such investments are contributing towards development goals. Decision makers desire information and evidence on the efficiency with which public funds are allocated and the productivity of these investments (Maredia et al., 2014).

13.1 Conceptualizing the impact of agricultural technology

The focus and methods of impact assessment have evolved over time in response to developmental need, interest of public funding and research mandates. At the same time, impact studies have faced both conceptual and empirical challenges, partly due to the complexities of the relationships between agricultural technology and rural livelihoods. As the goals of agricultural technology development change from increasing food production to the broader aims of reducing poverty, both technology development and studies of its impact become more complex. Yet, examining the impacts and impact pathways of different types of agricultural technologies is essential to guide future research and developmental activities in ways that will make the greatest contribution to ensure livelihood opportunity through agricultural diversification particularly in tribal areas.

Impact assessment, being a process, is better conceptualized as a cycle involving different types of impact studies at the different stages. Impact studies essentially have the same process as technology development itself. Based on the technology development process, therefore, four stages of impact assessment would constitute the impact cycle. These include impact for priority setting (i.e., ex ante impact), on-farm technology evaluation, adoption, and ex post impact. The different types of impact studies are not mutually exclusive; they rather serve distinct and at the same time

complementary functions in the technology development and dissemination process. It is pertinent to use the sustainable rural livelihoods framework (SRLF) in assessing the impact of new agricultural technologies (Kerr and Kolavalli 1999) as it considers most of the factors responsible for the livelihood improvement of tribals.

13.2 Technology dissemination and adoption

Suitable technologies were transferred to the farmers (Table 13.1) for efficient utilization of resources such as soil, water, nutrient, crop, animal and fish in an integrated farming system approach in which each components were optimized for efficient resource use in on station/farm trials and demonstrated to other farmers through on farm demonstrations. However, based on the resource endowment, constraints and need of farmers at different Islands, the technological interventions and methodology of dissemination were decided by the participating scientists.

Table 13.1 Details of technology disseminated and area covered

Technology	No. of FLD/OFT	Location and area covered
High yielding varieties of rice (CARI Dhan 5 & CSR-36)	145	North and Middle Andaman, 126 acres
Land configuration techniques for coastal degraded areas	210	Andaman islands, 208 acres
Organic waste recycling and nutrient enrichment by Effective Microorganisms	30	Nicobar Islands
Water harvesting and multiple use	10	Nicobar & Little Andaman
Homestead based integrated farming system	25	Nicobar islands, 2.5acre
Pond based IFS model	12	South & Little Andaman, Havelock & Neil Islands
Animal reproductive management	40	-do-
Live stock Health care	50	-do-
Improved breed of dairy cattle	33	-do-
Integrated carp culture	200	Andaman Islands
Agri-aqua culture	1	South Andaman
Potential Fishing Zone (advisory)	40 -60	Andaman & Nicobar Island
Agromet advisory	1100	-do-

Poultry /duck farming	3262	-do-
Azolla cultivation for feed supplement to poultry	5	-do-
Fodder cultivation for Dairy	15	-do-
Goat farming	66	-do-

Land shaping is one of the economically ecologically viable option for the coastal degraded areas of tropical islands. Therefore, a total of 200 farmers have adopted different land shaping interventions which brought about 210 acres of coastal degraded land into cultivation which was otherwise unutilized. At Car Nicobar, after seeing the success more number of farmers opted for homestead based IFS. So as to meet the nutrient requirement and sustenance of the introduced system, organic waste recycling and nutrient enrichment was very much essential and methods for organic waste recycling and nutrient enrichment were disseminated to the farmers using native effective microbes. Roof top water harvesting and run off harvesting in lined ponds were also demonstrated for its effective use. The opportunities of AIR / Doordarshan to disseminate the technologies were aptly utilized. The success stories of farmers adopted the new technologies were also popularized by DD and press media. All these measure led to the increased production and productivity of vegetables, fruits and tuber crops resulting in increased consumption and nutritional security of the targeted population.

13.3 Productivity enhancement

The interventions in the form of improved rice varieties have immensely benefited the farming community (Table 13.2). In case of rice, CSR-36 and CARI Dhan-5 have gained popularity among the rice growing farmers in low lying and salinity areas in place of traditional variety (C-14-8). Under Island condition CSR 36 it yielded 3.8 – 4.2 tone/hectare (± 0.5) with inputs and proper care at farmers field, while 2.8 – 3.2 kg/ha under low input conditions. Similarly the vegetable production increased 2-3 times due to proper soil and nutrient management, adoption of integrated pest and disease management measures.

Table 13.2 Performance of new varieties / improved breeds

Crop / variety / livestock	Average Yield (t/ha)	% increase
CSIR-36 (Medium duration)	4.2	120
CARI Dhan-5 (Long duration & salt tolerant)	4.0	100
Jaya (Medium duration local variety)	1.8	--
C 14-8 (Long duration local variety)	2.3	--
Vegetables (cucurbits & solanaceous)	10-15	150- 200
Goat (No.)	1-2	60
Dairy animal (litre/animal)	6 liters	60 - 80

13.4. Technology adaption

The land shaping interventions such as BBF, paired bed, rice-fish and farm ponds enabled rainwater harvesting and brought additional area under irrigation besides improving the drainage and productivity of degraded lands. The details are given in the following table 13.3.

Table 13.3 Effect of land shaping on rain water harvesting

S.No.	Land shaping techniques	Area covered (ha)	House hold involved (no.)	Rain Water harvest (m ³ /ha)	Rain Water harvested (m ³)	Additional area irrigated (ha)
1	Farm pond	9.55	88	8000	76400	8.595
2	Paddy-cum-fish	12.69	42	3564	45227	10.79
3	BBF	9.19	51	3812	35032	7.35
4	Three tier system	1.38	8	4509	6222	1.24
5	Paired bed system	2.7	16	3750	10125	2.29
6	Drainage & land improvement	47.81	50	--	--	--
	Total	83.32	255	-	173006	30.265

By integration of crop, fish and animal components, net farm income increased by 1.5 to 2.5 times, mainly through vegetable cultivation even in degraded areas.

Similarly, potential fishing zone (PFZ) advisories increased the fish catch and the success of PFZ forecasts was 94% with 34.35% increase in catch per unit effort (CPUE). Horse mackerel (*Megalapsis cordyla*) was the predominant fish species in the PFZs, constituting more than 38% (Table 13.4).

Table 13.4 Impact of PFZ advisory on fish catch and income

S.No.	Name of the Place	No. of vessels		Average catch & Income		Increase in income per vessel per trip
		PFZ area	Non PFZ area	PFZ area	Non PFZ area	
1	Mayabunder	2	75 - 100	100 kg Rs.8000/-	50 kg Rs.4000/-	Rs.4000/-
2	Diglipur	3	100-150	75 kg Rs.6000/-	30 kg Rs.2400/-	Rs.3600/-
3	Landfall	24	100 - 200	150 kg Rs.12000/-	40 kg Rs.3200/-	Rs.8800/-
4	Light House	12	100 - 200	190 Rs.15200/-	50 kg Rs.4000/-	Rs.11200/-

13.5 Income enhancement

Farmers from Andaman and Nicobar region have benefited from the technological intervention carried out by the participating scientist. Though it is not possible to quantify each and every benefit emanated from the project activity, some of the quantifiable activities are presented below:

- Land improvement measures carried out in the tsunami affected degraded coastal areas shown significant benefit to the farmers (Table 13.5). In general, the net income varied from Rs. 1,23,000 to 2,11,000 per ha and maximum return was seen in paired bed system as this enabled round the year vegetable cultivation and fish culture. The interventions also generated employment opportunities in the tsunami affected areas to the tune of 40-270 mandays/ha. Paired bed system followed by Broad bed and furrow system created maximum number of man days in the intervention areas. In general, 4 to 9 times improvement in income and

employment generation was observed in the intervention areas benefiting 210 farm families.

Table 13.5 Impact of land shaping on economic parameters

Land shaping techniques	Net Income (Rs. ha ⁻¹)		Employment generated (man days ha ⁻¹)		Cropping intensity (%)	
	Before Intervention	After Intervention	Before Intervention	After Intervention	Before Intervention	After Intervention
Farm pond	10000	147600	40	110	100	200
Paddy-cum-fish	24000	147991	40	175	100	200
Broad bed and furrow	24000	212501	45	240	100	240
Three tier system	30000	221497	50	210	100	230
Paired bed system	24000	235582	45	270	100	240
Drainage and land imp.t	14000	26000	30	75	0	180

(NAIP final report, 2014)

- Similarly pond based Integrated farming system was implemented at 12 farmer's field in four Islands. The results showed that the income varied based on the resource endowment of farmers and their level of involvement. However, on an average Rs. 8,000 to 18,000 was realized in 0.2 ha area of intervention. One farmer Shri. Ramachandran, Mile Tilak close to the Jarawa tribal reserve has got 18,000 net returns from 0.2 ha area and net productivity of Rs. 49.3 per day.
- The revenue from total fish catch in PFZ increased to Rs.81000 with net profit of Rs.45000 as compared to Rs.31500 and a net profit of only Rs.16000 in non-PFZ. This amounts to 2.8 times higher net profit for those adopting PFZ advisories.

13.6 Nutritional improvement

The interventions carried out in the tribal areas significantly increased the production of vegetables, fruits, tubers, meat and egg. Due to the Homestead based IFS model along with organic waste recycling and water

harvesting resulted in higher production even better than large scale intervention carried out in the tribal areas by other agencies (Fig. 13.1). In addition, the participatory model and the efforts of scientific team resulted in greater involvement of tribal people especially women in the production system. This led to higher production of vegetables, fruits and tuber crops to meet the nutritional requirement of a tribal family of 5 members (Table 13.6). The excess production is normally shared with other members of the tuhet. In the intervention areas cereals and pulses are supplied through PDS. It was also seen that the animal meat and egg production has exceeded the requirements which created marketable surplus. Thus, the production model resulted not only in achieving nutritional improvement but also produced marketable surplus in certain food items.

Table 13.6 Change in average daily consumption of specific food items

Food Item	RDI/ person (g)	RDI/ Family [#] (g)	Consumption quantity (g/family/day)			Deficit/surplus	
			Before intervention	After intervention	Change	Before	After
Cereals	400	2000	1360	1625	265	-640	-375
Pulses	80	400	190	265	75	-210	-135
Vegetable	150	750	255	625	370	-495	-125
Greens	50	250	50	175	125	-200	-75
Fruits	100	500	265	480	215	-235	-20
Tuber	100	500	750	560	-190	250	60
Fish, Meat	50	250	200	300	100	-50	50
Egg (week)	3.5	17.5	0.5	12	11.5	-17.0	-5.5

* Not produced due to non-suitability of land, met through PDS & import

In the tsunami affected degraded areas introduction of salinity tolerant rice varieties resulted in higher production, 35% of which is used for self consumption. The local varieties are poor in amylase content (glutinous) and does not expand in volume, but CARI-D-5 and CSR-36 varieties have moderate (20-25%) to high (>25%) amylase content and are non-glutinous in nature having good cooking quality. Vegetable and fruit consumption has

significantly increased in areas where land shaping water introduced due to the year around vegetable production. It was also seen that broad bed and furrow and paired bed system favored diversification of farm activities resulting in stability in production and income to the farmers. In addition, 1 to 1.5 ton/ha of fresh water fish was produced which strongly supported the income and nutritional requirements of people living in the coastal degraded areas.



Fig. 13.1 A model IFS based garden at Car Nicobar

13.7 Socio-economic profile at post-intervention stage

The technological interventions have certainly increased the income level of farmers which has resulted in certain changes in his social profile as well as expenditure pattern. It was observed that the homestead based IFS model introduced in the tribal areas increased the diversity and productivity agricultural produces in which some of them are grown for the first time. It has not made very significant increase in the income level of tribal farmers because in the tribal society things are shared among them selves and mostly barter system is practised between tuhets. But, it made big impact on the consumption pattern of tribal family and ensured the nutritional security. The

increase in income in the last few years is due to increased procurement price of copra. However, the interventions reduced the expenditure on food items and resulted in capital investment. The average income of tribal household at present has increased to Rs. 85000 from Rs.46087/- estimated in 2009. However, the increased income resulted in more expenditure on health care and purchase of house hold articles.

In coastal degraded areas where land shaping interventions are carried out, net income, employment generation and cropping intensity were significantly increased. The increase in income level of farmer reflected in their expenditure pattern. Most of them spent the additional income on children's education, health care and renovation or construction of house and animal shed etc. Besides other perceptible change in their mind set and attitude which can be seen from,

- ✓ Shift towards production of high value crops and leasing in land for cultivation
- ✓ Consumption of diversified food items with increased consumption of vegetables, fish
- ✓ Became local leaders, role model for others sharing their knowledge and experience
- ✓ Younger generation taking up agriculture as business by having commercial livestock farming and fish breeding etc.

14. Sustaining the technology dissemination

Every government and developmental agencies spend their resources on dissemination of technology and its adoption by the farming communities and in most of the tropical islands this is a stated policy of government of the day. At the same time they are increasingly concerned about sustaining the process of technology adoption and agricultural growth. How and under what conditions can decentralised governance, capacity building and participation by farmers promote food systems that adapt to changing conditions and climates and maintain agricultural diversification and growth?. Sustaining the growth and adoption of technology will become difficult in due course of time until proper strategy is in place to continue the process. Different methods / strategy for sustaining the technology are discussed in this chapter.

14.1 The rationale

In many instances in the past farmers revert back to their old / traditional way of agricultural practices and resources after initial adoption of new technology. This will result not only in wastage of resources and time spend but also discourage the efforts to ensure food security of the tribals. There are several reasons for the fall back. Therefore, sustaining the adopted technology is as important as that of introduction of new technology particularly in the tribal areas. Unlike other mainstream farmers, tribals attach much value to their traditional way of lifestyle and agriculture is way of life in most part of the tribal areas across the globe.

In Nicobar Islands, the constraints for non-adoption were identified during the resource assessment and targeting stage itself which helped to devise sustainability strategy for these techniques. Diversification of agriculture was carried out in a holistic manner rather than a isolated and individual approach. The main focus to sustain the introduced technology was on skill upgradation, motivation, social networking, economic stability, market access and linkages. The following methods were employed depending on the location and technology transferred to make our interventions sustainable in the tribal areas.

14.2 Formation of Self Help Groups (SHG'S)

This is very important local level institution useful in sustaining the technology as well as can be used a conduit for introduction in the future. Several farmers SHG were formed in the intervention areas with their own compatible members. These groups have elected representatives among themselves and are interlinked with other similar groups. They share the ideas, information and help each other enabling the information flow between different islands and also between others down below. These SHG's have their own bank savings accounts. In the areas of land shaping interventions farmers were paid 10% of total cost of technology to their society. This is deposited in the form of sustainability fund in the bank which can be used for the maintenance and repair of their tools, equipments and land shaping interventions. This is one of the viable models to sustain the technologies involved in agricultural diversification and can be replicated in other tropical islands.

14.3 Entrepreneurial development and input support

Efforts should be made to develop entrepreneurial skills among the tribals so that demand can be created for the diversified farm products of the tribal at local level. This can be further networked linked to outside markets with required resource support by the local or tribal administrative body. In Nicobar Island, some of the interested tribal farmers were well trained, motivated and extended support to set up commercial units in integrated carp culture, dairy farming, goat rearing and poultry farming, they act as a source of information and inputs for other farmers in their locality. We have also conducted one training and established model dairy unit in collaboration with a cooperative society which deals with livestock products.

As the people of these islands prefer fresh water fish there is lot of scope for the tribal youth to take up employment in fish seed production. This opportunity was translated into practice by way of establishing satellite fish nursery in North, Middle and South Andaman at farmer's field after imparting technical skill on fish breeding to the farmers and unemployed youth. Initially they have been given fingerlings to grow and after breeding in the next

season sold the fingerlings to nearby farmers in nearby area. This ensured income as well as timely availability of freshwater fish seeds to the farmers. The model was successfully implemented with the active collaboration of Department of fisheries, Govt. of A & N, NGO's, farmers group and our team at CARI. The model can be adopted in other tropical islands where demand exists for fresh water fishes.

14.4 Creation of Community assets

Sometimes it is worth to invest in community assets which can promote community action in technology adoption. Homestead based IFS model was established on *tuhet* basis in a participatory mode in Nicobar Islands involving all the individual families of the *tuhet* (extended joint family of the tribals) with the main aim of providing nutritional security of the tribals. Fenced homestead garden, water harvesting structures and composting tank were constructed in the adopted villages which are to be maintained by the *tuhet*. Essential farm tools, equipments, farm animals, fish lings, boats, efficient micro organisms, seeds of high yielding varieties of suitable crops and multipurpose trees were distributed as a means of technology introduction. These are relatively durable and farmers are trained to maintain and produce themselves.

14.5 Agromet and potential fishing zone advisories

Farmers face problems due to climate change and changes in weather pattern. The information is vital to improve their efficiency and to build their confidence in the benefit of introduced technology. At the present level of technology use in the world it is very much possible to provide the farmers at their door step the required information. In Andaman and Nicobar Islands through advisory services the scientific team aiming for diversification and livelihood security of tribal could reach out to the farmers every week through print and electronic media. Advisories were also given for new technologies / methods and feed backs are also obtained from the farmers. In addition, the team has established very close linkage with local leaders who visits the host institute (CIARI) more often for information or input support which ensured two

way information flow, instilled confidence among the farming community resulting in sustainability of the interventions and production system.

14.6 Documentation of indigenous technical knowledge

Traditional knowledge is the acquaintances about particular thing that people in a given community have developed over time, and continue to develop. It is based on the experience, often tested over centuries of use, adapted to local culture and environment, dynamic and changing. During our course of work in tribal areas of Nicobar Islands attempts were made to document indigenous knowledge on various farm activities viz., agriculture, livestock and fishery.

The Nicobari tribes practice natural farming and maintain plantations and home gardens for growing fruits and vegetables. This helps them to fulfill dietary, economic and social needs and provide them with supplementary food, fruit, fodder and fuel. The traditional knowledge on all activities involved in coconut cultivation including drying and oil extraction were documented (Velmurugan et al. 2014). In addition, various terms in tribal language to denote different farming activities have been documented for better understanding and interactions.

Term used to denote various farm activities in Nicobari language

English	Nicobari	Hindi
Air	KufÖt	वायु
Animal	Törēula	पशु
Banana	TanyukngÖ	केला
Brinjal	Bahen	बैंगन
Coconut	Kuk (Kiltôchû) (chilka)	नारीयल
Cultivation/Ploughing	Inulō Tumlat	खेती
Deficiency	Kanunen	अभाव
Disease	Invāh	बीमारी
Earth Worm	KamlÖkÖ Tumlat	केंचुआ
Erosion	HanemÖ Tumlat	कटाव
Family	MinkÖunÖ	परिवार

Farming	TineuchÖ	खेती करना
Fish	Kāk	मछली
Food	Nga-a	आहार
Fruits	KulÖl TanyukngÖ	फल
Glyricidia	TÖanhchôn	जिंदा बल्ली
Goat	PokÖre	बकरी
Health/Healthy	Kanôlô Alaha	स्वास्थ्य
Heat	RanachÖ	गरमी
House	Pati	घर
Human	Tarik	मानव
Insect	KamlÖÖkÖ	कीट
Integrated	TÖ-HêngÖmülÖ	एकीकृत
Leaf	Rôy chôn	पत्ते
Lemon	Limong	नीम्बू
Loss	Yamengen	हानी
Maize	MilÖh	मकई, ज्वार
Money	Rupee	रुपया-पैसा, मुद्रा
Namaste	TalÖk Peuheu (Morning) Talök horap (Evining)	नमस्ते
Nicobari Fowl	TokiniÖt hayÖm	निकोबारी मुर्गी
Nutrient	Inkôlô Alaha	पुष्टिकर
Pig	Ha-un	सूअर
Pine-apple	Firung	अनानास
Poultry	ChukimhayÖm/Niwbaripoun:TokiniÖt	मुर्गी
Quality	TÖkeung	विशेषता
Rain	kumrah	बारिश
Ralling/fencing	KinlôngÖ	रेलिंग
Recycle	Chinvi.fÖ	पुनःइस्तेमाल
Sakthi/Energy	Knmlex	शक्ति
Seeds	Kari	बीज
Sesbania	TÖcharichôn	ढंन्चा

Shed	Pati TÖreula	छपपर
Soil	Tumlat	मृदा
Solar Heater	Infaich (LamÖktÖ kũÖtavũÖi)	सौर गर्म यांत्र
Thank You	Tolngoð	धन्यवाद देना
Time	Rē-taka	समय
Vermicompost	Lane-en Taneuch	कैचुआ खाद
Waste	TÖye-neng	अपशिष्ट
Water	Mak	पानी
Water tank	Chuk Māk	पानी कुण्ड
Yield	Poyen	उत्पादन

Similarly traditional knowledge on pig farming and fishing crafts and gears of the tribals have been evaluated and documented (*Jeyakumar et al. 2014*). The study showed that *Hodi*, an outrigger dugout canoe is the traditional fishing craft commonly used by the *Nicobarese* and the traditional fishing gears include spears, hook and line, trolling line and bow and arrow (Fig. 14.1). In addition, the study also elucidates the design and operation of them and the traditional practice of stupefying the fishes with an indigenous plant extract.



Fig. 14.1 Traditional fishing crafts used by Nicobari tribes

14.7 Skill upgradation by trainings

Trainings are very essential to upgrade the skills of the tribal in specific activity. Further, through training the knowledge and the confidence in inculcated among the tribals in implementing and utilizing any new

technology. Caution should be exercised to value the tribal customs and follow other extension principles while imparting trainings.

In the tribal areas of Andaman and Nicobar, training was imparted with special reference to natural resource conservation and livelihood improvement through production technologies of crop, fish and livestock in tribal areas. A total of 36 thematic trainings were organised in 6 major areas spread over a span of 7 years directly benefiting farmers of Andaman and Nicobar Islands. It was conducted in a participatory mode and mostly at the research farm or farmers field. In addition to this special health camp and field visit was conducted immediately after tsunami to improve the reproductive health care of livestock. Maximum participation was recorded for fish production technology followed by animal health care and crop production. A glimpse of some of the important training activities and the level of participation of farmers can be seen in Fig. 14.2.

14.8 Documentation of Success stories

It is obvious that all the farmers won't get the desired level of success in any agricultural developmental activities. There may be several internal external factors contributing to the success. But, the successful farmers might have given their hard labour with determination to ride over the hardships while accomplishing the target. They stand in the forefront of technological adoption among the other tribals, who can be the role model for other farmers to emulate. Their recorded experiences and accomplishments form the success stories. Due to the efforts of the team over the years, many farmers could achieve increase in production and productivity of farming enterprises acting as a motivation and role model for other farmers in their area. The achievements of such farmers are documented in the form of success stories in print and electronic form. This would act as a source of inspiration for others to follow and the success stories has the capability to invite the faith of the tribals towards the developmental agencies or the change agents.



Field day on water harvesting



Management of dry season crops



carp seed production



IMC culturing



Vegetable cultivation in degraded lands



Resource management in coconut

Fig. 14.2 Training an essential component for skill upgradation

14.9 Ways to increase the sustainability of agricultural diversification

It is very important that the technologies disseminated are sustainable in the years to come. It should not discontinued immediately after the withdrawal of the change agents from the trial areas. There are five ways in

which sustainability of technologies disseminated and adoption could be enhanced. They are as follows,

i). By ensuring immediate benefits

While environmental soundness and resilience are paramount, farmers must experience an immediate benefit if they are going to change their practice or implement the new technology. Only then can it be sustainable in the long term. Getting benefits from diversification of tribal farming is not always quick though, as it takes time for new approaches to be adapted to different agroecological and socio-economic conditions and to show their impacts. For example rebuilding organic matter dramatically improves soil fertility and moisture, but it can take two or more years for this to happen.

In Nicobar Islands, CIARI has promoted an improved variety of cassava and sweet potato that performs even better if grown using conservation practices. This has provided an incentive for the tribals to adopt conservation agriculture. Improved access to market can also trigger farmers' motivation to invest in agriculture.

ii). By providing intermediate, appropriate technology

In order to be attractive, sustainable practices need to be technically as well as economically efficient. Intermediate technological solutions such as light machinery and affordable tools can encourage small-scale farmers to test them. New tools and practices can be better tested to the local conditions through participatory research. Very advanced and high cost technology should not be introduced till they are known to it. Capital intensive technologies which are very important for diversification and sustainability should be introduced with government investment or in a cooperative approach so that the tribal share the benefit.

iii). By dissemination of alternate ideas with due value to the tribal ethics

Farmers know a lot, but they may not know about alternative options if they have not been introduced to them. Research and technical extension staff need additional resources to reach more farmers, and they need more training on 'non-conventional' farming methods and on innovative ways to

share their knowledge. Farmer Field Schools, trainings, scientist interaction allow organizations / change agents to transfer knowledge, for instance on rain water harvesting and use, while ensuring that farmers' interests and learning skills are prioritized.

iv). Increased coordination and planning

There should be increased interaction with the tribal organization, farmers group and the research institutes to engage in an open and honest conversation on technological adoption for diversification. Efforts should also be made to work with other agencies and line departments already working in this line so that the impact could be amplified by fostering synergies, making interventions more consistent and avoiding duplication of efforts.

v). Increased policy support and leadership

Addressing technical and financial constraints is important, but policy coherence is essential for scaling-up. One way to reinforce policy advocacy for diversified tribal farming system is by producing and consolidating evidence of its benefits, in contrast with the negative impacts of high-input intensive monocultures. A better shared understanding of these issues would provide common ground for local actors / tribal leaders to pursue the changes that are needed in agricultural policy and practice.

Conclusions

Diversification of tribal farming is the need of the hour to ensure the food and nutritional security. It has the greater potential to adapt to the changing climate if we include locally adapted crops, livestock and practices. In tropical islands across the world mixed farming provides more sustainability though the productivity is low compared to the specialized agriculture. The available genetic diversity should be documented and utilized to promote diversification.

The present study in tribal Islands of Nicobar clearly indicated that the agricultural production in these Islands is limited by biophysical factors such as rainfall, soil and water resources besides government policy on land use. Due to the efforts to diversify the tribal farming system, the nature and composition of different composition has significantly changed. The agricultural commodity baskets of adopted farmers have changed significantly during the last five years. A temporal comparison of the various constituents of agricultural income indicated that after the intervention livestock now accounts for around 40 percent of agricultural (crop and plantation) output. Similarly fisheries share in aggregate agriculture products has also improved.

Increasing public investments in infrastructure like roads, cold storage and port will ensure the greater phase of agricultural transformation and diversification. At the same time building efficient marketing networks is vital to ensure the sustainability of production system and instill the confidence in the tribal farmers mind. This should be core of any government initiative in islands as the farmers cannot afford to lose or can create themselves due to lack of financial power.

Actions in the technical, policy and institutional arenas can help ensure that plant genetic resources and seed delivery systems function effectively to support sustainable crop production and diversification. Although they will involve diverse institutions and take place at various scales, the required actions will have their greatest impact if they are coordinated.

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