Journal of the Andaman Science Association Vol 30 (1): 1-12 (2025)
ISSN 0970-4183, Printed in India

Sustainable technological support options for promotion of horticulture sector to attain nutritional security in tropical islands: a case study of Andaman and Nicobar Islands, India

Shrawan Singh[1]*, D. R. Singh[2] and I. Jaisankar[3]

[1]*Principal Scientist, Division of Vegetable Science, ICAR-Indian Agricultural Research Institute, New Delhi-110012*

[2]*Vice chancellor, Bihar Agricultural University, Sabour*

[3]*Senior Scientist, ICAR-CIARI, Sri Vijaya Puram*

***Corresponding author's E-mail:**- singhshrawan@rediffmail.com*

Abstract

Traditional staple diets are changing across the globe due to supply-driven farming systems. Breeding efforts in some crops for wider adaptation and stress tolerance helped the growers to opt for these crops in geographically challenging regions. Horticultural crops also have seen the same trend, and exotic crops have now become part of traditional and regular diets in native tribes in tropical island regions. These regions are geographically vulnerable to climate change, invasive species, fragile land topography, limited water balance, low scale of technology adoption, low market integrations, and have vulnerable marginal communities with poor techno-history. In such case, the CARI (now CIARI, Port Blair) has made significant impact in past four decades through technology development, refinement, promotions, human resource development, technology backstopping, and challenging frontier areas. Utilization of biodiversity, breeding improved cultivars from local germplasm, promotion of protected cultivation, redefining land use patterns, multi-storey cropping, micropropagation for local supplies, introduction of exotic horticultural crops, bioprospecting, processing and value addition are certain developments which contributing slow but steady improvement in horticulture sector. However, there is need to give adequate emphasis to production systems for quality produce of horticultural crops for year-round supplies with the available resources using sustainable technological options including advanced sensor-based techniques to benefit growers, consumers and ecology.

Key words: *Horticultural crops, Improved varieties, local biodiversity, Nutritional security, and Intercropping.*

Introduction

The Andaman and Nicobar Islands (ANI) are located in Bay of Bengal and have 86% forest cover with six indigenous and more than seven settler communities. The archipelago of Andaman and Nicobar Islands is constituted of 572 islands in Bay of Bengal in Indian Ocean with geographical area of around 8249 sq km area. About 38 of 572 islands inhabited having 94 % land mass having about 3.79 lakh population. The industrial development is slow but tourism, agriculture and fisheries are important livelihood options (Chand *et al*., 2015). The horticulture sector has crops like plantations, tropical fruits and vegetables, orchids, spices, medicinal plants as potential source of food and livelihood (Velmurugan *et al*., 2016; Singh *et al*., 2017). Indigenous fruits and vegetables are common in the islands and rich in essential dietary micronutrients and phytochemicals (Singh *et al*., 2018a). The innovative interventions such as improved varieties, protected cultivation, eco-tourism, high value crops, promotion of underutilized but nutritious crops, germplasm conservation and utilization, organic farming, propagation techniques and weather forecasting showed promise for boosting horticulture even in situation arising due to climate change (Velmurugan *et al*., 2016; Chadha *et al*., 2002; Malhotra, 2017; Singh *et al*. 2018b). Most of the horticultural commodities are perishable and bulky hence require local production for regular supplies for diets. Different region and scale-neutral technological support options for horticulture sectors are available, however, some standardized and time-tested options are available for the tropical island regions. The islands have great prospect for rejuvenation of horticulture and in present paper attempt for systematic analysis of the suitable technological support options for development of horticulture sector particularly to target nutritional security in the islands.

Nutritional status of island population

India has done tremendously well in food security front through increased foodgrain production and channelizing it to people through public distribution system and other channels. However, there are almost 21% of the populations in the developing world who suffer hunger.[2] Another bigger challenge is the nutritional security which has consequences for the family, society and nation. Underweight (23%) and stunting (34%) are prevalent in the developing world, respectively [3]. Undernutrition is the main threat to health and well-being in middle- and low-income countries, as well as globally. The islands have native tribes Nicobarese, Great Andamanese, Jarawa, Shompen, Onges and Sentenales and settler communities including Bengali, Tamil, Telugu, Ranchi, Malayali, Odiya and others. About 38 of 572 islands inhabited having 94 % land mass having about 3.79 lakh population. Manimunda and Sugunan (2017) reported the prevalence of 27% undernutrition, 36% stunting, and 81% anemia. In Shompen tribe, Rao *et al*. (1998) reported 85% children as undernourished which declined to almost an insignificant number as per the findings of Vijayachari *et al.* (2024). However, Vijayachari et al. (2024) reported anaemia prevalence as 48.3% and 54% in male and female, respectively. Undernutrition and anemia prevalence were significantly low among Nicobarese children (aged 6-59 months). Nicobarese children have prevalence of 14.7% and 58.4%, respectively. Andaman islands have higher prevalence of anemia than the rest of the India (NFHS-3, 2015). Prevalence of anaemia declined significantly from 87% (in 1997) to 51% 15 years later (Chandar *et al.,* 2018). The poor nutritional status of the children with the low intake of dietary requirements such as leafy vegetables (74.6% of RDA) and other vegetables (72.0% of RDA) less than the RDA (Rao *et al*., 2006; Manimunda and Sugunan, 2017).

Livelihood and income status

Service sector is the major contributor in Gross State Domestic Product (Base year 2011-12) of Andaman and Nicobar Islands with 65% share followed by secondary sector (20%) and primary sector (15%) on 201-12 price) (Basic Statistics, 2017). The share of primary sector is decling year-wise. However, in terms of livelihood, about 50% of the UT population is directly dependent on agriculture and allied activities. Per capita net state domestic product at current prices (base year 2011-12) was 1,97,275 in 2020-21. A large proportion of youth remain unemployed during tourist off-season, lack of industrial activities and limited opportunities in service sector make them 'sit-at-home'. Reduction in the share of agricultural activities was attributed to land submerged in Tsunami, movement of youth towards secondary and service sector, lack for agri-infrastructure to sustain interests and higher returns, volume cap in domestic market and poor export prospect in current scenario. Tourist sector is most emerging sector but to harness the full potential it is essential to equip the local growers for demand driven food items production.

Horticulture crops scenario

The horticultural crops are occupying about 70% percent of total cropped area (45000 ha) in islands.Coconut and arecanut based farming system dominant the upland agriculture while paddy-vegetable system is predominant in low land situation in Islands (Velmurugan *et al*., 2016). The plantation crops dominant component in terms of area while vegetables are playing important role in livelihood and nutritional security in islands (Singh *et al.*, 27 & 28). The islands have two distinct season wet season (May to November) and dry season (December to April). High rainfall hinders growing vegetables (with nearly 19% of total vegetable production) in open condition, however, dry season December to April (81% of total vegetable production) is the main vegetable growing season and create glut-like situation (Singh *et al.*, 27 & Srivastava and Ambast, 2011). However, utilizing the technique of protected cultivation it would now be possible to grow vegetables in another season also. Spices like black pepper, nutmeg, cinnamon, clove, turmeric and ginger are also important horticultural crops but their productivity is below the national average, which needs proper attention (Velmurugan *et al*., 2016; NHB database, 20). There are problems which restrict the progress of the sector but the are more opportunities for creating livelihood options with horticulture.

1. Sustainable technological support options for horticulture sector

a. Harnessing local biodiversity through genetic improvement

Andaman and Nicobar Islands are rich reservoir of horticultural diversity and harbour unique crops and landraces. Singh *et al*. (2016) documented 150 species of vegetables, 120 of fruits, 132 of orchids, 120 of ferns and 300 of medicinal plants from the islands. Collection, conservation and systematic evaluation of local germplasm of different leafy vegetables, tuber crops, and plantation crops resulted int improved genotypes for commercial release for the islands and similar conditions. In this line, five improved varieties were developed and identified by the institute variety identification committee in crops namely broad dhaniya, Indian spinach (poi) and amaranth. Broad dhaniya (Culantro: *Eryngium foetidum* L.) genotype 'CARI Broad Dhaniya (or CARI Dhaniya-1; IC No. IC 594500)' was developed through mass selection. It produces 30-35 percent higher foliage yield than the base materials collected from different places in Sippighat, Wandoor, Chouldhari Villages, South Andaman. It the most promising selection from locally collected materials for foliage traits and yield (Table 1). The Its leaves are rich in micronutrients such as iron calcium and phytochemicals than the base materials. The CARI Dhaniya-1 fits well in 'zero land cultivation' concept. The average yield is around 8-10t/ha/year. CARI Poi Selection (or CARI Poi-1; IC-0598152) of Indian spinach (*Basella alba* L.) or *Poi bhaji* has attractive green and broad leaves, short intermodal length and better shelf-life developed using local collections. It is rich in Fe and Ca, ascorbic acid and carotenoids. It is highly suitable to tropical climatic of Islands and yield around 18 t/ha (with single harvest) and 54 - 60 t/ha with multi-harvest which is around 42 to 57 % higher than local base materials. CIARI-Shan of *Basella rubra* L.) is the first improved genotype of red poi (*Basella rubra* L.) in the country developed through mass selection from local germplasm. It has dark attractive purple/magenta colour stems and green leaves with coloured veins and short intermodal length. It is rich in anthocyanin (leaf- 280 mg/100g; stem-410mg/100g FW) and micronutrients (Fe, 8.4mg/100g; Ca, 202.8mg/100g DW). It is ready to harvest at 35-40 days stage when it attains height of 25-30 cm. It has yield potential of 48-52 t/ha with multi-harvest and 15-18 t/ha in single harvest. CIARI-Harita (CARI AMA-1; IC 594501) of green Amaranthus was developed from local collections from Andaman and Nicobar Islands. It has attractive green and broad leaves, fast growth habit and more acceptances among the farmers and consumers. It is rich in antioxidants like chlorophyll (707.8±7.3 mg/100g) and carotenoids (509.5±2.5 mg/100g). The 'CARI Harita' is well suitable for open and intercropping in coconut or arecanut plantations. It has fast growing habit and high biomass yielding capacity. It becomes ready for harvest within 28-32 days of sowing and has yield potential of 13-15 t/ha in island conditions. CIARI Lal Marsha (CARI AMA-2; IC No. IC 594502) of Red Amaranthus was also developed using local collections from Andaman Islands. It has attractive broad and purple/ magenta leaves, fast growth habit. It is preferred in homegardens for its attractive colour which add ornamental value. It is rich in anthocyanin (288.7±1.8 mg/100g), a strong antioxidant for better health. It is ready for first harvest within 25-30 days and have yield potential of 14-16 t/ha in islands. Similarly, varieties of *Morinda citrifolia* (CIARI Sanjivini, CIARI Smapada, CIARI Rakshak and CIARI Samridhi), brinjal (CARI Brinjal-1), sweet potato (CARI SP-1 and CARI SP-2) were also developed using locally collected germplasm. These genotypes were identified by Institute Variety Identification Committee of CARI, Port Blair and proposal submitted to the State Variety Release Committee (SVRC) of Andaman and Nicobar Islands for Andaman and Nicobar Islands in 2010 to 2014 period unfortunately, there was no further progress for their release by SVRC. However, these materials were distributed to local farmers through demonstrations and training programmes to benefit them with improved genotypes.

Figure 1. Variability in Broad Dhaniya in Andaman and Nicobar Islands (for leaf size and shape)

Table 1: Marketable leaf yield (q/ha) of CARI Broad Dhaniya-1 in island conditions.

Genotypes	Marketable fresh leaf yield (q/ha)							% yield increase over	
	2009	2010	2011	2012	2013	2014	Mean	local check	farmers' material
CARI Dhaniya-1	88.1	108.4	106.3	108.7	100.3	82.0	99.0	58.6	65.5
LC BDC-1	67.4	79.5	69.0	72.0	63.3	57.7	68.2	9.2	14.0
LC BDC-3	76.3	81.4	76.3	73.2	69.0	51.0	71.2	14.1	19.1
LC BDC-4	NE	NE	73.7	69.7	68.7	71.3	70.8	13.5	18.5
LC BDC-5	NE	NE	66.3	64.3	52.5	53.3	59.1	-5.2	-1.1
Local	NE	NE	73.8	62.8	55.7	57.3	62.4		
Farmer's material	61.7	81.8	58.3	52.7	52.7	51.3	59.8		
Mean	73.4	87.8	74.8	71.9	66.0	60.6	70.1	18.0	23.2

NE-Not evaluated; Note- Data are sum of three crops harvested in different seasons.

b. Improved varieties for island conditions

Evaluation of improved varieties/hybrids (from mainland institutions) of different vegetables in open and protected conditions during 2008-15 period resulted in identification of suitable varieties for island ecology (Table 2). These are listed as: tomato (Arka Rakshak, Ayush, Arka Samrat); capsicum (Indra, California Wonder); French bean (IIHR-PB-7, IIHR-PB-2, Arka Anoop, and Arka Suvidha); cowpea (Arka Mangla, Arka Garima and Kashi Kanchan); Dolichos bean (Arka Jay and Arka Bold); chilli (Kashi Anmol, LCA-334); cauliflower (White Marble and White Shot); okra (Shakti and Arka Anamika); green onion (NHRDF Red and Agrifound Dark Red); red carrot (Pusa Vrishti, Pusa Rudhira). These varieties had significantly higher yield advantage than other tested varieties in the island condition. Promotion these varieties among the island farmers through government seed distribution system, customized seed kits for homegardens or kitchen gardens, seed village concept or commercial licensing system has the prospect to increase the vegetable production even in remote tribal habitations.

Further, the climate resilient genotypes of the indigenous vegetables are described by Singh and Bainsla (2014).

Table 2: Identified suitable varieties of different vegetables crops for island conditions

S. No.	Open condition		Sl. No.	Protected condition	
	Crops	Varieties/hybrids		Crop	Variety /hybrids
1.	Tomato	Ayush, ArkaRakshak, Arka Vikas, Laxmi	1.	Tomato	Ayush, Arka Vikas, G-600
2.	French bean	Arka Anoop, Arka Komal	2.	French bean	Arka Komal, Arka Anoop
3.	Cowpea	Arka Sumangala, Kashi Kanchan	3.	Cauliflower	White Marble, White Shot
4.	Dolichos bean	IIVR Sem-8, Swarna Utkarishta	4.	Capsicum	Indra, California Wonder, Arka Gaurav
5.	Brinjal	CARI Brinjal-1, VNR 218	5.	Knol khol	Early Spartan
6.	Chilli	LCA-353, ArkaLohit	6.	Chilli	KA-2, ArkaLohit, CARI Selection
7.	Okra	Shakti	7.	Poi	CARI Poi Selection, CIARI Shaan
8.	Bitter gourd	Priya	8.	Coriander	CO-1
9.	Ridge gourd	IAHS-1	9.	Green onion	Agrifound White
10.	Cauliflower	White Marble, White Shot	10.	Palak	All Green, Pusa Bharati
11.	Palak	All Green	11.	Broccoli	Pusa KTS-1
12.	Amaranthus	CIARI-Harita, CIARI- Lal Marsha	12.	Sag sarson	Pusa Sag-1
			13.	Broad dhaniya	CARI Broad Dhaniya

c. Improved production technologies for indigenous vegetables.

The improved genotypes of indigenous vegetable crops required to develop their growing practices while keeping in mind the organic nature of island horticulture. Raised bed cultivation, container or pot gardening and trench system were developed for growing these crops at commercial scale. Vermicompost (3 t/ha) as the source of nutrients. The leafy vegetables are short duration crops (25-40 days) and rarely face severe infestation of pests and diseases if harvested at appropriate time. However, leaf webber, leaf minor and leaf roller affect amaranth and Indian spinach. Spray 4% leaf extract of neem with soap water or neem seed kernel extract 5% for small pests and Dipel or Halt (0.7 ml/litre) for controlling leaf webber and leaf eating caterpillars. Need based spray of recommended chemical pesticides such as cypermethrin or rogor @ 0.5 ml/litre water for sucking pests and malathion @ 1.0 ml/litre for catterpillers can be opted depending upon level of incidence and prevailing climatic conditions.

d. Indigenous crops through homegardens or eco-huts

Homegardens are prominent feature in island region and they contribute a significant share of household demand of fruits, vegetables and other herbs. It also gained popularity in urban areas in form of terrace garden, roof top garden, balcony gardens, nutri-kitchen garden, vertical gardening, hydroponics and aquaponics. These are common in many island nations including Sri Lanka, Singapore, Vietnam etc. These gardens provide livelihood, assured market and better margin to growers (Chaturvedi and Chonkar, 2022). These household gardens contribute significant share of vegetable consumption in Port Blair. Tourist-oriented houses and eco-huts have indigenous crops as integral component and improved genotypes have better prospect is such customized sites. The improved genotypes of the indigenous crops need to be promoted particularly in tribal homegardens and school gardens for their integration in diets to overcome the nutritional deficiencies in tribal communities. Besides, these varieties have higher prospect in eco-tourism huts, tourists-oriented houses and eco-tourism farms.

e. Organic farming for attracting tourists

The native crops are well adapted to no input situations and application of organic sources of nutrients improve their yield and quality. These crops have soil binding properties due to their adaptative mechanism in tropical ecology of islands. These crops are naturally equipped with tolerance mechanism (escape or avoidance), however, need based use of botanical insecticides are suggest to retain the produce quality and attain yield level. Use of vermicompost, need oil extract, local or on-farm botanicals, organic formulations (*beejamrita*, jeevamrita, panchgavya, dash-parni etc.) and pheromone traps or sticky traps are commonly suggested tools in leafy vegetables.

f. Protected cultivation technology

The conventional polyhouses were not suited in tropical climate of islands due to inside high temperature (30-48 °C), high cost of construction (Rs. 1500-2000/sq meter) and lack of information on associated technologies for island conditions. The crop specific cost-effective protected structures (walk-in-tunnels, rainshelters, shadenet house, insect-proof net houses wtc.) for tropical islands were developed for cultivation of palak, cauliflower, capsicum, poi, tomato and gerbera. It has shown good performance in different demonstration trials in different islands in Nicobar for cultivation of cauliflower, high value leafy vegetables, brinjal and capsicum. Further, suitable varieties were identified in capsicum (Indra, California Wonder), tomato (Arka Vikash, Ayush, Arka Samrat), cauliflower (White Marble, White Shot), palak (All Green), Jerbera (manizel) and French bean (Arka Anoop, Arka Suvidha) (Birah *et al.,* 2010). The bacterial wilt is a serious problem in polyhouse and grafting technique using and *Solanum melongena* variety CARI Brinjal-1 and wild brinjal *Solanum torvum* as rootstock for tomato which has eradicated the wilt problem (Singh *et al*., 2014). The protected structures also found promising for indigenous high value vegetables such as broad dhaniya (CARI Braod Dhaniya) (Fig. 1a-b).

a b

Figure 1a-b. CARI Broad Dhaniya in shadenet and polyhouse in island condition.

g. Processing and other uses of horticulture in Islands

The Island economy is predominately primary sector based which need proper capital investment to engage the increasing population. Presently, the islands lack well established scientific processing unit for horticultural commodities. The establishment of these units in islands will help in value additions and employment generation. Besides, new concepts like aroma therapy, orchard tourism have good potential in islands (Chand *et al*., 2015). Aroma therapy is a form of alternative medicine that uses volatile plant materials, known as essential oils, and other aromatic compounds for the purpose of altering a person's mind, mood, cognitive function or health. Under such fears, eco- tourism is one the best option for benefit of local people as well as sustainable development of the region. Kerala has made significant progress for exploiting eco-tourism on large scale which has benefited even small farmers. Andaman and Nicobar Islands are having scenic beauty and abundance of biodiversity which can be utilized for promoting the islands for eco- tourism.

h. Hydroponics for growing nutritious vegetables

Hydroponics is cultivation of plants without soil, either in water or soil-less growing media. This system save land by 50%, water by 85-90%, fertilizers by 80-85% and increase crop productivity by 150-250% as compared to traditional farming system (Al Shrouf, 2017). Hydroponics cultivation has advantages of reducing chances of soil-borne pathogens, high yield better quality products, high water and nutrient use efficiency and year-round production of vegetables. Small-size hydroponics has immediate scope in islands, and large size hydroponics are needed to improve year-round availability of vegetables. There are different hydroponics options for growing high value vegetable crops for tourist needs such as Soil-less Grow Bag System, Soil-less Pot System, Pure Hydroponics NFT System and Pure Hydroponics Floating System and Aeroponics. This technology has big Recently CIARI has developed and commercialized 'Dweep Vertigrow' – a technology to grow vegetables in vertical gardens in hydroponics system (www.ciari.res.in).

i. Multi-story farming and intercropping

Horticultural crops most promising component in multi-story farming which provide opportunity to harness the potential of abundant sunshine and high soil moisture in tropics. The crops of different heights such as Plantations (Coconut, Arecanut) + inter crops (black pepper, vanilla) + Cocoa, Banana, drumstick, tree spices + Ginger, Turmeric, marigold and Pineapple. It is very perspective approach for sustainable productivity in fruit crops and plantation crops which natural resources are utilized efficiently to enhance the productivity of main crops (15-20%) and high revenue realization per unit area (50-90%) (Chaturvedi and Chonkar, 2022). Coconut+palak (Cv. All Green), Coconut+ Banana+CARI Broad Dhaniya (Fig.2), Arecanut+CARI Broad dhaniya, banana+CARI Broad dhaniya, Coconut+ Green and red poi (CAIRI Poi Seleciton and CIARI Shan) were promising to enhance farm income and resource use efficiency. Intercropping of cucurbits (bitter gourd)+Leaf vegetables (Poi, Amaranth; CIARI varieties/genotypes), cauliflower+brinjal, cauliflower+chilli are most remunerative options for dry season in island conditions.

Figure 2. CARI Braod Dhaniya in coconut + Banana + Broad Dhaniya intercropping system.

j. Land manipulation techniques

Horticultural crops are remunerative option for heavily invested land manipulation interventions. These crops grow well in broad bed and furrow (BBF) system, coconut husk based raised beds, soil-mount technique, plantation of mangroves and bio shield, brackish water integrated farming system (bwIFS), container gardening etc. The process for trench system developed for island conditions are given in Fig. 2. Similarly, for growing horticultural crops in uplands having rocky terrains, coral lands or problem soils, the technological options such trenches (20-30 cm deep and 30 -45 cm wide) filled with growing media (surface soil+FYM+vermicompost+crop waste or residues), container gardens, polybag cultivation, food cubes, deep pit with growing media etc. Besides, grafting on suitable rootstocks, selection of suitable crops, agro-forestry crops, salinity tolerant ornamentals etc. are also options for growing horticultural crops in the islands.

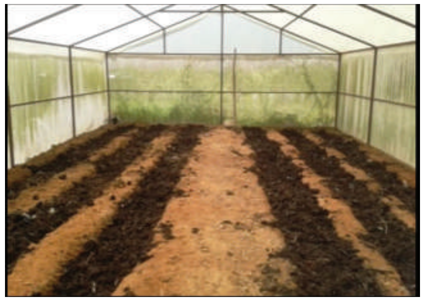
		
Trench making	Filling with media	Crop raising
		
Trench binding with coconut husk	Raising green onion crop in trenches	Raising carrot in fine trenches

Figure 2. Trench for growing vegetables in problem soils in Andaman Islands.

k. Food forests and avenue plantations with horticultural crops

The native tribes are predominantly rely on forest-collected food sources such as native fruits, tuber crops and wild leafy vegetables. In natural vegetations, the frequencies of these food plants generally remain low due to natural vegetation ecosystem. Hence, enriching the forests with food plants through dropping disease-pest free seed/propagules balls during rainy season. In similar way, establishing food forests with nutritionally-rich and locally improved/adapted crop varieties of horticultural crops in certain pockets of inhabited islands through community participation is a promising option for both native tribes and tourist attractions. Further, the roadside (highways or village roads) or avenue plantations of perennial fruit plants encourage native bird ecology and availability of fruits to local/native people.

i. Integrated disease & pest management

In commercial vegetables crops, promotion of integrated pest and disease management is most rewarding in term of farm income, crop yield, farm ecology, soil health and water bodies. Swarnam and Velmurugan (2013) have already flagged serious concerns about the excessive use of pesticides and the resulting contamination of water bodies in the islands. Integration of disease health nursery raising, crop rotation, soil amelioration (for pH), resistant varieties, grafting, pheromone traps, trap and barrier crops, clean cultivation practices, pest and disease monitoring and forecasting, use of botanicals or biopesticides from locally available plants, proper crop waste residue disposal practices etc. are crucial for the securing and further improving the horticultural sector in the geographically insulated island ecology.

j. Integration of conservation agriculture in island horticulture

The island ecology is extremely fragile to soil erosion through water during heavy rains. Unscientific soil work for construction activities, soil digging, excessive farm tillage operations, and poor concerns about soil erosion prevention are alarming issues. Promotion of conventional soil tillage practices for crops such as potato, tuber crops, root crops, vegetables etc. require due attention for locally suitable technologies. *The conservation agriculture is a farming system that promotes maintenance of a permanent soil cover, minimum soil disturbance, and diversification of plant species. It enhances biodiversity and natural biological processes above and below the ground surface, which contribute to increased water and nutrient use efficiency and to improved and sustained crop production* (FAO, 2019). Thus, promotion of conservation agriculture practices in horticultural crops is most important requirement for the island ecology. Raised with mulching, raised beds with closed ends with locally available materials (coconut husk, arecanut stems, coconut fronds, dried herbs etc.), farm or terrace bunds with fodder grass particularly in sloppy lands are needed to prevent effective soil profile in islands. This will also help to regenerate the degraded lands in tsunami-affected areas.

k. Bioprospecting and value addition of indigenous vegetables

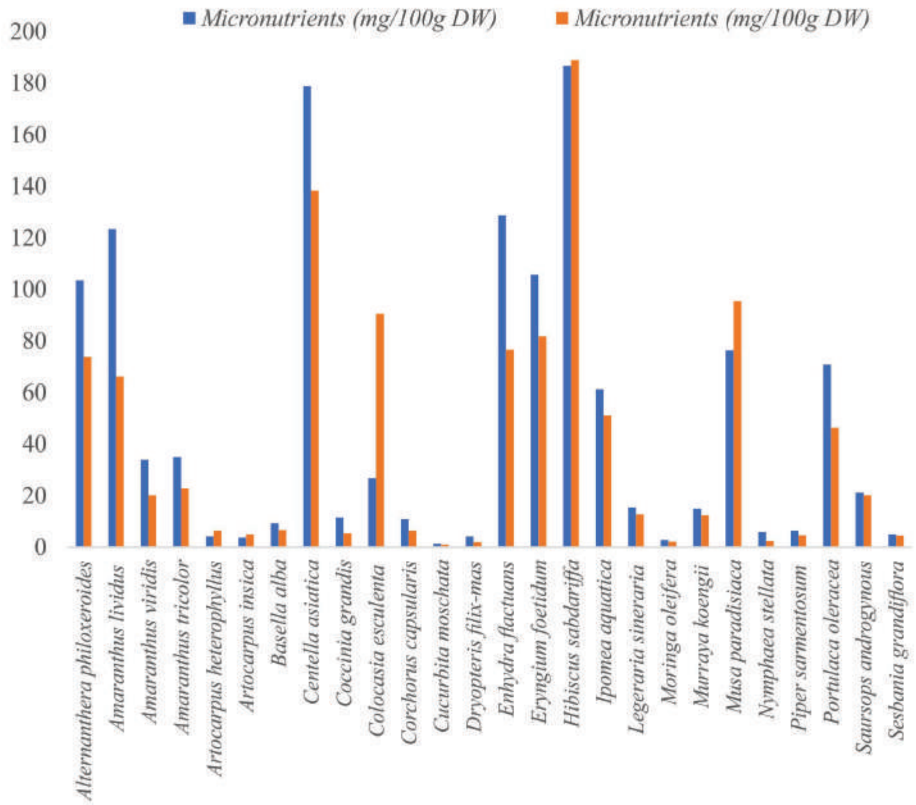
Bioprospecting of potential sources of phytochemical compounds such as lycopene (*Momordica subangulata* ssp. *renigera*, *Momordica cochinchinensis*) (356 µg/g fw), anthocyanin from *Basella* fruits (268mg/100g fw), red calyces separated from ripe fruits of *Hibiscus sabdariffa*, chlorophyll from green foliage leaves of *Eryngium foetidum*, anthraquinones from *Morinda citrifolia* etc. are found to be promising options from island biodiversity. Besides, diverse native horticultural crops have prospects in preparation of botanicals and organic formulations which require thorough investigation. Value-added products from these crops for local, regional and export-oriented food items can be explored. Broad dhaniya fortified local food items such biscuits, *Idli* and *Vada* were well accepted by the consumers. These fortified products 15-20% higher iron, calcium and antioxidants than conventional products suggesting their role in fight against micronutrient deficiencies in island populations particularly for anemic population.

l. Shifting from traditional to smart horticulture

Considering the fragile ecology and resource limitations in the islands, it is essential to shift towards smart horticulture. Smart horticulture is also known as Horticulture 4.0. Zhang *et al*. (2024) describe the Smart Horticulture as the deep integration of biotechnology, engineering, information technology, and regulation technologies, smart horticulture involves precise perception, smart operation, and smart control during the cultivation, transportation, and sale of horticultural products. It substantially improves the land output rates, resource-use efficiency, and productivity. This promotes the overall sustainable improvement of the horticulture industry. In islands, the modernization of horticulture is the need of hour for not only meeting the local demand but catering the need for upcoming developments. Sensor based drip irrigation (floating or raised drip lines) with fertigation system has immediate application in islands. Further, work towards net-zero horticulture is a necessity for island ecology. It requires optimizing production practices, breeding varieties fitting to resource use efficiency, reduce-reuse-repurposing horticultural wastes for crop or other purposes.

m. Promotion of nutrient rich vegetables in tribal habitats

Micronutrient deficiency in local public and tribal communities is a big health challenge which is being tackled through different supplemental and fortification approaches. However, enriching their homegardens with genetically improved and iron-rich endogenous vegetable varieties such as CARI Broad Dhaniya, CARI Poi Selection, CARI Harita, CARI Lal Marsha and CARI Shan should be encouraged in homegardens. Besides, the islands have different local vegetable crops which are rich in iron and have potential to fight against anaemia (Singh *et al.*, 2018a). These vegetables are rich in ascorbic acid hence the availability of iron is expected to be higher, however, proper cooking practices are required to retain ascorbic acid in cooked items as it is heat labile in vegetable plant matrix (Singh et al., 2015).



Commercialization of technologies

Commercialization of technologies increases adoption rate and ICAR-CIARI has licensed horticultural technologies such as "Dweep Vertigrow" and DweepHanGreens. The Dweep vertigrow is a vertical farming model for growing leafy vegetables in kitchen/ terrace garden with a spatial coverage of 5 sq m which can accommodate 100 pots and one tray (2 m^2). This has the provision for soilless cultivation, rain protection and rainwater harvesting. The system is suitable for year-round cultivation of high value leafy vegetables and other herbs besides aesthetic orchids/ornamental plants with efficient use of water, nutrients and space. "Dweep HanGreens" a compact model for cultivation of Culantro (Burmese coriander), a pricey culinary herb. It is a hanging model and occupies limited space in balconies, terraces, rooftops etc.

Challenges for horticulture sector

Climate change, loss of local biodiversity, decreasing interest of youth in agriculture and shift of youth towards ease of doing activities in urban habitations, invasive species, prominence of floating populations, poor export prospect of bulky fresh horticultural commodities, poor cold chain infrastructures etc. Island ecology is fragile hence, commercial horticultural technologies need to be reoriented as per the local conditions. Breeding climate resilient high yielding cultivars for island ecology is prerequisite for horticulture success. Notably, the affordability of technological options is a big issue in resource-poor and native tribes which need due attention. These issues need comprehensive discussion, planning and investments to upscale the horticulture sector in these geo-strategically important island regions. Training of farmers, SHGs and unemployed youth should be conducted in protected cultivation, nursery production and other skill-oriented activities in order to earn a decent and sustainable livelihood. At regional level, there is a need for development of linkages between the research institutes and various development departments. International institutions should also focus on consortia approach for development of horticulture sector in these islands nations. There is need to have more efforts on international collaborations for tackling climate change impacts and promotion of horticulture sector in tropical island regions.

References

AlShrouf, A., 2017. Hydroponics, aeroponic and aquaponic as compared with conventional farming. *Am. Sci. Res. J. Eng. Technol. Sci*, *27*(1), pp.247-255.

Basic Statistics (2017). Andaman and Nicobar Islands, India.

Birah, A., Sharma, T.V.R.S., Singh, S. and Srivastava, R.C., 2010. Effect of aqueous leaf extract of cloves (Syzygium aromaticum) on growth and development of tobacco caterpillar (Spodoptera litura).

Chadha, K.L., Choudhary, M.L. and Prasad, K.V. 2002. Hi-Tech Horticulture. Horticultural Society of India, New Delhi.

Chand, S., Singh, S., Parappurathu, S., Roy, S.D. and Kumar, A., 2015. Explaining the status and scope of ecotourism development for livelihood security: Andaman and Nicobar Islands, India. *Int. J. Sustain. Dev. World Ecol.* 22(4); 335-345.

Chander, M.P., Sugunan, A.P., Siddaraju, H.M., Shriram, A.N., Nagendra, B., Jawahar, P. and Vijayachari, P. (2018). Nutritional status of Onges of Little Andaman Island–current state and the change over the last fifteen years. *Homo*, *69*(1-2): 29-36.

Chaturvedi, A. and Chonkar, D.S. (2022). Multistoried cropping system: A sustainable land use approach for North eastern States. The Sangai Express, September 02 2022.

FAO (2019). https://climate-adapt.eea.europa.eu/en/metadata/adaptation-options/conservation-agriculture

Malhotra, S.K., 2017. Horticultural crops and climate change: A review. *Indian Journal of Agricultural Sciences*, *87*(1), pp.12-22.**57**

Manimunda, S.P. and Sugunan, A.P., 2017. Nutritional status of preschool children in Andaman and Nicobar Islands and food insecurity, food groups, and nutrient consumption among population. *Indian J. Community Med*. 42(2): 88-93.

NHB (2020). National Horticulture Board, Gurugram, Government of India, Haryana.

Nutrition in India. National Family Health Survey (NFHS-3) India 2005-2006. (2009). Mumbai, India: IIPS; 2009. Ministry of Health and Family Welfare, Government of India, International Institute for Population Sciences.

Rao VG, Sugunan AP, Sehgal SC. (1998). A profile of demographic and nutritional status of Shompens – The primitive Mongoloid tribe of Great Nicobar. Indian J Community Med. 23:38–41.

Rao, V.G., Sugunan, A.P., Murhekar, M.V. and Sehgal, S.C. (2006). Malnutrition and high childhood mortality among the Onge tribe of the Andaman and Nicobar Islands. *Public Health Nutr.*, *9*(1): 19-25.

Singh Shrawan, Singh, D. R., Salim, M. K., Singh, L.B., Srivastava, A. and Srivastava, R. C. (2011). Estimation of proximate composition, micronutrients and phytochemical compounds in traditional vegetables from Andaman & Nicobar Islands. *Int. J. Food Sci. Nutr.* **62**: 765-773.

Singh Shrawan., Singh, D.R., Singh, L.B., Chand Subhash and Roy, S. D. (2013). Indigenous Vegetables for Food and Nutritional Security in Andaman and Nicobar Islands, India. *Int. J. Agric. Food Sci. Technol.* **4**: 503-512

Singh, D. R., Singh Shrawan, Salim, M. K. and Srivastava, R. C. (2012). Estimation of phytochemicals and antioxidant activity of underutilized fruits of Andaman & Nicobar Islands (India). *Int. J. Food Sci. Nutr.* **63**: 446-452

Singh, D.R., Singh, S. and ROY, S. (2015). Climate change: resilient island horticulture. *Climate Dynamics in Horticultural Science, Volume Two: Impact, Adaptation, and Mitigation*, p.111.

Singh, S. and Bainsla, N.K. (2014). Breeding strategies for climate resilient vegetable production in tropical islands conditions. *Current Opinion in Agriculture*, *3*(1), p.14.

Singh, S., Chand, S., Singh, D.R. and Roy, S.D. (2017). Horticulture as a reliable source of livelihood in Andaman and Nicobar islands, India. In *Agricultural Development and Food Security in Developing Nations* (pp. 222-248). IGI Global.

Singh, S., Singh, D.R., Kumar, K. and Birah, A. (2014). Eco-friendly management modules for bacterial wilt (*Ralstonia solanacearum*) of tomato for protected cultivation in a tropical island ecosystem. *Biol. Agric. Hortic*, 30(4): 219-227.

Singh, S., Singh, D.R., Velmurugan, A., Jaisankar, I. and Swarnam, T.P. (2018b). Coping with climatic uncertainties through improved production technologies in tropical island conditions. In *Biodiversity and climate change adaptation in tropical islands* (pp. 623-666). Academic Press.

Singh, S., Singh, L.B., Singh, D.R., Chand, S., Zamir Ahmed, S.K., Singh, V.N. and Dam Roy, S., 2018. Indigenous underutilized vegetables for food and nutritional security in an island ecosystem. *Food Sec.* 10(5): 1173-1189.

Singh, S., Singh, L.B., Singh, D.R., Chand, S., Zamir Ahmed, S.K., Singh, V.N. and Dam Roy, S., (2018a). Indigenous underutilized vegetables for food and nutritional security in an island ecosystem. *Food Security*, *10*(5): 1173-1189.

Singh, S., Swain, S., Singh, D.R., Salim, K.M., Nayak, D. and Roy, S.D. (2015). Changes in phytochemicals, anti-nutrients and antioxidant activity in leafy vegetables by microwave boiling with normal and 5% NaCl solution. *Food Chem*, 176: 244-253.

Singh, S., Waman, A.A., Bohra, P., Gautam, R.K. and Roy, S.D., 2016. Conservation and sustainable utilization of horticultural biodiversity in tropical Andaman and Nicobar Islands, India. *Genetic Resources and Crop Evolution*, *63*(8), pp.1431-1445.

Srivastava, R.C. and Ambast, S. K. (2011). Water Policy of Andaman and Nicobar Islands. CARI, Port Blair.

Swarnam, T. P., & Velmurugan, A. (2013). *Pesticide residues in vegetable samples from the Andaman Islands, India. Environ. Monit. Assess. 185*(7), 6119–6127.

Velmurugan, A., Roy, S.D., Dagar, J.C., Swarnam, T.P., Jaisankar, I. (2016). Innovative Technologies to Sustain Saline Island Agriculture in the Scenario of Climate Change: A Case Study from Andaman Islands, India. In: Dagar, J., Sharma, P., Sharma, D., Singh, A. (eds) Innovative Saline Agriculture. Springer, New Delhi.

Vijayachari, P., Awaradi, S., Siddaraju, H.M., Nithin, K., Veerendra, S.S., Babu, U.S., Chander, M.P., Kartick, C., Anwesh, M. and Sugunan, A.P., 2024. Survey of the present health & nutritional status of Shompen tribe of Great Nicobar Island. *Indian J. Med. Res*., 159(1), pp.35-42.

Zhang, M., Han, Y., Li, D., Xu, S. and Huang, Y., 2023. Smart horticulture as an emerging interdisciplinary field combining novel solutions: Past development, current challenges, and future perspectives. *Hort. Plant J.*, 10(6): 1257-1273.

Received : 31st May, 2025 Accepted : 5th June, 2025