Food Security (2018) 10:1173–1189
https://doi.org/10.1007/s12571-018-0840-1

ORIGINAL PAPER

Indigenous underutilized vegetables for food and nutritional security in an island ecosystem

Shrawan Singh[1,2] · L. B. Singh[3] · D. R. Singh[1,4] · Subhash Chand[1,5] · S. K. Zamir Ahmed[1] · V. N. Singh[6,7] · S. Dam Roy[1]

Received: 7 September 2017 / Accepted: 24 August 2018 / Published online: 26 September 2018

Abstract

Indigenous plants are an important component of the traditional food and health systems of rural and tribal communities in tropical regions. However, they do not attract much attention from researchers or in commercial markets. The present study investigated 42 indigenous, under-utilized vegetable plants from the Andaman and Nicobar Islands of India for their food and ecological values. Predominantly, the plants belonged in the Cucurbitaceae, Amaranthaceae, Moraceae and Plantaginaceae families. Fifty seven percent of the vegetables were observed in home gardens and 21.4% were collected from wild habitats. Most of the indigenous vegetables were perennials (71.4%), and included trees, vines and shrubs. Commercial farmers grew mostly exotic vegetables, while many indigenous and under-utilized vegetables were preferred by tribal and local communities. Herbs with good flavour, taste and crispness were preferred in culinary preparations; vegetables with a bitter taste and unique flavour were considered best for health purposes. The indigenous and under-utilized vegetables contained a wide range of nutrients, including Ca, Fe, polyphenols, carotenoids, ascorbic acid and chlorophyll, although they also often contained anti-nutrients including nitrate, phytate, oxalate and saponins. Our findings support the greater use of indigenous underutilized vegetables as promising and locally accepted options to address micronutrient deficiencies among households in geographically challenged regions such as the Andaman and Nicobar Islands. The study also underlined the need to devise strategies for the promotion of these nutrient-rich indigenous foods to improve the nutrition and livelihoods of vulnerable communities.

Keywords Antioxidants · Climate change · Ecosystem · Micronutrients · Nutritional security · Tropical regions

1 Introduction

Advances in agriculture have improved food security, but over-dependence on a limited number of staple crops has caused deficiencies in some micronutrients in developing regions (Demment et al. 2003; Rao et al. 2006; Johns and Eyzaguirre 2007). Globally, anemia affects 1.62 billion people, with non-pregnant women (28.8%) and children (36.9%) the most affected (WHO 2008). Calcium deficiency and low levels of vitamin D are associated with osteoporosis and rickets, with more than 200 million people affected worldwide (Sanchez-Riera et al. 2014). A sustainable, food-based approach using nutrient-rich crops could overcome these deficiencies (Demment et al. 2003). For tribal and rural communities, indigenous vegetables are accessible and are accepted in their traditional food preparations. Many of these vegetables are rich in dietary micronutrients and phytochemicals (Baruah and Borah 2009; Singh et al. 2011), which benefit human health (Pieroni et al. 2007). Region-specific

✉ Shrawan Singh
singhshrawan@rediffmail.com

1 ICAR (Indian Council of Agricultural Research)-Central Island Agricultural Research Institute (CIARI), Port Blair, Andaman and Nicobar Islands 744101, India

2 Present address: Division of Vegetable Science, ICAR- Indian Agricultural Research Institute, New Delhi 110012, India

3 Krishi Vigyan Kendra, Port Blair, Andaman and Nicobar Islands 744101, India

4 Present address: ICAR- National Research Centre for Orchids, Pakyong, Sikkim 737106, India

5 Present address: ICAR- National Institute of Agricultural Economics and Policy Research, New Delhi 110012, India

6 Krishi Vigyan Kendra, Car Nicobar, Andaman and Nicobar Islands 744301, India

7 Present address: Krishi Vigyan Kendra, ICAR-Indian Sugarcane Research Institute, Lucknow 226002, India

information on important dietary nutrients in such food plants is necessary because the nutritive profile of plants varies with genotype and environmental factors (Badigannavar et al. 2016; Liu et al. 2016).

The shift to a few (often new) dominant crops appears to have contributed to the degradation of natural habitats without appropriate restoration, leading to reduced diversity of indigenous food plants, and even threatening some with extinction (Frison et al. 2006). This situation has raised special concern in tropical regions, which are highly vulnerable to climate change and increasing population pressure (UNFCCC 2005). Although major food crops contribute the most to assuring food security, more attention is required to explore nutrient-rich and ecologically sustainable food resources for nutritional security of poor communities. Indigenous underutilized vegetables are a significant source of food and dietary minerals for tribal and rural communities in central India (Chauhan et al. 2014; Ravishankar et al. 2015; Ghosh-Jerath et al. 2016; Gupta et al. 2017), in the Himalayan region (Aryal et al. 2018), north-eastern India (Tangjang and Arunachalam 2009), and in the Andaman and Nicobar Islands (Pandey et al. 2007; Singh et al. 2015; Swarnam et al. 2015). The promotion of such vegetables, through use of improved varieties, establishing market channels, and creating public awareness about their nutrition can benefit populations that are nutritionally at risk by providing cheap sources of dietary nutrition and extra income for local farmers (Pieroni et al. 2007; Msuya et al. 2010; Chauhan et al. 2014; Gupta et al. 2017; Vijaya Bhaskar et al. 2017).

The Andaman and Nicobar Islands of India (14 to 16 °N and between 92 to 94 °E) are located in the Bay of Bengal and form an archipelago of 572 islands with a total geographical area of 8249 km^2. The archipelago has a maritime climate with an annual mean temperature of 23.1 to 30.1 °C, average annual rainfall around 3100 mm, and relative humidity from 71 to 92%. Forests occupy about 87% of the total area of the islands, and are home to several native tribes that constitute 6.86% of the population (Majumdar 1975; Basic Statistics 2011). Among these, the Nicobari, the Jarawa, the Shompen, the Onge, the Sentinel and the Great Andamanese are the most important. The remainder of the population is made up of settler communities (which were relocated from India and adjoining regions to penal settlements during British Rule) and post-independence settlers. The food culture of local tribes is dominated by natural foods, including wild tubers, indigenous fruits and vegetables, wild animals and seafood products (Majumdar 1975). Transient populations and tourists prefer commercial exotic crops while the settler population consumes both indigenous and exotic vegetable crops (Singh et al. 2015). To accommodate these diverse food needs, the islands have a rich diversity of indigenous crops (Abraham et al. 2008; Singh et al. 2016), and various exotic vegetable crops are intensively grown (Singh et al. 2015). However, the indiscriminate exploitation of natural habitats makes it necessary to study the nutrient-rich wild and minor vegetables to ensure their effective conservation and management. Indigenous vegetable plants have better tolerance to biotic and abiotic challenges (Singh and Bainsla 2015; Sogbohossou et al. 2018) and grow well in low input farming systems (Allemann and Swart 2007). Promotion of their use could reduce intensive tillage practices and minimize the need for chemical fertilizers and pesticides.

This study was undertaken to determine the nutritive values of indigenous vegetables, and determine consumer perceptions for their promotion within a sustainable food-based approach to limit deficiencies of nutrients in humans in the Andaman and Nicobar Islands.

2 Materials and methods

2.1 Study location

Our study included 300 respondents from 15 villages in all three districts of the Andaman and Nicobar Islands. These locations included South Andaman, Baratang, Little Andaman, Havelock and Neil Island in the South Andaman district; Rangat and Diglipur in the North and Middle Andaman, and Car Nicobar, Camrota and Campbell Bay in Nicobar district (Fig. 1). The respondents were from settler communities, which are ethnically Bengali, Tamil, Telugu, Malayali, Ranchi and north Indian. Although the islands have six local tribes, due to administrative and accessibility reasons only the predominant Nicobari tribe was included in the study. The respondents consisted of settler and local Nicobari tribal communities and represented heterogeneous cultures and food habits. Males (220) and females (80) of 18–60 years of age were included in the survey. Although 70% of respondents were literate, some respondents that were illiterate or had poor communication skills were also included in the survey.

2.2 Sampling design and sample selection

The respondents were chosen by random sampling from the 15 villages in all districts. A questionnaire originally developed by Pieroni et al. (2007) was modified to obtain information on food use and nutritional perceptions. The survey was pilot tested with 15 respondents that were not included in the sample population. During the survey, respondents were assembled at a place for training and information exchange activities in each of the selected villages. After verbally obtaining prior informed consent, respondents were interviewed for information on wild and indigenous vegetables they used for food, including nutritional information, and the use of inputs and tillage practices used to grow the

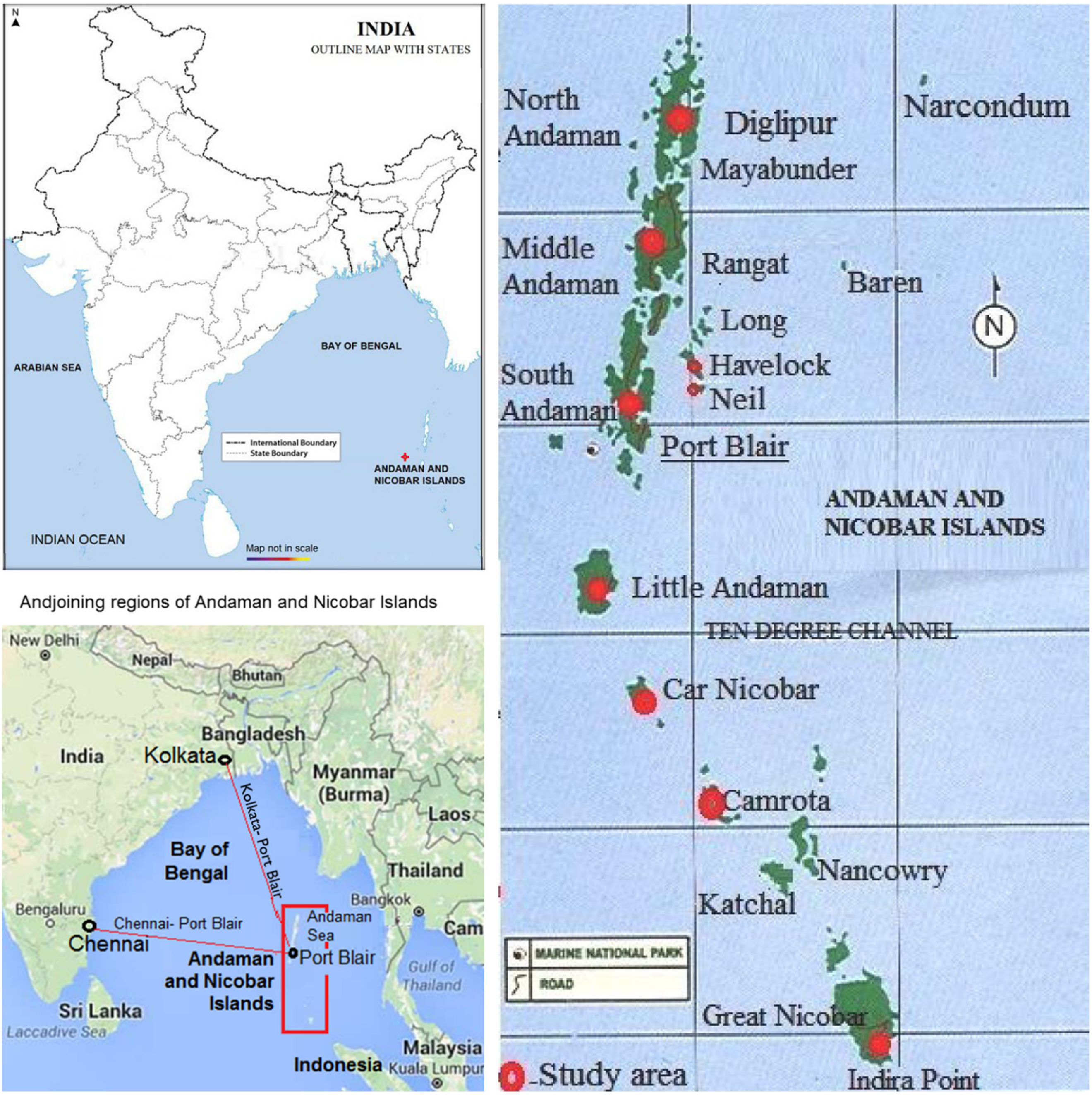

Fig. 1 Geographical location of study area in Andaman and Nicobar Islands, India

vegetables. Respondents were encouraged to participate in the survey through group discussions and Participatory Rural Appraisal (PRA) techniques. Mean scores were used for analysis. Because frequent visits were difficult in the more remote islands, telephone conversations were often used to gather information and make necessary corrections.

2.3 Taxonomic identification

The study assessed underutilized vegetable plants that consisted of culinary herbs, shrubs, trees, vines, and indigenous or introduced plants acclimatized to local conditions. To date, no agro-techniques have been developed or used to realize the potential of these crops. There was no systematic seed production or marketing system for them. Some of these vegetables are commonly grown in home gardens, or small-scale farms, for household use, or for sharing, or sale of excess production. These criteria are close to previous definitions of 'indigenous leafy vegetables' (van Rensburg et al. 2007) which are considered to be either genuinely native, or have been introduced to a particular region, and acclimatized, and evolved through natural processes, or farmer selection. These criteria fit within the

FAO's (1997) term of 'traditional food crops' for crops accepted by a community through habit and tradition, as appropriate and desirable sources of food, accustomed to local inhabitants knowing how to cultivate and prepare them for consumption. Keatinge et al. (2011) used the term 'indigenous traditional vegetables' for species with similar criteria that are locally important for the sustainability of economies, human nutrition and health, and social systems, but which have yet to attain global recognition to the same extent as major vegetable commodities. Respondents listed plants that were either commonly or rarely consumed. Taxonomic information for families, genus and species was generated by the Regional Station of the Botanical Survey of India, Port Blair, and through the use of information available on the internet or in published documents. Growing season, habitat source and growth habit (annual or perennial) of targeted plants were documented by personal observations and by information gathered from respondents. The islands have two growing seasons per year; a rainy season (May–December; RH >90%; average rainfall, >350 mm/month) and a dry season (January–April; RH <70%; average rainfall, <35 mm/month). The habitats were described as the growing region of an indigenous vegetable such as wild (forest land, not cultivated at all, no human intervention in growing of plants), home garden (an area near the family dwelling used to grow a diverse array of plants on a small scale to supplement food) and farm (plants grow naturally or through human intervention on farm land with subsistence farming practices). Potential minor vegetable species were protected by a system of off-site conservation at the Indigenous Germplasm Block of the ICAR-Central Island Agricultural Research Institute, Port Blair.

2.4 Observation of consumer perceptions

The opinions of respondents about their food preferences for wild and minor vegetables were graded on a modified scale for vegetables (Pieroni et al. 2007) where '1' = little preference and eaten when the alternative food is not available or used as a medicine, '2' = slight preference, '3' = moderate preference and frequently consumed, '4' = strongly preferred and commonly used, and '5' = highly preferred and frequently consumed. Respondents were asked to consider the following food characteristics; colour, taste, appearance, smell, pungency, bitterness, nutrient perceptions, flavour, texture, ease of cooking, waste, and traditional use practice while scoring the vegetables. Information on the quantity of household consumption (g/consumption day) and household consumption frequency (days/month) were obtained from 300 respondents representing individual households in all districts of the islands. Numbers of respondents varied from 18 to 61 in the different villages. Respondents shared memory-based values for quantity and frequency of consumption during the group and individual discussions. Respondents were asked to name and score any other vegetables they considered to be high preference. Nutritional perceptions by local people for the plant species were based on colour and taste factors. These observations were recorded by modifying the '1–5' scale of Pieroni (2001), where 1 = poor nutritive value (only used for taste and staple food), 2 = middle-low nutritive value (included in nutritive diets), 3 = middle-high nutritive value (used as nutrient source for specific purposes such as during pregnancy), 4 = high value of nutrients (food rich in nutrients and prescribed to cure deficiencies such as anaemia), and 5 = highly nutritious (food containing many nutrients). The mean score of respondents was used to represent individual vegetables.

2.5 Nutritive value analysis

Thirty-one common wild and minor vegetables were analysed for Ca and Fe, polyphenols, chlorophyll, carotenoids and ascorbic acid, and nitrate, phytate, oxalate and saponins. Chemicals and standards were procured from Sigma-Aldrich (St Louis, MO, USA), Merk Specialities Pvt. Ltd. (Mumbai, India) and Rankam (RFCL Ltd., New Delhi, India). Ca and Fe were determined with an atomic absorption spectrophotometer (Shimandzu Scientific Instruments, Inc., Columbia, Maryland, USA) according to procedures described by Sadasivam and Manickam (1995). Total polyphenol was determined using the Folin–Ciocalteau reagent method (Singleton et al. 1999) with minor modifications as described by Singh et al. (2011). Ascorbic acid was estimated using the standard procedure described by Sadasivam and Manickam (1995). Total chlorophyll content, as mg/100 g = $Chl_a + Chl_b$, was calculated from chlorophyll a and b, for absorbance of an acetone extract at 645 nm and 663 nm, and their contents determined using the equations: Chlorophyll a (Chl_a) = [($12.7 \times A_{663}$) - ($2.6 \times A_{645}$) × ml acetone/mg sample] and Chlorophyll b (Chl_b) = [($22.9 \times A_{645}$) - ($4.68 \times A_{663}$) × ml acetone/mg sample] (Sadasivam and Manickam 1995). Total carotenoid content was determined using the equation described by Lichtenthaler and Buschmann (2001), i.e., C(x + c) (mg/ml of sample extract) = $(1000A_{470}–1.90C_a- 63.14C_b)/214$, where C_a = chlorophyll a; C_b = chlorophyll b; C = carotenoids and x-xanthophyll. The anti-nutrients phytate, nitrate, saponins and oxalate were estimated using titration methods described by Hassan et al. (2011), and saponin content was determined by standard AOAC methods (AOAC 1995).

2.6 Determination of ecological indices

Chemical inputs and tillage practices can damage the ecological balance in fragile ecosystems. We were able to assess input use in indigenous vegetables through this study. Information on the use of common inputs in a commercial crop production system, including tillage practices, improved germplasm, use of chemical fertilizers, pesticides, fungicides, antibiotics, plant growth substances, herbicides, and pre- and post-harvest chemicals were recorded from respondents (*n* =

30) with home gardens or those that grew indigenous vegetables on small pieces of land in Hut Bay, Rangat, Diglipur, South Andaman, Neil Island, and Campbell Bay. From this, the input use intensity (IUI) was calculated as: IUI = (Number of inputs used in cultivation of an individual vegetable/total number of identified inputs i.e. 9) × 100. Cultivation frequency (CF) of vegetables was calculated using respondent inputs ($n = 30$) with the formula: (Number of respondents growing vegetable/total number of surveyed respondents) × 100.

2.7 Market analysis

Information on the market price of vegetables was collected in questionnaires ($n = 30$; with permanent and occasional vendors as respondents) from vegetable markets in Port Blair, Hut Bay, Rangat, Diglipur, Neil Island, and Campbell Bay. The percent market prevalence of individual vegetables was calculated from numbers of vendors selling particular vegetables divided by all vendors ($n = 30$).

2.8 Statistical analysis

The data were analyzed and reported using mean, range and standard deviations with Microsoft Excel software (ver. 2010). Pearson correlation analysis was with OPSTAT software (hau.ernet.in/opstat.html).

3 Results and discussion

3.1 Diversity and botanical description

The botanical description, habitat, edible portion, and food uses of 42 indigenous, underutilized vegetables from the islands were variable (see Table 1). They were dominated by herbs (47.6%), followed by trees (26.2%) and vines (21.4%). Most plants were perennials (71.4%); the remaining were annuals. Wild habitats acted as the main source for 19.1% of the indigenous vegetables; 54.8% species were reported to be in transition from 'wild to home garden or farm' cultivation. Among transition-phase vegetables, 14.3% were in a wild to home garden phase, 21.4% in a wild to farm phase and 16.7% home garden to farm phase. The rest of the vegetables (15.7%) were in wild, home garden or farm habitats. The tree vegetables or fruits, Drumstick (*Moringa oleifera* Lam.), Jackfruit (*Artocarpus heterophyllus* Lam.), Breadfruit (*A. incisa* L.), Curry leaf (*Murraya koenigii* Spreng.) and Tamarind (*Tamarindus indica* L.) were prevalent in most home gardens. In the Nicobar area, Pandanus (*Pandanus andamanensis* Hort. ex Balf.f., Pandanaceae), tender pods of Tree bean (*Parkia roxburghii* G. Don; Fabaceae), fruit of Morinda (*Morinda citrifolia* L.) and tubers of Yam bean [*Pachyrhizus erosus* (L.) Urb., Fabaceae] from wild habitats were consumed by the Nicobari tribe. Results of species diversity in home gardens and wild habitats agree with the earlier findings of Pandey et al. (2007) with greater species diversity in home - forest - garden and species richness in home gardens. They also agree with Abraham et al. (2008) who found a high degree of species diversity in legume crops, vegetable crops and tuber crops in wild habitats in the Andaman and Nicobar Islands. The use of four indigenous leguminous species in local food items (Table 1) supports findings by Singh et al. (2016) about the extent of diversity in legume vegetables in the islands.

3.2 Seasonal availability

Most of the indigenous vegetables (57.1%) were abundant in the rainy season, from May to December, in the islands; only 16.7% were harvested exclusively in the dry season, from January to April (Table 1). Some vegetables were present in both seasons (26.2%). However, the volume of harvest of indigenous vegetables was low in the dry season due to a lack of water in natural habitats and an emphasis on market-orientated exotic vegetables (Singh et al. 2015). Hence, indigenous vegetables need more support by breeding improved genotypes, developing eco-friendly growing practices, imparting training to tribal and other rural people and providing marketing facilities to grow more of them during the dry season when the islands experience a heavy influx of tourists.

3.3 Edible portion and culinary uses

Many parts of indigenous under-utilized vegetables were used to provide multiple edible foods. Almost half (49.0%) had two parts that were used, a small number (5.8%) had three parts that were useful, and many had a single part that was used (Table 1). Leaves constituted the edible portion of 64.7% of the plant types and tender stems and shoots comprised a little over a third (35.3%) of edible portions. Immature pods and fruit were the edible parts of a large minority (31.4%) of the vegetables. Tubers of Taro (*C. esculenta*), flowers of Pumpkin (*Cucurbita moschata* Dusch. ex Poir), Roselle (*Hibiscus sabdariffa* L.), *M. oleifera* and Agathi (*Sesbania grandiflora* Pers.), the inflorescence of *P. sarmentosum* Roxb. and immature seed of *A. heterophyllus* are all constituents of traditional diets. These findings agree with reports from North-East India (Baruah and Borah 2009) and in Africa (Msuya et al. 2010) where multiple plant parts of underutilized vegetables are also consumed. Thongam et al. (2016) reported that 24% of 68 surveyed vegetables from Manipur in India were consumed for more than one part of the plant whereas 52 species (76%) were collected for a single part.

The edible portions of indigenous vegetables are consumed after minimal processing by cleaning, boiling, frying, grinding, mixing or drying (Table 1). All vegetables with edible

Table 1 List of indigenous under-utilized plants used by tribal and settler communities in Andaman and Nicobar Islands

S. No.	Local name	Scientific name	Family	Habitat	Season	Habit	Edible portion	Culinary uses/preparations
A. Tree vegetables								
1.	Agathi	*Sesbania grandiflora* (L.) Pers.	Fabaceae	W, C	R	P, T	Flowers, leaves, tender pods	Cleaning, mixing, frying, chutney
2.	Bamboo	*Bambusa vulgaris* Schrad. ex Wendl.	Poaceae	W	R, D	P, G	Tender shoots	Cleaning, boiling, frying, pickle
3.	Bilayati katahal	*Artocarpus incisa* L.	Moraceae	H	R, D	P, T	Unripe fruit	Cleaning, peeling, frying, boiling, pickle
4.	Curry patta	*Murraya koenigii* Spreng.	Rutaceae	C,H	R, D	P, T	Leaves	Cleaning, chutney, drying, taste enhancer
5.	Dumoor	*Ficus hispida* L. f.	Moraceae	W	R	P, T	Leaves, unripe fruit	Cleaning, boiling, frying, chutney, pickle
6.	Imli	*Tamarindus indica* L.	Caesalpiniaceae	W, H, C	R, D	P, T	Unripe pods, leaves	Cleaning, boiling, taste agent, chutney
7.	Katahal	*Artocarpus heterophyllus* Lam.	Moraceae	H,W	R	P, T	Unripe fruit, seeds	Cleaning, peeling, frying, boiling, pickle
8.	Mitha bhaji	*Champereia manillana* (Blume) Merr.	Opiliaceae	W	R	P, T	Tender leaves	Vegetable, chutney
9.	Neem bhaji	*Azadirachta indica* A. Juss.	Meliaceae	W,H	R, D	P, T	Tender leaves	Chutney, fried or mix vegetables
10.	Putkal	*Ficus virens* Ait.	Moraceae	W	R	P, T	Tender leaves	Cleaning, frying, boiling, chutney
11.	Sahjana	*Moringa oleifera* Lam.	Moringaceae	C, H	R, D	P, T	Flowers, pods, leaves	Cleaning, boiling, frying, pickle, soup
12.	Tarkari kela	*Musa paradisiaca* L.	Musaceae	W, H, C	R, D	P, H	Pseudostem, immature fruits, male flowers	Cleaning, boiling, frying
13.	Golden shower	*Cassia fistula* L.	Fabaceae	W	D	P, T	Flowers	Cleaning, frying, mixes
B. Vine vegetables								
14.	Chichinda	*Trichosanthes anguina* L.	Cucurbitaceae	W, H, C	D	A, V	Unripe fruit, leaves	Washing, fried vegetable, drying
15.	Jangli bean	*Canavalia ensiformis* (L.) DC.	Fabaceae	W, H	R	P, V	Tender pods	Boiling, mix vegetable, roasting
16.	Jangli kakrol	*Momordica cochinchinensis* (Lour.) Spreng.	Cucurbitaceae	W	R	P, V	Unripe fruit	Cleaning, boiling, frying, pickles
17.	Kakrol	*Momordica subangulata* ssp. *renigera* (G. Don) de Wilde	Cucurbitaceae	W, H, C	D	P, V	Unripe fruit	Cleaning, peeling, frying, boiling, drying
18.	Kundru	*Coccinia grandis* (L.) J. Voigt	Cucurbitaceae	C, W	R	P, V	Unripe fruit, leaves	Washing, frying, drying
19.	Nalli bhaji	*Ipomea aquatica* Forsk.	Convolvulaceae	C, W	R	P, V	Leaves, stem	Boiled and fried vegetables
20.	Poi bhaji	*Basella alba* L., *B. rubra* L.	Basellaceae	C, H	R	A, P, V	Leaves, stem	Cleaning, washing, boiling, frying, mixing
21.	Jangli torai	*Luffa aegyptiaca* Mill., *Luffa sp.*	Cucurbitaceae	W, H, C	R, D	A, H	Unripe fruit	Washing, peeling, boiling, frying
22.	Chow chow	*Sechium edule* (Jacq.) Sw.	Cucurbitaceae	W,H	D	P, V	Unripe fruits, tubers, leaves	Cleaning, frying, boiling, mix vegetable items
23.	Velvet bean	*Mucuna pruriens* (L.) DC.	Fabaceae	W	D	P, H	Tender seed	Boiling, frying, roasting
C. Herb vegetables								
24.	Aam bhaji	*Limnophila chinensis* (Osbeck) Merr.	Plantaginaceae	W, C	R	A, H	Leaves, shoots	Cleaning, washing, chutney, mixing, drying, taste agent
25.	Brahmi	*Bacopa monnieri* (L.) Penn	Plantaginaceae	H	R	A, H	Leaves, tender shoots	Washing, cleaning, frying, mixing vegetables, drying, taste enhancer
26.	Burma dhaniya	*Eryngium foetidum* L.	Apiaceae	C, H	R, D	P, H	Leaves	Washing, cleaning, drying, mixing, grinding, chutney, taste and flavour agent
27.	Chundak	*Solanum torvum* Swartz.	Solanaceae	W, H	D	P, H	Unripe fruit	Washing, chutney, boiling, frying, pickle, mixing vegetable
28.	Deki bhaji	*Dryopteris filix-mas* (L.) Schott.	Polypodiaceae	W	R	P, H	Leaves, shoots	Cleaning, washing, boiling, frying, mixing
29.	Ghuniya	*Colocasia esculenta* (L.) Schott.	Araceae	W, C	R	P, H	Leaves, tender shoots, tubers	Cleaning, peeling, roasting, mixing, boiling, frying
30.	Helencho	*Enhydra fluctuans* Lour.	Asteraceae	W, C	R	P, H	Leaves, tender shoots	Cleaning, boiling, frying, chutney, mixing, drying
31.	Khatta bhaji	*Hibiscus sabdariffa* L.	Malvaceae	C, H	R	A, H	Leaves, flower buds, immature fruits	Cleaning, washing, mixing, frying, boiling, chutney
32.	Kulekhara	*Hygrophila spinosa* T. Ander	Acanthaceae	W, H	R	A, H	Leaves, shoots	Cleaning, washing, mixing, frying, chutney
33.	Madrasi bhaji	*Alternanthera philoxeroides* (Mart.) Griseb., *A. dentata* L., *A. sessilis* (L.) R.Br. ex DC.	Amaranthaceae	W, C	R	A, H	Leaves, shoots	Cleaning, washing, frying, vegetables, chutney
34.	Malencho	*Jussiaea repens* L.	Onagraceae	W	R	A, H	Leaves, shoots	Cleaning, washing, boiling, frying
35.	Marsha bhaji	*Amaranthus viridis* L., *A. tricolor* L., *A. lividus* L., *A. blitum* L.	Amaranthaceae	W, C	R, D	A, H	Leaves, shoots	Cleaning, washing, boiling, frying, mixing, chutney, drying

Table 1 (continued)

S. No.	Local name	Scientific name	Family	Habitat	Season	Habit	Edible portion	Culinary uses/preparations
36.	Medak bhaji	*Centella asiatica* (L.) Urban	Amaranthaceae	W, H, C	R	P, H	Leaves	Cleaning, chutney, mixing, taste agent
37.	Nuna bhaji	*Portulaca oleracea* L.	Portulacaceae	W, H, C	R	A, H	Leaves, shoots	Cleaning, washing, frying, mixing, boiling, taste enhancer
38.	Patt	*Corchorus capsularis* L.	Tiliaceae	C, H	R	A,H	Leaves, shoots	Cleaning, washing, boiling, mixing
39.	Greater yam	*Dioscorea alata* L., *D. bulbifera* L.	Dioscoreaceae	C, H,W	D	A, V	Tubers, arial tubers	Washing, boiling, peeling, frying
40.	Pipali sag	*Piper sarmentosum* Roxb.	Piperaceae	W, C, H	R, D	P, H	Leaves, spike	Cleaning, boiling, mixing, frying
41.	Sapla	*Nymphaea nouchali* Burm. f.	Nymphaeaceae	W, C	R	P, H	Shoots, flowers	Cleaning, washing, boiling, frying
D. Shrub vegetables								
42.	Chakurmani	*Sauropus androgynus* (L.) Merr.	Euphorbiaceae	W, H, C	R	P, S	Leaves, tender shoot	Cleaning, washing, frying, chutney, mixing

W-Wild, C-Cultivated, H- Homegarden; R-Rainy, D-Dry, A-Annual, P-Perennial, H-Herb. S-Shrub, T-Tree, V-Vine, HP- Herb, G-Grass, B-Bush

leaves required minimum processing (cleaning-boiling-grinding-frying and mixing) and less processing time than others that have immature fruit, tender shoots and tubers, which required cleaning-peeling-cutting-boiling-frying and mixing steps. *Limnophila chinensis* (Osbeck) Merr., *E. foetidum*, *M. oleifera, H. sabdariffa*, and *P. sarmentosum* were used as taste enhancement and flavouring agents. Sun-drying was common for green leaves of *Amaranthus viridis* L., *A. tricolor* L., *H. sabdariffa*, *M. koengii*, *C. moschata*, *M. oleifera* and *L. chinensis* and for small pieces of immature fruit of *Coccinia grandis* (L.) J. Voigt., Snake gourd (*Trichosanthus anguina* L.), pointed gourd (*Trichosanthus dioica* L.), *M. subangulata* spp. *renigera* and *M. cochinchinensis*. Fresh and dried forms of *E. foetidum*, *C. asiatica, A. tricolor* and *A. viridis* were occasionally used in the fortification of local food items including *pakora*, soup, *muruku*, biscuits, *vada*, *paratha*, *puri* and *maththi*. These fortified items from local nutrient-rich plants have the potential to sustain food-based schemes for nutritional security such as the Mid Day Meal scheme (http://mdm.nic.in/) for school-going children and the *Aganwadi* scheme for pregnant women and pre-school children in India (http://wcd.nic.in).

Immature fruit of perennial tree-vegetables are part of traditional diets. *A. heterophyllus* is common in the Andaman Islands, *A. incisa* is common in the Car Nicobar Island and both were commonly found in vegetable markets across the islands. Immature fruits of *Dillenia indica* L., *Ficus hispida* L. f., *F.virens* Ait. and *Garcinia cowa* Roxb. ex DC. were used for the preparation of vegetables, pickles and chutney, but require multiple processes (peeling, cutting, frying and boiling) and seasonal availability restricts their wide acceptance. Fruit of *A. heterophyllus*, *A. incisa, D. indica, G. cowa* and *F. hispida,* and leaves and shoots of *F. virens* contain latex which affects the removal of peel and makes the tissue take longer to boil or fry. The preference score of vegetables in the survey was influenced by colour, taste, flavour and use in traditional food items. There was variation in cooking practices used with the vegetables in the households which affected preference for vegetables by children (Colas et al. 2013), indicating that effective cooking practices are needed to increase the acceptance of some underutilized vegetables.

3.4 Nutritive value

The content of dietary nutrients and phytochemicals in 28 indigenous under-utilized vegetables varied as shown in Table 2. Some of these vegetables were rich sources of Ca and Fe (Table 2). The most Ca-rich tissues were leaves of *M. koenigii* (850 mg/100 g dw), *C. asiatica* (583 mg/100 g dw), *H. sabdariffa* (498 mg/100 g dw), *A. viridis* (416 mg/100 g dw), *S. grandiflora* (404 mg/100 g dw),

Table 2 Dietary nutrients and phytochemicals in 28 common indigenous vegetables of Andaman and Nicobar Islands

Indigenous vegetable	Part	Micronutrients (mg/100 g dw)		Phytochemicals (mg/100 g fw)				Anti-nutrients (mg/100 g fw)			
		Ca	Fe	Polyphenol	Chlorophyll	Carotenoids (μg/100 g)	Ascorbic acid	Nitrate	Phytate	Oxalate	Saponin
A. Tree vegetables											
1. *Artocarpus heterophyllus*	Immature fruit	43	4.2	230	50	418	73	40	24	41	234
2. *Artocarpus insica*	Immature fruit	40	3.8	287	58	682	87	37	22	36	198
3. *Moringa oleifera*	Immature fruit	20	1.5	231	43	591	140	NA	NA	NA	NA
4. *Moringa oleifera*	Leaf	18	2.8	296	230	595	130	31	18	16	113
5. *Murraya koenigii*	Leaf	830	15	234	238	777	250	69	12	23	127
6. *Musa paradisiaca*	Flower	32	76	254	200	292	249	84	8.9	43	237
7. *Sesbania grandiflora*	Leaf	404	5.0	236	146	1946	304	28	14	34	88
B. Vine vegetables											
8. *Basella alba*	Leaf	138	9.4	311	233	786	297	86	19	40	184
9. *Basella rubra*	Leaf	203	8.4	142	10	179	138	45	287	29	N.A.
10. *Coccinia grandis*	Fruit	125	12	258	98	115	86	29	17	20	69
11. *Momordica cochinchinensis*	Fruits	110	12.8	198	15	463	210	NA	NA	NA	NA
12. *M. subangulata* ssp. *renigera*	Fruits	198	15.7	521	13	289	88	NA	NA	NA	NA
13. *Ipomea aquatica*	Leaf	286	61	230	193	510	245	43	27	38	65
C. Herb vegetables											
14. *Alternanthera philoxeroides*	Leaf	354	104	244	263	1276	227	48	19	48	191
15. *Amaranthus lividus*	Leaf	215	124	231	173	567	308	99	14	37	153
16. *Amaranthus viridis*	Leaf	416	34	284	207	483	252	100	22	32	319
17. *Amaranthus tricolor*	Leaf	437	35	222	71	510	245	60	18	40	169
18. *Baccopa moneiliforae*	Leaf	250.0	95.0	306.0	190.5	745.4	120.0	58.8	43.1	30.6	176.5
19. *Centella asiatica*	Leaf	583	179	225	173	283	262	58	17	26	130
20. *Colocasia esculenta*	Tuber	100	27	225	NA	110	250	114	24	40	269
21. *Corchorus capsularis*	Leaf	298	11	308	264	384	282	84	26	31	155
22. *Diascorea alata*	Tubers	138.2	59.6	256.4	NA	115.0	80.6	194.5	222.5	21.3	NA
23. *Dryopteris filix-mas*	Leaf	40	4.2	243	260	431	282	64	16	41	25
24. *Enhydra flactuans*	Leaf	365	129	216	188	502	309	39	31	26	55
25. *Eryngium foetidum*	Leaf	354	106	220	199	499	285	78	41	43	60
26. *Hibiscus sabdariffa*	Leaf	498	187	250	220	225	283	80	26	29	371
27. *Hygrophila spinosa*	Leaf	332.0	112.0	305	170	415	103	62.2	49.5	32.2	278.5
28. *Jussiaea repens*	Leaf	142.0	25.0	218	478.8	430	220	65	17	20	69
29. *Piper sarmentosum*	Leaf	280	6.5	219	138	182	263	89	56	15	51
30. *Portulaca oleracea*	Leaf	115	71	236	220	290	287	69	9.3	29	80

Table 2 (continued)

Indigenous vegetable	Part	Micronutrients (mg/100 g dw)		Phytochemicals (mg/100 g fw)				Anti-nutrients (mg/100 g fw)			
		Ca	Fe	Polyphenol	Chlorophyll	Carotenoids (µg/100 g)	Ascorbic acid	Nitrate	Phytate	Oxalate	Saponin
E. Shrub vegetable											
31. *Sauropus androgynous*	Leaf	409	21	1151	197	195	314	49	34	28	225
Mean		256	45	276	179	506	233	62	31	33	153
Range		18–830	1.5–187	142–1151	10–267	110–1946	73–314	28–114	8.9–287	15–48	25–371

N.A.-not analysed

and *Enhydra flactuans* Lour. (354 mg/100 g dw). The lowest Ca content was in Banana (*Musa paradisiaca* L.) flowers. Fe-rich vegetables were *H. sabdariffa* (187 mg/100 g dw), *C. asiatica* (179 mg/100 g dw), *E. flactuans* (128 mg/100 g dw), *A. lividis* (124 mg/100 g dw) and Culantro (*E. foetidum*) (106 mg/100 g dw) (Table 2). Intake of these indigenous leafy herbs in the recommended amount (100 g/capita/day for leafy vegetables; NIN 2011) can contribute from 0.4 to 18.9% of the recommended dietary allowance (RDA) of Ca (calculated on the basis of Ca content in the vegetables and prescribed RDA of 600 mg/person/day). The plants meet from 0.9 to 151.2% of the RDA for Fe (calculated on the basis of Fe content in the vegetables and prescribed RDA of 17 mg/day for men, 21 mg/capita/day for women). The average consumption of vegetables by a family of five was 59.2 kg/month during the rainy season and 23.9 kg/month in the dry season. Theoretical estimates from respondent data indicated a per capita availability of 394.6 g/day in the rainy season and 159.3 g/day in the dry season (Table 3). However, the amount and consistency of intake varied with the number of 'attempt-to-collect'[1] vegetables from natural growing areas, community specific preferences, limited availability to households in peripheral areas, and high kitchen waste. The study was able to establish the role of indigenous underutilized vegetables during the rainy season in meeting prescribed RDAs for vegetables (300 g/capita/day; NIN 2011) in rural settings.

A higher daily intake of vegetables is associated with improved antioxidant status and reduced cardiovascular disease (Anlasik et al. 2005). Polyphenols are natural plant-based antioxidants, which are strongly correlated with antioxidant activity in plants (Singh et al. 2011). Polyphenols ranged from 142.0 mg/100 g fw (*Basella rubra* L.) to 1151.0 mg/100 g fw [*Saursopus androgynus* (L.) Merr.] (Table 2). Chlorophyll content ranged from 49.8 mg/100 g fw in *A. heterophyllus* to 267.0 mg/100 g fw in *C. esculenta*. Carotenoids have strong activity against free radicals and minimize the incidence of cardiovascular disease and cancers (Rahman 2007). Carotenoids in the vegetables ranged from 109.7 to 1946.0 µg/100 g fw; the highest in *S. grandiflora* and lowest in *C. esculenta*. The vegetables were rich in ascorbic acid, which ranged from 72.5 mg/100 g fw (*A. heterophyllus*) to 314.3 mg/100 g fw (*S. grandiflora*).

Anti-nutrients affect the bioavailability of nutrients and hamper activity of digestive enzymes in humans (Akwaowo et al. 2000). Many of the indigenous underutilized vegetables had high levels of nitrate (28 to 114 mg/ 100 g fw), phytate (8.9 to 287 mg/100 g

[1] From visits by tribal members or settlers to forest or farmland to collect indigenous underutilized vegetables from natural sites

Table 3 Consumption and market and ecological perceptions for indigenous vegetables in Andaman and Nicobar Islands

S. No.	Indigenous vegetable	Avg quantity of household consumption (g/consumption day) ($n = 300$)	Avg household consumption frequency (days/month) ($n = 300$)	Avg preference score (on 1–5 scale) ($n = 300$)	Cultivation frequency (%) ($n = 30$)	Input use intensity (%)	Avg market price (INR./kg) ($n = 30$)	Market prevalence frequency (%) ($n = 30$)	Avg. score for nutritional perceptions ($n = 300$)
	A. Tree vegetables								
1	*Artocarpus heterophyllus*	535.2	3.4	2.3	15.5	11.1	37.2	26.1	2.0
2	*Artocarpus insica*	460.0	4.0	2.4	5.0	11.1	30.0	10.0	1.0
3	*Azadirachta indica*	150.5	1.8	1.0	0.0	0.0	11.6	6.7	1.4
4	*Bambusa vulgaris*	360.0	2.3	2.1	0.0	0.0	26.5	6.7	1.6
5	*Cassia fistula*	60.0	2.5	2.2	6.7	11.1	45.0	3.3	1.4
6	*Champereia manillana*	160.0	1.5	3.2	0.0	0.0	13.6	3.3	1.6
7	*Ficus hispida*	380.0	1.7	2.5	10.0	0.0	20.0	3.3	1.2
8	*Ficus virens*	200.0	1.4	2.5	0.0	0.0	30.0	3.3	1.2
9	*Morinda citrifolia*	410.5	2.4	2.3	0.0	11.1	35.6	6.7	1.5
10	*Moringa oleifera*	493.7	5.8	3.1	54.2	22.2	10.2	33.3	3.3
11	*Murraya koenigii*	63.0	17.2	3.2	26.7	11.1	21.4	46.2	2.4
12	*Musa paradisiaca*	455.6	7.5	1.6	19.2	44.4	31.3	23.6	2.0
13	*Sesbania grandiflora*	480.0	3.7	2.7	4.2	11.1	24.5	6.7	1.2
14	*Tamarindus indica*	52.8	10.1	2.0	15.8	0.0	25.1	10.4	1.0
	B. Vine vegetables								
15	*Basella alba*	715.6	8.4	2.0	29.2	33.3	24.5	53.5	4.0
16	*Coccinia grandis*	470.4	2.9	2.3	6.7	11.1	17.6	20.0	2.1
17	*Cucurbita moschata*	619	4.8	3.9	25	44.4	12.4	40	3.5
18	*Luffa aegyptiaca*	520.0	3.6	3.5	25.0	33.3	15.2	26.7	2.8
19	*Ipomea aquatica*	515.0	5.3	3.3	10.0	11.1	12.6	46.7	3.1
20	*Canavalia ensiformis*	450.0	3.2	2.8	16.7	11.1	30.5	20.0	1.9
21	*Momordica cochinchinensis*	546.8	2.7	3.1	0.0	0.0	46.6	26.7	1.5
22	*M. subangulata* ssp. *renigera*	665.6	4.6	2.2	4.2	44.4	35.5	26.7	2.0
23	*Piper sarmentosum*	205.9	2.4	2.6	1.7	11.1	18.0	23.3	1.8
24	*Trichosanthes anguina*	205.1	3.8	1.8	5.2	44.4	18.2	13.2	1.0
	C. Herb vegetables								
25	*Alternanthera dentata, A. philoxeroides*	480.0	5.5	3.6	16.7	11.1	10.0	13.3	3.0
26	*Amaranthus viridis, A. tricolor*	625.0	4.5	3.2	35.0	33.3	15.2	33.1	3.8
27	*Bacopa monnieri*	125.2	2.4	2.5	13.3	11.1	20.0	6.7	2.8
28	*Centella asiatica*	160.9	3.2	3.1	20.0	11.1	78.0	40.2	4.0
29	*Colocasia esculenta*	635.5	5.6	2.1	22.5	11.1	8.3	26.7	3.5
30	*Corchorus capsularis*	535.9	3.3	2.4	10.8	33.3	15.4	20.5	3.0
31	*Diascorea alata*	570.0	2.4	1.8	20.0	44.4	15.0	15.0	1.0
32	*Dryopteris filix-mas*	453.1	3.0	2.6	0.0	0.0	20.6	13.3	3.0
33	*Enhydra flactuans*	379.6	3.4	2.0	3.3	22.2	16.6	13.3	3.0
34	*Eryngium foetidum*	75.0	18.1	3.7	46.7	22.2	66.6	86.7	4.2
35	*Hibiscus sabdariffa*	442.5	3.1	2.4	16.7	33.3	10.5	46.7	2.5
36	*Hygrophila spinosa*	350.0	3.5	2.6	16.6	22.2	15.0	13.3	2.2
37	*Jussiaea repens*	400.5	3.5	2.1	0.0	0.0	15.5	53.3	3.0
38	*Limnophila chinensis*	56.5	7.4	3.1	3.3	11.1	60.5	6.7	2.2
39	*Nymphaea stellata*	587.5	3.3	1.8	2.5	0.0	15.6	6.7	2.5

Table 3 (continued)

S. No.	Indigenous vegetable	Avg quantity of household consumption (g/consumption day) ($n = 300$)	Avg household consumption frequency (days/month) ($n = 300$)	Avg preference score (on 1–5 scale) ($n = 300$)	Cultivation frequency (%) ($n = 30$)	Input use intensity (%)	Avg market price (INR./kg) ($n = 30$)	Market prevalence frequency (%) ($n = 30$)	Avg. score for nutritional perceptions ($n = 300$)
40	*Portulaca oleracea*	404.8	4.7	1.4	12.5	11.1	11.6	20.0	2.5
41	*Solanum torvum*	105.6	4.2	2.1	3.5	0.0	16.5	16.7	1.2
	D. Shrub vegetable								
42	*Saursops androgynus*	265.5	2.4	1.5	2.5	0.0	14.2	6.3	3.0
	Mean	374.7	4.7	2.5	12.8	17.1	24.3	21.9	2.3
	Range	52.8–715.6	1.4–18.1	1.0–3.9	0.0–54.2	0.0–667	8.3–78.0	3.3–86.7	1.0–4.2

fw), oxalate (15 to 48 mg/100 g fw) and saponins (25 to 371 mg/100 g fw) (Table 2). *Coccinia grandis* and *Dryopteris filix-mas* (L.) Schott. had low amounts of anti-nutrients but *C. esculenta* had high amounts, which agrees with Aletor and Adeogun (1995). According to Rao et al. (2006), the occurrence of partial deficiency of iron (in 63.3% of surveyed families), vitamin A (in 96.7% of families) and ascorbic acid (in 100% of families) in the Onge tribe in the islands was associated with low intake of leafy vegetables (93.3% families consumed 82.8% less than the RDA) and over-dominance of fish meat items (95.8% excess of RDA by 73.3% of families). Interactions with the Nicobari tribe in rehabilitation sites developed after the 2004 Tsunami in Little Andaman, Car Nicobar and Campbell Bay revealed that the growing of vegetables, including indigenous crops, had improved in home gardens and natural habitats due to interventions after the tsunami. These observations confirmed the findings of an earlier study by Chand et al. (2012) which indicated improvement in vegetable cultivation in the Andaman and Nicobar Islands due to post-tsunami interventions by CARI (now CIARI), non-government organizations (NGOs) and local administrations. The present study revealed that the intake of minor vegetables remained adequate in the rainy season (311.3 g/capita/day) but low in the dry season (54.9 g/capita/day). High contents of anti-nutrients in some indigenous vegetables (Table 2) might limit the bioavailability of dietary micronutrients.

Settlers and members of tribal groups in the islands have traditional knowledge about local food plants (Singh et al. 2011; Gupta et al. 2004; Chander et al. 2015). The perception of local people about nutritive values of the investigated vegetables was observed on a 1–5 scale. Respondents gave scores to individual vegetables based on their traditional knowledge that ranged from 1.0 to 4.2, with minimum scores for *A. insica, T. indica*, *T. anguina,* and *T. dioica*, and the highest scores for *E. foetidum* (Table 3). Amaranth (*Amaranthus tricolor*) (4.0), *A. dentata* (4.0), *Basella alba* L. (4.0) and *A. viridis* (3.8) also had high perception scores. This perception was positively correlated with measured Fe and Ca contents ($r = 0.35$; $p > 0.05$) and phytochemicals ($r = 0.18$; $p > 0.05$), supporting the traditional way of identifying nutritive vegetables through the use of color intensity, texture and cooking properties. Consumer scoring of minor vegetables for nutritional value was correlated with colour, i.e., the chlorophyll content in vegetables ($r = 0.38$; $p = 0.05$).

3.5 Consumption pattern and food value

There was wide variation in the frequency of household consumption (from 1.4 to 18.1 days/month) of minor vegetables. There were high values for *M. koenigii* (17.2 days/month), *M. oleifera* (13.8), *T. indica* (10.1), *B. alba* (8.4), *L. chinenensis* (8.1), and *M. paradisiaca* (7.5), and low values for *Champereia manillana* (Blume) Merr. (1.5), *Azadirachta indica* A. Juss. (1.8), *F. hispida*, and *P. sarmentosum* (2.4). Other underutilized vegetables with high household consumption (in g/day) were *M. subangulata* ssp. *renigera* (665.6 g/day), *C. esculenta* (635.5) and *A. viridis* (625.0); low consumption occurred for *E. foetidum* (75.0), *M. koengii* (63.0), *D. indica* (60.0), and *L. chinensis* (56.5). Variation in frequency and quantity of household consumption could be attributed to differences in the pattern and purpose of use, season of availability, family size and preference level (Colas et al. 2013). Preference of the local population for indigenous underutilized vegetables ranged from 1.0 to 3.8, with the highest preference recorded for *A. tricolor* leaves and least for *A. indica*. Other vegetables with high preference levels were *E. foetidum* leaves (3.7), *Luffa* spp. leaves (3.7), *M. oleifera* fruits (3.7), and *Ipomea aquatica* Forsk. leaves (3.3). A wide range in preferences for indigenous vegetables has been reported elsewhere, including by Pieroni et al. (2007) in South-Asian migrants living in Bradford, Northern England and Msuya et al. (2010) in Uluguru North and West Usambara Mountains of Tanzania. The study and promotion of indigenous vegetables holds promise for household food security in marginal communities in many parts of the world, including Africa (van Rensburg et al. 2007), India (Ravishankar et al. 2015; Ghosh-Jerath et al. 2016; Thongam et al. 2016; Gupta et al. 2017) and east Asian countries (Ebert 2011; Kongkachuichai et al. 2015). These vegetables are easily accessible and acceptable to tribal and other rural communities, and accordingly their promotion as sources of dietary minerals is easy in these communities. The prescribed RDA for intake of vegetables is 300 g/day/capita, split into leafy vegetables (100 g), tubers and roots (100 g) and others (100 g) (NIN 2011). Indigenous under-utilized vegetables were common items in daily diets of tribal and rural households in the Andaman and Nicobar Islands, with the majority of leafy vegetables available during the rainy season and tuber crops during the dry season (Singh et al. 2015). As we have seen, in the rainy season most of these indigenous minor vegetables are collected from the wild, grown in home gardens, or in subsistence farming (Table 1). The sale of excess quantities in local markets earns between INR 1200 to 3900 per month for individual vendors (Personal discussions with vendors, August–October 2011). We also identified a need for the protection of growing areas and habitats such as forests, home gardens and other natural growing sites of underutilized vegetables to increase earnings from them in poor communities. There was variation in preference across communities for some of the under-utilized vegetables such as *Corchorus capsularis* L. which was preferred by Bengali households, and *A. philoxeroides* preferred by Tamils, indicating efforts are required to bridge knowledge gaps to improve preference and acceptance of nutrient-rich vegetables across the communities.

3.6 Market analysis

The customer price of the under-utilized vegetables varied substantially [Indian Rupee, INR. 8.3–78.0/kg (US$ INR 1.0 = US$ 68.65; on 30th July 2018)] (Table 3). Highest returns were obtained from the leaves of *Centella asiatica* (L.) Urban (INR. 78.0/kg) and *Eryngium foetidum* L. (INR. 66.6/kg), and the fruits of *M. oleifera* (INR. 58.0/kg), Gac [*Momordica cochinchinensis* (Lour.) Spreng.] (INR 46.6/kg) and Teasel gourd [*M. subangulata* ssp. *renigera* (G. Don) de Wilde] (INR. 35.5/kg). This was likely due to limited supply and higher preference among both native and settler communities. Under-utilized vegetables arrive in local markets after being harvested from the wild, from home gardens, or produced on small-scale farms. Some low priced vegetables, such as *C. esculenta* tubers, leaves from *A. dentata*, *H. sabdariffa*, *P. oleracea*, *A. philoxeroides* or *I. aquatica* were commonly sourced from wild habitats. Post-tsunami (2005 to 2008), agricultural activities, including the promotion of indigenous fruit and vegetables, raised interest in these commodities by consumers and growers (Chand et al. 2012). But poor markets, the non-availability of quality genotypes, and lack of appropriate agro-techniques are often limiting factors in the commercial exploitation of many under-utilized crops. In the present study, we observed the market prevalence as a percentage of the number of vendors selling the indigenous vegetables out of all surveyed vendors. Around 29% of investigated vegetables had less than 10% prevalence in the markets while only two vegetables, namely *Eryngium foetidum* (86.7%) and *Basella alba* (53.5%), had more than 50% market prevalence. Improved genotypes and appropriate agro-technologies are necessary to exploit the commercial potential of under-utilized vegetables (Singh et al. 2015). For example, Sogbohossou et al. (2018) have recently provided a plan for breeding *Gynandropsis gynandra*, which is a highly nutritious leafy vegetable in Africa and Asia.

3.7 Ecological relevance

Vine vegetables had the highest input use intensity (26.7 ± 21.1; 0.0–44.4%) followed by herbs (15.0 ± 11.7; 0.0–

33.3%) and tree vegetables (7.4 ± 8.0; 0.0–44.4%) (Table 3). The most commonly used input for growing these vegetables was a tillage practice (with 71.4% of vegetables), use of locally selected seed/planting materials (33.3% of vegetables), and use of fertilizers (for 28.6% of vegetables). Synthetic insecticides (7.1%), fungicides (4.8%) and herbicides (2.4%) were used with only a few vegetables. No respondent claimed to use antibiotics or plant growth substances when growing indigenous vegetables either pre-harvest or post-harvest. There was no input use in 13 minor vegetables including seven tree vegetables, four herbs and one vine and shrub vegetable. This pattern of low input use when growing indigenous vegetables agrees with findings of Allemann and Swart (2007), however, the extent of the influence of indigenous vegetable production on ecosystems and environment needs further investigation.

Naturally-grown plants in wild or farm/home garden habitats are still the predominant source of edible portions of plants for food in the islands. About 19% of the surveyed vegetables were entirely sourced from wild habitats. Although 30.9% of indigenous vegetables were grown in home gardens or farms, the frequency of respondents growing these vegetables was low (<10%). Cultivation frequency (the percentage of respondent households growing a particular vegetable out of all respondents) of these vegetables ranged from zero to 54.2% and was highest for *M. oleifera* (54.2%), followed by *E. foetidum* (46.7%), *A. viridis* (35.0%) and *A. tricolor* (30.0%) (Table 3). Although *M. oleifera* and *E. foetidum* were frequently cultivated, their input intensity was only 22.2%, indicating their ecological adaptation and cultivation was favorable for the ecosystem. The vegetables, *A. indica*, *Bambusa vulgaris* Schrad ex. Wendl., *D. filix-mas*, *Jussia repens* L., *S. androgynus, F. hispida, C. manillana, C. fistula, F. virens* and *M. cochinchinensis* were all grown entirely in wild habitats and were collected for consumption or for sale on the local market.

3.8 Correlation studies

Calcium content was positively correlated with Fe ($r = 0.379$; $p < 0.05$) in 31 of the minor vegetables. The amount of vegetable consumed by households was significantly correlated with market price ($r = 0.481$, $p < 0.01$), which was positively correlated with market prevalence ($r = 306$; $p > 0.05$). Consumption intensity was correlated with market prevalence ($r = 0.557$; $p < 0.01$) and cultivation intensity ($r = 0.613$; $p < 0.01$) (Table 4). Cultivation intensity was positively correlated with input use efficiency ($r = 0.502$; $p < 0.01$). Nutritional perceptions attract consumers because this was positively correlated with market prevalence ($r = 0.235$; $p < 0.01$). The quantity

Table 4 Pearson correlation matrix of food and market value of indigenous vegetables in Andaman and Nicobar Islands

Parameter	Avg quantity of household consumption (g/day)	Avg consumption frequency (days/month/household)	Avg preference score (on 1–5 scale)	Cultivation frequency (%)	Input use intensity (%)	Average market price (INR./kg)	Market prevalence intensity (%)
Avg consumption frequency (g/day/household)	-0.207^{NS}						
Avg preference score (on 1–5 scale)	0.064^{NS}	0.304^{NS}					
Cultivation frequency (%)	0.195^{NS}	0.571^{**}	0.511^{**}				
Input use intensity (%)	0.393^{*}	0.221^{NS}	0.238^{NS}	0.425^{**}			
Avg market price (INR./kg)	-0.326^{*}	0.273^{NS}	0.283^{NS}	0.053^{NS}	-0.014^{NS}		
Market prevalence intensity (%)	0.183^{NS}	0.608^{**}	0.459^{**}	0.631^{**}	0.267^{NS}	0.204^{NS}	
Avg score for nutritional perceptions (on 1–5 scale)	0.320^{*}	0.302^{NS}	0.346^{*}	0.594^{**}	0.148^{NS}	0.019^{NS}	0.656^{**}

NS-Non-significant; *- significance at $p > 0.05$; **- significant at $p > 0.01$

consumed per household and market price were negatively correlated ($r = -0.481$; $p < 0.01$). This might be due to growing the crops in home gardens, on subsistence farms and harvesting from natural habitats. There was a poor correlation between preference, and quantity and frequency of consumption, indicating time of availability and the ease of cooking processes affects the quantity of consumption. Positive correlations between consumption and growing practices and nutritional perception indicated that the cultivation of these vegetables could be expanded by growing them in home gardens, in school gardens and on small to large commercial farms.

4 Conclusions

Over the centuries, plant biodiversity has played a crucial role in meeting the food and nutritional needs of people. Domestication of a relatively few wild plant species between 10,500 and 4500 years ago in different parts of the world (Diamond and Bellwood 2003), and recent research and development efforts, have led the evolution of agriculture. This has allowed the production of sufficient food to provide at least 2720 kcal per person per day (FAO 2002). However, the continued expansion of human populations and changing climates pose threats to feeding and nourishing people in vulnerable regions in the future. It is therefore necessary to look for additional alternative sources of food plants, particularly those that are nutritious and require low cost inputs, to be integrated into sustainable agriculture in regions vulnerable to climate change. The many indigenous vegetables we studied in this paper fit well with these criteria and are strongly preferred by local people. In our study, we documented 42 indigenous vegetable species in the Andaman and Nicobar Islands. Many of them are common in traditional cuisines. Some of them were identified to be rich in dietary minerals such as Fe and Ca along with health benefiting polyphenols, carotenoids and ascorbic acids. Rao et al. (2006) and Manimunda and Sugunan (2017) indicated that low intake of leafy and other vegetables could be the reason for Fe, vitamin A and vitamin C deficiencies in settler and tribal communities in the islands. Promotion of these vegetables will increase their consumption frequency in the daily diet which will help to overcome micronutrient deficiencies.

Since these crops depend on few external inputs, they fit well with the emerging concept of eco-friendly agriculture. These indigenous vegetable crops have great potential to supplement the programmes run by local administrations to restore the Andaman and Nicobar Islands as 'organic islands' (http://agri.and.nic.in). Promotion of nutrient-rich minor vegetables will benefit custodian populations nutritionally in remote localities, and their commercial production will increase farm income through a regular marketing system in the islands and by exports to other parts of India. Since these vegetables were observed to be easily accessible for household consumption by local people and have better nutritive quality, they fit well in a food based approach to overcome micronutrient malnutrition.

To realize the potential of indigenous nutrient-rich vegetables to contribute significantly to nutritional security and to provide livelihood opportunities to the local tribal and settler communities in rural areas it is essential to increase their cultivation. The promotion of these vegetables can be done through (i) enriching existing home gardens by growing more types and increasing areas devoted to vegetables; (ii) establishing new home gardens in rural and urban areas with a larger share of nutrient rich indigenous vegetables; (iii) enriching the natural habitat of perennial vegetables by spreading seeds or planting saplings. We were able to initiate the enrichment of home gardens with vegetables in the Nicobari tribe area (Car Nicobar, Little Andaman) through an ICAR sponsored Tribal Sub Plan (TSP) scheme run by the CIARI in the region. For this, we gave hands-on-training to youth and women, distributed quality planting materials, and supplied essential inputs during 2013–15 (CIARI 2015); (iv) growing vegetables on farm land to increase the volume of harvest to meet the demands for the fresh market and processing sector; and (v) promoting the diverse culinary uses of indigenous vegetables in food businesses in tribal and rural areas and by providing outlets at tourist sites or other prime localities.

However, anti-nutrients found in some of the underutilized vegetables need adequate attention from crop breeders and from processing experts to reduce them to safe levels (Sogbohossou et al. 2018). Additionally, the adaptability of indigenous vegetables to existing climatic situations in the islands such as low light intensities, heavy rains and excess water during the rainy season, moisture deficit during the dry season, and salt tolerance (Singh and Bainsla 2015), needs to be investigated further for their potential use as donors of climate resilience traits.

In conclusion, the findings from our study indicate several areas for intervention to improve the contribution of indigenous vegetables to food and nutritional security and to provide livelihood opportunities to the local tribal and settler communities in the Andaman and Nicobar Islands.

Acknowledgements The authors thank the Director of the ICAR-Central Island Agricultural Research Institute, Port Blair, India for financial assistance and laboratory facilities. We also acknowledge the support of *Krishi Vigyan Kendra* at Car Nicobar and Port Blair, the Out Reach Centre of CIARI at Diglipur, North Andaman, and the respondents and volunteers from the settler community, the Nicobari tribe and in the markets.

Compliance with ethical standards

Conflict of interest The authors declared that they have no conflict of interest.

References

Abraham, Z., Senthilkumar, R., Joseph, K. J., Sharma, T. V. R. S., Nair, N. V., et al. (2008). Collection of plant genetic resources from Andaman and Nicobar Islands. *Genetic Resources and Crop Evolution, 55*, 1279–1289.

Akwaowo, E. U., Ndon, B. A., & Etuk, E. U. (2000). Minerals and antinutrients in fluted pumpkin (*Telfaria occidentalis* Hook F.). *Food Chemistry, 70*, 235–240.

Aletor, V. A., & Adeogun, O. A. (1995). Nutrient and antinutrients components of some tropical leafy vegetables. *Food Chemistry, 53*, 375–379.

Allemann, J., & Swart, W. J. (2007). Cropping systems for indigenous neglected vegetables: As ecological perspective. *Acta Horticulturae, 752*, 615–619.

Anlasik, T., Sies, H., Griffiths, H. R., Mecocci, P., Stahl, W., & Polidori, M. C. (2005). Dietary habits are major determinants of the plasma antioxidant status in healthy elderly subjects. *British Journal of Nutrition, 94*(5), 639–642.

AOAC (1995). *Official Methods of Analysis*. Association of Official Analytical Chemists, 16th ed. Washington, DC.

Aryal, K. P., Poudel, S., Chaudhary, R. P., Chettri, N., Chaudhary, P., Ning, W., & Kotru, R. (2018). Diversity and use of wild and non-cultivated edible plants in the western Himalaya. *Journal of Ethnobiology and Ethnomedicine, 14*, 10. https://doi.org/10.1186/s13002-018-0211-1.

Badigannavar, A., Girish, G., Ramachandran, V., & Ganapathi, T. R. (2016). Genotypic variation for seed protein and mineral content among post-rainy season-grown sorghum genotypes. *The Crop Journal, 4*, 61–67.

Baruah, A. M., & Borah, S. (2009). An investigation on sources of potential minerals found in traditional vegetables of North-Eastern India. *International Journal of Food Science and Nutrition, 60*(S4), 111–115.

Basic Statistics (2011). Basic statistics of Andaman and Nicobar Islands. Andaman and Nicobar administration, Port Blair, India.

Chand, S., Srivastava, R.C., & Singh, D. R. (2012). *Post-tsunami impact of rehabilitation Schemes in Andaman & Nicobar, India*. LAP LAMBERT academic publishing, Saarbrucken, Germany, pp. 1−76.

Chander, M. P., Kartick, C., & Vijayachari, P. (2015). Herbal medicine and healthcare practices among Nicobarese of Nancowry group of islands - an indigenous tribe of Andaman and Nicobar Islands. *Indian Journal of Medical Research, 141*(5), 720–744.

Chauhan, D., Shrivastava, A. K., & Patra, S. (2014). Diversity of leafy vegetables used by tribal peoples of Chhattisgarh, India. *International Journal of Current Microbiology and Applied Sciences, 3*(4), 611–622.

CIARI. (2015). *Annual Report*, ICAR- Central Island agricultural research institute, Port Blair, Andaman and Nicobar Islands, India.

Colas, M. V., Vaccaro, J. A., Zarini, G. G., & Huffman, F. G. (2013). Impact of vegetable preparation method and taste-test on vegetable preference for first grade children in the United States. *International Journal of Child Health and Nutrition, 2*, 316–325.

Demment, M. M., Young, M. M., & Senesenig, R. L. (2003). Providing micronutrients through food based solutions: A key to human and national development. *Journal of Nutrition, 133*, 3879S–3885S.

Diamond, J., & Bellwood, P. (2003). Farmers and their languages: The first expansions. *Science, 300*, 597–603.

Ebert, A. (2011). Promotion of indigenous vegetables in Asia: Conservation and use of selected crops in Indonesia, the Philippines, and Taiwan. *Acta Horticulturae, 918*, 397–403.

FAO (1997). Traditional food plants. *Food and Nutrition Paper,* 42, Food and Agriculture Organization, Rome.

FAO (2002). The state of food and agriculture. Food and Agriculture Organization of the United Nations, Rome.

Frison, E. A., Smith, I. F., Johns, T., Cherfas, J., & Eyzaguirre, P. B. (2006). Agricultural biodiversity, nutrition, and health: Making a difference to hunger and nutrition in the developing world. *Food and Nutrition Bulletin, 27*, 167–179.

Ghosh-Jerath, S., Singh, A., Magsumbol, M. S., Kamboj, P., & Goldberg, G. (2016). Exploring the potential of indigenous foods to address hidden hunger: Nutritive value of indigenous foods of santhal tribal community of Jharkhand, India. *Journal of Hunger and Environmental Nutrition, 11*(4), 548–568.

Gupta, S., Porwal, M. C., & Roy, P. S. (2004). Indigenous knowledge on some medicinal plants among the Nicobari tribe of car Nicobar island. *Indian Journal of Traditional Knowledge, 3*(3), 287–293.

Gupta, S., Srivastava, A., & Lal, E. P. (2017). Food and nutritional security through wild edible vegetables or weeds in two district of Jharkhand, India. *Journal of Pharmacognosy and Phytochemistry, 6*(6), 1402–1409.

Hassan, L. G., Umar, K. J., Dangoggo, S. M., & Maigandi, A. S. (2011). Anti-nutrient composition and bioavailability prediction as exemplified by calcium, iron and zinc in Melocia corchorifolia leaves. *Pakistan Journal of Nutrition, 10*(1), 23–28.

Johns, T., & Eyzaguirre, P. B. (2007). Biofortification, biodiversity and diet: A search for complementary applications against poverty and malnutrition. *Food Policy, 32*, 1–24.

Keatinge, J. D. H., Yang, R.-Y., Hughes, J. d.' A., Easdown, W. J., & Holmer, R. (2011). The importance of vegetables in ensuring both food and nutritional security in attainment of the millennium development goals. *Food Security, 4*, 491–501.

Kongkachuichai, R., Charoensiri, R., Yakoh, K., Kringkasemsee, A., & Insung, P. (2015). Nutrients value and antioxidant content of indigenous vegetables from southern Thailand. *Food Chemistry, 173*, 838–846.

Lichtenthaler, H. K., & Buschmann, C. (2001). Chlorophylls and carotenoids: Measurement and characterization by UV-VIS spectroscopy. In R. E. Wrolstad (Ed.), *Current protocols food analytical chemistry* (pp. F4.3.1–F4.3.8). New York: John Wiley & Sons.

Liu, W., Yin, D., Li, N., Hou, X., Wang, D., Li, D. & Liu, J. (2016). Influence of environmental factors on the active substance production and antioxidant activity in *Potentilla fruticosa* L. and its quality assessment. Scientific Reports, 628591. doi:https://doi.org/10.1038/srep28591.

Majumdar, R. C. (1975). *Penal Settlement in Andamans. Publications division, Department of Culture, Ministry of Education and social welfare* (pp. 256–357). New Delhi: Government of India.

Manimunda, S. P., & 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 Journal of Community Medicine, 42*, 88–93.

Msuya, T. S., Kideghesho, J. R., & Mosha, T. C. (2010). Availability, preference, and consumption of indigenous forest foods in the Eastern Arc Mountains, Tanzania. *Ecology of Food and Nutrition, 49*(3), 208–227.

NIN (2011). *Dietary Guidelines for Indians – a manual*. National Institute of nutrition (Indian Council of Medical Research), Hyderabad, India. pp. 91.

Pandey, C. B., Lata, K., & Medhi, R. P. (2007). Diversity and species structure of home gardens in south Andaman. *Tropical Ecology, 47*(2), 251–258.

Pieroni, A. (2001). Evaluation of the cultural significance of wild food botanicals traditionally gathered in northwestern Tuscany, Italy. *Journal of Ethnobiology, 21*(1), 89–104.

Pieroni, A., Houlihan, L., Ansari, N., Hussain, B., & Aslam, S. (2007). Medicinal perceptions of vegetables traditionally consumed by south-Asian migrants living in Bradford, northern England. *Journal of Ethnopharmacology, 113*(1), 100–110.

Rahman, K. (2007). Studies on free radicals, antioxidants and co-factors. *Clinical Interventions in Aging, 2*(2), 219–236.

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

Ravishankar, M., Kaur, D. P., Easdown, W. J., & Bhusan, K. B. (2015). Traditional leafy vegetables of a tribal community in Jharkhand, India. *Acta Horticulturae, 1102*, 43–52.

Sadasivam, S., & Manickam, A. (1995). *Biochemical methods*. Wiley Eastern Ltd., Madras, India, pp. 246−248.

Sanchez-Riera, L., Carnahan, E., Vos, T., Veerman, L., Norman, R., Lim, S. S., et al. (2014). The global burden attributable to low bone mineral density. *Annals of the Rheumatic Diseases, 73*(9), 1635–1645.

Singh, S., & Bainsla, N. K. (2015). Analysis of climate change impacts and their mitigation strategies on vegetable sector in tropical islands of Andaman and Nicobar Islands, India. *Journal of Horticulture, 2*, 126.

Singh, S., Singh, D. R., Salim, K. M., Srivastava, A., Singh, L. B., & Srivastava, R. C. (2011). Estimation of proximate composition, micronutrients and phytochemical compounds in traditional vegetables from Andaman & Nicobar Islands. *International Journal of Food Science and Nutrition, 62*(7), 765–673.

Singh, S., Singh, D. R., Chand, S., Birah, A., & Roy, S. D. (2015). Analysis of perspectives of self-sufficiency in vegetable production under tropical conditions. *International Journal of Vegetable Science, 22*(1), 53–68.

Singh, S., Waman, A. A., Bohra, P., Gautam, R. K., & 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), 1431–1435.

Singleton, V. L., Orthofer, R., & Lamuela-Raventos, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin–Ciocalteu reagent. *Methods in Enzymology, 299*, 152–178.

Sogbohossou, E. O. D., Achigan-Dako, E. G., Maundu, P., Solberg, S., Deguenon, E. M. S., Mumm, R. H., Hale, I., Deynze, A. V., & Schranz, M. E. (2018). A roadmap for breeding orphan leafy vegetable species: a case study of *Gynandropsis gynandra* (Cleomaceae). *Horticulture Research, 5*, 2. https://doi.org/10.1038/s41438-017-0001-2.

Swarnam, T. P., Velmurugan, A., & Kumar, V. S. (2015). Studies on tribal farming in Nicobar Islands, India. *IOSR Journal of Agriculture and Veterinary Science, 8*(1), 41–49.

Tangjang, S., & Arunachalam, A. (2009). Role of traditional home garden systems in Northeast India. *Indian Journal of Traditional Knowledge, 8*(1), 47–50.

Thongam, B., Konsam, S., & Handique, A. K. (2016). Assessment of wild leafy vegetables traditionally consumed by the ethnic communities of Manipur, Northeast India. *Journal of Ethnobiology and Ethnomedicine, 12*, 9. https://doi.org/10.1186/s13002-016-0080-4.

UNFCCC. (2005). Climate change, small island developing states. Climate Change Secretariat (UNFCCC), Bonn, Germany.

van Rensburg, W. S. J., van Averbeke, W., Slabbert, R., Faber, M., van Jaarsveld, P., van Heerden, I., Wenhold, F., & Oelofse, A. (2007). African leafy vegetables in South Africa. *Water SA, 33*(3), 317–326.

Vijaya Bhaskar, A. V., Nithya, D. J., Raju, S., & Bhavani, R. V. (2017). Establishing integrated agriculture-nutrition programmes to diversify household food and diets in rural India. *Food Security, 9*(5), 981–999.

WHO. (2008). *Worldwide prevalence of Anaemia 1993–2005: WHO global database on anaemia*. Geneva: World Health Organization.

Shrawan Singh worked as a Scientist in the ICAR-Central Island Agricultural Research Institute (CIARI), Port Blair, Andaman and Nicobar, India, from May 2008 to March 2015. He holds a PhD in Horticulture-Vegetable Science from the Indian Agricultural Research Institute, New Delhi. At CIARI his areas of research were the documentation, conservation, genetic improvement and development of nutritional profiles of indigenous vegetables of the Andaman and Nicobar islands, and understanding their role in the food and nutritional security of vulnerable communities. Shrawan is currently a scientist in the Division of Vegetable Science, Indian Agricultural Research Institute, New Delhi. His present research includes handling breeding materials of Indian cauliflower for nutritional quality traits, heat tolerance and disease resistance through conventional and molecular breeding approaches. In addition, Shrawan works on the genetic improvement of broccoli and tropical cabbage for quality traits and heat tolerance. As a way to address nutritional and livelihood security issues in farming, he takes the improved varieties of these crops to farmers' fields.

L. B. Singh is working at Krishi Vigyan Kendra (KVK), Port Blair, South Andaman to build the capacity of Island farmers with horticultural crops. He holds a PhD in Plant Physiology from BCKV University of Klayani, Kalyani, India. L. B. Singh is a pioneer in organizing interaction with tribal and settler communities to obtain survey data on foods, livelihoods and related issues. He managed the collection of plant samples from home gardens and farm land from the islands and tribal home gardens on Little Andaman for nutritional analysis. At present, he is conducting front line demonstrations and training on improved varieties of horticultural crops and other agricultural technologies, and the conservation of local biodiversity in the islands, to benefit the farming community.

D. R. Singh holds a doctoral degree in horticulture and has made significant contributions to island horticulture research with emphasis on indigenous fruits, medicinal plants and tropical orchids. He worked as Head of the Division of Horticulture and Forestry and as Director at CIARI, was Chairman of the Technical Committee on High Value Agriculture Development Agency of the Andaman and Nicobar Administration, and served as a member of high level committees on Island Biodiversity. He led various research projects, conducted training and demonstrations on indigenous crops and horticultural technologies. D. R. Singh also led an important programme on the domestication and industrial exploitation of *Morinda citrifolia* (a medicinal plant) in the Andamans. He is currently the Director of the National Research Centre for Orchids, Sikkim, India and manages horticulture (floriculture) development in the north-eastern region of India.

Subhash Chand , Principal Scientist, Social Science Section, CIARI, Port Blair, has contributed to surveys of indigenous vegetables for consumer preference, ecological niche, price and input needs. Subhash holds a doctorate degree in Agricultural Economics and Post Graduate Diploma in Dairy Enterprises. He has expertise in technology impact assessment and forecasting through his training in Science, Technology and Policy research at the International Food Policy Research Institute, Washington DC, USA. At present he is working in institutional innovation on an irrigation water management system and livestock service delivery system in India to provide policy options for the future.

S. K. Zamir Ahmed is a Principal Scientist in CIARI, Port Blair. Holding a doctorate degree in Agricultural Extension, he has expertise in social surveys, participatory rural appraisal, and the design and implementation of extension programmes. He has planned surveys and interactions with island farmers as a part of training programmes that helped with the study of indigenous vegetables. He took many promising technologies to farmers' fields in North Andaman through the ORC Out Reach Programme funded by the National Bank for Agriculture and Rural Development (NABARD). These have improved the livelihoods and nutritional levels of island farmers. Zamir now works on *technology assessment and refinement,* promoting agri-based micro-business modules, impact assessment of improved agro-technologies and macro-level planning for island agriculture.

V. N. Singh worked as Subject Matter Specialist (Horticulture) in Krishi Vigyan Kendra, Car Nicobar. He holds a PhD degree in Horticulture-Vegetable science. He has expertise in the interaction and sensitization of local tribes and remains involved in uplifting the Nicobari tribal community. V. N. Singh is now working in Lucknow as a subject matter specialist engaged in the promotion of improved varieties, agro-technologies and household-level processing activities in horticultural crops to benefit farmers.

S. Dam Roy , the Director of CIARI, Port Blair, has a high reputation in the scientific community involved in island ecosystem research. He holds a doctorate in Fisheries Science. S. Dam helped to guide, plan and coordinate this research and review the article. He is working on island fisheries resources for livelihood and nutritional security, and to develop policies for the conservation and sustainable management of fisheries resources and the mangrove ecosystem. Overall, he is involved in the development of policies to uplift island agriculture and the livelihoods of local farmers.