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Status of indigenous and minor vegetables Research – Way forward

NUTRITION has captured the international spotlight in an unprecedented way as persistent global hunger and under nutrition has underscored the need for urgent action. One in eight people around the world still suffer from hunger, and more than double that number are victims of hidden hunger. Indigenous (traditional) Indian vegetables can make an important contribution to food and nutritional security and can enhance the livelihood of marginal and smallholder farmers. In comparison with globally important vegetables, indigenous vegetables have been shown to be rich in micronutrients such as iron, zinc, pro vitamin A and phytochemicals that help protect people against non-communicable diseases. In addition to their nutritional and medicinal importance, indigenous (traditional) vegetables are considered valuable because of their ability to fit into year-round production systems. Many indigenous vegetables have high yields within a short period of growth, are easy to harvest with minimum labor and have widely acceptable taste. Despite the wealth of agronomic, economic and nutritional benefits, indigenous vegetables provide, the production and marketing of these crops are constrained by factors such as poor quality and availability of quality seeds and other production-related risks, lack of appropriate market information and support systems (e.g., cold storage), high postharvest losses – all of which prevent farmers from exploiting the opportunities indigenous vegetable crops present. This partly stems from the fact that most past and some ongoing efforts to address food security have concentrated on the provision of calories by enhancing the availability of staples, particularly cereals, and root and tuber crops, rather than placing emphasis on appropriate nutritional elements that can be attained from a balanced diet. Awareness of the importance of nutrition has recently increased in many parts of our country, which should create new opportunities for indigenous (traditional) vegetables. Research is needed to better understand the potential opportunities and perceived critical bottlenecks faced by smallholder farmers in their decisions to produce and consume indigenous vegetables to devise effective dissemination and adoption strategies. The underlying factors on the supply side of vegetable consumption outcomes seem to be quite well understood, but the socioeconomic behavioral constructs of producers and their perceptions of the nutritional benefits of indigenous vegetables from the demand side require further evidence. Since plants were first domesticated, our Indian societies have used indigenous vegetables to meet their nutritional needs. Depending on the region considered, most of these indigenous vegetables are found as weeds in wild and/or cultivated areas, are semi-cultivated, or are grown as crops that require very little management or additional inputs. It is generally believed that Indian indigenous vegetables are old-fashioned foods used mainly by 'backward' rural people and destined to be superseded by "more modern" vegetable species. However, the evidence shows that these plants are rich in micronutrients, are crucial to the household food security of millions of low income people,

Brinjal – Ramnagar Gaint

Dudaim melon

and are emerging as cash crops as demand increases. In nearly two-third of the households in NEH region, for example, leafy vegetables are prepared four to seven times a week. Nutritional studies have shown that most indigenous vegetables have higher levels of protein, vitamins (A and C), carotene and minerals, compared to cereals and fruits. Moreover, numerous studies have shown that indigenous vegetables are important for both subsistence production and income generation, especially in urban and peri-urban cropping systems. Despite the contribution of indigenous vegetables to food security, nutrition and income, the lack of resources allocated for the development of the vegetable sector has meant that in our country they have not received the attention they deserve. Until recently, most research and development efforts have focused on improving production systems for exotic vegetables, and have ignored the more diverse and abundant indigenous species and varieties and the ways in which they are used.

Indigenous vegetables are increasingly recognized as essential for food and nutrition security. Indigenous vegetables production provides a promising economic opportunity for reducing rural poverty and unemployment and is a key component of farm diversification strategies. Today, neither the economic nor nutritional power of indigenous vegetables is sufficiently realized. To tap the economic power of indigenous vegetables, governments will need to increase their investment in farm productivity (including improved varieties, alternatives to chemical pesticides, and the use of protected cultivation), good postharvest management, food safety, and market access. To tap the nutritional power of indigenous vegetables, consumers need to know how these vegetables contribute to health, and find them at affordable prices or be able to grow them themselves. Indigenous vegetables consumption must therefore be nurtured through a combination of supply-side interventions and behavioral change communication emphasizing the importance of eating vegetables for good nutrition and health. To fully tap the economic and nutritional power of indigenous vegetables, governments and donors will need to give indigenous vegetables much greater priority than they currently receive. Now is the time to prioritize investments in indigenous vegetables, providing increased economic opportunities for smallholder farmers and providing healthy diets for all. Food security has long been associated with a vision of an abundance of grains, roots, and tubers – the staple crops that provide affordable sources of dietary energy. But this picture is changing as the concept of nutritional security has become embedded in that of food security and the importance of dietary diversity for good health has moved to the fore. Healthy, high-quality diets require the consumption of a wide range of food categories in the right quantities. Globally, the prevalence of hunger has declined, indicating progress in ensuring adequate access to staple foods as measured in terms of calorie intake. But an estimated 2 billion people are affected by insufficient intakes of micronutrients (WHO, 2016) and a further 2.1 billion people are overweight or obese. Potassium in indigenous vegetables helps to maintain healthy blood pressure, their dietary fiber content reduces blood cholesterol levels and may lower the risk of heart disease, folate (folic acid) reduces the risks of neural tube defects, and vitamin A keeps eyes and skin healthy, while vitamin C not only keeps teeth and gums healthy but also aids in iron absorption and supply needed micronutrients (especially calcium, iron, iodine, vitamin A and zinc). Indigenous vegetables also typically provide more employment per hectare than cereals; on an average 297 labour-days per hectare per season against 116 labour-days for cereal production. Particularly for youth, indigenous vegetable farming may offer a profitable business opportunity. Indigenous vegetables including traditional vegetables production, processing and marketing offer potential opportunities that can be especially attractive to youth: production requires only small amounts of land, is technology-sauvy, and high profits can be obtained in a relatively short period of time. Public investments in infrastructure, training and subsidies in support of value chains could advance such employment. The potential of indigenous vegetables to generate positive economic and nutritional impacts, however, has been limited by the relatively low levels of support that national governments and international donors direct to public sector vegetable research and development. Public and private investments in agriculture are still largely focused on staple crops and

Dark purple brinjal

Greenish purple brinjal

oil crops, not on commodities rich in micronutrients. There are indications of underinvestment in indigenous vegetable research, especially by the public sector and in improving 'indigenous' or 'traditional' vegetables that primarily reach local and regional markets.

Indigenous vegetable crops

The indigenous vegetable crops are popular and culturally known native varieties. Every region of our country has unique traditional vegetables that are widely consumed by a group of people, or by a particular community. The traditional vegetables and based products that once occupied a part of the regular Indian diet are lost in time due to the emphasis on mono-cropping post-Green Revolution. The revival of indigenous vegetable crops is necessary, measures should be carried out to conserve the indigenous vegetables of the nation and also to carry knowledge to the future generations by reviving the crops back into cultivation. The government of India may initiate the acquisition and management of germplasm of all indigenous vegetables by the Indian National Genebank at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi. Furthermore, the primary factors that contribute to the revival of indigenous vegetable crops include the passion of farmers, administrative measures initiated by the stakeholders, and the marketing strategies of vendors. Additionally, the knowledge about the health benefits of indigenous vegetable crops may also prevent its extinction and ensure the availability of these foods in local markets and the methods of cooking for future generations. Nevertheless, the revival of indigenous vegetables crops is possible only when all the stakeholders define and bring these crops under a special category similar to the one initiated in Kyoto, Japan. In Kyoto Prefecture, the "native varieties" are categorized into "Kyo-no-dento-yasai," and outside the prefecture, it is called "Brand-Kyo-yasai". Additionally, traditional vegetables led-food products of India may be collectively registered with the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) Food Heritages as Intangible Cultural Heritage of Humanity similar to the registrations obtained for the washoku, a traditional dietary culture of Japan; the kimjang and kimchi of Republic of Korea; the Le repas gastronomique des Français (the gastronomic meal) of France; the Mediterranean diet; traditional Mexican foods; and the ceremonial keşkek of Turkey. India may also adopt a geological indication (GI) for the traditional products like the one followed in the European Union and Japan.

Traditional health perceptions

Though Indigenous (traditional) vegetables were predominantly used as food source but some of them also got acclaimed for their medicinal properties. Local people use them for curing the health problems like anemia, vision, skin problems, digestive irregularities, scurvy, wound healing, intestinal worms etc. The indigenous vegetables of islands have manifold traditional health perception. *Ipomea aquatica* for heat strokes and *Enhydra flactuans* for small pox. Tribes also use leaf paste on face and hands to prevent from sun burn or UV rays.

Stress tolerance of indigenous vegetables

The indigenous vegetables have better tolerance to biotic and abiotic stresses which reduce the use of chemical inputs and favour ecosystem concept. Biotic tolerance could be due to their phytochemical profiles which contribute in insect repellence or inhibit establishment or growth of microbes. Abiotic stress tolerance is also inherent in their genetic makeup which is established by the natural selection process. These species face two contrast climatic extremities like drought, high incidence of ultra-violet (UV) rays and high canopy temperature during dry months, and water logging, high humidity (>90%), low sun light, weed competence, poor soil conditions during prolonged rainy season. These indigenous vegetables might have common or different survival mechanisms in such stress situations which is an investigable issue.

Household fortification with indigenous vegetables: a new concept

The indigenous vegetables have less preference among children particularly in rich and educated rural and urban households than exotic vegetables. Thus, high content of micronutrients in these vegetables can be supplied to children through household fortification of their staple foods or fast food items like biscuits, *idli*, *vada*, *pakora*, sandwich, chutney, *paratha*, *kurkure* etc at household or *aganwadi* or school (mid day meal scheme) levels. This concept will help in increase in intake of essential micronutrients like Ca, Zn, Fe, β-carotene and ascorbic acid contribute by these vegetables. The concept will assist in targeting the micronutrient malnutrition along with food security schemes in marginal communities. The powder of drumstick, palak and broad dhaniya is used for supplementing the dietary items for pregnant women and children in health conscious households. Amongst other indigenous vegetables, cucurbits, specifically bitter gourds (*Momordica charantia*) which are important indigenous vegetables in the tropics and possess good nutrient density. Bitter gourd fruits are a rich source of β-carotene, vitamin C, folic acid, magnesium, phosphorus and potassium. The fruits are often used in folk medicine to treat type

Large deep purple brinjal

Summer Squash

II diabetes, a rapidly spreading non-communicable disease that afflicts millions of people. In addition to the fruits, which are eaten stir-fried, in soups, pickled or raw, the young tender shoots of bitter gourd also can be consumed.

Rescue, conservation and utilization of the genetic diversity of cultivated and wild forms of Indigenous vegetables under threat of genetic erosion

Competition for the ever-shrinking land area available and suitable for horticultural crop cultivation is increasing due to rapid human population growth. Indigenous vegetables and other neglected and underutilized plant species compete for land, water and labour resources with other crops and with many other human activities, especially in peri urban areas. Genetic biodiversity in all cropping systems and in home gardens is under constant threat from habitat loss, overexploitation of land for commercial or subsistence reasons, the introduction of exotic species, and rapid urbanization. These factors discount the importance of many indigenous vegetables as mainstays of a number of local communities for food, nutrition, income and for their medicinal value. For example, while still holding only a niche market in NEH region, indigenous vegetables are regularly produced and gathered for home use and also sold fresh or in semi-processed form at both local open markets and urban supermarkets. The market share of indigenous vegetables in our country has been going up recently, accounting for about 35% of overall vegetable sales. Likewise, the consumption of indigenous leafy vegetables has been increasing in several parts of country. Similarly, in region of eastern ghats, western ghats and north west Himalayan region of India many indigenous vegetables are either collected from the wild or are cultivated. The products are sold fresh in the harvesting season, dried and used in home consumption during 'hungry months', or sold in markets for income generation. Regional demand for vegetable crops of underutilized indigenous species needs to be better identified, particularly for the collection of those species showing traits of high yield, good quality, resistance to diseases and pests, or tolerance to abiotic factors. Nevertheless, research and development funding for indigenous vegetable crops is chronically deficient – a situation that demands urgent attention. The factors likely to predetermine support for research and development funding for these crops are, first, an enhancement of descriptors of the socio-economic and cultural value of indigenous vegetables; second, actions to counteract their perceived stigma as 'famine foods' among the general public, and third, better provision of the evidence of their potential for wide use in overcoming malnutrition through effective, balanced diets. Indigenous vegetables often are the principal sources of essential micronutrients especially for the poorest people, as shown from surveys of people across a wide range of incomes in different part of the country. More research is needed to strengthen the case of the value to society of indigenous vegetables, such as indigenous vegetables also holds high levels of anti-inflammatory phytochemicals such as flavonoids and other antioxidants that are of value to human health. Our indigenous vegetables play a significant role in addressing increasing incomes, reducing malnutrition and maintaining biodiversity. Traditional leafy vegetable diversity is an important part of bio-cultural heritage, particularly with regard to food security, nutrition and health. In many part of our country locally adapted landraces are known as 'farmer varieties' and these still contribute significantly to sustainable food production, household nutrition and increased incomes. Typically, landraces are mainly grown for family use or for the local market. Indigenous leafy vegetables can provide a substantial contribution not only to poverty reduction but also to increasing food security and maintaining health in vulnerable communities, as indigenous leafy vegetable production can often be done with little capital investment. These indigenous vegetable crops have been neglected by researchers, policy makers and funding agencies and are currently threatened with extinction, which would mean a substantive reduction in biodiversity. Indian indigenous vegetables have yet to be fully integrated into the mainstream of agricultural production. The introduction of new vegetable varieties into traditional agro-ecosystems is one of the major factors driving genetic erosion, can lead to loss of landraces and associated local knowledge. The main objective is to conserve indigenous vegetable germplasm and to provide seeds of the crops that are vital to meet the nutritional needs of the Indian population and to determine whether

Round Summer Squash

such crops have opportunities for expansion at a national level. Opportunities remain in Indian environments for *in-situ* strategies for vegetable species to conserve crop evolutionary processes and provide scope for ongoing evolution, particularly in response to environmental changes, and pathogen and pest pressures which fluctuate in numbers and genetic composition. The preservation and utilization of crop genetic diversity is of particular importance in the more marginal, diverse agricultural environments where modern plant breeding has had much less success. Moringa (*Moringa* spp.) is a well-known, very versatile, high-nutrient density vegetable crop in most tropical countries, and is most commonly produced in home gardens rather than in cultivated field situations. The few existing breeding programs have yet to produce consistent success. National gene banks need support and encouragement to increase and fully categorize their collections of local indigenous vegetable germplasm now and into the future.

How can the lack of quality seed be overcome?

Lack of a sustainable supply of quality seeds is the main bottleneck in the development of indigenous vegetables, with more than 75% of seeds being supplied through informal sources. Until very recently farmers were the sole sources of such seeds with informal supply systems remaining important, particularly for indigenous vegetable crops. More recently private seed companies have been encouraged to help in the role of public organizations as a formal approach to seed systems, but with varying levels of success in the indigenous vegetables sector. Community seed production and storage systems must be set up in villages, where growers can be trained to produce reasonably genetically pure seed to store in low relative humidity conditions after drying. The availability of quality seed for indigenous vegetables can be increased through the development of primary and elite seed production facilities in research institutes and by the private sector. Training farmers to develop specialized skills for seed multiplication and encouraging them to become contract seed growers for the private sector would be a major factor in overcoming the present poor and irregular seed supply. Farmer training to improve efficiency in pesticide use, harvesting, seed extraction, and seed marketing has shown that seed yields can be increased substantially. The mounting interest in consumption and use of indigenous vegetables demands that this situation now be addressed effectively. The breeding programmes for indigenous vegetables are in its infancy; selections are made from within existing natural populations (landraces) and gene bank accessions. The public sector has released a few improved cultivars of these crops, but may not produce enough seed for wide distribution. Some exceptions exist, such as the Indian Institute for Horticultural Research in Bengaluru, which has its own seed production and distribution agency. Other actors in the seed production sector can include non-governmental organizations (NGOs) involved in agricultural development, disaster relief and rehabilitation. World vegetable center, in collaboration with a local NGO in the eastern part of India, started producing superior home garden seed for year-round production of vegetables, including indigenous vegetables such as green leafy types (Malabar spinach and kangkong) and gourd species (bitter, bottle, ridge, etc.). A range of indigenous local vegetables are being tested for year-round cultivation such as kangkong, Indian spinach, bitter gourd, ridge gourd, snake gourd and eggplants. Ensuring the availability of quality seed is a key issue to assure the sustainability of home gardens with indigenous vegetables. Private sector seed companies and large NGOs have expressed keen interest in this new market and seed packs for small-scale home gardens which can now be purchased widely in the country. The nutrient-dense nature of many indigenous vegetables and their adaptation to local environments makes them most appropriate for NGOs that address problems of hunger and malnutrition. Collaboration between the research system, extension, seed (formal and informal seed systems) and NGOs is very important if the potential of indigenous vegetables is to be adequately exploited to improve nutrition, food security and income generation. Community seed production projects that can be classified as a semi-formal system have become quite common to address the widely known spatial, time, information and value gaps which inhibit development of the seed sector, provision of emergency seed relief, or simply the generation of income, but they often require external support with corresponding challenges regarding their sustainability.

Plant insect interactions

Information on the major insect and mite pests constraining indigenous vegetable production is scanty.

Jack bean pods

Snap melon

Monitoring the incidence and infestation of various insect and mite pests on selected indigenous vegetables is being carried out by entomologists at different ICAR institutes. Aphids are common in nightshade (*Solanum nigrum*) and on mint (*Mentha* spp.), reducing the quality of the produce. *Solanum torvum* fruits are readily infected by the eggplant fruit and shoot borer (*Leucinodes orbonalis*) and act as reservoir for the pest in entire India. Changing climate, especially increased carbon dioxide (CO_2) concentration and rising temperatures, may substantially alter the status of a pest species. Besides CO^2, temperature also impacts insect pest species. Climate change may also modify the performance of natural enemies under field conditions. Understanding the population dynamics of different phytophagous insects and their natural enemies in indigenous vegetable production systems will become a major scientific issue as the world warms rapidly.

Developing integrated pest management strategies

(i) Host plant resistance offers great scope for avoiding pest damage on indigenous vegetables.

(ii) Sticky traps have been widely used in the management of sucking insects such as thrips, whiteflies and leafhoppers. However, recent findings have shown that use of kairomones (volatile chemicals from host plants) increased trapping of some thrips species up to six-fold. This strategy can be combined with the use of entomopathogens has effectively controlled thrips. These novel strategies could be validated for use against the sucking insects on different indigenous vegetables.

(iii) Pheromones are widely used as monitoring and/or mass-trapping tools in integrated pest management programs. Effective pheromone lures are commercially available for pests such as *H. armigera*, *S. litura* and *P. xylostella*, and are being used in pest monitoring.

(iv) Given the short harvest intervals of most indigenous vegetables, biopesticides are highly suitable for pest management as they leave no residues and thus have no requirements for pre harvest intervals. Several commercial *B. thuringiensis*, nuclear polyhedrosis virus (NPV), *M. anisopliae*, *B. bassiana* and neem (*Azadirachta indica*) products have been registered for the control of *S. litura*, *H. armigera*, *P. xylostella*. These biocontrol agents may have a much greater role in the future for defending indigenous vegetables against key pests globally. Formulated essential oils from the neem and tea trees (*Melaleuca alternifolia*) were tested for their toxicity against *A. gossypii*.

Importance of plant diseases on sustainable production of indigenous vegetables

Information about yield losses of indigenous vegetables caused by plant diseases is very limited. This is largely due to the meager research efforts devoted to such neglected crops. Nevertheless, potential yield losses have been indicated from the results of surveys conducted by different agencies. Farmer knowledge of plant diseases of indigenous vegetables is insufficient. Damage caused by less conspicuous problems, such as viruses, nematodes, and wilting were not regarded by farmers as diseases but as issues caused primarily by climatic factors. Their knowledge of diseases affecting global crops was better than that for indigenous vegetables. The need to enhance the capacity of both scientists and farmers at the national level on disease diagnosis and management, as well as the different management options, is urgent.

Can postharvest management be improved, thus making market chains more effective and profitable?

Like other horticultural crops, indigenous vegetables are very often perishable and are easily damaged by poor handling. Careful attention must be given to handling at harvest, during transportation, during value addition, transport to market, and in storage. In most cases this requires considerable investment in ensuring good grower/packer knowledge of suitable postharvest handling techniques, the availability of appropriate on-site or nearby cooling facilities, suitable good quality packaging, and effective transport and storage infrastructure. Postharvest problems that occur during handling and storage include loss of moisture, which leads to weight loss and thus value of the product at market. Many indigenous vegetables are leafy types, and are very susceptible to wilting and weight loss. Quantitative information on the extent of postharvest losses of indigenous vegetables is limited, but some studies indicate that up to 23% of brinjal is lost on farm. Optimum storage temperature regimes have been elaborated for most crops; information on oxygen and carbon dioxide levels for modified atmosphere storage require further development. Optimum temperature for bitter gourd has been worked out to be 12-13°C. Postharvest methods suitable for resource poor farmers are being developed to prolong the shelf life of indigenous vegetables, such as the use of ice in bottles packed with leafy vegetables – a modification of the top icing treatment for greens. Low cost treatments such as the use of 2% bicarbonate wash to reduce microbial contamination have been developed and tested and are being promoted by ICAR-IIVR, Varanasi for suitable indigenous vegetables. It is generally recommended to place vegetable crops in a cool environment to prolong their shelf life. The use of cold rooms and cooling equipment that are mechanically powered is now widespread and very effective, but many smallholder producers do not have

Basella – bush type

access to such equipment and the necessary infrastructure such as a regular electricity supply may not be available. Evaporative cooling principles can be employed using various materials such as using shade and covering vegetables with moist hessian sacks or using charcoal/ moist brick walled structures to provide lower cost cooling options. Effectiveness will depend on the ambient humidity but results from trials show temperatures can be reduced by about 4°C and can thus help provide a longer useful storage period even in high humidity environments. The use of these methods will allow smallholders to deliver a higher quality product. These value chain linkages have used the methods highlighted above, including evaporative coolers and improved packaging such as plastic crates for transporting the crop, and have enabled growers to deliver a higher quality product to market. Improvements in knowledge of postharvest handling requirements for vegetable crops and use of the opportunities for better market linkages mean that growers and traders should be able to increase their income from the production and marketing of indigenous vegetables as demand for these crops increases among consumers.

Can greater consumption of such diverse and nutritious indigenous vegetables be encouraged, knowing that changing dietary habits is a difficult exercise?

A growing population is now conscious of the need for healthy diets. This enhanced awareness may increase the consumption of indigenous vegetables, as seems to be the case in many parts of the country. Sharing and disseminating information about the different indigenous vegetable types and species, their nutritional value for health, and how they can be source of income generation can be done through extension events (farmer days, women's groups and youth training, recipe formulation, preparation and testing) and exposure in the mass media in which indigenous vegetables can be further popularized. Consumption of an important, health-promoting indigenous vegetable such as bitter gourd can be encouraged by breeding non-bitter or less bitter cultivars that may be more palatable to different consumers and developing bitter gourd recipes that increase phyto nutrient retention but moderate the bitter taste. However, this must not compromise the anti diabetic and deworming qualities of the vegetable, which may be associated with its bitter chemistry. In addition to policy makers, the public needs to be well-informed about accessible and affordable sources of micronutrients and antioxidants. A strong promotional campaign is required at the national level to enhance consumption and better understanding of the benefits of nutrient-dense indigenous vegetable crops. This need for popularization should go beyond traditional dissemination activities to reach larger number of people as quickly as possible. Studies that can provide more in-depth information and knowledge about the nutritional value of indigenous vegetables will also help to enhance their use. Many factors have limited greater consumption of indigenous vegetables, including (1) loss of traditional knowledge and skills in their utilization, especially following large-scale urban migration; (2) low priority given to research on improvement of local indigenous vegetable landraces to meet production and market requirements; (3) the highly perishable nature of leafy indigenous vegetables compared to cabbage, onions and eggplants; (4) altered or changing consumption patterns and food habits; and (5) food systems characterized by easier (physical and economic) access to foods of low nutritional quality. Factors influencing food systems (from agricultural inputs to market and consumption factors) and nutritional outcomes need to be taken into consideration in problem analysis, research and design of possible interventions. Strategies can be incorporated into programmes to enhance public awareness and increase consumer knowledge about the benefits of healthy, balanced diets, eventually leading to sustainable behavior changes that will increase demand for more local nutritious food, which will include indigenous vegetables. Changing diets is difficult but can occur, as has been observed over the last decade with the success of moringa as a vegetable in our country, where this little-known seasonal crop is sold throughout the year in principal markets and is recognized as a highly nutritious and valued vegetable.

Developing capacity in research, teaching, policymaking, trading and farming of indigenous vegetables

The entire agricultural sector needs to recognize the importance of indigenous vegetables and to protect

and conserve traditional knowledge about indigenous vegetables for future generations. This means training farmers and other groups along value chains, for example, crop management, producing good quality seed, selecting varieties, intercropping systems, managing soil health, adding value and developing products, packaging and marketing. Training is particularly important for women as it empowers them to play an important role in taking indigenous vegetables to markets. Broadening agricultural curricula to include the conservation and use of indigenous vegetables along with the staple crops will encourage young scientists to take food and nutritional approaches to agricultural development. Information campaigns can help convince policymakers of the need for incentives and support for programmes promoting the use of indigenous vegetables. Supporting the development of infrastructure and institutions, such as providing better cultivation tools, processing machinery and storage facilities, will also be important.

Put in place legal frameworks, policies and financial incentives to promote indigenous vegetables and encourage agricultural diversification

Policies, such as including indigenous vegetables in school feeding programmes and promoting them as components in sustainable diets, enriching food aid with nutritious indigenous vegetables and subsidizing cultivation and marketing of indigenous vegetables, can encourage their use. Incentives can support farmers to grow and conserve indigenous vegetables on-farm, and can be complemented by incentives to conserve indigenous vegetables *ex situ*. Governments can mainstream indigenous vegetables best practices, methods and tools into routine operations. Financial support can take the form of schemes such as payment for conserving agro biodiversity. At the international level, including indigenous vegetables in the International Treaty on Plant Genetic Resources for Food and Agriculture will be important.

Undertake more research on indigenous vegetables, particularly with regard to their adaptive qualities and the links between indigenous vegetables and nutrition and livelihood

Investing in research on indigenous vegetables will help realize the full potential of these crops. Properly documenting, characterizing and collecting and sharing data on indigenous vegetables are essential. In particular, research on the nutritional aspects of indigenous vegetables, and their adaptive traits are important. Research will need to include molecular work to identify indigenous vegetables material suitable for breeding. Links between scientific and traditional knowledge systems will need to be created and inter-disciplinary research networks established.

Encourage collaboration in research, promoting, conserving and sustainably using indigenous vegetables and coordinate activities and multi stakeholder platforms across sectors

More needs to be done to ensure that indigenous vegetables are no longer ignored and neglected by researchers and markets. This means strengthening cooperation among stakeholders and creating synergies at national, regional and international levels. Coordination to promote indigenous vegetables at different levels and in different areas will help establish common approaches, such as standard methods for documenting and monitoring on-farm conservation and international policies for trading indigenous vegetables. The current lack of interaction across sectors (agriculture, nutrition, health, education) and stakeholder groups (farmers, researchers, value chain actors, decision makers) limits the potential of indigenous vegetables. Mechanisms and processes that facilitate strategic synergies among national, regional and international networks, and collaborative platforms, need to be encouraged and supported. Indigenous vegetables are nutritional powerhouses, key sources of micronutrients needed for good health. Indigenous vegetables add diversity, flavor, and nutritional quality to diets. A strengthened focus on indigenous vegetables may be the most direct and most affordable way to deliver better nutrition for all. Indigenous vegetables are also economic engines for productive, profitable agricultural economies. Intensified indigenous vegetables production has the potential to generate more income and employment than other segments of the agricultural economy, making indigenous vegetables an important element of any agricultural growth strategy. Today, however, neither the economic nor the nutritional power of indigenous vegetables is sufficiently realized. Governments and donors need to raise the priority given to increasing the productivity of indigenous vegetables production systems, reducing postharvest losses, and increasing affordability and market access. With a growing understanding of the linkages between dietary quality and health, policymakers must also be prepared to support additional interventions to promote indigenous vegetables consumption.

Involve the full range of stakeholders in participatory partnerships to promote and conserve indigenous vegetables, particularly farmer and women's organizations

Addressing challenges, needs and opportunities related to promoting indigenous vegetables calls for active collaboration with local communities and mainstreaming gender-sensitive approaches. Through each step of the research and development processes, stakeholders – from smallholder farmers to policymakers – must be consulted and involved through open participatory processes. Farmer organizations and traditional seed systems can help make programmes to promote the relevance and effectiveness of indigenous vegetables more effective.

Find innovative ways to upgrade indigenous vegetables market chains and develop and market value-added products

Key priorities in marketing indigenous vegetables are improving access to markets, adding value and stimulating demand. Because new technologies developed for commercial crops are not always suited to traditional indigenous vegetables, this means finding innovative

Basella alba

solutions to simplify processing, create new products and establish multi-stakeholder platforms for indigenous vegetables value chains. Top chefs, restaurants and food retailers can play a leading role in promoting the use of indigenous vegetables in gastronomy and food systems.

Conservation plans for the indigenous vegetables

Setting up national indigenous vegetables conservation programmes will strengthen *in situ* conservation of wild species and *ex situ* conservation in gene banks. A combination of *in situ* and *ex situ* approaches will empower local farmers, particularly women. To do this, local, national, regional and international agencies can finance programmes to conserve and use indigenous vegetables, and leverage existing mechanisms and programmes that focus on major staples and commodity crops.

Genetic erosion constitutes great threat to human survival. The extent and impact of the erosion may not be visible to the present generation. Future generations will have to pay dearly for the carelessness of the earlier generations. In order to prevent this future disaster, the following step-wise conservation plans are suggested for the indigenous leaf vegetables and fruits. With the realization of the threat to plant diversity, the first step in the conservation effort should be a collection mission of samples of the remaining useful indigenous plants as a matter of urgency. It is imperative therefore that the diversity within the gene pools, including the wild relatives are adequately collected, conserved and used in the broadening of the genetic base in crop improvement programmes. India is well endowed with a wide diversity of indigenous useful plants and there is a dire need for greater investment in their conservation and sustainable utilization in order to broaden the base of agriculture and improve food security. Seeds are the most convenient part of plant for storage, with the exception of a few species that have recalcitrant behaviour. In storage, under good temperature and humidity regimes, seeds can be stored for several years. Therefore, following collection, reliable seed banks must be put in place for conservation of the collected samples. It must be emphasized that regular checks are carried out to test the viability of the stored seeds periodically. The seed bank will serve as a major insurance against permanent loss of any species that had been previously collected.

Crop type collection center (CTC)

This is also called 'Field gene banks'. Field gene banks are the most suitable for species that do not produce seeds easily and those with recalcitrant seed behavior. At the CTC, collected plant species are planted out in orderly manner – species by species, variants by variants and family by family. The CTC should be well guarded against fire as this can lead to a total loss of the conserved species. The management and maintenance of the CTC should also be accorded high priority because it is capital intensive. There must be reliable source of water especially during the dry season when water is limiting.

Conservation in natural ecosystem

The objectives of conservation in natural areas have been to protect a representative sample of each ecosystem and to establish a world network of plant reserves in their natural ecosystem. In this way, landraces of the indigenous

vegetables are protected in their natural habitat. This practice is as old as the beginning of live. The forests are indirectly serving plant conservation purposes. Therefore our interest as scientists should be in how many rare species we could find and collect in these forests. To ensure a successful conservation in natural ecosystem, there must be enabling laws and willing government in place to deal with illegal exploitation of the conserved species.

Cryopreservation

The best answer for long-term conservation of germplasm *in vitro* lies in cryopreservation i.e. the storage of frozen tissue cultures at very low temperatures in liquid nitrogen at –196^{0}C, which virtually stops all biological activity. This process puts the cells in suspended animation where they can retain their viability indefinitely. This method is also the best for handling the storage of recalcitrant seeds and is also suitable for species that do not form seed and those that are propagated from bulbs and rhizomes.

Application of novel technologies

India must be able to develop and adapt scientific procedures and technologies that can solve her problems. For example, the Geographic Information System (GIS) applications could contribute significantly to the understanding of inter-specific diversity and its spatial distribution thereby enabling scientists to develop more articulate *in situ* and *ex situ* conservation strategies. Other novel technologies in the public domain and from which India can derive maximum benefits are the application of molecular marker technology in the assessment of intra-specific diversity, germplasm characterization and evaluation, development of core collections, marker assisted selection, gene mining and functional genomics among others. The responsibility is therefore on Indian continent to acquire and develop the necessary human resources to make the best use of these technologies. Indian government should as a matter of urgency demonstrate seriousness by rising to protect what is left of our plant heritage. To achieve this, we need development of enabling legal and policies framework, capacity and infrastructural building and reasonable financial investment to develop our plant genetic resources for the improved livelihood of our people, well being of our citizen and economic development of our continent. The world is going through a stage of conservation and biotechnological revolution and we in India must not be left behind. Institutional, groups and individual intervention to save what is left of our natural resources. To achieve this, the following suggestions are made.

Capacity building

Inadequate expertise in the science of plant genetic resources is at the moment posing serious problems for the ability of India to embark on serious plant conservation programme. For a well-organized plant conservation programme, there is the need for molecular geneticist, biochemist, horticulturist, physiologist, pathologist, entomologist, ecologist, statistician and ethno botanist. It is therefore an urgent task for India to strengthen the technical capacity for *in situ* and *ex situ* conservation and utilization of plant genetic resources at the sub-regional and national levels, with a special focus on human resources development and development of the necessary institutional conservation infrastructures. For conservation efforts to succeed there must be material/ financial resources and human expertise. Therefore in India, especially the Eastern, Western and North west Himalyan region need to invest more in human resources development to be able to face the challenges of conservation of plant resources.

Strategies for the promotion of Indigenous vegetables

A strategy for the promotion of Indigenous vegetables must include appropriate measures to increase both production and consumption. This is because it would be futile to try to promote consumption without ensuring adequate supply. In the same vein, sufficient availability without market demand will create gluts and thus act as a disincentive to further production. Success of promotion programmes, therefore, will depend on how these factors can be synchronized. To achieve this objective, a promotional strategy must include the following:

(i) Adequate baseline data to quantify the contribution of indigenous vegetables in ensuring national food security, to help identify the constraints to their further development, and to forecast future demands and potentials. It should also help to determine the type of policies, programmes and support that would be necessary for promotional activities.

(ii) A strong advocacy to obtain political commitment and government support to long-term programmes of promotion.

(iii) A well-planned research and extension programme and development of appropriate technologies for increasing production, marketing and preservation. High priority should be given to the development of new recipes that will increase market value and competitiveness against exotic species. Recipe-driven increases in demand are exemplified by industrial processing of many indigenous vegetable products.

(iv) Measures to increase public awareness on nutritive value, economic benefits and social prestige in the national diet.

(v) The long-term aim of the promotion programme for indigenous vegetables is to improve the food security and nutritional status of the rural and urban poor, and in so doing recognize the pivotal role played in the rural areas by women in their dual capacity as subsistence food producers and processors.

Selection criteria and future strategy

Indigenous vegetables fulfill multiple roles in the diet, not just as unique carriers of certain nutrients, but also adding flavour, colour and texture that relieve the monotony of an otherwise bland starchy diet. As a group they provide improved nutrition for people of all economic levels and are important sources of income for small farmers. Vegetable production and marketing, particularly of the indigenous vegetables, frequently offer income-generating opportunities for women. Some species

of indigenous vegetables are fully domesticated, others partially domesticated and others almost untouched. Yet among the partially domesticated and the untouched, there may be some with great potential either with or without further improvement. For those species that cannot play major roles, there may be special niches where they can be useful. The discovery of appropriate roles for little-known plant species will depend on careful examination of promising types in many localities. For this purpose, comparative evaluation criteria could be applied. An indigenous vegetable diversification programme should include carefully chosen traditional species to meet the criteria and specific needs of the potential beneficiaries - producers and consumers in various ecological settings. Secondary food crops do not always remain secondary, and as all food plants were gathered at one time before man learned to domesticate them, it is the role of the agricultural and allied sciences to re-examine potential species hitherto neglected.

Utilization strategies

(i) Development/identification of high yielding, disease and pest resistant varieties of indigenous vegetables.

(ii) Develop a platform to exchange and conserve information and materials, identify key task and relevant lead centres for networking of research and development activities to address key knowledge gaps and resource needs for nutritional security, climate change associated stresses, heat tolerance, flooding and salinity tolerance by participatory approach with indigenous and advance knowledge for promising indigenous vegetables.

(iii) The efforts on collection and conservation of indigenous vegetables germplasm need to be strengthened by developing *ex-situ* conservation block or through participatory approach.

(iv) Experiments for establishing the role of indigenous vegetables in improving micronutrient in human.

(v) Selective habitat enrichment for identified indigenous vegetables and their promotion.

Conclusion and policy considerations

Collect, preserve, and effectively characterize traits of those indigenous and traditional species in gene banks using modern molecular characterization. Characterization is the first step in new breeding programs for indigenous vegetable crops, and should be initiated. It is likely to be a myth that these crops are more permanently 'resistant to pests and diseases' than conventional field crops or global vegetable crops. Thus, defensive strategies through breeding, grafting, integrated pest management and good agronomic practices will be required for a sufficient quantity and quality of crops to be produced on-farm in a profitable and efficient manner. Better regimes for shading, cooling, packaging, transporting and storing will be required along the value chain from field to kitchen, particularly in the case of nutrient dense leafy green vegetables with an apparently short shelf life. Many of indigenous vegetables are preferred by consumers for their taste, appearance and vitamin and mineral content. Packaging and marketing to ensure food wholesomeness, cooking to ensure taste and nutrient bioavailability, and attractive meal presentation are all crucial aspects for acceptance of these food products by consumers. The present compilation highlighted the often ignored demand-side factors guiding smallholders' decision to cultivate nutrition-sensitive crops such as indigenous vegetables and their contributions in addressing the nutritional aspects of food security within the household. There are several challenges in the indigenous vegetable value chain (mainly due to high perishability of produce, particularly of leafy types) that are important to all actors in the sub-sector, yet interactions among them are hampered by information asymmetry that results in farmers neglecting or evading recommended practices. The following recommendations are offered: Householders seem to be aware of the higher farm gate values for indigenous vegetables per unit area. They also understand the importance of indigenous vegetables for nutrition – a main driver of their production decisions. Detailed measurements of indigenous vegetables, staples and other food items consumed by households are required to understand other psychological constructs. Family labour size is positively and significantly related to crop concentration on traditional vegetable cultivation. This is an indication of the preference allocation of more labour resources for the cultivation of indigenous vegetables as compared to other crops, perhaps because of their relatively higher farm gate values and household nutrition needs.

- There are marked regional differences in indigenous vegetable preferences that need to be noted for targeting future interventions.
- Since female-headed households involved in indigenous vegetable production are more intensively engaged in it than male-headed households, it is necessary to provide adequate farm management training and knowledge to female farmers to upgrade the value chain. However, a study of decision making on indigenous vegetable production by females within male-headed households would be an interesting area for future research, to better understand gender roles and division of labour in the supply chain, and to explore options to empower women via indigenous vegetable value chains.

It is also important for government to implement enabling policies to enhance timely availability for indigenous vegetable seeds and to avoid spatial gaps, as farmers tend to grow less indigenous vegetables when they perceive that seed is not available in time for cultivation. As a complement, advocacy for enabling collaborative policies that will encourage public–private partnerships can enhance timely availability of seeds to smallholders to bridge the spatial and time gaps in seed systems.

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