Journal of Marine and Island Cultures (2014) 3, 125–133

HOSTED BY ELSEVIER

Journal of Marine and Island Cultures

www.sciencedirect.com

Ensuring food security in the small islands of Maluku: A community genebank approach

Semuel Leunufna [a], Mike Evans [b,c,*]

[a] Center for the Conservation of Maluku Biodiversity, Faculty of Agriculture Pattimura University, Ambon, Maluku, Indonesia
[b] School of Arts and Social Sciences, Southern Cross University, Lismore, NSW, Australia
[c] Community, Culture, and Global Studies, University of British Columbia, Okanagan, British Columbia, Canada

Received 1 July 2014; accepted 2 November 2014
Available online 2 December 2014

KEYWORDS

Genetic diversity;
Community genebank;
Food security;
Small islands

Abstract As a province composed of hundreds of small islands, Maluku is highly susceptible to decreasing biodiversity of plant resources for agriculture. Pressures from pests and disease infestations, difficulty of seed storage, market demands for specific cultivars, and the introduction of new superior varieties are decreasing crop and plant genetic diversity and will impact the food security in the islands. The establishment of community genebanks is proposed to ensure the continuing existence of plant genetic resources and thus the food security of the islands of Maluku Province. The development of facilities and training of personnel to support the survey, collection, and conservation of materials is required, in part to facilitate their cycling of the crop/plant materials to farmers in need. Also required is the study of role and the problems faced by farmers in order to propose supports for bio-diversity that maybe sociological as well as technological.

Introduction

Food security has become a concern throughout the world due to the prevalence of food scarcity in many different areas. The Food and Agricultural Organization (FAO) reports progress in achieving the Millennium Development Goals at the targeted year of 2015, specifically for the first goal to "eradicate extreme poverty and hunger". The data showed that in developing regions, the proportion of people living on less than $1.25 a day fell from 47% in 1990 to 22% in 2010. About 700 million fewer people lived in conditions of extreme poverty in 2010 than that in 1990. As well, the proportion of undernourished people in developing regions decreased from 23.2% in 1990–1992 to 14.9% in 2010–2012. However, one in eight people in the world today still remain chronically undernourished (Wu, 2013).

The United States Agency for International Development (USAID) (2013) has further indicated that in order to meet the needs of a world population which is expected to reach 9 billion by 2050, agricultural production will need to increase by at least 60%. With the present scarcity of resources, there needs to be a more efficient way to fulfil this demand. Ensuring that people have sufficient food requires aligning short-term

* Corresponding author at: Community, Culture, and Global Studies, UBC Okanagan, 1147 Research Rd., Kelowna, BC V1V1V7, Canada. Tel.: +1 250 807 9401.
E-mail addresses: sleunufna@yahoo.com (S. Leunufna), mike.evans@ubc.ca (M. Evans).

Peer review under responsibility of Mokpo National University.

http://dx.doi.org/10.1016/j.imic.2014.11.001
2212-6821

assistance with a long-term development strategy which will help countries feed their own people. Data released by the Indonesian Central Bureau of Statistics placed Maluku Province as the third most impoverished among all provinces in Indonesia during the years 2008 and 2009 (Badan Pusat Statistik, 2009). According to the data almost 30% and over 28%of the Malaccan population lived in poverty in the years 2008 and 2009 respectively. This data implies that even though much progress has been made, significantly more effort still has to be made to improve the living standard of the Malaccan.

The development of Maluku Province in order to attain the goals of the Provincial and National Development Plans, as well as Millennium Development Goals concerning the eradication of poverty, is closely related to the availability of plant genetic resources for agricultural practices. The richness of plants (cultivated crops and wild relatives) as well as animals and marine biology in Maluku has been well known for centuries; many of these components of biodiversity are unique and can only be found in this region. This biodiversity has been exploited for the economic improvement of the community in this island province. However, being a province comprised of a great number of small and medium size islands which are characterized by mountainous and hilly topography and low agricultural land availability, Maluku is ecologically susceptible to the erosion of plant genetic resources – that is the irreversible and irreplaceable loss of genetic resources specifically for agriculture. Studies conducted by comparing the reports of past surveys with present observations, as well as through information provided by the community agricultural leaders indicated a tremendous loss of plant genetic resources of various agricultural crops in the islands. This loss of agricultural plant genetic resources, which have supported the life of the islands' community, will have an impact on the food security of the community on the islands. This process arises, in part, through processes of globalization; pressures arising from climate change are likely to create an even more urgent situation. The objectives of this paper are, therefore: to describe the diversity and loss of genetic resources, especially for agriculture in the small islands of Maluku; to explain the causes of the germplasm loss and discuss its impact on food security; to propose possible solutions for the maintenance of the crops/plants germplasm and for the improvement of food security in the small islands of Maluku.

Methods

The studies were conducted in several ways and in several locations (Fig. 1). Studies in the islands of Kisar, Leti and Moa were accomplished through a visitation accompanied by a member of the parliament from the Maluku Province. Data collection was completed by questioning a number of farmers using a questionnaire, and then field interviews. Data collection was followed by discussion with the community leaders in the islands. Studies in Ambon and surrounding islands were accomplished by field work and direct observation by the author (SL) and the students of the Pattimura University, Ambon. Data collections were done by interviewing the farmers' groups, extension service personnel of the provincial government, and field and market visitations and observations. Studies in the Ceram, Saparua and Yamdena islands (specifically of tuber crops) were accomplished through participation in the project of "Crop Potentials of Underexploited Tuberous Yams and Aroids", a joint project between the United States Agency for International Development (USAID) (2013) and the Pattimura University, Ambon, Indonesia. Data collection was done through surveys of the agricultural institutions at the regency/village levels, followed by field visits which included collection of samples.

Familiarity with genebanks was accomplished through participation in an advanced training on the "Utilization of Plant Genetic Resources as a Contribution to Food Security" (*Nutzbarmachung pflanzengenetizer Ressourcen als Beitrag zur Ernaehrungssicherung*) in Germany (Leunufna, 2010a). Training included lectures, seminars, and participation in the field work of the genebank at the Institute for Plant Genetics and Crop Plant Research (*Institut fuer Pflanzengenetik und Kulturpflanzenforschung-IPK*), Gatersleben, Germany and visits to other genebanks including that of Arche Noach in Wien, Austria.

Results

Some of the diversity and uniqueness of the genetic resources in the small islands of Maluku can be seen in Figs. 2 and 3. The Savanna ecological area has a micro-climate specific to the South West South Maluku Regency (Kabupaten Maluku Barat Daya – MBD) of Maluku Province. It is the habitat of Moa buffalo (*Buballus buballus* L.), and includes the dry climatic condition (agroclimatic zone of C3 with 5–6 wet months and 4–6 dry months, and zone D3 with 3–4 wet months and 4–6 dry months. In combination with other environmental factors, this has provided a habitat and niche for the presence of koli palm (palmae), Kisar orange (*Citrus* sp.) as well as other unique species including Kisar sheep (*Ovis* sp.) and Leti goat (*Capra* sp.), which are present only in the region (see Oldeman and Las, 1980).

In terms of food crops, corn (*Zea mays* L.) has been the main crop; judging from the variety in color of seed endosperm alone, there are a number of cultivars present. It is cultivated in a multiple cropping system with other food crops such as cassava (*Manihot esculenta* L. Crantz), cucurbits (Cucurbitaceae), and peas/legumes (Leguminoceae). Other food crops which are also found include ground nut/pea nut (*Arachis hypogaea* L.), bean (*Phaseolus vulgaris*), yams of the species lesser yam (*Dioscorea esculenta* (Lour.) Burkill), breadfruit (*Artocarpus altilis* (Parkinson) Fosberg) of two cultivars, one with the round fruit shape and the other with an elliptical fruit shape.

Influenced by the climatic condition of a long wet season (agroclimatic zone of B1 with 7–9 wet months and less than 2 dry months, and zone C1 f with 5–6 wet months and less than 2 dry months, Oldeman et. al., 1980), diversity of plant/crop genetic resources in Ambon and the surrounding islands of Ambon Municipality (Kota Madya Ambon), Central Maluku Regency (Kabupaten Maluku Tengah), West Ceram Regency (Kabupaten Seram Barat) and East Ceram Regency (Kabupaten Seram Timur) seemed to be greater in comparison to that of South West South Maluku Regency. Some of this diversity can be seen in the diverse commodities present in Ambon city traditional markets (Fig. 3).

Food crops mainly found in this region include Sago (*Metroxylon sagu* Rottb.), various cultivars of Cassava, banana and plantain (*Musa* spp.), species and cultivars of

Fig. 1 Map of the Maluku Province depicting research locations: Ambon island and surrounding areas; Ceram, Saparua and Haruku islands of Ambon Municipality and Central Maluku Regency (rectangle), Kisar, Leti, Moa and Lakor islands of South West South (Maluku Barat Daya) Maluku Regency (octangle), and Yamdena island of South East West (Maluku Tenggara Barat) Maluku Regency (circle). Inset: Geographical position of Research location (Maluku Province); Irian island to the East, Halmahera island to the North, Celebes island to the West, and Timor island and Australian continent to the South. Source: Lencer (2013).

yams (*Dioscorea* spp.), tania (*Xanthosoma sagittifolium* (L.) Schott.), Taro (*Colocasia esculenta* (L.) Schott), sweet potato (*Ipomoea batatas* L.), corn (*Z. mays* L.), breadfruit (*A. altilis* (Parkinson) Fosberg), and etc.; while that for vegetables includes cabbages (*Brassica* spp.), buko (*Gnetum gnemon* L.), bitter cucumber (*Momordica charantia* L.), water spinach (*Ipomoea aquatica* Forssk.), spinach (*Spinacia oleracea* L.), papaya (*Carica papaya* L.), cucumber (*Cucumis sativus* L.), pumpkin (*Cucurbita moscata* (Duch.) Poir.), eggplants (*Solanum melongena* L.), tomatoes (*Solanum lycopersicum* L.), mung beans (*Vigna radiata* L. Wilczek), wing bean (*Psopocarpus tetragonolobus* L. D. C.), long bean (*Vigna unguiculata* subsp *sesquipedalis* (L.) Vedc), pea (*Pisum sativum* L.), bamboo (*Dendrocalamus* sp.), etc. For spices and medicinal plants, onion (*Alium cepa* L.), syalot (*Alium ascalonicum* L.), garlic (*Alium sativum* L.), chili peppers (*Capsicum* spp.), ginger (*Zinginber* spp.), and curcuma (*Curcuma* sp.) are among the crops/plants found, while mangosteen (*Garcinia mangostana* L.), duku (*Lansium domesticum* var. duku), langsat (*L. domesticum* var. *domesticum*), kokosan (*L. domesticum* var. aquaeum), snake fruit (*Salacca edulis* Reinw), and jackfruit (*Artocarpus heterophyllus* Lam.) are among the fruit trees, which make up the diversity of the region. The commodities that can be found in the market everyday include sago and banana, while other fruits are available only in season.

Despite the diversity described above, the loss of plant genetic resources for agriculture in the Maluku islands including Ambon, Saparua, Haruku, and islands of Southeast Maluku has taken place at a very high rate. For example, corn and beans/peas/nuts in Kisar and Leti islands which were previously of a high genetic diversity (have a great number of cultivars), are very low in number today with only two cultivated varieties for corn and a few for the legume. The number of local cultivars of vegetables and pulses, corns and tuber crops (yams and aroids) in Ambon, Ceram and Saparua islands has been drastically reduced. Yams (*Dioscorea* spp.) cultivated in Saparua, Ceram, Ambon and Yamdena islands was reported to be of eight species in the year 1978 Bogor (Guharja et al., 1978); ten years later based on the surveys conducted by the project of "Underexploited Tuberous Crops Yams and

Fig. 2 Some of the genetic resources found in the Kisar, Leti and Moa islands South West South Maluku Regency of the Maluku Province. Kisar orange (*Citrus* sp.), koli palm (Palmae) and Moa buffalo (*Bubalus* sp.) (a)–(d) are considered some of the germplasm specific to the region. Corn (*Zea mays* L.) is the main food crop, grown in a multiple cropping system with legume, cucurbits (Cucurbitaceae) and cassava (*Manihot esculenta* L. Crantz) are mostly attacked by Grasshopper (e)–(h). Ground nuts (*Arachis* spp.) and beans (*Phaseolus* spp.) are also cultivated while lesser yams (*Dioscorea esculenta* Lour. Burkill) is mainly grown wild, uncultivated (i)–(l). Two different kinds of perennial food crops such as breadfruit (*Artocarpus* sp.) are also found.

Aroids'', a joint project between Pattimura University Ambon and United States Agency for International Development (USAID) (Lalopua et al., 1990), only four species were found.

Discussion

The erosion of these plant resources arises from the following causes:

1. Long dry seasons causing harvest failures, forcing the farmers to consume seeds provided for the next planting season.
2. Infestation of pests and diseases resulting in harvest failure. Crop cultivation is predominantly done without controlling pests and diseases. Mixed cropping of multiple cropping systems is always practiced by farmers, in which the crops are cultivated together in the same field (at the same period/season). This practice is considered beneficial in certain ways, for example: the legumes can provide nitrogen in the soil needed by corn. In the long run, however, there is a possibility that the pests and diseases develop for and attack every crop species. Sequential cropping could be part of the solutions, in which, life cycle of the diseases/pests is disrupted by changing the host crops. Grasshopper (*Melanoplus differentialis* (Thomas)) was the main pest infesting the crops in the islands found during the study.
3. Lack of knowledge in seed storage causing seed deterioration or loss of seed vigor before the next planting season. Seed storage is practiced by farmers in the islands, usually by sun drying the seeds for three to four days before storing the seeds in the cans and placing them on the ceiling of their houses. Variation in seed moisture arising from fluctuations in air temperature and humidity can sometimes render these methods ineffective.
4. Market demands for specific cultivars are causing the abandonment of other cultivars by farmers. In the case of yams, cultivars coconut yam (ubi kelapa) and white yam (ubi putih) of *Dioscorea alata* L. sell well in the traditional markets. Other cultivars of *D. alata* such as fan yams (ubi kipas) and snake yam (ubi ular) are, therefore, not often cultivated in comparison to the two others.
5. Introduction of new superior varieties which can be sold commercially and are recommended by extension officers in certain areas are causing the abandonment of local cultivars. A number of superior cultivars developed through modern plant breeding programs are desired distributors in the big cities. With their superiority, specifically of higher yield, these varieties are more attractive to farmers and recommended by the extension services because they provide more income in comparison to local cultivars or land races.

Fig. 3 Daily scenery at the traditional market of Pasar Mardika Ambon showing some of the diversity of foods, vegetables, spices, and fruits. Different kinds of bananas and plantains (*Musa* spp.), as well as various products of sago (*Metroxylon sagu* Rottb.) can be found every day in the market. Other foods such as taro (*Colocasia* sp.) and sweet potato (*Ipomoea* sp.) usually come in season similar to that of fruits such as dukuh and langsat (*Langsium* spp.), jackfruit (*Artocarpus* sp.), mangosteen (*Garcinia* sp.). Vegetables such as cabbage (*Bassica* sp.), peas (*Pisum sativum* L.), long beans (*Phaseolus* sp.), cassava leaves (*Manihot* sp.), water spinach (*Ipomoea* sp.*)*, spinach (*Spinacia* sp.*)*, tomatoes (*Solanum* sp.), eggplant (*Solanum esculentum* L.), bitter cucumber (*Momordica charantia* L.), as well as spices such as chili pepper (*Capsicum* sp.), ginger (*Zingiber* sp.), onion and garlic (*Alium* spp.), can also be found almost every day. While most of the commodities present in the market come from Ambon and the surrounding islands of the Maluku Province, garlic and onion are mainly introduced from other provinces.

The first three of causes listed above were specifically observed in the islands of Kisar, Leti and Moa the South West South Regency of Maluku Province, while the last two were issues in the islands of Ambon, Haruku, Saparua and Ceram, Ambon Municipality and Central Maluku Regency of Maluku Province.

Reviewing diversity theory and terminology in relation to scale of applicability, Whittaker et al. (2001) emphasized the importance of holding the geographical scale constant in the analysis of diversity. They indicated that the diversity of species or grand clines of species richness is explainable or determined generally by climatic conditions and historical events. Thus, the grand cline in richness of woody plants is climatically determined; this is a model that can further be applied to other taxa. The pattern at local scale of analysis, however, is determined by historical events and geographical feature such as that of isolation. Biota present in islands are the result of two events; colonization and local diversification (Paulay, 1994), and dispersal is the only mechanism through which oceanic islands, which have never had a connection with continental land mass, received their biotas (Paulay, 1994; Cowie and Holland, 2006). The role of historical dispersal in shaping the modern distribution of islands' biodiversity has been proven for many animal and plant taxa through studies using analyses of polymorphic molecular markers (Cowie and Holland, 2006).

Paulay (1994) further noted that local diversification within an oceanic archipelago can take place through speciation in inter- and intra-island contexts: inter-island speciation generally occurs for organisms such as vertebrates and plants, which have good dispersal abilities. Intra-island or ''continental'' speciation, on the other hand, takes place on islands which are large enough to enable an effective isolation of populations through extreme geographic localization (topographic, climatic and other environmental variation) which limits species ranges and facilitates species diversification. Gillespie et al. (2008) examined the relative importance of immigration vs. *in-situ* speciation, and concluded that speciation occurred more rapidly or played a more important role in determining the diversity in isolated islands than that of colonization. However, due to the establishment of transportation routes within the last few centuries, the unique aspect of islands, that is isolation, has mostly disappeared and these relatively new forms of connectedness will influence the future of the biota and biodiversity (Gillespie et al., 2008). Indeed, as is evident from the root causes of decreasing bio-diversity in Maluku, the relative isolation of Maluku Islands has decreased as regional and national infrastructures have grown.

According to Paulay (1994), biodiversity erosion in islands is more apparent and in need of urgent attention than of that in any other geography. The two most important causes of human-induced biodiversity extinction are direct habitat destruction and species introductions, in addition to direct actions of humans, who are predators themselves. Habitats which are easily accessible, suitable for human's needs, and lacking the resilience to disturbance are the ones most vulnerable to the destruction (Paulay, 1994; Gillespie et al., 2008). Among the most vulnerable areas in the islands are dry, gentle sloping and lowland areas while those of wet, steep, and mountainous areas are among the less susceptible. Building construction and conversion of land for agricultural practices are among the direct causes of forest destruction, coupled with the subsequent perturbations that go along with these activities (e.g. pollution, erosion, etc., see Paulay, 1994).

Introduced species can cause biodiversity erosion directly through habitat alteration, and indirectly through interaction with native species (Paulay, 1994; Bowen and Van Vuren, 1997). Studies conducted on Santa Cruz Island compared morphological, structural and chemical defenses of insular endemic plants and their mainland closest relatives, revealed that development of defenses in island shrubs was lower than that of inland shrubs (which had more pronounced morphological defenses). This translated to increased vulnerability to depletion by herbivores which resulted in the destruction or alteration of the plant communities upon which endemic animals depended, eventually causing their extinction (Bowen and Van Vuren, 1997).

Climatic change is another cause of biodiversity extinction. Studies on the Pacific Islands' cloud forest indicated that climate change can cause the rise of the elevation (reduction) of cloud forest habitat since relatively small climatic shift can trigger a major local shift in rainfall, cloud cover and humidity. This can result in the disappearance of cloud forest habitat and the associated biota (Loope and Giambelluca, 1998; Gillespie et al., 2008).

The advent of increased regional connectivity and indeed global processes like climate change has then, profound consequences. The processes of speciation and dispersion that are responsible for the rich biodiversity of Maluku now face countervailing processes which threaten that genetic heritage.

Food security and community genebanks

The loss of plant genetic resources will surely influence food security and can even result in food crisis. Various institutions and organizations have provided a definition for food security. The FAO Conference in 1943 indicated "secure, adequate and suitable food supply for everyone", the World Bank (1986) indicated "secure access at all times to sufficient food for a healthy life", (in Maxwell and Smith, 1992). In Indonesia, based on Undang-Undang (National Act) No. 7, the Year 1996 (Indonesians Clearing House Mechanism for Biodiversity, 2013), food security is defined as a condition in which a household is provided with sufficient food. This condition is achieved when food is: (1) availability both in quantity and quality, and from different sources including crops/plants, animals and fish to meet the need for carbohydrates, protein and fat; (2) in a condition, i.e. secure from hazardous chemical, biological and other harmful elements which can endanger human health and/or compromise religious belief; (3) distributed through the whole country and at all times; (4) easily accessible and within a reasonable price.

In small islands/archipelagos (like South East Maluku) which are lacking infrastructure (including transportation to connect one island to the other and in a short time) most of the aspects of food security mentioned above are hardly met without self-reliance. Even if an abundant food is produced in other parts of the country, it cannot be guaranteed that the food will be easily accessible, obtained in fresh/healthy condition and with a reasonable price in the small islands. Thus even as regional and national connectivity may drive a loss of biodiversity, economies of scale and the relative fragility of transportation networks in (relatively) isolated regions like South East Maluku can create situations in which the resiliency and self-reliance founded on bio-diversity is all the more crucial to the sustainability of humans and their Islands' ecologies.

Community seed (gene) bank can be defined as a community driven and community-owned effort to conserve and use both local and improved varieties for food security and to improve the livelihoods of farmers. The term 'community seed bank' should not be used if conservation and sustainable use of plant genetic resources for food and agriculture are not the major objectives (Sthapit, 2012). A community genebank is one way of ensuring food security in the small islands. Such a genebank aids in the goal of maintaining the existence of various crops/plants genetic resources, to in turn make them available for cultivation by farmers; a genebank can ensure that the food can be produced in quantity and quality in situ, and thus be easily accessible, in a healthy condition and with a reasonable price for each family in the community. Moreover, a community genebank can provide the seed (genetic resources) for the restoration of genetic base of crops species or cultivars in cases of disappearances in certain islands. A community genebank is also a genetic reservoir for the improvement of agricultural performance (producing new, superior varieties) of crops/plants through breeding programs (Leunufna, 2004), or conserving heritage species for use in the context of changing climactic conditions.

In certain ways a community gene bank has, in fact, been at work in some islands of Maluku Province. Farm management (*inter-situ* conservation), in which, families are assigned to grow certain cultivars of certain crops (yams, for example) can be considered one those practices. Competition in preparation of various kinds of foods out of one or various cultivated crops is the other. Many of these practices, however, are now disappearing.

Lewis and Mulvany (1997) describe and compare different community seed (gene) banks practiced in the world and grouped them into five main different types; *de facto* community seed bank; community seed exchange which can be further divided into traditional seed fairs and seed shows or competition; organized seed banks which can be categorized into multiplying farmer varieties, multiplying *ex-situ* seed, multiplying modern variety; relief seed and seed savers' networks; and ceremonial seed banks. They indicate that in terms of physical quality of seeds as well as seed security, the organized seed banks performed better than the other community seed banks.

Organized seed banks such as that of Arche Noach in Wien, Austria, which is supported financially by a number of donors or members, as well as by selling of the services and products it offers, has been successful in collecting and conserving a great number of seeds, tubers, and bulbs of crops/plants varieties and species including those of vegetables, grain crops, spices, ornamental crops, etc. With the vision to ensure "new diversity continuously developed and the loss of crops diversity is stopped", Arche Noach conserved the crops/plants cultivars and species by cultivating them in personal gardens or lands of its members within a network established and organized by Arche Noach, in addition to storing the planting materials in a suitable environmental condition. The main activities and services offered by Arche Noach include; (1) yearly publication of a cultivars handbook which contains nearly 4000 crops/plant kinds cultivated by the members and in the Arche Noach collection garden, as well as in storage, (2) conducting crops/

Fig. 4 Some of the facilities provided in the project either by the community or by the authority of the village, island, or region, and through the project funds. Includes a storage room (a) in which, seeds are kept for certain period of time and for various purposes, a recycle garden (b) where the seeds are planted periodically for seed multiplication and for description of plants/crops characters as well as for other purposes, and an administration building (c) where various activities such as the training of the community genebank personnel take place.

plants markets periodically where collections are sold and exchanged among the members, (3) working jointly with the bio-companies to re-plant and place the old cultivars in the market, (4) providing data bank of the collections containing description of each accession, (5) conducting fruits services in which Arche Noach provide help for determination of old fruit trees and other advice concerning cultivation of fruit trees etc.; and (6) conducting training and seminars as well as joint work with other institutions including government institutions, breeding companies and universities (Arche Noah, 2013, Leunufna, 2010b).

Scarascia Mugnozza Community Genetic Resource Centre (SMGRC) and Gene Bank in India is another community genebank focusing on rice and millet as food crops as well as medicinal plants in the forms of *inter-situ* (on farm management) conservation and *ex-situ* seed bank collecting and conserving traditionally cultivated varieties, land races including farmers cultivated varieties and developed varieties. This community genebank, established through funding provided by the Italian government, is presently supported by a number of governments, national and international organizations on plant genetic resources conservation, and other non-governmental organizations working in the area. As well, it is working together with more than 30 tribal communities in the region. The collections of the genebank are deposited by farmers (farming communities), maintained under a controlled temperature and humidity, and a duplicate of each accession is sent to the National Genebank as an additional safeguard. The database established on each accession includes the ethnobotanical and traditional knowledge associated with them, registration, passport data and characterization data with the nationally and internationally accepted scientific descriptors. All the accessions and information are accessible to the farming communities (M S Swaminathan Research Foundation-MSSRF, 2013).

In Nepal, more than 113 community seed banks were established within the years 1994–2011, prioritizing either local crops species or improved varieties. Lessons learned from the practices in Nepal are that:

> *"Community seed banks (CSB) and community field genebanks (CFGB) are effective and efficient systems for conserving agriculturally important varieties of different crop species in a particular locality. Conservation through utilization is the strategy followed in the CSB and CFGB which are dynamic systems for the conservation and evolution of genes. This ultimately contributes to food security due to the higher adaptability of varieties. All farmers in the community have access to all kinds of planting materials and associated knowledge that are available at the local level. Different approaches and strategies should be followed based on the localities and communities for sustaining the CSB and CFGB (Joshi, 2012)".*

The community genebank proposed to be developed in the Maluku islands, therefore, is one that is run by the community of a village, an island, or a region, in partnership with institutions such as that of the Centre for the conservation of Maluku biodiversity. This is to ensure the existence and the availability of seeds of various different species and cultivars of food crops, horticultural crops and their wild relatives for the continuation of agricultural practices and which will result in food security on the small islands.

The proposed project will be accomplished through a number of activities such as:

1. Provision of facilities for the establishment of the community genebank including office room, seed storage room, a piece of land for the recycled garden (Fig. 4), tools and materials. Most of the facilities will be provided by the authorities/governments of the villages, in the island, or the region. Some of the tools and materials are made available by the project fund.
2. Conduct trainings on genebank management and various tasks in the genebank for the selected personnel (youth) of the villages, islands, and regions. Further trainers or personnel for running the community genebank also need to become prepared.
3. Conduct surveys, collections, and conservations of the plant genetic resources on the villages, islands, and regions.
4. Growing/circulating the plants/crops periodically to demonstrate the cultural practices/techniques to the village community, to accomplish morphological description, to provide seeds for the farmers when needed, and to exchange seeds with personnel and/or organizations.
5. Conduct studies concerning seed longevity in an attempt to solve the problems of seed deterioration or lack of germination ability before planting season, which will be able to help farmers in case of crop failure.

6. Conduct promotions on conservation and sustainable use of plant genetic resources among the community, including preservation of endogenous knowledge and practices.
7. Promoting the use of organic farming to improve security of food (food health) and a sustainable environment within the community.
8. Conduct joint venture with different parties and organizations engaging in agricultural plant genetic conservation.
9. Other activities.

Conclusion

This study indicated that, although some diversity of agricultural genetic resources in small islands of Maluku is still present, the loss of such genetic resources has occurred very rapidly. As previous studies suggest, general causes of the disappearance can be attributed to several factors including: climate change, establishment of transportation facilities connecting the islands resulting in species introduction, habitat alterations, and other human interventions. Specifically for cultivated crops, the causes of the disappearance indentified in this study are climate, pests and disease infestation, lack of knowledge in seed storage, specific market demands, and introduction of new superior varieties. This disappearance of genetic resources, on some islands, has threatened food security in the islands and it is therefore necessary to take actions to conserve the existing genetic resources, and to revitalize agricultural activities which will improve food security in those small islands.

Conservation of agricultural plant genetic resources has been done mostly by means of *ex-situ* conservation (conservation outside the natural habitat of biodiversity components) and *inter-situ* conservation (conservation at farmers' level by periodic cultivation of the crops or *on-farm management*). Community gene/seed banks established in many different parts of the world have been very successful in: conserving a great number of crops cultivars/species, recovering cultivars or species which were nearly extinct, providing seeds for the use by farmers, providing knowledge associated with the crop materials; these activities contribute to food security in the regions these institutions serve. The establishment of community genebank(s), in which community members of the small islands are trained to manage the genebank in a joint work with the government and institutions, such as that of the Centre for the Conservation of Maluku's Biodiversity, is therefore, proposed as a viable mechanism to stem the loss of biodiversity in the region, and enhance the prospects for medium and long term food security as a result.

Acknowledgements

The authors wish to thank Ir. J. Tipka, former member of the Maluku Provincial Parliament, for the technical assistance during the study in the islands of Kisar, Leti, and Moa, the late Ir. J. R. Lalopua MACE, former Principal Investigator of the "Underexploited Tuberous Crops Yams and Aroids Project" for the guidance during the project activities, and Dr. E. Hehne and Dr. Alchinawi, former head and field coordinator, Szhortau office, for the organization and execution of the advance training on "Utilization of Plant Genetic Resources as a Contribution to Food Security".

References

Arche Noah, A-3553 Schiltern, 2013. 'Aktivitäten' Arche Noah Gesellschaft Für Die Erhaltung Der Kulturpflanzenvielfalt Und Ihre Entwicklung. <http://www.arche-noah.at/etomite/> (accessed October 2013).

Badan Pusat Statistik, 2009. Profil Kemiskinan di Indonesia Maret. Berita Resmi Statistik 43 (7), 1–9.

Bowen, L., van Vuren, D., 1997. Insular endemic plants lack defences against herbivores. Conserv. Biol. 1, 1249–1254.

Cowie, R.H., Holland, B.S., 2006. Dispersal is fundamental to biogeography and the evolution of biodiversity on oceanic islands. J. Biogeogr. 33, 193–198.

Gillespie, R.G., Claridge, E.M., Roderick, G.K., 2008. Biodiversity dynamics in isolated island communities: interaction between natural and human-mediated processes. Mol. Ecol. 17, 45–57.

Guharja, E., Sudiarto, A., Wiroreno, O.N., 1978. Dioscorea di Indonesia. Institut Pertanian Bogor (IPB), Bogor.

Indonesians Clearing House Mechanism for Biodiversity, 2013. Regulations, peraturan perundangan, Indonesians clearing house mechanism for biodiversity. <http://bk.menlh.go.id/?module=pages&id=uu (accessed October, 2013).

Joshi, B.K., 2012. A brief overview of community seed bank initiatives in Nepal. In: Shrestha, P., Vernooy, R., and Chaudhary, P. (Eds.), Proceedings of a National Workshop Community Seed Banks in Nepal, Past, Present, Future, LI-BIRD/USC Canada Asia/Oxfam/The Development Fund/IFAD/BioversityInternational, Pokhara, Nepal, pp. 41–46.

Lalopua, J.R., Wattimena, R., Walsen, A., Raharjo, H.T., Leunufna, S., Rehata, H., Bremmer, R., Kesaulya, H., 1990. Crop Potentials of Underexploited Tuberous Crops; Yams and Aroids Project. Final Report. Faculty of Agriculture Pattimura University, Ambon, United States Agency for International Development (USAID), Ambon.

Leunufna, S., 2004. Strategi Pemanfaatan Bank Gen untuk Konservasi Plasma Nutfah Tanaman. Bull. Agrobio. 6 (2), 64–71.

Leunufna, S., 2010a. 'Was man macht – weiss man (Apa yang dilakukan – dipahami)," Harian Pagi Siwalima October 7, 6.

Leunufna, S., 2010b. "Arche Noah (Bahtera Nuh)," Harian Pagi Siwalima March 19, 6.

Lewis, V., Mulvany, P.M., 1997. A Typology of Community Seedbanks. Natural Resources Institute University of Greenwich, Intermediate Technology Development Group, London.

Lencer, 2013. Map of Maluku islands, wikipedia, the free encyclopedia, wikimedia commons. <http://en.wikipedia.org/wiki/File:Maluku_Islands_en.png> (accessed October 2013).

Loope, L.L., Giambelluca, T.W., 1998. Vulnerability of island tropical montane forests to climate change, with special reference to East Maui, Hawaii. Clim. Change 39, 503–517.

Maxwell, S., and Smith, M., (Eds.), 1992. Household food security: a conceptual review, *UNICEF – IFAD*. <http://www.ifad.org/hfs/tools/hfs/hfspub/hfs_1.pdf> (accessed October 2013).

M S Swaminathan Research Foundation-MSSRF, 2013. Scarascia Mugnozza Community Genetic Resource Centre and Gene Bank, M S Swaminathan Research Foundation. <www.mssrf.org> (accessed October 2013).

Oldeman, L.R., Las, I., 1980. The agroclimatic maps of Kalimantan, Maluku, Irian Jaya and Bali, West and East Nusa Tenggara. Contr. Centro Res. Inst. Agric. Bogor 60, 1–32.

Paulay, G., 1994. Biodiversity on oceanic islands: its origin and extinction. Am. Zool. 34, 134–144.

Sthapit, B. 2012. Emerging theory and practice: community seed banks, seed system resilience and food security. In: Shrestha, P., Vernooy, R., and Chaudhary, P. (Eds.), Proceedings of a National Workshop Community Seed Banks in Nepal, Past, Present, Future, LI-BIRD/USC Canada Asia/Oxfam/The Development Fund/IFAD/BioversityInternational, Pokhara, Nepal, pp. 16–40.

United States Agency for International Development-USAID, 2013. Agriculture and food security, increasing food security through feed the future. USAID. <http://www.usaid.gov/> (accessed October 2013).

Whittaker, R.J., Willis, K.J., Field, R., 2001. Scale and species richness: towards a general, hierarchical theory of species diversity. J. Biogeogr. 28, 453–470..

World Bank, 1986. Poverty and Hunger: Issues and Options for Food Security in Developing Countries, Washington DC.

Wu, H., 2013. Overview. In: Jensen, L., (Ed.), The Millennium Development Goals Report 2013, United Nations, New York, pp. 4–5.