

Current Status of Agro-biodiversity in Lebanon and Future Challenges

Chalak L.^{1,2*}, Noun J.³, El Haj S.¹, Rizk H.¹, Assi R.⁴, Attieh J.⁵, Maalouf F.⁶, Abi Antoun M.⁷, Sabra N.¹

1 Lebanese University, Faculty of Agricultural Sciences, Dekwaneh, Beirut, Lebanon.

2 Lebanese Agricultural Research Institute, P.O. Box 287 Zahle, Lebanon.

3 Lebanese University, Faculty of Sciences, Beirut Fanar, Lebanon.

4 United Nations Development Program, Beirut, Lebanon.

5 University of Balamand, Institute of the Environment, P.O. Box 100 Tripoli, Lebanon.

6 International Center for Agricultural Research in the Dry Areas, P.O. Box 5466 Aleppo, Syria.

7 Lebanese Agricultural Research Institute, P.O. Box 90-1965 Jdeidet El Metn, Lebanon

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Introduction

Though a small country (10 452 km²), the phyto-geographic position of Lebanon as a geo-centre between the three continents of the Old World makes it an exile for regional surrounding biodiversity. The topographical and landscape diversity and the presence of high mountains close to the coast and oriented north-south with numerous perpendicular valleys in the east-west direction, resulted in five geomorphological regions (Figure 1) that give rise to around 22 bioclimatic zones and many types of

habitats (Abi Saleh and Safi, 1988). In addition, it contains many semi-natural habitats that have adapted to anthropogenic activities and pressures and that contain a large number of plant and animal species and where the plant domestication started ten thousand years ago (Harlan, 1992). Moreover, it is characterized by the presence of microclimatic conditions and biological reshuffling (Sattout et al., 2005). The above ecosystems diversity allows the cohabitation of cold requiring crops and subtropical crops within a distance of less than 20 km.

Despite the severe degradation of the vegetation cover caused by human activities, Lebanon is still regarded as very diverse, sheltering an estimated number of 4 633 flora species and 4 886 fauna species (Zurayk, 2000).

Besides ornamental, medicinal, forest and forage plants, species of the wild flora harvested and used as food, spices and condiments, more than 80 species for food and agriculture are currently cultivated and/or utilized in the country.

Despite the difficulties and constraints of crop production and marketing of almost all commodities, the agricultural sector has always been an essential component of the Lebanese economy. About 40% of the Lebanese population is currently involved in the agricultural sector and the agro-food industries. Only 34% of this sub-population is entirely counting on agriculture. Out of the total Lebanese area, about 36% are cultivated lands, 7% are covered by forests and 57% are non-cultivated lands or natural pastures. In 2007, the cultivated area was about 277 000 Ha out of which 135 000 Ha are irrigated (Anonymous, 2007). The agricultural lands are located mainly in the narrow coastal plains, in Akkar, in the in-land Bekaa valley, Marjioun plain in the South and the terraces along the mountain sides.

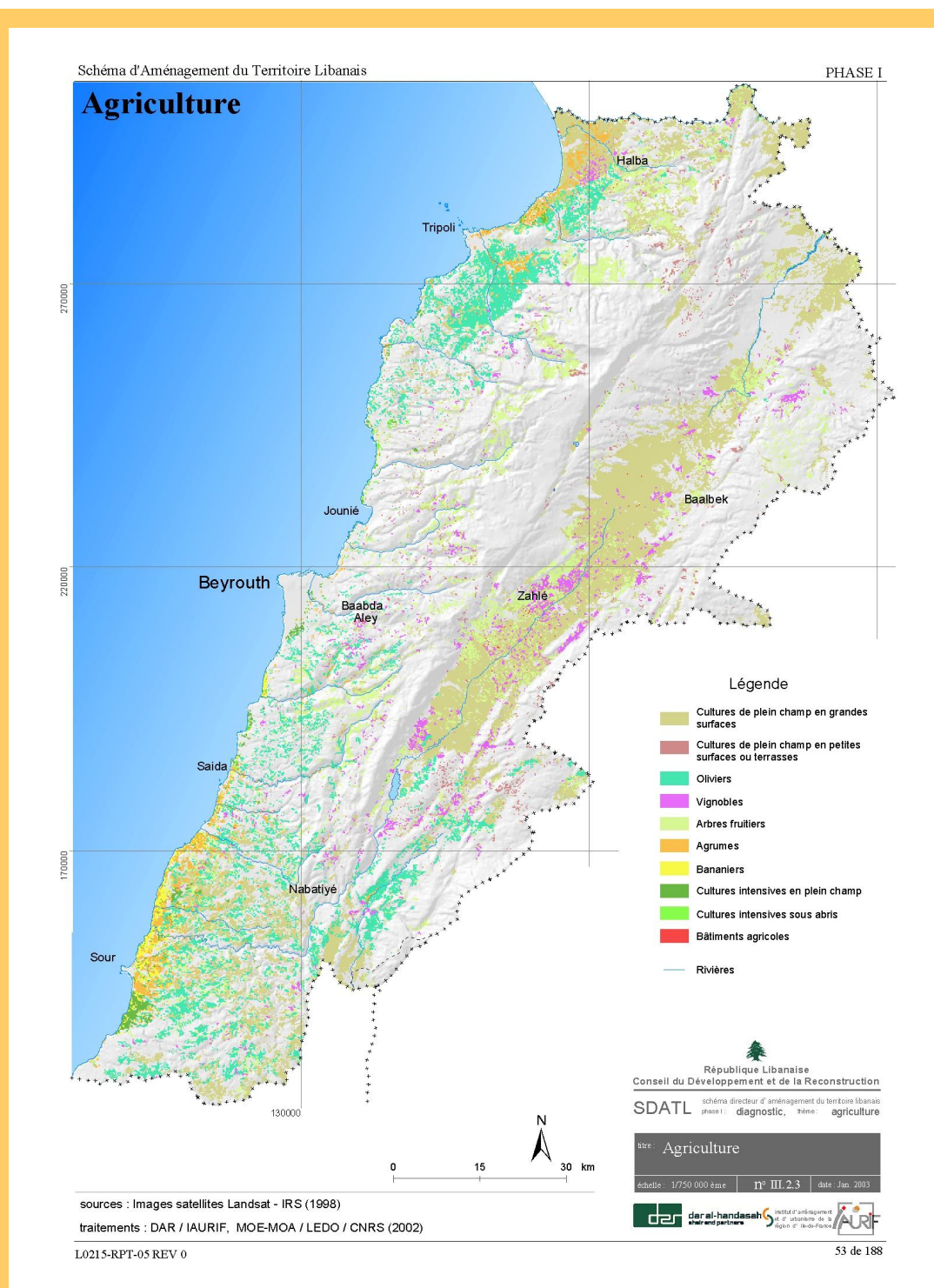


Figure 1. Agricultural map of Lebanon (CNRS, 2002).

Plant genetic resources have been, are and always will be a primary element around which agricultural systems develop and evolve. Their conservation and sustainable utilization should therefore be thoroughly considered in the development and implementation of any agricultural developmental policy.

The national data here presented constitute a comprehensive review for the major activities related to agrobiodiversity in the country and should serve as a basis for the assessment of food security challenges in Lebanon (Chalak and Sabra, 2007).

The state of diversity of crops in Lebanon

The state of diversity of Major Crops

According to the statistics of the Ministry of Agriculture in 2007, the crops that contribute to food security in the country are:

- Olive

The total cultivated area has been estimated at 59 100 Ha with an average annual production of 177 300 tons. Most of the production is locally consumed. More than 12 local and introduced varieties are currently cultivated. The local variety Sourì (or Baladi) is the most commonly grown variety for fruit and oil production. In collaboration with FAO, the Lebanese Agricultural Research Institute (LARI) is promoting, through cuttings, foreign varieties such as Ascolana, Manzanilla, Picholine and Nabali. Moreover, LARI is currently introducing new foreign varieties such as Frantoio, Leccino and Pendolino. In parallel, continuous efforts are undertaken to characterize and inventory the Lebanese olive diversity and to broaden the local genetic base and make it available for farmers.

- Cereals

Among the cereal crops, wheat ranks first with a total area of 52 800 Ha producing

116 200 tons. Most of the consumption is covered through import, which is 3.5 times greater than local production. Landraces such as Hourani, Bekaii, Salamouni, Douchani, and Nabeljamal are still used in the main plains (Bekaa and Akkar) by farmers. Many improved varieties such as Lahn 2, Masarra and Stork, released through collaborative projects between LARI and ICARDA, are also cultivated. Durum wheat landraces are commonly used for parboiled wheat (bourghol) and for bread making in mixture with common wheat imported mainly from Australia and USA.

Barley is the second cereal cultivated in the country (15 750 Ha, 33 100 tons) as feed crop. Its culture is located in South Lebanon and the North of Bekaa. Several improved varieties such as Rihan, Assi and Litani, released through collaborative projects between LARI and ICARDA are cultivated.

- Potato

Potato is considered as the most important field crop in Lebanon. The cultivated area has increased from 14 800 Ha (281 000 tons) in 1999 to 20 100 Ha in 2007 (514 600 tons). For French fries, Spunta is still the preferred variety for consumers since many

years. Recently introduced varieties such as Lady Rosetta, Remarka and Fabula are being cultivated but are still unable to compete with Spunta. Agria is the main cultivated variety for chips industry, and is also used in households.

Currently, efforts are made to increase the number of cultivated varieties via the introduction of new improved varieties. The production is constrained by low profitability due mainly to the absence of a local seed production system and high production costs.

- Fruit species

Citrus plantations are estimated at 14 600 Ha producing 3451 000 tons. About 60% of the production is locally consumed, while the remaining 40% is exported to the Arab countries. The Lebanese plantations are constituted of both traditional and improved varieties. The most cultivated varieties of orange are Hamlin, Baladi, Yafawi, Chammouti, Soukari, Mawardi, Valencia, Washington navel, Navelina, Navelate, Tarocco, Lanelate, and New Hall. Those of lemon are Ashouri, Kabbad, Semaani, Saasali, Sabsabi, Eureka, Malti, Meyer, Dona, and Santa Theresa.

- Grapes plantations are estimated at 10 500 Ha with a production of 106 000 tons, 40% of which is exported to the Arab countries. About 30 local varieties are identified, the most famous of which are Beytamoni, Tfayhiy and Merwah that are used for fresh consumption. Currently, grafts are locally produced. About 97 clones have been collected in the country by LARI. These are under characterization in order to sort out eventual duplications, finalize a list of cultivated varieties and make them available to farmers.

Apples are grown on 10 100 Ha, producing about 125 200 tons. The cultivated varieties are of the Starking and Golden groups. An increasing number of modern improved varieties are currently being introduced from France, Italy, and recently from USA, through the private sector. Certified plants are not yet locally produced.

Cherry is the most cultivated stone fruit in Lebanon (8 100 Ha, 30 000 tons). Plantations are located in high altitude areas (more than 1300 m) and are mainly constituted of traditional varieties such as Ferawni, Kalbeltair, Kaws kozah, Nouwari, and Zahri. Fruits are used exclusively for fresh consumption and more than 40% are exported to the Arab countries. This crop is of great interest for the national economy since it is not competing with cherries of neighboring countries and is a luxury fruit. Currently, efforts are made to introduce cultivars and rootstocks.

Apricot is also one of the major fruit crops in the country (6 397 Ha, 32 000 tons). Its culture is located mainly in the North of Lebanon and northern Bekaa. Fruits are used for fresh consumption and in juice and jam industries. Plantations are mainly constituted

of traditional varieties such as Ajami, Byadi and Um Hussein. Efforts are needed to introduce modern varieties, especially those that are suitable for processing of dried fruits.

Almond is widely cultivated in the country (6 250 Ha, 29 400 tons). Its fruits are mostly used for fresh consumption. Around 10 000 tons of dried kernels are regularly imported per year to meet the local consumption. Almond commercial orchards in Bekaa valley are constituted of one or two varieties. These varieties are characterised by early blooming and in certain years may be injured by spring frost, which causes an important decrease in national production. It would therefore be important to widen the diversity of cultivated varieties in order to maintain the sustainability of the crop.

Banana is successfully cultivated in South Lebanon (3 000 Ha, 89 700 tons) for both local consumption and export to the Arab countries. The local variety denominated Baladi (or Abou Nekta) is the most cultivated one followed by Grande Naine. Fruits are produced in both natural and greenhouse conditions without phytosanitary treatment. This leads to the production of fruits with less residues in comparison with those produced elsewhere in the world and could have a great potential on the international market.

- Legumes and vegetables

Several vegetable crops are considered important in Lebanon namely tomato (4 060 Ha, 305 300 tons), cucumber (3 100 Ha, 142 600 tons), water melon (2 384 Ha, 85 600 tons), cauliflower (1 950 Ha, 87 700 tons), cabbage (922 Ha, 24 100 tons) and lettuce (889 Ha, 22 200 tons). Green pulses like common beans (1 420 Ha, 14 200 tons) and green faba beans (1 845 Ha, 14 800 tons) are widely cultivated legumes. Areas are cropped only to improved varieties, the seeds of which are regularly imported by seed companies.

The state of diversity of Minor Crops and Underutilized Species

Some crops considered as major ones in many countries are considered as minor crops in Lebanon due to their low contribution in land occupation and food security. The final product is regularly imported to meet the local needs consumption.

Corn has been introduced in the country particularly for feeding livestock and human consumption. Its culture is located in the Bekaa valley but remains limited mainly because of the lack of mechanization and its relatively high irrigation requirements in irrigation. Efforts to promote sunflower cultures failed due to the lack of oil industry in the country.

Legumes grown for dry seeds are considered as minor crops, although they constitute a major component of the Lebanese culinary traditions. The most important ones are chickpeas (1800 Ha, 1400 tons) followed by lentils (762 Ha, 1400 tons) and beans (340 Ha, 400 tons). Both local and improved varieties are used. The local consumption is covered through import, which is 3.5 times greater than local production.

Sugar beet has been subsidized by the Government and thus widely cultivated for years. With the suppression of its subsidy in the late nineties, its cultivation area experienced a sudden and sharp decrease from 7 000 Ha in 1999 to 430 Ha in 2007.

Regarding fruit trees, many crops well adapted to Lebanese conditions lack sufficient exploitation but represent a potential for local and regional markets. Their culture is generally neglected and localized in marginal lands or scattered at the periphery of the orchards. This is mainly the case of fruit crops such as fig, walnut, pomegranate, carob, pistachio and pine. As for the newly introduced subtropical crops such as avocado and annona, their relative importance is expected to progressively increase in the littoral zone for both local and foreign markets.

The state of diversity of wild harvested plants for food

Numerous aromatic plants, spices and condiments are harvested from the wild and used as food. These species are absent from the priority agenda of the relevant Lebanese Ministries. Nevertheless, they gain more and more importance in development projects launched by non governmental organizations. In this context, studies on selected areas conducted in collaboration with international institutions showed that hundreds of species have a potential for cultivation, because of their edible and medicinal importance. Moreover they are considered as a source of revenue for women and as a factor for poverty alleviation.

The main group of edible plants includes species of *Cichorium*, *Eryngium* and *Scorzonera* genera. They are used as salads as well as cooked and snack foods.

The second large group is the group of aromatic plants, mainly of the *Lamiaceae* family (Anonymous, 1996) and they are used as condiments, spices and flavors. These species are of special importance because of their ethno-botanical heritage, local food habits and nutritional value. Harvesting activities without any consideration for natural regeneration are generating threats on the wild populations.

These threats have been the driving force for the domestication efforts of representative species such as *Origanum syriacum*, *Salvia fruticosa*, *Gundelai tournefortii*, *Cichorium* sp., *Malva* sp. and *Capparis spinosa*. A successful example of wild species domestication is the case of *Origanum syriacum*, which

became an interesting crop in many areas of Lebanon mainly in the South.

The third neglected group is the group of wild fodder plants comprising around 69 species belonging mainly to the Poaceae and the Fabaceae families. Efforts for the enrichment of the range land flora in fodder plants with species such as *Medicago*, *Trifolium* and *Vicia* showed promising results.

Recently, efforts to promote the in situ conservation of useful wild species and their sustainable use have been undertaken by few projects that covered species of *Aegilops*, *Allium*, *Centaurea*, *Gundelia*, *Hordeum*, *Lathyrus*, *Lens*, *Malva*, *Medicago*, *Pistacia*, *Prunus*, *Pyrus*, *Trifolium*, *Triticum* and *Vicia*. Lately, new markets for “Baladi” (local) products and fairs for diversity rich products are slowly gaining place.

Wild species domestication could also provide opportunities for increasing farmers income and crop diversification.

More efforts are needed for diversity assessment, seed distribution, valorization of ethno-botanical heritage and associated use of useful wild plants and marketing. Another central point that has been neglected and which requires more attention is the study of the ethno-pharmacology properties of the local medicinal plants of traditional use such as *Capparis* species.

Uses of plant genetic resources in Lebanon

In Lebanon, the characterization and evaluation of plant genetic resources is mostly limited to morphological descriptors and agronomical traits. It has been applied so far to landraces and improved varieties of fruit trees, field crops and some vegetables. Molecular characterization has only been applied to a limited number of crops using European funds. Financial and technical support are needed to expand plant genetic resources characterization and evaluation by using advanced techniques and by strengthening skills and adopting adequate equipments.

Only few breeding activities have been carried out in Lebanon. They are limited to wheat, barley, chickpea and lentil. Regarding fruit species, breeding activities are restricted to some clonal selection activities that have been recently conducted for stone fruits and grapevines. There is an urgent need to establish a national strategy for the breeding and improvement of the Lebanese plant genetic resources for target crops. As a precaution, some actions are needed now to broaden the genetic basis used on-farm.

An increasing attention is being paid to the wild edible flora which is harvested from its

natural habitat and for which domestication attempts are being produced. There is a need to establish a legal framework to support the sustainable use and marketing of under-utilized crops, and the domestication of wild edible species.

Regarding seed production, there is no official program in Lebanon for most of the major crops except for wheat and barley which are produced and distributed to farmers by LARI. For vegetables, seeds of improved varieties are regularly imported by the private sector from different countries and sold to farmers at high prices. For fruit trees, the production and distribution of planting materials is predominantly carried out by the Ministry of Agriculture and the private sector.

Surveying and inventorying diversity in Lebanon

Surveying and inventorying activities in Lebanon have been rather neglected. Only two references are available in this regard (Post and Dinsmore, 1932; Mouterde, 1966). No mechanisms are set for assessing genetic erosion and monitoring it in the country.

Only in recent years, few projects have been carried out by the Ministry of Environment to monitor and assess the diversity in Natural Reserves. Between 1999 and 2005, LARI has executed in collaboration with the United Nations Development Program (UNDP) as managing agency and the Global Environment Fund (GEF) as funding agency an important agrobiodiversity project aiming at the identification of three main priority areas located in the semiarid zone of Bekaa valley and experiencing a quick loss in plant diversity and richness (Barnes, 2002; Assi, 2005).

Other efforts have been undertaken in this regard mainly as research activities by universities, public institutions and non governmental organizations such as the certification project executed by LARI which aimed at performing clonal selection and pomological description of stone fruits and grapevine (Hamze et al., 2007).

Threats affecting the state of diversity

In Lebanon, multiple threats are endangering plant genetic resources contributing to their genetic erosion.

Among those factors figures the replacement of traditional and genetically diversified farming systems by modern large scale homogenous ones. The tendency of farmers to adopt one or two cultivars makes the future of crops more vulnerable especially in case of climatic variations or occurrence of new diseases

Urbanization, fires, intensive agricultural systems, over-exploitation, over harvesting and overgrazing (the latter two factors are mainly observed in the upper highlands

domain of endemic plants) impose great pressure on biodiversity.

Market trends are also pushing towards the introduction of new improved and more marketable varieties leading to the disappearance of varieties having no competitive market traits.

In addition, activities undertaken by the Ministry of Agriculture under the Green Plan Program and initially aiming at the rehabilitation of marginal lands constitute an additional pressure since sometimes these destroy diversity rich forests in order to establish unsustainable agriculture. The introduction of annual crops in the weak agro-ecosystems of northern Bekaa where adapted flora is destroyed may lead to increased salinity in the near future and eventually to land degradation. This situation is even worsened by national legislation which neglects the cultivation of local varieties and traditional species.

Additionally, the collection of wild stocks now threatens the conservation of globally significant wild edible and aromatic plants biodiversity by current harvesting practices.

Finally, the poor awareness among decision makers about the real dangers of plant genetic resources loss, together with the lack of skilled personnel, appropriate technology and financial resources are all responsible for the absence of a monitoring system for genetic erosion assessment.

Managing agro-biodiversity in Lebanon

In-situ management

Concern for in-situ conservation and management of genetic resources has increased in Lebanon over the recent years. This is reflected by an increase in the number of protected areas spread across the country. Seven Nature Reserves have been established by law between 1992 and 1999. Management plans were developed for some of the nature reserves and other protected areas to identify the activities needed for the protection and conservation of biodiversity and for the sustainable use of the sites. In addition, the draft law for the establishment and the management of nature reserves in Lebanon, prepared by the Ministry of Environment divides the nature reserve into two zones: "Zone for strict conservation" and "zone for sustainable development". Management guidelines restrict activities in the first zone but allow and promote sustainable activities with economic returns for the local communities in the second zone (Anonymous, 2005).

Outside protected areas, some projects have been implemented to support in-situ conservation and sustainable use of biodiversity like the previously mentioned LARI-

UND-GEF Agrobiodiversity project (1999-2005). The International Center for Agricultural Research in the Dry Areas (ICARDA) was responsible for the regional coordination of the project and the technical backstopping in cooperation with ACSAD and IPGRI. The project followed a community-based approach and worked with local communities, farmers and non governmental organizations (NGOs). Focus was given to target crops of global significance for food and agriculture such as wheat, barley and many local fruit trees. Agro-ecological and eco-geographic studies, as well as socio-economic, indigenous knowledge, and botanical surveys were conducted in some rural villages. Nurseries and seed-cleaning units have also been established in order to promote in situ conservation (Assi, 2005).

Ex-situ management

The collection of plant genetic resources in Lebanon started fifty years ago, covering mainly the traditional landraces of wheat, barley and forages through collaborative project between LARI and ICARDA. Around 1969 accessions are conserved at CGIAR/ICARDA gene banks (Barnes, 2002).

On the other hand, around 355 Lebanese accessions of wild and cultivated species are currently stored in European genebanks. Long-term conservation of seeds is applied to around 1000 Lebanese wild species at both LARI and the Royal Botanic Gardens. The material stored in the Lebanese collections is only characterized by its morphological traits.

At the local level, seeds of cultivated wheat, barley, lentils, chick pea and vicia are conserved as ex situ collections at LARI and are regularly regenerated every five years. National infrastructures for ex situ conservation such as gene banks and arboreta are absent. Actually, many collections have been made and field gene banks were established at LARI for olive, grapes and stone fruits. In vitro facilities are already available but no conservation activity in this regards has been undertaken nor cryo-preservation techniques.

Concretely, the establishment of ex-situ collections in Lebanon is limited by multiple constraints due mainly to the absence of a national action plan recognizing the priority of ex situ conservation and the necessity to establish a national gene bank.

International conventions and national legislations

Lebanon has signed several agreements related to biodiversity, has taken part or has contributed to different conventions related to plant genetic resources and has ratified most of them, including the Convention on Biological Diversity (1994), the UN Convention on Combating Desertification (1995), the UN Framework Convention on

Climate Change (1994), the International Treaty on Plant Genetic Resources for Food and Agriculture (2004), and more recently the Cartagena Protocol for Biosafety (2008). Accordingly some laws have been adopted aiming at protecting biodiversity. However, the full implementation of these international agreements needs further work at country level, inter alia to satisfy monitoring and reporting obligations. In this regard, Lebanon should have a unified and regularly updated plant genetic resources database and a platform for better information exchange and dissemination at the national, regional and international levels.

On the other hand, Lebanon is one of the few countries that have not signed the “Convention on International Trade of Endangered Species of Wild Fauna and Flora” (CITES). This convention is a strong tool for the control over international trade of endangered animal and plant species. Since Lebanon has not ratified CITES, Parties have no obligations towards trade affecting the endangered species of Lebanon.

In addition, a national seeds registration law is currently under preparation at the Ministry of Agriculture. At this time, there are crop groups for which variety registration is a legal requirement in Lebanon including wheat, barley, lentil and chickpea. The agencies in charge of the registration are LARI and the Office of Cereals and Sugar beet.

On the negative side, a number of significant obstacles is still hindering the development of legislation and regulations relevant to plant genetic resources. These obstacles are mainly of a policy/legal and marketing/commercial nature. The lack of a national strategy focusing on sustainability and on diversification and the lack of funds are aggravating the present situation.

Challenges facing agro-biodiversity in Lebanon

The value of agro-biodiversity is not easy to estimate. Besides its direct economic value, the indirect environmental, ecological and cultural landscape values are of high importance to eco-tourism and need to be determined.

For a better understanding of the role and values of plant genetic diversity, species and varieties of potential interest should be prioritized and promoted for sustainable use and conservation. Local traditional knowledge dissemination through public awareness programs and training activities among key actors of the civil society such as women, teachers, or teenagers should be enhanced. Exhibitions including awards for the best traditional dish, the most diverse table, the widest know-how and the most diverse home garden are different ways of communicating the message to civil society actors. Restaurants and food processing industries dealing with local traditional food recipes can be supported as well. At the level of farmers, awareness campaigns are needed in

order to prioritize the conservation of local varieties and landraces. Also, assistance should be provided to many small scale farmers in marginal environments to allow them to use plant genetic resources in a sustainable manner.

The development of indicators and early warning systems is urgently needed to monitor genetic erosion. The following activities should be encouraged: surveying plant genetic resources, characterization of both local and imported varieties, in situ and ex situ conservation and establishment of appropriate documentation systems. This can be achieved by using advanced techniques, by strengthening skills, and by ensuring sufficient and sustainable financial resources. Relevant fields such as plant taxonomy, GIS mapping, breeding, biotechnology and molecular tools, and public awareness should be covered.

At the institutional level, more efforts should be provided regarding the development and most importantly, the implementation of legislations related to the conservation of plant genetic resources. Mechanism to facilitate rapid acquisition, multiplication, distribution and cultivation of germplasm in case of disaster situations and to restore degraded ecosystems should be urgently developed.

The infrastructure of the public and private Lebanese institutions should serve the needs of ex-situ conservation practices more specifically the storage facilities including long term conservation and cryo-preservation.

For a better use of plant genetic resources, breeding and seed technology programs should be enhanced on the basis of well defined breeding strategies.

Finally, to ensure food security, the Government of Lebanon should support the management of plant genetic resources management in a sustainable way in order to face the future challenges of the climate changes and the economic crises. A comprehensive national strategy should be clearly declared and adopted in this regard defining the roles and responsibilities of each involved institution in terms of conservation, sustainability and diversification. Appropriate policies and legislations in diversifying crop production and broadening diversity in crops are strongly needed.

Accordingly, a food system should be established on the following bases in a way to meet Barraclough's theory (1991):

- Maximum autonomy and self-determination, which reduces vulnerability to international market fluctuations and political pressures;
- Reliability, such that seasonal, cyclical and other variations in access to food are minimal;

- Sustainability, such that the ecological system is protected and improved over time;
- Equity, meaning, as a minimum, dependable access to adequate food for all social groups.

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References

Abi Saleh B. et Safi S. (1988) Carte de la végétation du Liban. In: Ecologia Mediterranea, XIV (1/2): 123-141.

Anonymous (1996) Ministère de l'Agriculture Libanaise, 1996. Programme des Nations Unies pour l'Environnement. Etude de la Biodiversité du Liban.

Anonymous (2005) Ministry of Environment-UNDP. Third Country Report to CBD.

Anonymous (2007) Ministry of Agriculture - FAO, 2007. Global Agricultural Census in Lebanon.

Assi R. (2005) Project on "Conservation and Sustainable Use of Dry Land Agrobiodiversity in the Near East". UNDP, GEF, LARI and ICARDA. Final Report of the Lebanese Component. <http://www.lari.gov.lb/agrobio/documentation.asp>

Barnes J. (2002) Overview of the status of agrobiodiversity and the factors affecting its conservation in the project sites. Project on "Conservation and Sustainable Use of Dry Land Agrobiodiversity in the Near East". UNDP, GEF, LARI and ICARDA. Lebanon.

Barracough S.L. (1991) An end to hunger? The social origins and food strategies. A report prepared for the United Nations Research Institute for Social Development (UNRISD) and the South Commission based on UNRISD research on food systems and society. London and Atlantic Highlands, USA, Zed books Ltd in association with

UNRISD.

Chalak L. and Sabra N. (2007) Second Country Report on Plant Genetic Resources for Food and Agriculture. pp. 61. www.pgrfa.org.

Hamzé M., Chalak L., Stephan J., Andraos L., Choueiri E. (2007) Stone Fruits and Grapevine Cultivars from Lebanon: Clonal and Sanitary Selection survey. Edited by CNRSL, Beirut, pp. 66.

Harlan J.R. (1992) Crop and Man. Second edition. American society of Agronomy. In. Crop Science Society of America, Inc Madison, Wisconsin. USA pp 283.

Post G.E. and Dinsmore J.E. (1933) Flora of Syria, Palestine and Sinai. American Press. Beirut.

Mouterde P. (1966) Nouvelle Flore du Liban et de la Syrie. Imprimerie Catholique, Beyrouth.

Zurayk R. (2000). Indigenous agro-ecological zoning. Project on "Conservation and Sustainable Use of Dry Land Agrobiodiversity in the Near East". UNDP, GEF, LARI and ICARDA. Lebanon. Annex 1.

Sattout E, Jamali D, Nasser W (2005) National Biosafety Framework for Lebanon. UNEP - GEF / UNDP / MoE Lebanon.