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COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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INTERGOVERNMENTAL WORKING GROUP ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE

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NATIONAL LEVEL CONSERVATION OF CROP WILD RELATIVES DRAFT TECHNICAL GUIDELINES

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BACKGROUND

1. The Commission on Genetic Resources for Food and Agriculture (the Commission), at its Fifteenth Session, invited its Working Group to review and revise the Draft Technical Guidelines, *National level conservation and use of Crop Wild Relatives*[1].

2. This document contains *the* Technical Guidelines, as revised following peer review.

FOREWORD

3. The entire diversity of species, varieties and populations of plants, including cereals, legumes, vegetables, roots and tubers and fruits, that are used, or with the potentials to be used, in agriculture for the production of food, fodder and fibre are referred to as Plant Genetic Resources for Food and Agriculture (PGRFA). These include accessions conserved in genebanks (*ex situ*), wild species found in nature (*in situ*) – some of which are related to crops (i.e. crop wild relatives or CWR); landraces or traditional varieties maintained on-farm; the breeding materials used in crop improvement programmes; and the improved varieties that have been registered or released, or both, for cultivation. These resources are the foundation for food production, people's livelihoods and a country's agricultural and economic development. Apart from being of direct use, PGRFA also constitute a potential source of the hereditary materials that control the expressions of plant characteristics and agriculturally important traits, which are used in plant breeding for improving the productivity and quality of crops and for adapting crops to changing climatic conditions. A major challenge for agriculture is to be significantly more productive in order to produce the 60 to 70 percent more food needed to feed the ever increasing human population in the face of climatic and other environmental changes that lead to unpredictable biotic and abiotic stresses. This unprecedented challenge underscores the critical importance of PGRFA as the unique source of the heredity factors needed to confer the enhanced productivity, especially as natural resources (arable land and water) available to agriculture are either finite or dwindling.

4. Increasing and evolving patterns of human food consumption, together with high rates of urbanization, pollution, unsustainable use of natural resources, spread of invasive species, displacement of local varieties and environmental changes are all threats to the world's rich and highly adapted PGRFA. Despite the increased public, political and scientific interest in conserving plant genetic resources, many countries lag behind in protecting CWR, especially in their natural environments, where they would continue to evolve as they develop adaptive features in response to environmental impulses.

5. To prevent the loss of CWR diversity and to maximize their availability, especially for crop improvement, there is an urgent need to ensure their appropriate conservation and sustainable use at the global, regional, national and local levels. This need has been recognized by international conventions and agreements, including the Convention on Biological Diversity (CBD)[2] the International Treaty on Plant Genetic Resources for Food and Agriculture (International Treaty)[3] and the Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture (Second GPA)[4]. They each underline the commitment of governments to ensure that conservation and sustainable use of plant genetic resources continue to be a key element in the global efforts to alleviate poverty and increase food security and nutrition. They also highlight the need to develop and implement national strategies and action plans for PGRFA conservation and sustainable use.

6. These Technical Guidelines are intended to be reference material for national governments in their activities toward conservation and sustainable use, when preparing a *National Plan for the Conservation and Sustainable Use of Crop Wild Relatives (National CWR Plan)*. The focus is on *in situ* conservation and fostering linkages between it and *ex situ* conservation, and ultimately toward the use of CWR. The precise process of preparing the National CWR Plan will depend on the national

[1] CGRFA-15/15/Report, paragraph 51
[2] http://www.cbd.int/convention/text/
[3] http://www.planttreaty.org/content/texts-treaty-official-versions
[4] http://www.fao.org/docrep/015/i2624e/i2624e00.htm

context, including the availability of baseline data, the existing policy framework and remit of the agencies that are responsible for formulating and implementing the National CWR Plan, as well as on the resources available for its implementation. Even so, the process will require a series of decisions and actions that essentially follow a similar pattern in all countries, including developing an effective consultation process, establishing a knowledge base, analysing conservation gaps, identifying priorities, and planning and implementing specific conservation actions. These Technical Guidelines are intended to be reference material for national governments in their activities on the conservation and sustainable use of CWR. They are particularly useful for preparing a *National Plan for the Conservation and Sustainable Use of Crop Wild Relatives (National CWR Plan)*.

ABBREVIATIONS

CBD	Convention on Biological Diversity
CSO	Civil society organization
CWR	Crop Wild Relative(s)
FAO	Food and Agriculture Organization of the United Nations
FIGS	Focused Identification of Germplasm Strategy
GIS	Geographical Information System
GPA	Global Plan of Action
GPS	Global Positioning System
GSPC	Global Strategy for Plant Conservation
International Treaty	International Treaty on Plant Genetic Resources for Food and Agriculture
IUCN	International Union for Conservation of Nature
Nagoya Protocol	Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization [protocol to the Convention on Biological Diversity]
National CWR Plan	National Plan for the Conservation and Sustainable Use of Crop Wild Relatives
NBSAP	National Biodiversity Strategy and Action Plan
NGO	Non-governmental organization
NUS	Neglected and underutilized species
PA	Protected Area
PES	Payment for Environmental Services
PGR(FA)	Plant Genetic Resources (for Food and Agriculture)
PIC	Prior informed consent
Resource Book	Resource Book for Preparation of National Conservation Plans for Crop Wild Relatives and Landraces
SIS	Species Information Service [of IUCN]
SNP	Single nucleotide polymorphism
SSR	Single sequence repeat(s)
TDGW	Taxonomic Databases Working Group – developing Biodiversity Information Standards
Technical Guidelines	A National Approach to the Conservation of Crop Wild Relatives – Technical Guidelines

INTRODUCTION

The importance of crop wild relatives for food security and economic development

7. Crop wild relatives (CWR) are wild species or subspecies closely related to crops. CWR are recognized as a vital component of agricultural biodiversity (agrobiodiversity). In general, CWR are genetically diverse, locally adapted and represent a potential source of genes and alleles for adapting crops to changing environmental conditions and human needs. The actual potential for a CWR to serve as a gene source for crop improvement depends on identifying their useful genes. In addition, it is necessary to determine the genetic relationship between the crop and its wild relatives.
That relationship is unknown for many CWR×crop species combinations. In practice, an estimate of the numbers of CWR can be obtained by assuming that any species belonging to the same genus as a crop is a CWR. On that basis, it has been estimated that there are 50 000 to 60 000 CWR species worldwide[5].

Why are crop wild relatives threatened?

8. Like all wild plant species, CWR are increasingly subject to a wide range of threats, some of which are anthropogenic, i.e. are linked to human activities. Overall, some of the key factors threatening the existence and diversity of CWR are:

- unsustainable use of natural resources, including over-exploitation and excessive use or extraction of wild plants for timber, fuel, feed, etc.;
- habitat conversion for agricultural production, industrial development or urban expansion;
- habitat destruction, degradation, homogenization and fragmentation;
- climate change;
- changes in agricultural practices and land use;
- introduction of exotic species (other plants, animals or microorganisms) that compete with, hybridize with, cause physical or biological damage to, or kill native species; and
- natural calamities, such as, floods, landslides and soil erosion.

Conservation and sustainable use of crop wild relatives

9. A systematic and coordinated effort to conserve CWR is required to address the negative effects of genetic erosion. It is widely agreed that this involves an integrated application of *in situ* and *ex situ* conservation strategies[6].

10. ***In situ*** conservation involves the location, designation, active management and monitoring of target plant populations within their natural habitats or where they have developed their distinctive characteristics. *In situ* conservation of wild plant populations often takes place in Protected Areas (PAs), whether formally designated or informal, and the conservation can target either the populations themselves or the full ecosystems in which they occur.

11. ***Ex situ*** conservation involves the location, sampling, transfer and storage of plants away from where they grow naturally. A range of *ex situ* conservation techniques are available, but seed storage in genebanks predominates as the most practical *ex situ* conservation technique for many plant species. Other means of maintaining samples of plant species *ex situ* are as living plants or explants *in vitro*, or cryopreserved.

12. The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture[7] summarizes positive developments in conservation and sustainable use of CWR

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[5] FAO. 2009. Establishment of a Global Network for In situ Conservation of Crop Wild Relatives: Status and Needs, by N. Maxted & S. Kell. Commission on Genetic Resources for Food and Agriculture. Rome. 211p. www.fao.org/docrep/013/i1500e/i1500e18a.pdf
[6] See Resource Book, Section Context 1.5.
[7] http://www.fao.org/docrep/013/i1500e/i1500e00.htm

worldwide, including an expansion of protected areas, an increase in the number and size of genebanks, and more interest in collecting and maintaining CWR in botanical gardens and genebanks. The report also identifies a number of gaps and needs in the conservation and sustainable use of plant genetic resources, and highlights the need to document, collect and protect CWR *in situ*, and to collect and ensure that CWR are safeguarded in *ex situ* storage.

Policy Developments[8]

13. Major policy developments have taken place in recent decades to promote and regulate the conservation, use and exchange of PGRFA, including CWR. The most important ones include those below.

14. The **Convention on Biological Diversity** (CBD)[9] was agreed in 1992 and entered into force in 1993 as a global and legally binding framework on biodiversity conservation and use. In 2010, the CBD adopted a revised and updated Strategic Plan for Biodiversity for the 2011–2020 period, including 20 targets, known as the **Aichi Biodiversity Targets**[10]. The maintenance of CWR is specifically referred to in Target 13 "By 2020, the genetic diversity of cultivated plants and farmed and domesticated animals and of wild relatives, including other socio-economically as well as culturally valuable species, is maintained, and strategies have been developed and implemented for minimizing genetic erosion and safeguarding their genetic diversity".

15. In 2010, the CBD also adopted the **Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity**[11], a legal framework for the effective implementation of fair and equitable sharing of benefits arising out of the utilization of genetic resources, and established its Global Strategy for Plant Conservation (GSPC) with 16 global targets set for 2020. Target 9 refers to the conservation of CWR: "70 percent of the genetic diversity of crops including their wild relatives and other socio-economically valuable plant species conserved, while respecting, preserving and maintaining associated indigenous and local knowledge". The CBD requires that each party "shall develop national strategies, plans or programmes for the conservation and sustainable use of biological diversity", explicitly including its agrobiodiversity.

16. The **International Treaty on Plant Genetic Resources for Food and Agriculture** (International Treaty)[12] was adopted by FAO's Member Countries in 2001 and came into force in 2004, and is in harmony with the CBD. The International Treaty is legally binding on Contracting Parties and its objectives are the conservation and sustainable use of PGRFA and the fair and equitable sharing of the benefits derived from their use. The International Treaty refers to CWR in Article 5: *Conservation, Exploration, Collection, Characterization, Evaluation and Documentation of Plant Genetic Resources for Food and Agriculture*. Articles 5, 6 and 7 of the International Treaty contain clauses that mandate contracting parties not only to conserve and use PGRFA sustainably but also to develop policy instruments to underpin such activities.

17. **The Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture** (Second GPA)[13] was adopted by FAO Member Countries in 2011. Based on the findings of the *Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture*[14], the Second GPA is an agreed set of 18 priority activities that directly address the new developments, opportunities and challenges facing plant conservation and use in the twenty-first century. It provides a framework of action, with these priority activities guiding action and progress at the community, national,

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[8] See Resource Book, Section Context 1.9.
[9] http://www.planttreaty.org/content/texts-treaty-official-versions
[10] http://www.cbd.int/sp/targets
[11] http://www.cbd.int/abs
[12] http://www.fao.org/docrep/015/i2624e/i2624e00.htm
[13] FAO. 2009. Establishment of a Global Network for In Situ Conservation of Crop Wild Relatives: Status and Needs, by N. Maxted & S. Kell. Commission on Genetic Resources for Food and Agriculture. Rome. 211 p. www.fao.org/docrep/013/i1500e/i1500e18a.pdf
[14] See Resource Book, Section Context 1.9.

regional and international levels, and is a supporting component to the International Treaty. Almost half of the priority activities of the Second GPA make special reference to CWR, highlighting the need to strengthen their conservation and sustainable use *in situ*; improve documentation and assess gaps in the conservation of CWR in protected areas and *ex situ* collections; create a better understanding of the value and contributions of CWR; test and refine methodologies for location, establishment and management of CWR genetic reserves; assess genetic erosion and threats to all priority CWR populations; develop novel techniques to promote CWR utilization by breeders, farmers and other users; and develop CWR management strategies, well integrated into existing conservation strategies.

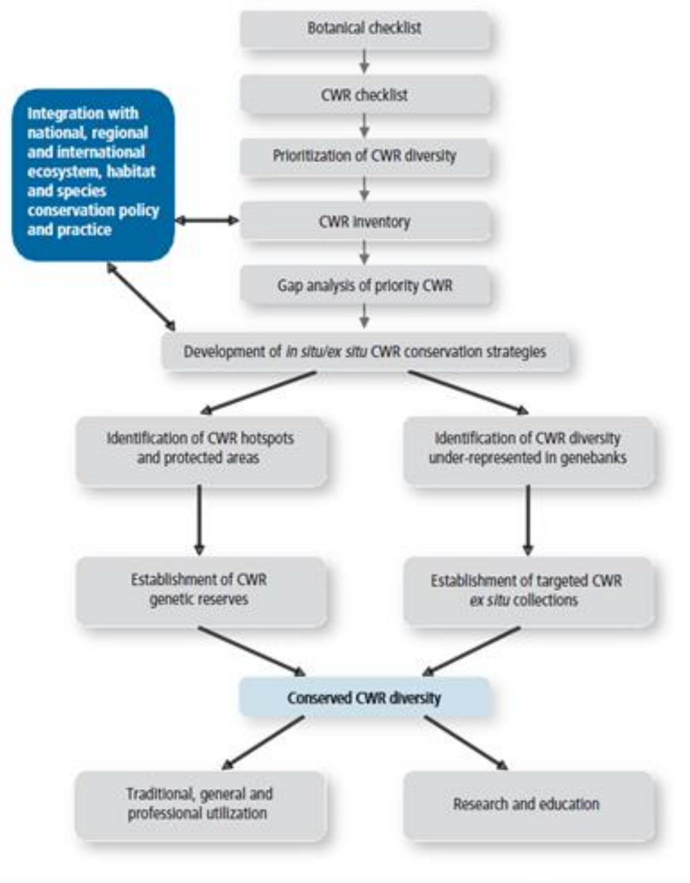
Conservation and sustainable use of crop wild relatives at the national level

18. The conservation and sustainable use of CWR involves a wide range of stakeholders at the national level. Both the public and private sectors, including organizations working in the agricultural and environmental domains, should be involved. National governments have, in many cases, established National PGRFA programmes, to spearhead efforts towards the global targets and requirements for PGRFA conservation and sustainable use. The Second GPA identifies strengthening of national programmes as one of its primary objectives, emphasizing that a national programme needs to contribute to the development of enabling policies, support strategies and action plans; coordinate and oversee the implementation of national activities; allocate resources; distribute roles and responsibilities; and strengthen linkages between all relevant stakeholders. It also has a central role in establishing regional and global linkages and strengthening international collaboration.

The purpose of these technical guidelines

19. The conservation and sustainable use of CWR take different forms in different countries, depending on the diversity of CWR present, the available data, the financial and human resources allocated to conservation and the level of commitment by national agencies and governments. Some of the key elements governing the conservation and use of CWR in a country are the policy and legal frameworks relevant to CWR, along with strategic plans agreed upon by the stakeholders.
A systematic approach to conservation and sustainable use of CWR can be reached through the preparation and implementation of a *National Plan for the Conservation and Sustainable Use of CWR (National CWR Plan)*. These guidelines were produced to facilitate the ability of national authorities to develop and strengthen their conservation and sustainable use of CWR. The guidelines consist of a set of steps and methods that can guide the formulation of a National CWR Plan. The guidelines are primarily intended for staff associated with National PGRFA programmes, but they can also be beneficial for universities and research organizations, NGOs and other partnering institutions of national authorities. It is important to stress that there is no single method for developing a National CWR Plan, and the approach depends on human and financial resources, current status of CWR in the country, available baseline data, national stakeholders and policy framework. Nevertheless, the process of developing a National CWR Plan can be viewed as a series of decisions and actions that follow a similar pattern in all countries. The guidelines should thus be viewed as a framework, bearing in mind that the suggested steps do not necessarily have to be followed in the same predefined order.

20. **Figure 1.** Generalized model for the development of CWR conservation and use strategies



21. The general process of developing CWR conservation and use strategies is illustrated (see Figure 1) and the steps described in this guide include the following sections:

1) **Leadership and stakeholders.** To start the process of developing a National CWR Plan, it is necessary for decisions to be taken regarding the leadership of the process. If, as is most likely, several ministries include important stakeholders for the process, it is essential to establish cross-ministry coordination. There needs to be agreement among ministries on the leadership and stakeholders to be involved at the national and local levels. It may be necessary to establish an inter-ministerial advisory board to help the national coordination mechanism for the endeavour, in addition to a support team for it. To ensure momentum in the development and implementation of the National CWR Plan a time frame should be agreed at an early stage.
2) **Understanding the country context.** To formulate any strategic plan the policy context in the country where it should be implemented must be considered. In addition, the current status in the country of CWR conservation and use must be determined as well as legislation in the country that affects CWR. This will provide the basis for priorities and issues to be addressed, and guide the formulation process of the National CWR Plan.
3) **Planning CWR conservation**. For a National CWR Plan to be effective, it must be based on relevant, reliable and up-to-date information and data on occurrence and management of CWR in the country. This might involve prioritization of CWR taxa, developing inventories of CWR, eco-geographical assessments and characterization studies. The data collected related to CWR need to be analysed, to enable conservation priorities to be set and strategic actions to be formulated. Some methods that are commonly used when analysing data for this purpose are threat assessments and conservation gap analysis.
4) **Writing the strategic plan.** A National Plan for Conservation and Sustainable Use of CWR (National CWR Plan) is a document that describes what the country aims to do to ensure appropriate conservation and sustainable use of CWR, and how this should be accomplished. The National CWR Plan can be structured in a variety of ways, but should include certain common elements, such as clearly defined goals and objectives, strategic actions to achieve the objectives and a timeline, management responsibilities and a monitoring plan.

5) **Implementing strategic actions.** To implement a National CWR Plan means turning it into reality, and taking action towards accomplishing the set objectives. It should, as much as possible, follow the outline of the strategy. Three key objectives should be implemented:

(1) Establishment of sites for active *in situ* conservation of CWR;
(2) Formulation and implementation of complementary *ex situ* conservation of CWR; and
(3) Promotion of the sustainable us of CWR.

6) **Monitoring and information management.** Monitoring of plant populations means the systematic collection of data over time to detect changes, to determine the direction of those changes and to measure their magnitude. The monitoring of CWR populations and habitats in which they occur aims at providing data for assessing trends in population size, structure and genetic composition, and determining the outcomes of management actions and guiding management decisions. Based on the monitoring of plant populations, changes in their management plans, including new goals and objectives and alternatives for achieving them, can be introduced as appropriate. The entire process of developing the National CWR Plan will require attention to integrated information management at all stages. Consideration of the most appropriate and efficient information management system will greatly enhance the effectiveness of the National CWR Plan.

I. LEADERSHIP AND STAKEHOLDERS

A. Leadership

22. The usefulness of a National CWR Plan depends on the preparatory steps that lead to its formulation, provisions made for its implementation, and the commitment from stakeholders. To develop an effective consultation process, the provision of leadership by the government – through its relevant Ministries, authorities or National PGRFA Programme – is necessary.

23. Once it is agreed at a high level that the development and implementation of a *National Plan for Conservation and Sustainable Use of CWR* is a national priority, it is necessary to appoint a leader or leaders for the process [National Focal Point(s)]. In most countries two or more Ministries are relevant to the conservation of CWR, such as the Ministry of the Environment, Ministry of Agriculture and Ministry of Forestry. Therefore it is essential that inter-ministry coordination is agreed at a high level, and that leadership for developing the National CWR Plan is included in all relevant branches of government. This is particularly important, because, as discussed later, an effective National CWR Plan may require the government or local authority to enact legislation to ensure that *in situ* conservation of habitats is effective. It may be useful to establish an inter-ministry advisory board to provide guidance to those chosen to lead the process of developing the National CWR Plan.

24. Once the National Focal Point(s) has been appointed, a support team will need to be established to assist in providing logistic and technical support, such as arranging meetings and developing databases. Developing a stakeholder list will be one of the first activities.

B. Stakeholders

25. A stakeholder refers to any organization, network or individual that is actively involved in a specific project, process or sector relevant to CWR, and whose interests may be affected positively or negatively by developments related to CWR. Since CWR tend to fall between the remit of the nature conservation community and the plant genetic resources and agricultural community, it is essential to fully involve stakeholders from all these sectors. In order to ensure appropriate stakeholder involvement and inter-sectoral collaboration, the formulation process needs to be conducted in a participatory manner, where all relevant stakeholders are consulted and involved.

26. The following stakeholders should be considered in the consultation process:

- government, including ministries and authorities in the agriculture, environment and natural resources sectors;
- local authorities, farmers and local communities;
- national research institutions, including genebank curators and plant breeders;
- universities and other educational institutions;
- civil society organizations (CSOs), such as farmer and community-based organizations;
- non-government organizations (NGOs), such as professional development and conservation organizations;
- private sector entities, including those conducting plant breeding and seed delivery activities, or other CWR users;
- regional and international organizations, research centres and networks; and
- bilateral technical cooperation or funding agencies, and UN agencies as relevant.

27. Stakeholders should early on agree on a timeline to achieve specific objectives so that a momentum is built-up to achieve implementation of the National CWR Plan. Fundamental to the development and implementation of the National CWR Plan is that the process should be pragmatic, taking into consideration all the constraints as well as opportunities available.

II. UNDERSTANDING THE COUNTRY CONTEXT

28. A National CWR Plan needs to be based on the specific context and current situations in the country where it will be implemented. These can be deduced by the assessments of existing relevant policies, strategies, laws, the state of CWR conservation and use, human and financial resources, institutional arrangements and the range of stakeholders and their interrelationships. The prior determination of the country context, based on above parameters, will help define the scope of the National CWR Plan. This section will provide guidance for this preparatory work.

A. Constitutional, legal and institutional framework

29. The National CWR Plan needs to align with national goals, and be based on the broader environmental and agricultural contexts, and usually also the economic development policy context, of the country. An assessment of the constitutional, legal and institutional framework should include:

- international agreements entered into by the country, that are relevant to CWR, e.g. the CBD and the International Treaty;
- regional and sub-regional programmes and networks established;
- national policy framework, including development plans, poverty reduction strategies, climate change adaptation plans, and agricultural and environmental policies;
- national laws, policies and strategies governing the conservation and use of PGRFA, including sector-specific strategies and national programmes; and
- programmes and activities under the National Plant Genetic Resources Programme.

30. It is important to harmonize sector-specific strategies with overall national policy objectives and existing strategies in the country. Thus, if a National PGRFA Strategy is in place, the National CWR Plan should be in full alignment with it.

B. State of conservation and use of crop wild relatives

31. A brief assessment of the current status of conservation and use of CWR will quickly reveal gaps and help to establish priorities in the planning phase. In many cases, such an assessment is already available, either as part of a Country Report on the State of Plant Genetic Resources for Food and Agriculture[15], previous CWR research projects or as an independent study. If such an assessment is lacking or out of date, a brief review of the status of CWR should be conducted prior to the elaboration of the National CWR Plan. The following points should be included in the country assessment:

- the agricultural and environmental situations in the country;
- an overview of the known CWR diversity in the country, including the main factors affecting that diversity;
- current status of *in situ* conservation of CWR, inside and outside protected areas;
- current status of *ex situ* conservation of CWR, including type and state of the germplasm, storage facilities and collection missions; and
- current treatment and use of CWR, including characterization, evaluation, use in pre-breeding and breeding activities, and local uses of CWR.

C. Scope of the National Crop Wild Relatives Plan

32. The scope of the National CWR Plan will define what it sets out to accomplish, and help stakeholders to plan the necessary steps for its formulation and subsequent implementation. The scope of the National CWR Plan should be elaborated with the full participation of stakeholders. Some specific considerations when deciding the scope of a National CWR Plan are discussed below.

[15] Available at http://www.fao.org/docrep/013/i1500e/i1500e00.htm

1. Geographical coverage and taxa

33. What will be the appropriate breadth of coverage of CWR in the National CWR Plan? Two possible approaches are either (i) a monographic approach focusing on priority crop gene pools within a geographical area; or (ii) a floristic approach that includes all CWR occurring in a defined geographical area[16]. Although both approaches may be carried out at any geographical scale, the monograph approach is more likely to be regional or global in scope, while the floristic approach is more likely to be local or national in scope. Whether the National CWR Plan takes a floristic or monographic approach will depend on the quantity and quality of existing data, the human and financial resources available, and the scope of the teams undertaking the conservation. To maximize protection of CWR diversity, it is recommended to consider a combination of both approaches, e.g. to prepare a National CWR Plan encompassing all CWR in the country, in addition to specific objectives for crop gene pools of the highest priority crops for the country. If, for financial or practical reasons, the scope of the plan needs to be limited, a focus on prioritized CWR might be followed (see Section 3.2). Pragmatic decisions should be made with regard to the inclusion of wild relatives of crops not cultivated in the country, as well as CWR introduced from other countries.

2. Complementarity with national, regional and global initiatives

34. A National CWR Plan should not be viewed as a standalone endeavour, but should rather be in harmony with the national PGRFA strategy and complement, and linked to, other national, regional and global conservation and use initiatives. It must be ensured that different conservation plans and *in situ* conservation sites are designed to promote partnerships amongst stakeholders in order to maximize the utility of human and materials resources through pooling, enhance efficiencies and avoid wasteful duplication of efforts.

3. In situ and ex situ conservation are complementary

35. The adoption of a holistic approach requires conservationists to look at the characteristics and specificities of the CWR being conserved and then assess which combination of the techniques offer the most appropriate options for maintaining the diversity. The following points might be considered to identify the most appropriate combination of conservation approaches and techniques:

- species' breeding systems, i.e. self- or cross-fertilizing;
- species' *ex situ* storage characteristics;
- location of species populations;
- accessibility of CWR populations and possible legal implications;
- types of storage facilities available;
- capacity to use CWR sustainably; and
- financial and human resources available.

4. Participatory approach

36. Local communities, including indigenous communities, have been managing landscapes for millennia. National authorities will need to work directly with farmers and local communities in monitoring and managing specific CWR in those landscapes. Successful implementation of the National CWR Plan will require local community buy-in and action. The National CWR Plan will also need to take into account regulations or legislation related to interaction with local communities, such as prior informed consent (PIC) and protection of indigenous knowledge as provided for in the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity, for instance. It is therefore recommended that early in the development of the National CWR Plan, the National CWR Plan development team considers opportunities for local communities to be involved.

[16] See Resource Book, Section Context pages 21–26.

5. Legislative protection

37. Experience from ecosystem and wild species conservation has repeatedly shown that the establishment or expansion of protected areas, or even less formal sites where *in situ* conservation occurs, requires significant investment of resources and that legislative protection is required to ensure the long term sustainability of the sites. When promoting *in situ* conservation of CWR there might be a need to encourage and facilitate local and national legislative protection of sites, e.g. genetic reserves designated for active conservation.

6. Conservation linked to use

38. The concept of sustainable use is fundamental to CWR conservation. The National CWR Plan should therefore encourage and promote sustainable use, determining potential local strategies for enhanced benefits from the conservation site. Thus communities may use *in situ* conservation sites for such products as feed for animals, fish production (aquatic CWR) and fuel. In addition, some local communities use CWR in rituals or for other specific uses. At a local level, CWR can be viewed in terms of their ecosystem services, such as their importance for pollinators, as biodiversity corridors and as carbon sinks, particularly in the case of perennials. The use of CWR in crop improvement will involve taking samples of CWR populations from a site for characterization and evaluation in research institutes, for potential varietal development. In addition, it will be beneficial if efforts are made to strengthen the links not only between all stakeholders and programmes working with *ex situ* and *in situ* conservation, but also with those involved in crop research and agricultural extension.

7. Financial and human resources for implementation

39. Implementing a National CWR Plan needs considerable funding and commitment from all stakeholders and partners. If the financial resources in the country are limited or not secure, the scope of the National CWR Plan might need to be adjusted accordingly. Similar considerations should be made if the country has limited human resources or few committed stakeholders to implement the strategy.

III. PLANNING CROP WILD RELATIVES CONSERVATION

40. To determine how to conserve CWR effectively, it is necessary to know what CWR exist in the country, where they grow and what conservation measures should be adopted to protect them. A National CWR Plan should therefore be as specific as possible in targeting priority CWR species, populations and locations. This section provides a general guide for developing a CWR knowledge base in the country, focusing on inventorying, genetic and eco-geographical analyses, assessment of current threats, and recommendations for conservation measures.

A. *National crop wild relatives checklist and inventory*[17]

1. What is a national crop wild relatives checklist?

41. A national CWR checklist is a list of CWR taxa present in a country, whether restricted to those associated with plant species used for human food, or using a broader, more inclusive definition, including wild taxa related to any cultivated plant species. The checklist taxa can be prioritized to produce a shorter list for which specific active conservation is considered most necessary. The prioritized national CWR checklist forms the basis of the national CWR inventory.

[17] See Resource Book, Section B.3.

2. What is a national crop wild relative inventory?

42. A national CWR inventory uses the checklist, to which is added a broad range of information on taxa in the checklist.

3. Why are both a national crop wild relative checklist and inventory necessary?

43. The national CWR checklist and inventory provide the baseline data that enables biodiversity assessment, monitoring of diversity, and planning appropriate conservation actions. Policy-makers, conservation practitioners, plant breeders and other user groups require this baseline data to guide their actions.

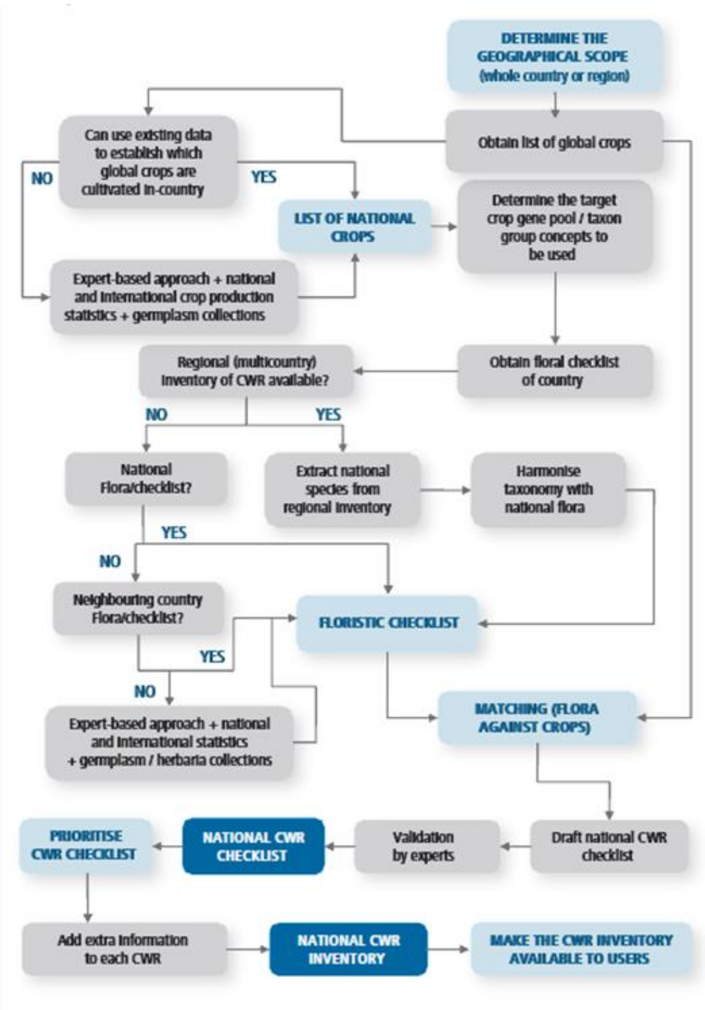
4. Methodology for creating a national CWR checklist and inventory

Determine the geographical scope and the target crops

44. A CWR checklist and inventory (see Figure 2) is the basis of the National CWR Plan. It will be necessary to determine at the beginning: both (i) the geographical scope, such as whether the whole country or just a particular region in the country is covered; and (ii) coverage of crops for which CWR information is needed. The comprehensiveness of the checklist and inventory will depend on the time, financial resources and human capacities available. However, to enhance its usefulness a checklist and inventory that covers all CWR within the country will be most useful.

45. **Figure 2:** Overview of the steps for developing a national checklist and inventory of CWR

Produce a computerized checklist of national crops (if not available)



46. A computerized checklist in a spreadsheet or database form can be easily analysed and shared. If a list of the crops grown in the country is not available, several sources may need to be consulted to compile this. Key sources are:

- globally cultivated species publications;
- regional crop checklists;
- neglected and underutilized species (NUS) and crops lists;
- individual crop studies;
- national, regional or international agricultural statistics; and
- farmers, researchers and other crop experts.

Consult a national botanical checklist or Flora

47. Countries usually have some form of national botanical or floral checklist, containing a list and description of all the plants occurring in the country. The process of generating the national CWR checklist is likely to be more inclusive if a computerized floristic checklist is available. However, if a national botanical checklist is not available, its production would require extensive specialized taxonomic work, and so an alternative approach is required. The scope of the National CWR Plan will define the crops for which CWR are included. Then a floristic checklist is built for the taxa found in the same genus as the crop, or closely related genera that have historically been used as a breeding source for the crop. The following steps should be considered when preparing this partial checklist:

- use available botanical checklists;
- compile the partial checklist based on the specialized knowledge of botanists, taxonomists and other experts in the country;
- compare the partial checklist with global or regional floras, or the flora of a neighbouring country. However, taxa present in neighbouring countries can be absent in the target country, and vice versa; and
- to the extent possible, the validity of species names should be validated by using published taxonomic data and floristic experts.

Produce a national CWR checklist

48. Once the lists of national crops and wild plant species are available, the genus name of the crop can be matched against the species of the same genera found in the country. Taxa found in the same genus as a crop may be regarded as the first approximation in identifying a CWR. More precise definitions of what constitutes a CWR have been proposed[18], but these require detailed knowledge of the taxonomy or genetic diversity, or both, of each taxon. Thus, it is important at this stage to involve, for each crop, experts in plant breeding, genetics and systematics, particularly, because some important CWR are present in genera closely related to crops. All assignments or identifications of CWR should be reviewed on a crop-by-crop basis to identify CWR which can exchange genes with the crop. The CWR checklist should provide information regarding the taxonomic system used at the genus level to determine species names.

49. Once the draft national CWR checklist has been generated it should be validated through broad consultation in order to eliminate errors. The checklist is the starting point for elaborating the inventory.

Compile a national crop wild relatives inventory

50. An inventory is developed by adding as much relevant data as possible about each taxon on the prioritized national CWR checklist. A CWR inventory generally comprises priority taxa, as those are the taxa that need immediate conservation action (see Section 3.2). Data recording standards are

[18] Maxted, N., Ford-Lloyd, B.V., Jury, S., Kell, S. & Scholten, M. 2006. Towards a definition of a crop wild relative. *Biodiversity & Conservation*, 15(8): 2673–2685

available, e.g. Biodiversity Information Standards (TDWG)[19], and using accepted international standards to develop the inventory will be highly beneficial. Information at the taxon level can be gathered from relevant literature, such as monographs, field guides, floras, soil, vegetation and climatic maps and atlases. At the population level, information can be obtained from specimens in herbaria and genebank databases. Both herbaria and genebanks usually have original collecting reports. The type of data to use in the inventory will include: nomenclature data and taxonomic descriptions; use; threat status and conservation status; socio-economic data; and site and environment data.

Use and availability of a crop wild relatives inventory

51. A national CWR inventory is useful for a wide arrange of institutions and individuals when defining policy and planning conservation action. It should be published and made easily available, ideally via a web-enabled database

Box 1. Global inventory of priority CWR
Recently, within the context of the project 'Adapting Agriculture to Climate Change: Collecting, Protecting and Preparing Crop Wild Relatives', a web-enabled global priority inventory of CWR taxa has been created. The inventory contains background information on 173 food and agricultural crop gene pools, and 1667 priority CWR taxa from 37 families, 109 genera, 1392 species and 299 sub-specific taxa. See: www.cwrdiversity.org.

B. Conservation priorities[20]

1. Why is conservation prioritization?

52. Conservation prioritization of CWR is the process of ascribing relative value to CWR taxa as an aid to planning their conservation. Conservation prioritization will often occur prior to elaborating the full national CWR inventory.

2. Why is conservation prioritization needed?

53. In most cases, a national CWR checklist will identify a greater number of taxa than can be conserved with the national financial resources and expertise available. The CWR taxa must therefore be prioritized as a means of selecting taxa for which active conservation should start immediately, and taxa for which conservation actions can be delayed.

54. Conservation prioritization depends on a number of factors, including the number of CWR taxa in the country, the resources available for their conservation, the differing needs of the target areas and local communities, as well as the policies and interests of the implementing body.

3. Methodology for producing a list of prioritized crop wild relatives

Set prioritization criteria

To determine which CWR to conserve, an agreed set of prioritization criteria needs to be defined. This should be done involving all relevant stakeholders. The most commonly used priority criteria for CWR are:

- **Economic importance of crop(s) related to CWR.** Priority should be given to wild relatives of crops that are of high value in terms of nutrition and food security. Value refers to both the economic value of the crop, nationally in terms of production, and also the extent to which the crop is critical in economic, nutritional and cultural terms to local communities.
- **Genetic potential for having useful traits.** The potential of a CWR as a gene donor is commonly estimated as its relative ability to hybridize with the crop to form fertile hybrids. In general, priority should be given to CWR closely related to the crop, those that are known gene donors or have shown promise in crop improvement. The relationship between a crop

[19] http://www.tdwg.org/about-tdwg
[20] See Resource Book, Section A.4

and the wild relative(s) can be determined using the Gene Pool concept[21] or, where this is not possible, the Taxon Group concept[22]. Alternatively, available information on genetic and/or taxonomic distance could be analysed to make reasoned assumptions about the most closely related taxa.

- **Threat status.** The more threatened a plant species is, the greater the likelihood of genetic erosion or extinction. Priority should be given to those species that are the most threatened. Determining the threat status can be done in some cases through Red List assessment[23].
- **Conservation status.** Before a taxon is given priority for conservation, current conservation activities should be reviewed. If sufficient genetic diversity of the taxon is being conserved *in situ* and *ex situ*, additional conservation efforts may not be justified, and resources should be focused on those species that are insufficiently conserved.
- **Legislation.** If the taxon is designated under global, regional, national or local legislative protection, it will require conservation attention because national or local governments are under a legal obligation to protect them. However, such species may already be afforded some level of conservation action due to their legislative protection status, and so further conservation action may not be required.
- **Species distribution.** Geographically restricted species are potentially more adversely affected by localized threats. Thus for species of restricted distribution, the loss of any single population or group of populations may affect the entire viability of the species. Taxa that are known to be endemic to a country or those that occur in only a few countries or regions would be considered vulnerable. Species with a restricted distribution should therefore be given higher priority than species occurring more widely.
- **Other criteria** that might be considered when prioritizing CWR for conservation include status of occurrence (whether the CWR is native to the country or introduced, and if it is known to be invasive), population data, species and area management, genetic diversity, and relative costs of conservation.

Defining a prioritization scheme

55. Based on the set of criteria that are applicable in each particular case, a prioritization scheme, i.e. the assignment of priority rankings for each CWR, should be developed. A prioritization scheme will often include a rule-based scoring system, where the chosen criteria, or a combination of criteria are weighed (or not), according to the priorities of the stakeholders.

Produce a list of prioritized crop wild relatives

56. When the prioritization scheme is applied to the national checklist, priority CWR will be identified. The list of prioritized CWR now forms the basis of the national CWR inventory and should be considered for specific conservation and sustainable use measurements, and covered specifically in the National CWR Plan.

C. Eco-geographical analysis[24]

1. What is an eco-geographical analysis

57. An ecogeographical analysis of CWR refers to the interpretation of the effects of environment and ecology on distribution of CWR. The information in the national CWR inventory can provide sufficient information about a species’ taxonomy, geographical distribution and ecology to permit ecogeographical analysis. However, if this information is considerable, it might need to be collated into a separate database, but one linked to the CWR inventory.

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[21] Harlan, J.R. & de Wet, J.M.J. 1971. Toward a Rational Classification of Cultivated Plants. *Taxon*, 20(4): 509–517. doi:10.2307/1218252 (see http://dx.doi.org/10.2307/1218252).
[22] See footnote 18.
[23] http://www.iucnredlist.org/technical-documents/assessment-process
[24] See Resource Book, Section A.6.

2. Why conduct an ecogeographical analysis?

58. The incorporation of ecogeographical data into inventories can improve the usefulness of inventories. An analysis of ecogeographical data of specific CWR helps in formulating and implementing conservation priorities, e.g. by helping to identify particularly important CWR populations, suitable sites for *in situ* conservation, and where samples should be collected for *ex situ* conservation

3. Methodology for doing an ecogeographical analysis

Methodology for doing an ecogeographical analysis

59. An ecogeographical survey of a taxon and populations (accessions) uses standard descriptors[25] where available.

60. Taxon-level information comprises:

- **Taxonomy and nomenclature.** Genus, species, authority, infra-specific epithet, infra-specific epithet authority, taxonomic rank, synonyms, vernacular names;
- **Taxon biology.** Descriptive information, phenology[26]; pollination, autecology[27], synecology[28];
- **Taxon-related crop.** Related crop, degree of relationship to crop, how the relationship is defined, i.e. whether gene pool[29] or taxon group[30] knowledge is used, which gene pool source used;
- **Taxon distribution.** Known distribution of the taxon;
- **Taxon habitats and ecology.** Altitude, aspect, slope, soil texture, soil drainage, soil pH, temperature, rainfall, habitat, vegetation type, associated species, human pressures;
- **Taxon threat status.** Threat status of taxon using IUCN Red List categories[31] where applicable, and threats facing taxon, e.g. urbanization, intensive agriculture, competition from alien species;
- **Taxon conservation status**. legislation, *in situ* and *ex situ* conservation status, method of selection of seed to be stored, method of seed storage, whether it is adequately managed *in situ*, threat of genetic erosion, length of seed storage, etc.; and
- **Taxon utilization potential**. Previous use as trait donor, potential use as trait donor, other uses.

61. Population-(Accession)-level information:

- **Population identification**: accepted identification for population;
- **Population occurrence**: geo-referenced location, coordinates;
- **Population characteristics**: size, age structure, genetic diversity, dynamics;
- **Population ecology**: altitude, aspect, slope, soil texture, soil drainage, soil pH, temperature, rainfall, habitat, vegetation type, associated species, human pressures, specific threats and land use data;

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[25] Examples of standard descriptors can be found in:
(a) "FAO/Bioversity. 2012. Multi-Crop Passport Descriptors V.2 (June 2012)" available at:
http://www.bioversityinternational.org/index.php?id=19&user_bioversitypublications_pi1[showUid]=6901
(b) The EC-funded PGR Secure project descriptors, available at:
http://www.pgrsecure.bham.ac.uk/sites/default/files/documents/helpdesk/LRDESCRIPTORS_PGRSECURE.pdf
[26] Phenology is the study of periodic plant life cycle events and how these are influenced by seasonal and inter-annual variations in climate, as well as habitat factors (such as elevation).
[27] Autecology is the study of the interactions of an individual organism or a single species with the living and non-living factors of its environment.
[28] Synecology is the study of relations between natural communities and their environments.
[29] http://www.tdwg.org/about-tdwg
[30] http://www.tdwg.org/about-tdwg
[31] http://www.iucnredlist.org/technical-documents/categories-and-criteria

- **Population characterization and evaluation data**: leaf shape, flower colour, plant habit, seed colour, chromosome number, plant height, days to maturity, etc; and
- **Population images**: Photographs/illustrations/links to digital images.

Create an ecogeographical database structure

62. The ecogeographical data should be organized and made available in a database. If a relevant database does not already exist, a simple structure will need to be designed. Several database software packages are available, e.g. Microsoft Access, MySQL. It is recommended that the database software both employs a user-friendly interface and is able to accommodate the complexity of a database of this kind. The database may comprise two or several linked tables in order to manage the ecogeographical data and it should be directly linked to the CWR inventory through a unique identifier (CWR taxon ID or Life Science Identifier – LSID).

Collection of ecogeographical information

63. **Review existing sources**[32]: As an initial step in collecting ecogeographical information, it is recommended to start by reviewing the literature, such as published information on the floras, monographs, recent taxon studies, environmental impact assessment studies, databases[33], scientific papers, atlases and maps of soil, vegetation and climate. Specific tools for ecogeographical analysis have also been developed under the International Treaty[34]. Experts on the taxa and people with specialist knowledge of the flora of a target area should also be consulted. Herbaria and genebank curators will be able to provide and verify the information related to stored accessions and also have much primary source information in their databases and libraries.

64. **Conduct a field survey**: If the amount of ecogeographical data is limited, or data are insufficient to undertake a meaningful analysis, a field survey may be conducted. When collecting information standardized data descriptors should be used.

Verification of ecogeographical information

65. Collected data should be verified, and special attention should be paid to correct taxonomic designation and avoidance of duplicates, errors and inaccuracies. In the process of verifying data, a level of geographical precision (Table 1) can be assigned to each record. To verify information collected from other sources, a field study might be needed.

Table 1. Examples of location data and their corresponding level of geographical precision

Level of precision	Location data
1	Exact place (e.g. 21 km along the road from location X to location Y)
2	Within a defined area of 1 km^2
3	Within a defined area of 10 km^2
4	Within a defined area of 20 km^2
5	Within a defined area of 100 km^2

Ecogeographical data analysis

66. Analysis of the collected data will permit the development of detailed ecogeographical profiles of a species. The types of ecogeographical analyses that are useful for establishing conservation priorities include:

- distribution of the CWR in a country or region and the identification of possible outlier locations and locations subject to abiotic and biotic stresses;
- distribution of specific characterization and evaluation traits, e.g. pest resistance, frost tolerance, among populations of a CWR or for the species itself;

[32] See Annex.
[33] See Annex.
[34] http://www.planttreaty.org/content/tools-capfitogen.

- mapping and detection of ecogeographical patterns, e.g. life cycle of the species in different areas, whether a particular CWR grows in a particular soil type, or whether the frequency of a character state changes along an environmental gradient;
- identification of populations targeted for *ex situ* sampling and conservation;
- identification of hotspots or populations suitable for long-term *in situ* conservation;
- environmental change analysis to identify threatened populations that require specific conservation measures;
- genetic diversity assessments of the taxa (ecogeographical diversity can be used as a proxy for genetic diversity, assuming that genetic diversity correlates to ecogeographical diversity); and
- spatial analysis and ecogeographical land characterization maps, using tools such as Geographic Information Systems (GIS).

Data synthesis

67. When ecogeographical data have been collected and analysed, the following products can be made available:

- Ecogeographical database, containing raw data;
- Ecogeographical conspectus, which is a summary of all the data collated for each CWR; and
- Full report, containing the analysis of the data obtained.

D. Genetic data analysis[35]

1. What is genetic data analysis?

68. In this context, genetic data analysis is the use of molecular techniques to characterize species and varieties, study their genetic relatedness and assess the genetic composition or diversity within and between populations and species. Molecular markers can be used to understand genetic relationships within and between populations and have particular value when they are known to be linked to particular traits. Molecular markers are useful to understand the genetic structure of populations, recognize patterns of diversity in space and time, and this can serve to guide more focused conservation efforts.

2. Why undertake genetic data analysis of crop wild relatives?

69. Studies of genetic diversity provide useful information for conservation planning, and are commonly used to:

- **Identify and classify populations.** Molecular markers can help distinguish between closely related taxa and identify gene flow between taxa.
- **Provide genetic baseline information.** An understanding of the pattern of allelic richness and evenness across the geographic breadth of a species establishes a relative baseline against which change can be measured during later monitoring. By assessing genetic diversity regularly over time, genetic erosion can be detected early and necessary population management measures can be implemented before significant genetic loss occurs.
- **Identify populations for conservation.** The amount and patterns of genetic diversity both within and between populations of a species can help identify which CWR populations should be targeted for *in situ* and *ex situ* conservation. Duplicate accessions, as well as novel genetic variability and gaps in collections, can also be identified.
- **Assist in identifying traits of interest for crop improvement.** Genetic diversity analysis can also help detect particular populations for characterization and evaluation. Genetic diversity analysis is a common approach to establishing genebank core collections[36].

[35] See Resource Book, Section A.5.

[36] van Hintum, Th.J.L., Brown, A.H.D., Spillane, C. & Hodgkin, T. 2000. Core collections of plant genetic resources. IPGRI Technical Bulletin No. 3. International Plant Genetic Resources Institute, Rome, Italy. http://www.agron.agr.ku.ac.th/doc/56_nodari_workshop/day2/05-Core_collections_of_plant_genetic_resources_Hirtum.pdf

- **Understand evolutionary forces.** Assess and understand how natural selection and neutral evolutionary forces are affecting populations targeted for conservation.

3. Methods for planning genetic data analyses

70. This section highlights some considerations that should be taken into account prior to a genetic analysis.

Review existing studies

71. Numerous studies have been undertaken to understand the patterns of genetic diversity of species and might already be available for the target CWR being studied[37]. Studies concerning reproduction of the species, breeding systems, seed dispersal and other life history traits, are also essential in determining patterns of genetic diversity among and between populations.

Consider the financial resources

72. Funding to undertake the study, as well as commitment from partners and researchers, need to be secured before any research starts. If the required laboratory space and trained personnel are not available or the financial resources are insufficient to conduct a molecular genetic diversity study, an ecogeographical diversity survey, together with information on reproduction and dispersal systems, can be used as a proxy for molecular genetic diversity analysis (see Section 3.3).

Consider available staff and capacity

73. Molecular studies need to be undertaken by trained personnel. If the necessary staff are not available, plant samples can be sent to collaborating experts for analysis. The genetic data analysis should be carefully planned together with the researchers that will conduct it.

Plan acquisition of material

Samples of the target species might already be present in *ex situ* collections, or germplasm can be collected through collecting missions. Regardless of whether stored or newly collected samples are being used, they should represent the known ecogeographical range of the species to the extent possible.

Determine the type of assessment[38]

74. Genetic variation can be adaptive or neutral. Adaptive variation would be ideal for assessing genetic variation of CWR as this variation affects fitness and a species' ability to respond to changing environments. However, it is currently more difficult and expensive to analyse adaptive variation than presumed neutral variation. Hence most molecular studies employ molecular markers that assess neutral genetic variation, such as microsatellite or single nocleotide polymorphism (SNP) markers[39]. Assessment of neutral genetic variation allows for the study of gene flow, migration and dispersal.

E. Threat assessment[40]

1. What is a crop wild relatives threat assessment?

75. A threat assessment refers to the process of formally evaluating the degree of threat to a CWR population or species and estimating the likelihood of genetic erosion or extinction. The assessment of

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[37] Examples of web sites where molecular genetic information can be found are: http://www.ncbi.nlm.nih.gov/genbank/ or crop specific efforts at: http://www.kazusa.or.jp/tomato/, or http://oryzasnp.org/iric-portal.

[38] See Resource Book, Section A.5(iv).

[39] Microsatellite markers are also called single sequence repeats (SSR). In most cases variation in these markers are believed to correspond to neutral genetic variation.

[40] See Resource Book, Section A.7.

a threat to diversity can be carried out at the individual taxon level or at the genus level, and can be done at different geographical scales (i.e. global, regional or national) (Figure 3).

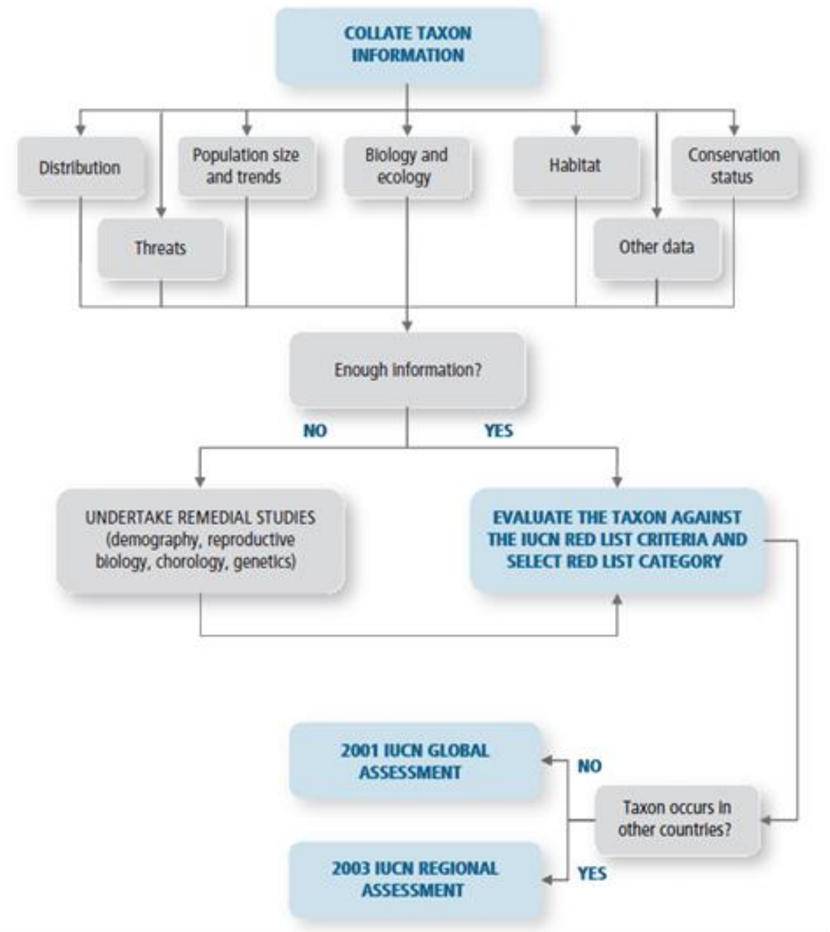
2. Why is a threat assessment needed?

76. A threat assessment will help to identify species and populations of CWR that are especially vulnerable to genetic erosion or extinction, and thereby assist in the prioritization of species for conservation.

3. Threat assessment methodology

77. The threat assessments for individual species that have not previously been carried out or are out of date – due to the availability of new data, for instance – should be undertaken. Figure 3 shows the schema for conducting a threat assessment, while descriptions of the individual steps are provided in the subsequent sections.

78. **Figure 3**. Schema for the threat assessment of CWR taxa



Review existing threat assessments (at national and global level)

79. Before undertaking a threat assessment, it is essential to identify sources of information on threats to CWR, as well as previous threat assessments. The IUCN Red List of Threatened Species[41] is

[41] http://www.iucnredlist.org/

considered to be the world's most comprehensive repository of information related to the conservation status of the world's biodiversity[42].

Identify and collect taxa information

80. If a thorough ecogeographical analysis has been conducted, most of the information needed to conduct a threat assessment will already have been gathered. Relevant information can be gathered from taxon experts, literature, databases and websites, and also through field studies, and should include:

- taxonomy and nomenclature;
- distribution and occurrence;
- population characteristics;
- habitats and ecology;
- use and trade;
- threats; and
- conservation status.

Assess the taxon against the IUCN Red List Criteria and selection of the Red List Category

81. The most common way to assess threats to a wild species is to undertake a Red List assessment. It is advised to consult the IUCN Red List website[43] for more detailed information and training materials before undertaking the assessment. The IUCN Red List Categories and Criteria (Figure 4) are used as a standard methodological approach to assess the risk of extinction of species based on information relating to the distribution, population status, ecology and natural history, threats and conservation actions. The IUCN Red List Categories and Criteria were developed to improve objectivity in the threat assessment process, and thereby improve consistency and understanding among users. There are five main Red List Criteria and each is quantitative in nature:

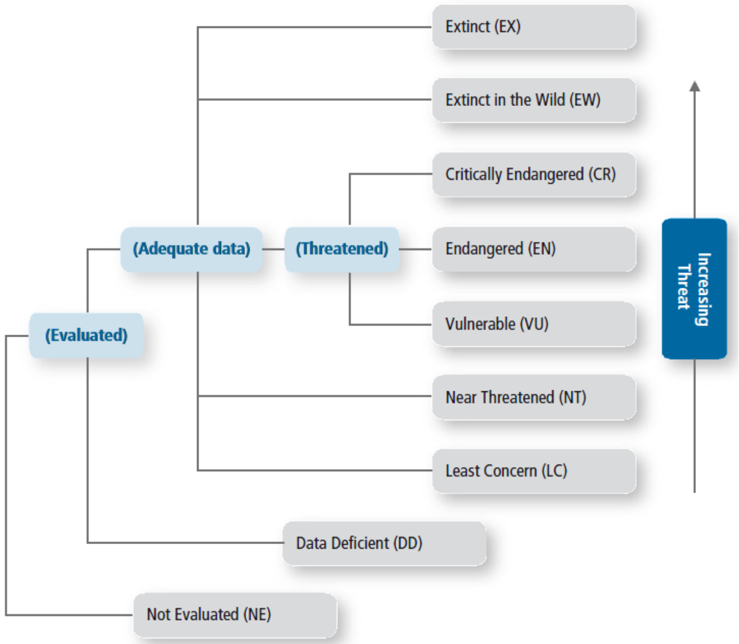
- population reduction;
- limited geographical range;
- small population size and declining;
- very small or restricted population; and
- quantitative analysis indicating the probability of extinction.

82. The evaluation of the criteria, following IUCN methodology, permits species to be assigned to the different categories shown (Figure 4).

83. IUCN has developed the Species Information Service (SIS)[44], which is a web application and stand-alone database for conducting and managing species assessments for the IUCN Red List of Threatened Species. Where possible, the use of SIS will facilitate Red List assessment.

84. **Figure 4.** Structure of the IUCN Red List Categories[45]

[42] When very little data is available for assigning Red List categories to a species alternative approaches can help identify tentative Red List categories two examples are: GEOCAT (http://www.kew.org/science-conservation/research-data/resources/gis-unit/geocat) and using Species Distribution Models as Red List criteria (https://www.repository.cam.ac.uk/handle/1810/245525)
[43] See footnote 41.
[44] http://www.iucnredlist.org/
[45] Adapted from figure in IUCN Red List Categories and Criteria version 3.1 (2000) available at http://jr.iucnredlist.org/documents/redlist_cats_crit_en.pdf



F. Conservation gap analysis[46]

1. What is crop wild relatives gap analysis?

85. A CWR gap analysis is an evaluation technique that identifies missing elements in the conservation of particular species or populations of a CWR. It involves a comparison between the range of natural diversity and the diversity that is effectively represented in genebank collections (*ex situ*) or actively conserved *in situ*.

2. Why conduct a crop wild relatives gap analysis?

86. A gap analysis is undertaken to identify *in situ* and *ex situ* conservation priorities, so that conservation actions (e.g. collection missions, and establishment of protected areas with active management of CWR populations) can be appropriately targeted.

3. Methodology for in situ *and ex situ gap analysis*

87. *In situ* and *ex situ* conservation gaps can be detected at the multi-taxon, individual genetic, individual ecogeographical, or trait levels (Figure 5). The level(s) at which the gap analysis is undertaken depends on the gap being investigated and the types of data available for the study. Only the most accurate species data should be used when undertaking a gap analysis as the quality of the data will directly affect the quality of the gap recognition. The following are descriptions of the methods commonly used in gap analysis.

Multi-taxon CWR level

88. ***In situ***: Assess CWR taxa not conserved *in situ* versus CWR taxa for which active *in situ* conservation measures are already in place; the analysis will identify the CWR taxa not actively conserved *in situ*.

89. ***Ex situ***: Assess CWR taxa not conserved *ex situ* versus the CWR taxa where accessions are appropriately stored in genebanks; the analysis will identify the CWR taxa not actively conserved *ex situ*.

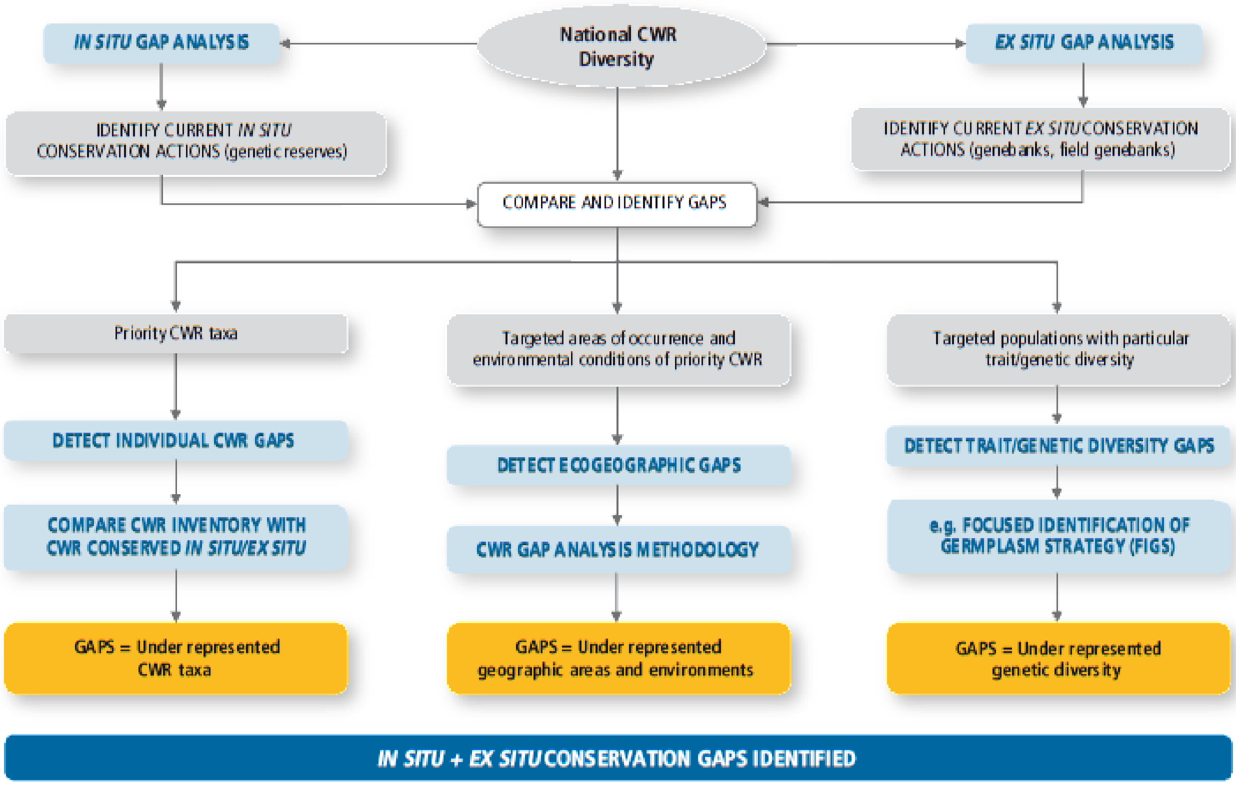
[46] See Resource Book, Section A.8.

Individual-CWR genetic level

90. ***In situ***: Assess whether specific CWR populations that contain a high level of genetic diversity are adequately conserved *in situ* and compare the natural distribution of a CWR with genetic diversity data to identify which populations are actively conserved; the analysis will identify specific populations not targeted by *in situ* conservation activities.

91. ***Ex situ:*** Assess whether specific CWR populations that contain a high level of genetic diversity are adequately conserved *ex situ*; the analysis will identify specific populations not conserved in *ex situ* collections.

92. **Figure 5.** Schema of the methodology for the gap analysis of crop wild relatives diversity i*n situ* and *ex situ*.



Individual-CWR ecogeographical level

93. ***In situ:*** Assess whether the whole ecogeographical range of the CWR is covered by *in situ* conservation measures; the analysis will identify the CWR in areas or environments not covered by *in situ* activities.

94. ***Ex situ***: Assess where collection missions have been conducted, to identify whether or not the whole ecogeographical range of the CWR is likely to be conserved *ex situ* ; the analysis will identify ecogeographical areas where collection of the CWR have not been conducted previously.

Individual-CWR trait level

95. Determine which CWR populations have particularly interesting traits that are not conserved *versus* populations with that same trait that are conserved.

96. ***In situ:*** Assess whether specific CWR populations containing traits of particular interest are adequately conserved *in situ*. Populations that are likely to contain desirable traits (e.g. insect pest resistance) can be identified by GIS-based predictive characterization, for instance, Focused

Identification of Germplasm Strategy (FIGS)[47]. The analysis will identify specific CWR populations likely to contain the trait of interest that are not adequately targeted by *in situ* conservation activities.

97. Ex situ: Assess whether specific CWR populations that contain a particular trait of interest are adequately conserved *ex situ* or not. GIS-based predictive characterization can be used to identify populations that are likely to contain desirable traits. The analysis will identify specific CWR populations likely to contain the trait of interest where collection could focus.

[47] Bari, A., Street, K., Mackay, M., Endresen, D.T.F., De Pauw, E. & Amri, A. 2012. Focused identification of germplasm strategy (FIGS) detects wheat stem rust resistance linked to environmental variables. Genetic Resources and Crop Evolution, 59(7): 1465–1481 and references therein (doi:10.1007/s10722-011-9775-5). For more details on predicted characterization, guidelines have been produced and are available at: http://www.bioversityinternational.org/e-library/publications/detail/predictive-characterization-of-crop-wild-relatives-and-landraces/

IV. WRITING THE STRATEGIC PLAN

A National Plan for Conservation and Sustainable Use of CWR is a document that draws on the materials generated from a preparatory review of CWR conservation in the country, and describes what the country plans to do to conserve CWR most appropriately, and how these plans should be accomplished. The time frame could be aligned with other relevant long-term national development plans. The National CWR Plan can be structured in a variety of ways, but the basic elements are described below.

A. Goals and objectives

98. A National CWR Plan needs clearly defined goals and objectives. The goals should be stated as general intentions, describing the overall purpose and desired overall outcome of the National CWR Plan. The goals of the National CWR Plan need to ensure that target CWR are protected, managed and monitored in their natural habitats, maintaining their natural evolutionary processes and ensuring availability of these resources for use and that these are complemented by *ex situ* conservation. The goals should reflect the country context and policies, and be broadly discussed among stakeholders, and agreed. Ideally, the goals should also complement regional and global CWR initiatives. The goals should be fully integrated into national programmes, e.g. National Biodiversity Strategies and Action Plans (NBSAPs) and National Strategies for PGRFA. Consultation with appropriate National Focal Point(s) involved in different conservation-related programmes should ensure information exchange and enhance linkages. The goals of a National CWR Plan might include:

- establishing a national network of *in situ* conservation sites inside and outside of formal protected areas, where long-term active conservation and sustainable use of CWR is carried out, as a contribution to national and local food security and nutrition.
- implement a programme for complementary *ex situ* conservation of CWR in the country; and
- promote the sustainable use of CWR in the country.

99. The objectives of the National CWR Plan should be more specific and define the concrete targets that the plan intends to accomplish for priority CWR taxa. The objectives should be based on the assessments of threats, conservation gaps and conservation priorities. To allow measurable and tangible objectives, it is recommended that the objectives are specific about locations and CWR taxa. An example of an objective for a National CWR Plan might be: “To establish a network of [number] *in situ* conservation sites, with *ex situ* back-up, to conserve the [number] highest priority CWR taxa in the country”.

B. Strategic actions and timeline

The content of the strategy should be in the form of an action plan, where activities required to fulfil the objectives are described, along with who does what, where, when and how. The National CWR Plan should include both strategic actions, aimed at providing enabling conditions and necessary incentives to achieve the objectives of the National CWR Plan and concrete actions that should describe practical measures to be taken. Strategic actions often refer to activities aimed at a political, institutional, legislative, or economic level, while concrete actions refers to specific actions implemented on the ground by stakeholders, programmes and projects. It is recommended that the action plan be as specific as possible when defining the priority actions, referring to taxa, locations, institutions and methods. However, the National CWR Plan can also include indicative actions, acknowledging that specific approaches will need to be adapted in the light of experiences while implementing the National CWR Plan. An action plan has a specified implementation and review cycle, clearly indicating the time intervals between activities mentioned taking place, and when key outputs should be achieved. This will provide an overview of all actions planned for the period of the National CWR Plan, and the timeline will guide regular monitoring of outputs and progress.

C. Monitoring the National Crop Wild Relatives Plan[48]

100. The monitoring of the National CWR Plan is part of the overall responsibility of the implementing authority and is an iterative process (Figure 6). When preparing a National CWR Plan it is necessary to include provisions that will allow efficient monitoring of progress, including human resources, financial resources and time.

101. There are several reasons why monitoring is an essential part of any strategic plan, including:

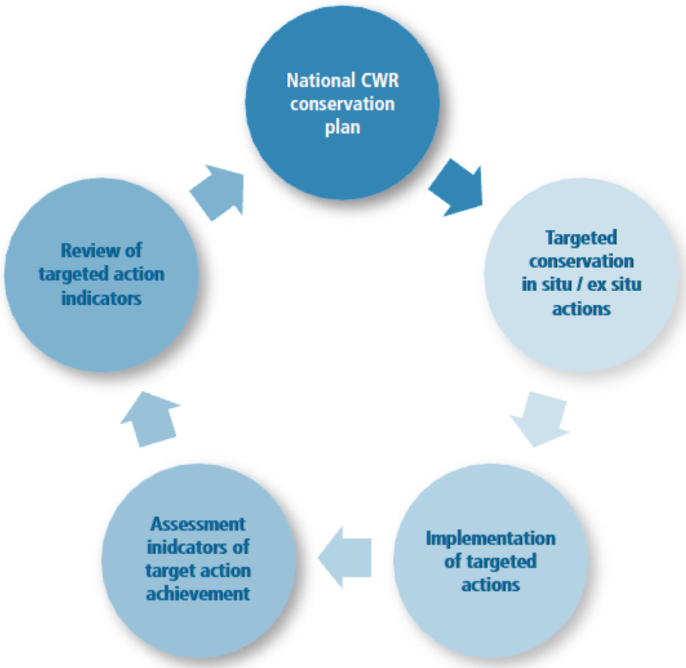
- to evaluate the effectiveness of the activities;
- to facilitate early detection of potential or emerging problems;
- to record changes over time; and
- to make informed decisions and adjustments, and plan ongoing management activities.

102. It is recommended to include details for *when*, *how* and *by whom* the activities and outputs in the National CWR Plan should be monitored. The National CWR Plan should therefore include a specific monitoring plan, where these details are outlined for all the priority actions and outputs. The following questions can be useful when preparing a monitoring plan:

- What are the key objectives of monitoring the activity?
- What should be monitored?
- When and how often should activities and deliverables be monitored?
- Who should be involved in monitoring?
- How should the monitoring data be managed and used?

103. Monitoring the implementation of the National CWR Plan is quite distinct from the monitoring of individual CWR populations being conserved (discussed in Section 6.1).

104. **Figure 6.** Monitoring cycle of the National CWR Plan



D. Management, coordination and resource mobilization

105. The roles and tasks of national and local stakeholders should be outlined in the National CWR Plan, including responsibilities in managing and coordinating. Lines of authority, communication

[48] See Resource Book, Section A.12

requirements, staff capacity and training needs required to maintain quality standards should also be included. The National CWR Plan needs to have been approved and adopted by the national authorities and key stakeholders in the country. An efficient way of doing this is to arrange a stakeholder meeting and ensure wide participation. Stakeholders should be sensitized to the rationale and necessity for the National CWR Plan and agree on the proposed action points in terms of implementation and timeline. Agreement is needed on how the National CWR Plan should be promoted in the country, both among decision-makers and the wider public. To implement the National CWR Plan, financial resources need to be secured and committed. These funds should primarily come from the institutes of implementing stakeholders, but could also be obtained from other sources, including the national budget, external partners or donor assistance, or innovative financial mechanisms. It is recommended that a resource mobilization scheme is agreed between stakeholders and included in the National CWR Plan.

V. IMPLEMENTING STRATEGIC ACTIONS

106. The implementation of the National CWR Plan is the process of realizing the actions it describes and in the timeline envisioned. This section provides guidance for the implementation of three key strategic goals associated with the efficient conservation and sustainable use of CWR:

1) Establishing sites for active *in situ* conservation of CWR.
2) Formulating and implementing complementary *ex situ* conservation of CWR.
3) Promoting wider use of conserved CWR.

A. Establish sites for active *in situ* conservation of crop wild relatives[49]

107. The establishment of protected areas (PAs) is the most common mechanism for the conservation of wild species. However, CWR occurring in PA are often not monitored and maintained, meaning that the conservation is passive as opposed to active. When conservation is targeting other plant or animal species, or a whole ecosystem, individual CWR populations might decline or disappear, or even be unnoticed by the PA manager. A key role for a countries' management of CWR should be to establish sites for their active *in situ* conservation, such as national genetic reserves or specific CWR management sites. One of the key objectives in ensuring active *in situ* conservation is to identify sites where this can take place and to form a national network of *in situ* conservation sites.

1. Methodology for establishing a network of in situ conservation sites

Review in situ conservation gaps

108. The *in situ* conservation gaps identified from the gap analysis (Section 3.6) should be the foundation for planning national genetic reserves and CWR management sites where priority CWR can be actively conserved. Sites identified by gap analysis would be added to the existing sites where CWR are currently conserved *in situ*, to form a coherent network that maximizes overall CWR diversity conservation.

2. Preliminary selection of crop wild relatives conservation sites

109. One objective for setting up an *in situ* conservation site is to ensure that maximum genetic diversity of the target CWR gene pool is conserved at specific sites, and contributes meaningfully to the national network. To establish sites for active conservation of CWR, a preliminary selection of sites should be made based on the results of the genetic, ecogeographical and gap analyses of priority taxa. Depending on the taxa and the results of the diversity analysis undertaken, single or multiple sites may be selected.

110. **Multiple-CWR conservation sites.** Multiple-CWR conservation sites focus on areas where the most CWR taxa are present. If a network of genetic reserves and informal CWR management sites are planned, they can be selected based on the minimum number of locations that contain the maximum CWR diversity. A complementary analysis will identify the minimum number of sites needed to conserve the full range of diversity of a particular CWR, and is the recommended approach for selecting sites. Hotspot analysis can also be used. Hotspot analyses identify one or more locations that have significantly greater CWR diversity than other locations.[50].

111. **Single-CWR conservation sites**. Multiple-CWR conservation sites are unlikely to represent the breadth of diversity for each CWR. Therefore, if financial and human resources are sufficient, single-CWR sites for exceptionally important CWR populations could be established based on geographical location or other types of data, such as particular traits, genetic diversity or ecogeo-graphical diversity.

[49] See Resource Book, Section A.9.
[50] Both complementary analysis and hotspot analysis can be carried out using DIVA-GIS (www.diva-gis.org/).

Incorporating threat data during the preliminary site selection

112. When considering the establishment of in situ conservation sites, the sites themselves should be assessed for inherent threats and long-term suitability for CWR conservation. The threats maybe split into known threats (e.g. plans to develop the potential PA site) or potential threats (e.g. predicted climate change impact on potential PAs). Knowledge of existing threats affecting sites, climate prediction maps and similar information should be used whenever available. Sites most highly threatened should be avoided when selecting *in situ* sites.

Evaluation of potential in situ *conservation sites*

113. In preparing a list of potential *in situ* conservation sites, priority CWR populations should be targeted, and then the sites should be evaluated in order to see if the prediction matches the reality at the site. There may be various reasons why even high priority sites may be unsuitable as conservation sites, including land ownership, current land use, whether inside or outside a PA, the type of PA, e.g. defined using the IUCN classification[51], potential threats and conflicting wishes from the local community.

114. Some important considerations when evaluating potential sites are:

- **CWR population**. If the target CWR population size is too small to be expected to survive in the long term, alternative sites are preferable.
- **Ownership of the site**. If the site is publicly owned it is more likely that the future management of the site can be amended to favour the target CWR population, particularly if the implementation of the *in situ* conservation site fulfils government policy objectives. If the site is privately owned, the owner may be less amenable to introducing potential management changes to the site.
- **Existing status of the site.** If the site is already under conservation management, it would be easier to amend the site management for CWR conservation than if the site were being managed for commercial purposes. It is, however, necessary to see that the objectives of the existing management are not in conflict with CWR conservation, e.g. management of large herbivores or planting of coniferous trees could conflict with the management of herbaceous CWR species.
- **Community support.** Local community support is required for the CWR conservation to be successful. To help ensure the support of local communities they should be involved in the development and implementation of CWR action plans to the extent possible.
- **Incentives.** If provision of government incentives is used, it must be linked to some form of guarantee from the landowner to ensure that the CWR diversity thrives. A management agreement including a conservation prescription may be required in order to ensure CWR are properly managed and that the local community's role in conserving a CWR is recognized.

Production of in situ *conservation site action and management plans*

115. When *in situ* CWR conservation sites occur within existing PA, the PA management plan may need to be amended to facilitate the conservation of the target CWR's genetic diversity. The first step in formulating a new or revising an existing area-specific management plan is to observe the ecological dynamics of the site for both CWR and non-CWR species. A survey of the species present at the site should be done to help understand the species interactions within the reserve. Conservation goals and means of implementation should be decided, which may involve some compromise between the priorities for CWR and non-CWR species conservation. Most importantly, the management plan should give an outline of the agreed management interventions for the site and how the CWR are to be actively monitored. Even for a less formally managed site outside a PA there will need to be some form of management plan to ensure site management favours the maintenance of the CWR population.

[51] See Resource Book, Section A.7.

Ensure the in situ *conservation sites comply with minimum quality standards*[52]

116. The quality standards for the conservation of CWR *in situ* are a set of criteria for the establishment of genetic reserves within existing PAs, and a set of management standards to optimize the efficacy of genetic reserves. The standards may be minimum or optimum quality standards. Minimum quality standards stipulate the minimum requirements that must be met for any genetic reserve established in a PA to operate and fulfil its conservation objectives. Optimum quality standards include a more stringent set of requirements to be met by genetic reserves over the longer term. The quality standards commonly relate to the location, spatial structure, target taxa, populations and management of the genetic reserve. The process of elaborating the standards involves identification of the parameters and constraints for adequate *in situ* conservation of CWR, review of relevant literature concerning the establishment of quality standards in biodiversity conservation, and preparation of a document for discussion and dissemination.

Integrate the in situ conservation priorities with national and international agro-environmental programmes

117. The selected *in situ* sites should be integrated with the national policies and agro-environmental programmes, so that their management is nationally coordinated and the conservation of the target CWR is effective. Efforts to strengthen the relationship between agriculture and the provision of ecosystem services should be explored. Payment for Environmental Services (PES)[53] and similar schemes can be set up in an attempt to encourage and reward local communities for their role in conserving and managing plant diversity. Whether CWR are conserved *in situ* within a PA or outside such an area, it is also recommended to ensure that the sites have some form of legal protection to enhance the status and long-term security of the conserved populations.

Ensure that local communities value and use the local CWR diversity

118. Promoting the involvement of local communities in conservation and sustainable use of CWR is often crucial for conservation to be effective, especially when *in situ* conservation sites are located within private land. Awareness of the National CWR Plan should be raised among all stakeholders, by holding local activities such as biodiversity fairs, community conservation trainings and workshops. In the preparation of management plans, the potential of local benefits can be considered.

119. For example, CWR occurring in wetlands might benefit local people if the site is used to rear fish or ducks, or *in situ* sites may become biological field laboratories for schools.

Create a national network of conservation sites

120. The establishment of CWR genetic reserves within existing PAs is likely to be a widely adopted option for *in situ* CWR conservation, given the additional costs associated with the creation of new PAs for CWR conservation. However, this is not always practical or possible, especially in countries with a limited existing PA network and where priority CWR do not occur in any formal PA. In addition, many close relatives of crops grow in disturbed or semi-disturbed habitats more commonly found outside PAs. Therefore, a national network of conservation sites is likely to include a mix of CWR genetic reserves and informal CWR management sites. A well balanced set of *in situ* conservation sites will contain a mix of genetic reserves established in existing PAs, informal CWR management sites and possibly even newly established PAs to contain genetic reserves. These will together form a national network of *in situ* conservation sites that can be managed as a coherent whole with links to non-CWR PA conservation and with back-up of CWR diversity in ex situ collections.

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[52] See Resource Book, Section A.10-iv.

[53] Pagiola, S. & Platais, G. 2002. Payments for Environmental Services. Environment Strategy Notes 29671. World Bank. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2004/08/26/000112742_20040826104114/Rendered/PDF/296710English0EnvStrategyNote302002.pdf

B. Formulate and implement a programme for complementary ex situ conservation of CWR

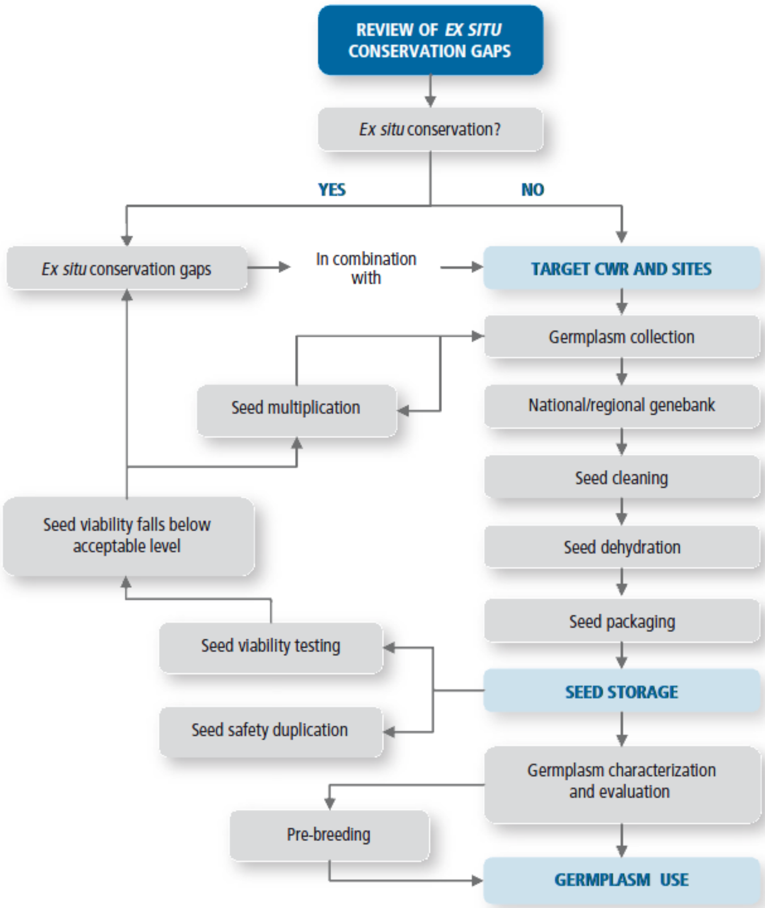
121. *Ex situ* conservation involves the conservation of plant diversity away from its natural habitat, and allows easy access for characterization, evaluation and use. Techniques employed are efficient and reproducible, aimed at effective conservation over the medium to long term (see Figure 7). However, in many cases, CWR are not well represented in genebanks around the world. To ensure that the genetic diversity of CWR is safeguarded in national collections, programmes systematically targeting and collecting CWR should be implemented.

1. Methodology for the establishment of a programme that is linked with ex situ *conservation and the use of crop wild relatives*[54]

Review the ex situ conservation gaps

122. By comparing national CWR diversity with the CWR diversity already conserved *ex situ*, gaps will be evident, and these gaps will form the focus of the national *ex situ* collecting programme.

123. **Figure 7.** Schema for the ex situ conservation of crop wild relatives



Select crop wild relatives and sites for targeted collecting

124. Priority should be given to collecting CWR from populations that are not adequately conserved *in situ*, not represented in existing *ex situ* collections or are threatened in the wild. It may not be necessary to collect fresh material if the specific germplasm is held by a collaborating genebank

[54] See Resource Book, Section A.11.

from which accessions can be obtained through inter-genebank exchange. All CWR collecting should be undertaken legally with the necessary national and local permissions while ensuring that the collection is in line with international conventions and legislation. Many organizations have developed specific protocols to guide the collection of plant material for *ex situ* collections[55].

Sampling of crop wild relatives

Collections that capture as much genetic diversity of the species as possible will have the greatest conservation value. For CWR collected from natural or semi-natural habitats, the following are basic field sampling considerations:

- **Distribution of sites.** While appreciating that CWR populations are not evenly distributed over an area, collectors can use a stratified random approach within the target area. They are stratified to ensure that all major ecosystems where the species is found are sampled but within each ecosystem each sampling site is selected randomly.
- **Total number.** Samples should be collected from the maximum number of sites possible with the resources available.
- **Delineation of a site**. Related to the size of the interbreeding unit, the limits of the site may also be delineated by dominant habitat changes.
- **Distribution of plants sampled at a site**. Collecting should be done randomly throughout the site, ensuring sampling from distinct habitat types. Particularly interesting material and off-types can be collected as separate samples.
- **Number of plants sampled per site** will be species and population-size dependent, hence the number of plants sampled and seeds collected should be determined on a case-by-case basis. For small-seeded CWR from large populations, 5 000 seeds should be collected from a total of 100 individuals; alternatively, if resources are limited or the species is rarer, 2 500 seeds can be sampled from a total of 40 to 50 plants as a minimum.
- **Indigenous knowledge held by local communities.** Field collectors should note the knowledge held by local people concerning CWR found in their area. This may relate to population locations, threats, habitat associations and uses.

125. Each of these factors will vary depending on the nature of the CWR being sampled. Many CWR might be found as individual plants or in small clusters, which does not allow for the application of an ideal sampling strategy. Collected germplasm is virtually worthless unless it has detailed passport data associated with the collection location. Of passport data, the passport number uniquely identifies the collected sample and site it was collected from. The passport number should always be associated with the seed sample even when subsequent numbers, such as genebank accession number, are applied to the sample. Passport data forms should be used to record field information such as the initial taxonomic classification of the sample; the global positioning system (GPS) coordinates of the collecting site; a description of the habitat of the collected plants; the number of plants sampled; and other relevant data. Passport data are collected in the field, organized and made available to the user's community in a web-enabled database. It is advisable to collect herbarium voucher specimens so the botanical identification of the accessions can be verified post-collection.

126. At the time of collecting, seeds should be visually inspected for damage, such as that caused by seed-boring insects. Collecting the seeds as close as possible to maturation but prior to natural dispersal, avoiding collection of dispersed seeds from the ground which may be contaminated with saprophytic or pathogenic microorganisms, can ensure the best physiological seed quality.

127. Unfavourable extreme temperatures and humidity during the post-collecting period and during transport to the genebank could cause rapid loss of seed viability and reduce longevity during storage. Collected material should be conserved in the country of origin whenever possible, in facilities with

[55] Such as Bioversity International http://cropgenebank.sgrp.cgiar.org/index.php/procedures-mainmenu-242/collecting and the Millennium Seed Bank, the Royal Botanic Gardens, Kew http://www.kew.org/science-conservation/millennium-seed-bank/collecting.

the capacity to manage them, and duplicate samples deposited elsewhere for safety purposes, as agreed prior to the collecting mission.

Genebank seed processing[56]

128. After collecting, when the sample arrives at the genebank, it is processed in a standard manner: seed cleaning, seed health evaluation, seed viability testing, dehydration, packaging, registration and storage. When collecting CWR from the field, it may not always be possible to obtain a sufficiently large seed sample. In these cases, it will be necessary to carry out a seed multiplication cycle before the seed can be processed and incorporated into the genebank. Not all species have seeds that remain viable for long periods after being dried to 5 percent relative humidity and stored at –18°C, the optimal genebank seed storage conditions. These species would need to be conserved using alternative techniques, such as keeping live specimens in a field genebank, or as explants in vitro or in cryopreservation facilities.

Post-storage seed care and regeneration

129. Once the seed sample, now a genebank accession, is incorporated into the genebank, the seed viability will gradually decrease over time and there will be a need to extract a sample of seeds and test its viability at regular intervals by a germination test. Viability is a measure of how many seeds are alive and able to germinate. It is usually expressed as percentage germination; above 75 percent is generally an acceptable level of viability. Viability is usually determined initially before the seeds are packed and placed into storage, and subsequently at regular intervals during storage. When germination falls below 75 percent the accessions require regeneration. The aim of regeneration is to increase the quantity of viable seeds of an accession, but while doing so it is necessary to ensure that the original genetic characteristics of the accession are retained as far as possible. Each multiplication and regeneration cycle involves risks to the genetic integrity of the accession, such as:

- contamination due to geneflow from other accessions (as a result of hybridization);
- contamination through seed mixing during planting, harvesting, threshing and packaging;
- natural changes caused by mutations during gamete formation;
- genetic drift due to random loss of alleles, particularly when regenerating from small numbers of individuals; and
- genetic shift due to unconscious natural or artificial selection, often related to diverse environmental conditions during regeneration and selection for seed production[57]

130. In plants requiring long intervals from sowing to reproductive maturity, seed regeneration in the field may be impractical. Re-sampling the original population can be undertaken when there are signs of declining vigour and viability. Maintenance of genetic integrity is equally important for germplasm that is conserved in vitro, especially in view of the risk of somaclonal variation. The risks involved with regeneration will vary considerably according to the crop species, but regeneration is a costly operation, so the most efficient and cost effective way of maintaining genetic integrity is to keep the frequency of regeneration to an absolute minimum. To avoid gene flow or contamination it is critically important to use proper isolation methods between the plots of accessions being regenerated. For species that depend on specific pollinators, isolation cages and the corresponding pollinators should be used. Morphological traits, such as flower colour or seed colour, or molecular markers, can be used to identify possible contamination or genetic drift.

Linkages between ex situ *conservation and use*

131. When formulating the *ex situ* programme, the short- and long-term user expectations for CWR need to be considered. A short-term demand could be to meet immediate needs for specific traits (e.g.

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[56] FAO's Genebank Standards for Plant Genetic Resources for Food and Agriculture can be found at: http://www.fao.org/agriculture/crops/thematic-sitemap/theme/seeds-pgr/gbs/en/

[57] A genebank seed file where seeds of the original collection, photographs and data on originally collected material can also be checked during and after accession regeneration to help maintain accession integrity.

to combat a new virulent form of a pest or disease). Long-term demand might be to have a pool of variation (e.g. to improve yield or quality) on which to draw. Preparatory work should be done to help the germplasm curator in anticipating these demands, so that germplasm meeting those demands can be included in the collecting programme. By using a relational database and plant record technology, record keeping for *ex situ* collections can help ensure the maintenance of critical links between germplasm accessions and collection data, thus supporting broader conservation and research activities (see Section 6.3).

C. Promote wider use of crop wild relatives[58]

1. How can crop wild relatives be used?

132. The use of CWR in breeding has traditionally focused on trying to identify traits of interest through phenotypic characterization and evaluation. However, the use of plant genetic resources encompasses the whole range of actions involving diversification, adaptation, improvement and delivery to farmers through seed systems. So, more comprehensive use of plant genetic resources involves determining technical solutions and actions, such as characterization, evaluation, plant breeding, genetic enhancement and genetic base-broadening, diversification of crop production, market development and commercialization of underutilized crops and diversity-rich products, and seed production and distribution.

2. Why link conservation with use?

133. As CWR are defined by their intrinsic potential to contribute novel traits for crop improvement, their conservation is explicitly linked to their use. Only by conserving CWR diversity, can countries take advantage of their potential, and, for instance, provide solutions for agriculture to cope with extreme weather conditions. There are numerous examples of the use of CWR in breeding[59]. Beneficial traits from CWR include traits to increase crop yields, furnish pest and disease resistance, providing tolerance to drought and genes for improved nutrition. The CBD, the International Treaty and the Second GPA all emphasize the need to link plant conservation to sustainable use. This section refers to some options for improving the use of CWR and how the links between *in situ* conservation and use can be strengthened.

Review and address the capacity needs in the country

134. Many countries lack, or are experiencing a deficit in, capacity and skills in plant genetic resources management, affecting equally governmental and non-governmental organizations, research institutions, universities and other relevant institutions[60]. This threatens all the activities related to PGRFA management, and constrains the optimal use of these resources, including CWR. To strengthen the capacity needs of the country, it might be relevant to:

- review the country’s capacity needs, involving all stakeholders involved in plant genetic resources conservation and use, including plant breeding;
- encourage the inclusion of plant genetic resources management in the education system, and provide training on conservation and use of plant genetic resources to researchers, conservationists, development workers and agricultural extension workers;
- organize information seminars, workshops and training for local and rural communities;
- organize technical training and refresher workshops for researchers and students;
- strengthen research stations and plant breeding programmes, and develop a national portfolio of expertise;
- upgrade the research facilities in the country; and
- seek opportunities for personnel training and exchanges with other countries.

[58] See Resource Book, A.13.
[59] See Resource Book, Section Context 1.5
[60] See Resource Book, Section Context 1.9

Link conservationists with germplasm users

135. Germplasm users may be able to access CWR germplasm conserved actively at *in situ* conservation sites, but more often they will request accessions that are stored *ex situ* in genebanks. Managers of genetic reserves and staff from the conservation authority should attempt to work with the professional user community to characterize, evaluate and publicize the germplasm found at their sites. In situ CWR conservation sites should be seen as both a means of conserving CWR diversity and as *in situ* research platforms for field experimentation. There is a need to better understand species dynamics within conservation areas to aid the sustainable management of specific taxa, and there is also a need for further ecological and genetic studies of CWR conserved *in situ*. Research activities on the material conserved should be encouraged as this will provide additional justification for establishment and long-term management of conservation areas. Monitoring studies, such as assessment of genetic diversity changes, can be facilitated by *in situ* site managers, possibly in collaboration with NGOs and local volunteer groups. In this way, changes needed in habitat management can be detected and actions taken to reduce rates of diversity loss.

Increase characterization and evaluation of crop wild relatives

136. One of the most significant obstacles to a greater use of CWR is the lack of adequate characterization and evaluation data, and the capacity to generate and manage such data. In order for breeders to effectively use CWR in their work, the diversity needs to be characterized and evaluated for novel traits. Various characterization techniques can be used to record the distinct and heritable features of accessions and identify their useful traits. Characterization data are descriptive and include morphological, genetic and agronomic parameters. Evaluation data are the response of the germplasm to stresses, such as diseases, pests, flooding and drought. To support the characterization and evaluation of CWR, the following points should be considered:

- expand the collection and conservation of CWR, both *ex situ* and *in situ*;
- develop and adapt molecular techniques and mainstream new biotechnological tools within plant breeding programmes;
- strengthen the operation and management of genebanks, as well as the internal organization of *ex situ* collections, e.g. by establishing trait-specific collections that include CWR;
- promote the access and exchange of CWR accessions and breeding lines that use CWR;
- provide adequate financial support for characterization and evaluation programmes involving CWR, and establish baseline characterization and evaluation data for CWR; and
- monitor progress in the evaluation and use of CWR germplasm.

Raise public awareness of the importance of crop wild relatives

137. Public awareness is often needed to stimulate political and practical action. One way of promoting awareness of the value of CWR to the general public is to encourage them to visit genetic reserves and during their visit supply them with various formal and informal education materials. CWR-based cook books, agrobiodiversity ecotourism and art competitions are examples of ways to raise awareness of the value of CWR and their conservation. The PA containing the CWR genetic reserve should have infrastructure to accommodate visitors, such as, visitor centres and nature trails. This is also likely to bring additional income to the PA and can help strengthen the management of the site.

Support traditional users of crop wild relatives

138. Local communities living in the vicinity of CWR populations are likely to have an extensive history of harvesting local wild plants. Whether a genetic reserve is to be established or a particular CWR population sampled for *ex situ* conservation, there are likely to have been traditional or local users of that resource prior to the conservation measures being put in place. People from these communities often also possess extensive knowledge of the ethno-botanical value and direct uses of plant species, including CWR. If the support of the local community for CWR conservation is to be obtained, active CWR conservation should promote local resource use while at the same time ensuring

target CWR populations are not overexploited. Unfortunately, a number of local communities are prevented from managing their own resources completely, and a number of conflicts have occurred with regard to developments for tourist or urban expansion. The conservationist’s role when formulating conservation actions may be just as much about resolving conflicts involving local communities as practical implementation of conservation. To achieve sustainable conservation, continued local community use of their plant genetic resources is essential.

Establish partnerships between all groups of stakeholders

139. The work of professional users, the general public and local communities can be linked through partnerships and networks. A large amount of activities contributing to the conservation and sustainable use of PGRFA is managed by local, regional and international networks. These activities range from local projects to global programmes, and can play a key role in conservation and use of CWR, for instance by linking organizations in the agriculture and environmental sectors. CWR thematic networks can help to promote specific conservation actions, as well as promote modern and traditional use of the plants. To establish or strengthen crop-specific thematic networks and partnerships, the following key points are important:

- encourage and engage broad participation, across sectors and stakeholder groups. It is recommended to ensure close involvement of local communities, encourage participation of rural women and indigenous communities, and foster public-private partnerships;
- ensure that the aim of the network supports the national goals and priorities for the conservation and sustainable use of PGR; and
- mobilize resources to sustain the networks and partnerships.

VI. MONITORING CROP WILD RELATIVES DIVERSITY, AND INFORMATION MANAGEMENT

A. Monitoring crop wild relatives diversity[61]

1. What is "monitoring crop wild relatives"?

140. Monitoring CWR means the systematic collection of data over time to detect changes, to determine the direction of those changes, and to measure their magnitude. Monitoring should allow results, processes and experiences to be documented and used as a basis to guide decision-making. The collected data are analysed in order to draw conclusions about the relevance, effectiveness, efficiency, impact and sustainability of a particular intervention.

2. Monitoring of crop wild relatives diversity

141. The monitoring of CWR populations and the habitats in which they occur aims at:

- providing data for modelling population trends;
- assessing trends in population size and structure;
- assessing trends in population genetic diversity; and
- determining the outcomes of management actions on populations and to guide management decisions.

3. Methodology for developing a crop wild relatives monitoring plan

142. The monitoring of CWR can focus either on the taxon as a whole or focus on population genetic diversity within a taxon. The methodology below only describes the development of a CWR monitoring plan at the taxon level, and focuses on CWR conserved *in situ* (Figure 8). Monitoring of CWR populations is likely to be implemented in a similar manner, whether it takes place in formally recognized genetic reserves or informal *in situ* conservation areas.

Identification and selection of the variables to monitor

143. The variables that are monitored may include demographic, ecological and anthropogenic parameters[62] It is important to take into account parameters such as the life form and breeding system of the target taxon, as well as the resources available for monitoring.

144. **Figure 8.** Schema for a monitoring plan at the individual CWR level

[61] See Resource Book, Section A.12.
[62] See Resource Book, Section A.12.2.

Design of the sampling strategy

145. The design of the sampling strategy involves making decisions as to the type, size, number and positioning of the sampling units, as well as the timing and frequency of sampling. The design should be based on a review of the available literature on the monitoring of taxa with similar life forms and biological traits, as well as through consultation with conservation management experts. The monitoring plan should be designed in a way to detect significant changes in the target population that may negatively impact population health rather than normal seasonal variations that need not trigger changes in management actions.

Selection and positioning of the sampling units

146. Sampling can be carried out using various methods, e.g. plot (or quadrats within areas of standard size); transect (sampling of diversity within a defined distance either side of a central line) or even monitoring of individual plants (or plant parts) for particular attributes (e.g. plant height, number of seeds per fruit). In an *in situ* conservation site, the establishment of permanent quadrats is most likely to be used.

Positioning of sampling units

147. Sampling units should ideally be randomly distributed throughout the entire area of distribution of the population. Methods of sampling include:

- **simple random** sampling;
- **systematic sampling**, with collection of samples at regular intervals in both time and space; and
- **stratified random sampling**: Dividing the population into two or more groups prior to sampling, where plants and habitats within the same group are very similar and simple random samples are taken within each group.

Determination of the timing and frequency of monitoring

148. Populations of CWR in genetic reserves should be surveyed regularly in order to detect changes. Monitoring is commonly most effective when the target species is flowering or fruiting, as this is the time they can be most easily identified. It also can be carried out when leaves are unusually coloured or about to fall, or when the surrounding vegetation does not obscure the target species, or other particular character of the target taxon. Anyway, it should be scheduled at the same phenological

time each year to ensure the data are directly comparable between monitoring events. The frequency of monitoring (time between surveys) is often dictated by the perception the researcher has during the initial surveys. However, it generally depends on the life form, the expected rate of change, the rarity and trend of the target species, as well as on the resources available for monitoring. It can be as frequent as every month (e.g. rare or threatened annuals) during several growing seasons, or annually (e.g. annuals) or less frequently (e.g. perennials). Generally, the monitoring in a newly established reserve is more frequent than in a well-established one. With time and experience, frequency of monitoring can be adjusted.

Implementation of a pilot study

149. A pilot study should be carried out once the monitoring scheme has been designed, in order to assess how efficient the experimental design is and whether the field techniques are efficient, before the implementation of a long-term monitoring strategy.

Data analysis and adjustment of monitoring plan

150. The results of the pilot study should be analysed in order to detect population trends as well as possible problems with the monitoring design and field methodologies. Frequently, refinement of the monitoring plan is needed based on data analysis. Sample size, position of sampling units, etc., may be inadequate to detect meaningful changes in the population, so they need to be adjusted. However, changes to the monitoring regime may negatively affect data comparison, so any changes need to be considered, possibly with the help of a statistician, before being implemented.

B. International reporting requirements and global linkages

151. National monitoring of PGRFA conservation and use make up the basis of any global assessment. All countries that are Members of the Commission on Genetic Resources for Food and Agriculture (Commission), a contracting party to the CBD or International Treaty have certain monitoring and reporting requirements related to conservation and use of plant genetic resources. Targets and indicators to assess the status and progress of PGRFA conservation and use have been developed to facilitate reporting of status and trends. These include the Aichi Biodiversity Targets[63] and the targets for PGRFA developed under the Commission[64]. Indicator frameworks for the Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets, as well as for the Second GPA, have been adopted and are available at the websites of the CBD[65] and the Commission.

152. Indicators of the Second GPA have been adopted in order to monitor its 18 priority activity areas; several among them relate to CWR. All countries that are members of the Commission are required to report on these indicators regularly. It is recommended that indicators developed to monitor specific programmes and projects at the local level are compatible with the relevant national indicators of the Second GPA, including:

- number of *in situ* (including on-farm) surveys/inventories of PGRFA carried out;
- number of PGRFA surveyed or inventoried;
- number of CWR and wild food plants under *in situ* conservation and in sustainable use areas with institutional support;
- percentage of national *in situ* conservation sites with management plans addressing CWR and wild food plants;
- number of CWR and wild food plants species actively conserved *in situ*;
- existence of a strategy for identification of gaps in collections held by national genebanks, and for targeted collecting missions to fill gaps identified;

[63] http://www.cbd.int/abs
[64] See the Report of the Fourteenth Regular Session of the Commission on Genetic Resources for Food and Agriculture, http://www.fao.org/docrep/meeting/028/mg538e.pdf, Appendix C. Targets and indicators for plant genetic resources for food and agriculture for the complete list of indicators for Second GPA
[65] http://www.planttreaty.org/content/texts-treaty-official-versions

- number of targeted collecting missions in the country;
- number of new crops or wild, or both. species introduced into cultivation; and
- number of CWR conserved *in situ* documented in a publicly available information system.

153. Given the amount of information required from national authorities, it is essential that national PGRFA activities are well coordinated, and that the National Focal Point(s) and support teams have a central system for monitoring all national activities related to PGRFA.

C. Information systems and data management

1. Why should data be managed?

154. One major factor hindering effective conservation, use, monitoring and reporting related to PGRFA is the lack of easy access to data and complicated information exchange due to the many different approaches in managing data. If CWR are to be conserved and sustainably used, consistent data collation and management is required, and a means of bringing this information into an accessible and standard format is essential.

2. How should data be managed?

155. To conserve CWR efficiently information needs to be sourced, managed and analysed to help ensure that the most appropriate conservation actions are implemented. This process is likely to involve the CWR's taxonomy, ecogeography, threats and conservation status and genetic structure data, as well as the ability to track using time-series data and predict demographic and genetic changes within a species in relation to land management and environmental factors. Information on CWR is available from a wide range of sources, but retrieving it can present a challenge as CWR accessions are often not distinguished as such in many collections and much of the data is held by those outside of the plant genetic resources community. When collecting information on CWR, it is essential to include a wide community of stakeholders, as CWR are also collected, conserved and studied by scientists such as botanists, taxonomist, ecologists, geneticists, physiologists that are not directly associated with the plant genetic resources or agriculture communities. Accessing such information is not only time-consuming, but comparing data sets is often difficult due to the diversity of information management models used. These challenges demand a carefully considered and tested approach. However, like all data mining activities the more background data available the more predictive the analysis can be resulting in formulation of effective conservation plans.

156. The types of data managed will fall into four basic types:

1) Ecogeographical Field population data and genetic data:

    - taxonomy and nomenclature;
    - degree of relationship between crop and CWR;
    - CWR uses: historical, current and potential;
    - ecology and habitat;
    - geographical distribution;
    - genetic diversity;
    - threat status; and
    - current conservation measures

2) Field population data (passport):

    - precise population location (GPS coordinates);
    - land management regime (protected area, private ownership, common land); and
    - population characteristics, including size, cover, genetic characterization, age structure, and associated species.

3) Conservation management data (curatorial)

In situ criteria:

- management regime and interventions;
- monitoring regime;
- place in national, regional and global CWR networks;
- place in non-CWR specific conservation networks; and
- local community participation

Ex situ criteria:

- number of accessions of different taxa in the genebank;
- physical location of accessions in genebank;
- germination and regeneration testing; and
- access and benefit sharing policy

4) Characterization and evaluation data (descriptive):

- taxonomic and morphological description;
- genetic description;
- agronomic description; and
- breeder-desired characteristics evaluation (disease, pest, drought resistance, etc.).

157. Each of these data types are collated using some type of standard descriptors. A descriptor may be defined as "any attribute referring to a population, accession or taxon which the conservationist uses for the purpose of describing, conserving and using this material". Standard descriptors for ecogeographical, field and conservation data are included in the Descriptors for CWR available at the CWR Global Portal[66]. The descriptors for *in situ* conservation of CWR have also been developed as part of this portal. Formal characterization and evaluation descriptors are associated with various standardized crop descriptor lists published by FAO[67], Bioversity[68] and UPOV[69]. It should be stressed that standard lists of descriptors should be used whenever available. The use of well-defined, tested and rigorously implemented descriptor lists for scoring descriptors considerably simplifies all operations concerned with data recording, such as updating and modifying data, information retrieval, data exchange, data analysis and transformation. When data are recorded, they should be classified and interpreted with a pre-defined list of descriptors and descriptor states. This saves a considerable amount of time and effort associated with data entry and reduces errors.

158. It is highly recommended to establish ways in which each country can be part of a worldwide network of government and partner organizations facilitating scientific and technical cooperation through information exchange. Such networks can provide support to the coordination of efforts, raise resources and create more awareness. In recent years there has been an exponential growth of online inventories and ecogeographical datasets (Annex 1 provides examples).

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[66] www.cropwildrelatives.org
[67] http://www.bioversityinternational.org/e-library/publications/detail/faobioversity-multi-crop-passport-descriptors-v2-mcpd-v2
[68] http://www.bioversityinternational.org/research-portfolio/information-systems-for-plant-diversity/descriptors
[69] http://www.upov.int/en/publications/tg_rom/tg_index.html

ANNEX 1

Examples of internet resources for crop wild relatives

Name	Description	URL
AEGRO – An Integrated European *In Situ* Management Work Plan: Implementing Genetic Reserves and On Farm Concepts	A project site, focusing on the development of conservation strategies for both CWR and landraces, including a helpdesk and Crop Wild Relative Information System (CWRIS)	http://aegro.jki.bund.de/aegro/index.php?id=188
Botanical Garden Conservation International	Botanical garden holdings information	http://www.rbgkew.org.uk/BGCI/
Crop Wild Relatives Atlas	Provides information on distributions and collecting priorities of CWR of major crops	http://www.cwrdiversity.org/distribution-map/
Crop Wild Relative Information System (CWRIS)	PGR Forum CWR Catalogue for Europe and the Mediterranean	http://www.pgrforum.org/cwris.htm
Crop Wild Relatives Global Portal	The Portal currently offers access to CWR National Inventories, external datasets, image archive, publications, training resources, and list of experts and institutions working for CWR conservation	http://www.cropwildrelatives.org
European Native Seed Conservation Network (ENSCOBASE)	European database of major *ex situ* botanical garden genebank holdings	http://enscobase.maich.gr/
European Plant Genetic Resources Search Catalogue (EURISCO)	European database of major *ex situ* agrobiodiversity genebank holdings	http://eurisco.ecpgr.org/nc/home_page.html
FAOSTAT	Agricultural statistics and data	http://faostat.fao.org/
GBIF	Global biodiversity data	http://data.gbif.org/
GENESYS	Global database of major *ex situ* genebank holdings	http://www.genesys-pgr.org/
Harlan and de Wet Global Priority Checklist of CWR Taxa	Global checklist and database of priority CWR taxa in 173 crop gene pools	http://www.cwrdiversity.org
GlobCover	European Space Agency Global Land Cover map, latest version, 2009	http://ionia1.esrin.esa.int/
IUCN Red List	Database of red list (extinction threat) assessments	http://www.iucnredlist.org/
JSTOR herbaria	Herbaria resources	http://plants.jstor.org/
Millennium Seed Bank, Kew	One of the largest *ex situ* plant conservation project in the world	http://www.kew.org/science-conservation/save-seed-prosper/millennium-seed-bank/index.htm
Plant list	Working list of all known plant species	http://www.theplantlist.org/

Name	Description	URL
PGR Secure	Resources and tools on all aspects the CWR and LR conservation strategy planning, with particular reference to Europe	http://www.pgrsecure.org
Royal Botanic Gardens Kew	Herbarium catalogue containing images and information on a large range of specimens	http://apps.kew.org/herbcat/navigator.do
Tropicos (Missouri Botanical Gardens, USA)	Herbaria resources	http://www.tropicos.org
UNEP WCMC World Database of Protected Areas	World Database of Protected Areas	http://www.protectedplanet.net/
US Genetic Resources Information Network (GRIN)	Database of USDA *ex situ* genebank holdings	http://www.ars-grin.gov/npgs/acc/acc_queries.html
World information sharing mechanism on the implementation of the Global Plan of Action (GPA) for PGRFA (WISM-GPA)	Provides access to National Mechanisms' portals and databases on conservation and sustainable use of PGRFA	http://www.pgrfa.org