Meeting the information challenge for crop wild relatives *in situ* conservation: A global portal hosting national and international data on CWR.

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Abstract

Crop wild relatives (CWR) can be defined as wild species more or less genetically related to crops, but unlike them, have not been domesticated. CWRs are under major threat and continue to be seriously under conserved. Climate change predictions indicate that 16-22% of *Arachis*, *Solanum* and *Vigna* species could go extinct by 2055. Paradoxically many CWRs harbor genetic traits that could hold the key for crops to adapt to climate change. In this context, a global UNEP/GEF supported project involving Armenia, Bolivia, Madagascar, Sri Lanka and Uzbekistan, and coordinated by Bioversity International, was implemented (2004 – 2010) to enhance *in situ* conservation of CWR. The project included a major component on information management as baseline studies indicated this was a major gap for effective CWR conservation decision-making. During the project, all 5 countries brought together pre-existing and new data on CWR in one or more national databases, all based on the same set of descriptors. Pre-existing data was gathered in each country from a variety of sources, available in different electronic formats or often not even digitized. New occurrence data on CWR was gathered during numerous field surveys. Given the different national contexts and varying levels of expertise and use of software programs, all five national inventories have been designed according to appropriate national needs. Detailed information for hundreds of CWR species is now available. The national information systems are complemented by a global portal that provides access to CWR information at global level at www.cropwildrelatives.org . All national inventories are searchable through the portal. Further resources on CWR provided by the portal include publications, searches for projects and experts, news, images. The portal has been developed using a content management system (Typo3) which provides for ease of management and updating ensuring the portal remains an important global resource for those engaged in CWR conservation.

Introduction

In general terms, a crop wild relative (CWR) may be defined as a wild plant species that is more or less closely related to a particular crop and to which it may contribute genetic material, but unlike the crop species has not been domesticated (Heywood *et al* 2007). Crop wild relatives collectively constitute an enormous reservoir of genetic variation that can be used in plant breeding and are a vital resource in meeting the challenge of providing food security, enhancing agricultural production and sustaining productivity. CWR occur in a wide range of habitats but as numerous assessments testify, habitats continue to be lost or degraded across the world, putting many of these species at risk. Predictions are that 16-22% of CWR species studied could go extinct by 2055 under certain climate change scenarios (Jarvis et al, 2008).

It is essential that urgent steps are taken to conserve CWR both in the wild (*in situ*), where they can continue to evolve and adapt, and in genebanks (*ex situ*) where those species currently under threat can be safeguarded and the genetic diversity they contain made available. However, there are many factors that make this particularly challenging, especially *in situ* conservation. *In situ* conservation, as opposed to *ex situ* conservation, is a much more complex and demanding task, the scale of which should not be underestimated. While there are some successful examples of *in situ* conservation they are few.

These challenges are often most common in developing countries which also happen in many instances to be biodiversity-rich countries where great numbers of CWR exist. Although some of these countries have listed the conservation of CWR in their national biodiversity or agricultural development strategies, few possess the necessary capacity and funds to invest in the long-term programmes that are necessary to support effective CWR conservation. A UNEP/GEF supported project, '*In situ* conservation of crop wild relatives through enhanced information management and field application' (2004 – 2010), coordinated by Bioversity International, was specifically designed to address many of these issues and sought ways to meet national and global needs to improve global food security through effective conservation of CWR. Five countries were involved in this UNEP/GEF CWR project – Armenia, Bolivia, Madagascar, Sri Lanka and Uzbekistan – and a number of international partners provided resources and technical support such as Botanic Gardens Conservation International (BGCI), the Food and Agricultural Organization of the United Nations (FAO), International Union for Conservation of Nature and Natural Resources (IUCN) and United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC). The German Federal Agency for Agriculture and Food (BLE) also played a minor early role in the project.

CWR conservation and information management

The UNEP/GEF CWR project included a significant component on information management. Information management is an essential part of CWR conservation (Ford-Lloyd and Maxted 1997), but a major limitation most countries and agencies will face when implementing a CWR conservation programme is the capacity and tools to bring together and use information that does exist. A substantial amount of relevant and useful information often already exists both within different institutions in a country and in international sources but it is highly dispersed and difficult to bring together.

With this in mind the objectives of the UNEP/GEF CWR project were to develop National Information Systems (NIS) for CWR that include data on species biology, ecology, conservation status, distribution, conservation actions as well as a Global Portal on CWR, and to build the capacity of national partners to use this information for developing and

implementing rational and cost-effective approaches to conserving CWR *in situ*. There was also an intention to link the national systems to the CWR Global Portal.

The purpose of this paper is to outline how the information systems were developed, i.e. the 5 national information systems where each country presented unique local and institutional settings regarding the availability and management of information and technical capacities, and a CWR Global Portal. This paper will highlight the challenges faced and will draw some general conclusions in the form of lessons learned from these activities that might be useful to others considering future activities in this field.

Context prior to the implementation of the UNEP/GEF CWR project

Thormann et al. (1999) carried out a review on internationally available information sources for CWR and found an ever-increasing number of resources available on the internet and recommended their use to support the development of *in situ* conservation strategies. Further, a review of past and ongoing activities related to CWR, published in 2004 by Meilleur and Hodgkin, identified only two activities that fell into the category "information management (IM)". These were a Plant Genetic Resources (PGR) IM system created in Turkey which included *in situ* CWR conservation data fields (Tan and Tan 1998), and an existing protected area database in Paraguay that was populated with CWR information in collaboration with a United States Department of Agriculture – Agricultural Research Service (USDA-ARS) project (Meilleur and Hodgkin, 2004).

In carrying out a baseline survey before the UNEP/GEF CWR project, the countries recognized that relevant information was available to help them achieve their conservation goals but that it was usually dispersed and in a form that they could not easily access or use. In all partner countries information existed in herbaria and *ex situ* genebanks that could be used to determine the likely location of populations of CWR. Information on the extent and distribution of protected areas was also available from responsible agencies in the ministries of environment, forestry, and planning or similar. Institutions attached to ministries of agriculture, universities and colleges possessed information on CWR evaluation and utilization. However, in Armenia, Madagascar and Uzbekistan, little of this information was available in computerized form and in all countries most of the location data had still to be digitized. Where parts of the information had been computerized (Bolivia, Madagascar and Sri Lanka) the different agencies had developed independent systems with different data structures and formats. No country had information sharing procedures and agreements on sharing information between key stakeholders. In addition, none of them had a separate national CWR strategy or action plan to support *in situ* conservation. The only systematic information on CWR that had been generated by a project prior to the UNEP/GEF CWR project was one that produced the Bolivian Atlas on CWR, implemented jointly by Fundación Amigos de la Naturaleza (FAN) and the Museo de Historia Natural Noel Kempff, with the support of the Directorate General on Biodiversity and Bioversity International and in consultation with the New York and Missouri Botanic Gardens and Smithsonian Institute. The global UNEP/GEF CWR project however provided the framework and support for finalizing the atlas, which is now available at http://www.cwrbolivia.gov.bo/atlaspsc/ (Fig. 1).

Further, no example of a national inventory was available that could have served as a model to develop a national information system on CWR. No consistent set of data fields was available that described information on CWR adequately to conserve them. The existing capacity to use software tools and programs and pre-existing IT infrastructure varied considerably among the five countries. However, since it was the intention that national data compiled into national information systems would be made available from one unique access point, the CWR Global Portal, serious consideration was needed on how information from

different sources could be integrated in an appropriate way. Data provided in different formats from a variety of institutions, such as herbaria, genebanks, and nature protection agencies, ministries of agriculture or environment, within each country would need to be integrated. Apart from work on data quality, this would require new collaborations be established within the countries between institutions that had previously not worked together. Capacity to use GIS tools to analyze the data that would be collected during field surveys and to produce distribution maps, calculate potential distribution and so forth had to be further developed. Finally, as mentioned earlier, data needed to be digitized.

The implementation of the UNEP/GEF CWR project

An inventory of existing data and information sources had already started during the UNEP/GEF CWR project preparatory phase and was completed by the beginning of full project implementation. Identified important data sources available only in hard-copy format were digitized. The UNEP/GEF CWR project dedicated considerable time and resources to develop a list of descriptors describing the data types and fields considered necessary to capture all information that is useful in supporting decision-making processes for conservation actions, and these descriptors provided the basis for the content of national CWR databases. New collaborations between different institutions were established, including informal collaboration, formal and official national data sharing agreements. National training courses on GIS tools and data management were provided to each country by trainers well acquainted with the UNEP/GEF CWR project to target the training to the specific needs of the project. Systems were as far as possible embedded into existing structures, using readily available software for which the capacity existed in order to guarantee technical sustainability. As a result NIS are now hosted in national organizations with relevant capacity who are committed to maintenance, updating and long-term sustainability.

Implementation and solutions at national level

The establishment of the inventory varied from building up a web based system from scratch, to adapting existing Access databases through providing CWR to an already existing national data portal instead of developing a specific dedicated CWR national portal.

Armenia

Armenia has only a few experts on CWR, and information flow between experts did not present problems. Six institutions collaborated in the development of the national inventory and agreements for data exchange and collaboration were established in a straightforward and quick manner. Armenia developed a web-based system with PHP and MySQL with a data input mask used in the institutions that have CWR data. Data are sent from the institutions to the central database and data quality is checked prior to upload to the central database. In addition to *ex situ* records and occurrence data it includes plant images and red listing information as well as a GIS-based mapping functionality. Out of 6,930 distribution coordinates, 967 were collected during field surveys carried out during the UNEP/GEF CWR project. 2000 species are listed in the national inventory and detailed information is available for 104 species. The national CWR data is accessible for browsing at www.cwr.am (Fig. 2).

Bolivia

The Bolivian system comprises eight institutional databases distributed physically in each national institution that participated in the UNEP/GEF CWR project. From these institutional databases, data is made available to a national portal via web services. The databases contain approximately 3.220 records for 190 species from 15 genera of which 33 species are endemic to Bolivia. The data shared with the national portal is defined in data sharing agreements between the institutions and the national portal. Google Map has been customized to function as an integrated GisWeb and is integrated to the national portal, providing for the

visualization of distribution maps, maps of collecting sites etc. The Bolivian system website is available at http://www.cwrbolivia.gob.bo/index.php?option=com_frontpage.

Madagascar

Existing, digitized and new data gathered through field surveys is centrally stored in an Access database based on the CWR descriptors developed within the UNEP/GEF CWR project (Fig. 3). The database contains records for 282 taxa of 17 genera with nearly 2000 records. Among these are passport data of 524 specimens from two national herbaria and data related to *ex situ* collections of about 50 *Coffea* species, all of which were digitized, as well as 460 records gathered during CWR ecogeographic surveys carried out during the UNEP/GEF CWR project. Madagascar has chosen to customize an existing national data portal on biodiversity data, REBIOMA (Réseau de la Biodiversité de Madagascar; http://www.rebioma.net), for the publishing of CWR data at the national level rather than developing a new CWR web site. Data is uploaded from the national Access database to the REBIOMA portal. ArcGIS, DIVA-GIS and other GIS tools are used to map distribution of CWR, to predict potential distribution and to identify priority areas for species conservation. CWR data through the REBIOMA portal is expected to be available soon.

Sri Lanka

A database has been developed based on the CWR descriptors developed in the UNEP/GEF CWR project, called CWR Spatial Database ver. 1.00, with an elaborate input interface (Fig. 4). It incorporates a high level of data security through a multi-level access password based security system to avoid unauthorized access or changes in the database. It includes displays of spatial distribution of CWR data. Using Google Earth, it enables the user to generate maps overlaying eco zones, roads, districts, and site locations of Sri Lanka. Sri Lanka has set up a national web site about the UNEP/GEF CWR project at http://www.agridept.gov.lk/other_pages.php?heading=CWR, but the CWR data was not yet available from the national website at the time of writing this paper.

Uzbekistan

The national CWR inventory database in Uzbekistan was developed starting from two existing Access databases. It now contains information on CWR in *ex situ* collections from 6 research institutions (868 records on 31 species) and descriptions of more than 737 plants in 338 sites obtained through eco-geographic surveys, and maps of priority species. The *in situ* part of the database is developed based on the CWR field survey data collecting form developed in Uzbekistan at the beginning of the UNEP/GEF CWR project. The database can be searched online in English and Russian at www.cwr.uz/db/ (Fig. 5).

Implementation and solutions at global level

To provide the first one-stop-shop for CWR information, the UNEP/GEF CWR project developed a CWR Global Portal (Fig. 6). All five national inventories are searchable through a unique search function on this Global Portal. Furthermore, the CWR Global Portal provides links to international resources that provide additional information about the CWR taxa in the national inventories, information on projects, experts, institutions involved in CWR research, literature such as books, papers, theses and newsletters, and funding sources. News on CWR are a prominent feature of the home page and the discussion thread of a global CWR discussion group with over 300 members is captured in the portal. Guarino (2008) indeed advocates for the need of having such “news” on CWR, in addition to information derived from scientific literature.

An open source content management system (CMS) was chosen for implementation of the CWR Global Portal. A CMS allows the content manager of a portal, to focus straight on the content for adding and editing content without requiring knowledge about programming or

mark-up languages. As the CWR Global Portal is hosted and maintained by Bioversity International, it was most logical to make best use of existing software and capacity, therefore Typo 3 was chosen as the CMS for the CWR Global Portal, which is used for other Bioversity International websites.

The CWR Global Portal is a platform to which all users can easily contribute by sharing new information on experts, institutes, projects, funding opportunities, publications, by sharing their theses related to CWR or any comment they may have. It has been built in a way that is easily expandable to include additional national CWR inventories in its search functionalities. Data exchange with national inventories is based on a widely used standard, DarwinCore ver 1.4 (http://rs.tdwg.org/dwc/index.htm), and data can be provided either as CSV file or by setting up a connection using TapirLink. (http://wiki.tdwg.org/twiki/bin/view/TAPIR/TapirLink).

Conclusions

The process of making data available through digitization and compilation into one system has been a major collaborative activity at the national level as well as between countries and the global portal development team, and the international partners involved in the UNEP/GEF CWR project. This has resulted in comprehensive and context relevant national information systems which now act as repositories for new data on CWR, as reporting tools and as decision support tools for conservation actions on CWR, and in the establishment of the first global one-stop-shop for CWR information. The establishment of effective partnership in the countries among institutions that formerly had not worked together has been crucial to the successful development of the national inventories. A clear message being that it is essential to engage all major players in the area of content as potential contributors and users, in order to make the content provided as comprehensive as possible.

Further, being sensitive to the local context and embedding the newly developed national information systems well into the national context, building on existing capacity, infrastructure and ways of collaboration has shown to be a solution that best addresses issues of sustainability in the future.

The development of such a global portal requires continuous work to keep the content up-to-date, add new features and so forth. In terms of the CWR Global Portal there is a need to continue to identify further national and international sources of information, including integration of additional national inventories. With climate change and a growing interest in the genetic traits CWR offer for crop adaptation there is a need to consider how information on CWR evaluation and characterization can be identified and integrated into the portal. Unfortunately there is little information available on such evaluation. In light of this there is also an urgent need to undertake user-needs surveys with such target groups as plant breeders to ensure that the relevant information is presented and in formats that are acceptable and will be of value. In addition, the very limited practical experience in conserving CWR *in situ* to date means that there are no generally agreed protocols that can be recommended, and good practice is limited by the shortage of successful examples to draw upon. This means there are limited resources and training materials available for practitioners. The subject of training materials and capacity development will be a large focus of the ongoing development of the portal over the coming years. Here it is intended to put such resources on the CWR Global Portal drawing on examples of successful field based conservation actions from the UNEP/GEF CWR project in the five countries and elsewhere. A dedicated page for training has been allocated for this purpose. Finally, such maintenance and upgrading require money and Bioversity International will continue to seek funding and support for this purpose.

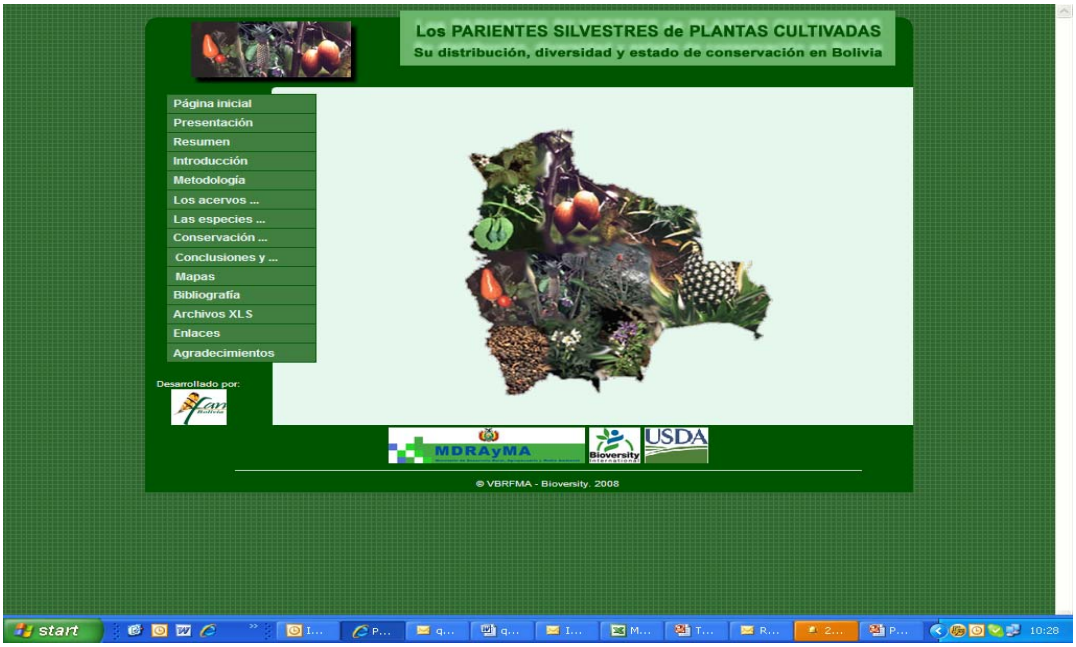

Fig. 1: Homepage of the Bolivian crop wild relative atlas

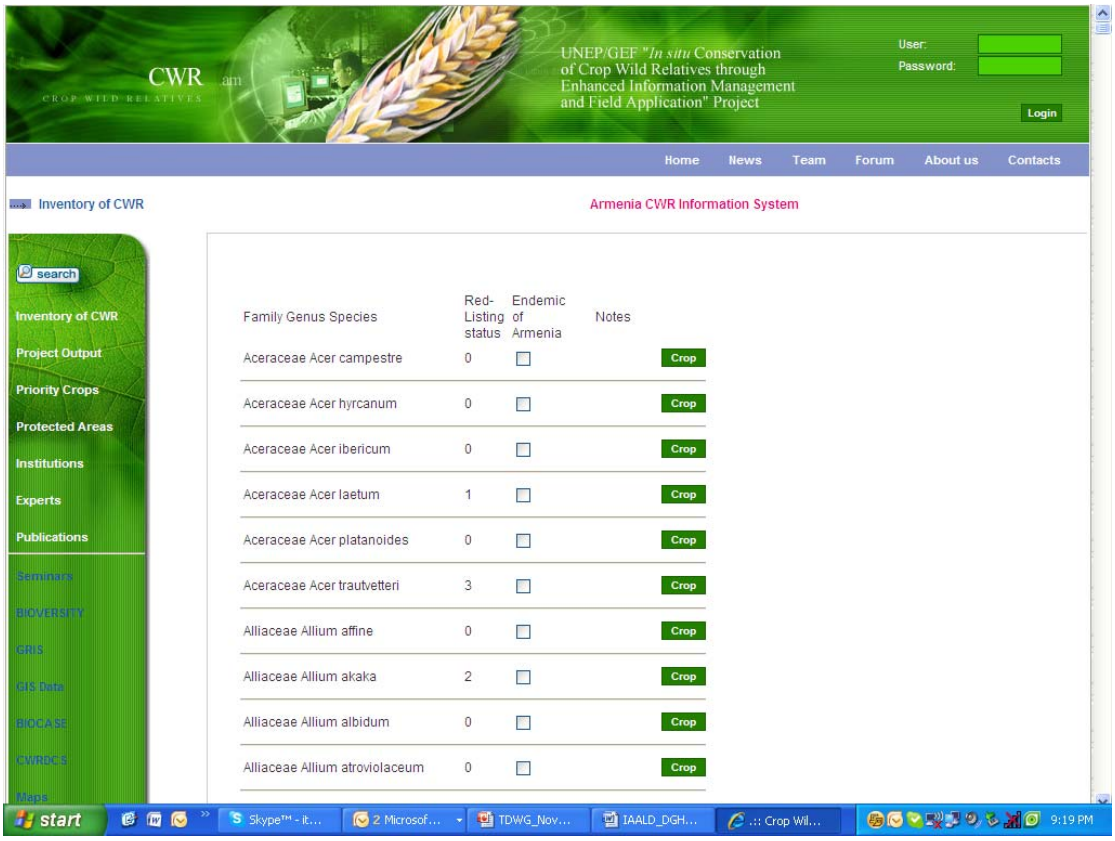

Fig. 2: Armenian crop wild relative web site; URL: http://www.cwr.am/index.php?menu=list

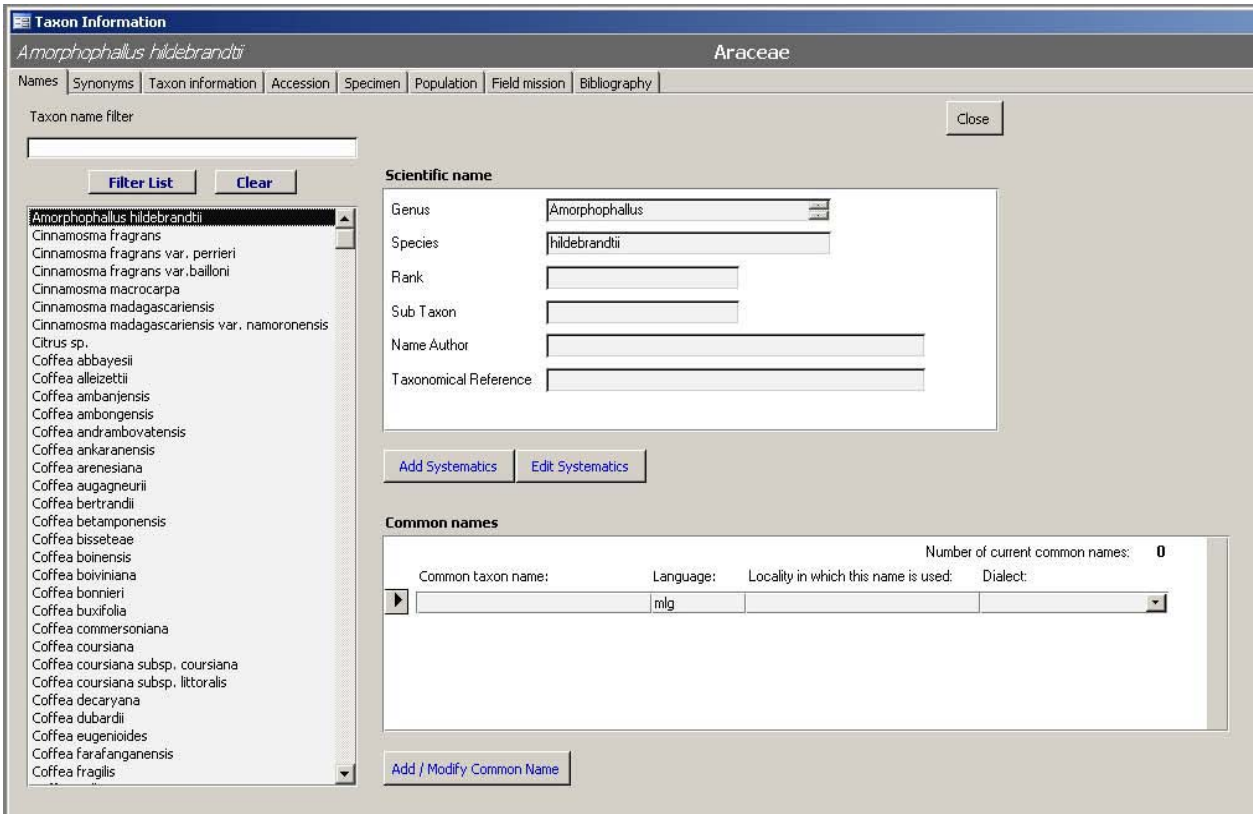

Fig. 3: Madagascar's Access database developed for managing crop wild relative data.

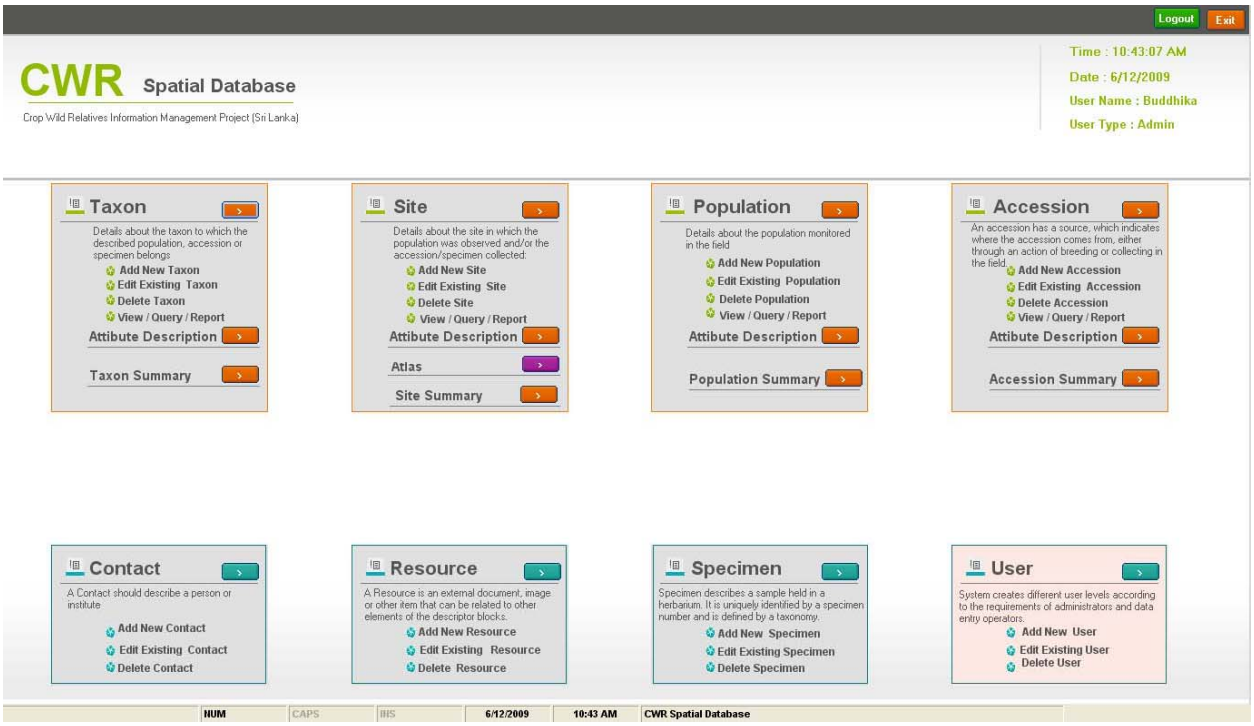

Fig. 4: Control panel of Sri Lanka's crop wild relatives information system.

Fig. 5: Homepage of Uzbekistan's crop wild relatives web site

Fig. 6: Homepage of the CWR Global Portal

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