Evaluation of ARCAD Flagship Project
Final report - 14.10.2013

1 Background

The overall aim of ARCAD (Agropolis Resource Centre for Crop Conservation, Adaptation and Diversity) is to set up an open multi-function platform devoted to the assessment and improved use of plant agrobiodiversity in Mediterranean and tropical regions.

ARCAD is supported by Agropolis Fondation and the Région Languedoc-Roussillon (France). It is being jointly developed by CIRAD, INRA, IRD and Montpellier SupAgro. The ARCAD programme includes three components: Infrastructure, Equipment, and Scientific project.

The scientific project of ARCAD was initially funded for four years from 2009 by Agropolis Fondation to the tune of EUR 3 million. The project duration has been extended by one year and will end in June 2014. About 80 scientists are involved in the scientific project activities. They are mostly permanent staff of two research units, AGAP and DIADE and three research institutes (INRA, CIRAD, and IRD). ARCAD also involves scientists belonging to other institutions in Montpellier (CNRS), as well as French and foreign partners.

ARCAD's scientific agenda focus on the study of the history and patterns of crop domestication and adaptation as well as on the analysis of key parameters underpinning adaptation and diversity, at various time scales, through studies of evolutionary genomics, population genetics and social sciences. This thematic focus, as well as the geographical focus on Africa and the Mediterranean Basin, was strongly encouraged during the maturing phase of the programme by Agropolis Fondation’s Scientific Council.

2 Organization of the review

The review of the Agropolis Resource Centre for Crop Conservation, Adaptation and Diversity (ARCAD) project funded by the Agropolis Fondation was carried out from 5-7 June 2013 at the Agropolis campus, Montpellier, under the terms of reference described in Annex 1. The composition and biodata of the review team are given in Annex 2.

Prior to the review meeting in Montpellier, the review team has received the document “Progress report October 2009-May 2013” of the ARCAD project. During the review meeting, the project coordinator and project leaders of the seven sub-projects made presentations in which they provided additional information on the progress of their sub projects. The review team also had the opportunity of meeting with project partners face to face and this allowed the review team to identify a series of issues for follow up with the sub-project leaders.

The review team also had a meeting with the Director of Agropolis foundation, Dr Anne-Lucie Wack, who gave a very good overview of the context in which the Fondation agreed to commission the ARCAD Flagship programme. She made a specific request to the review team to analysis the extent to which the ARCAD project has promoted the collaboration between the participating Research Units (UMR) in conducting a coherent research set of activities in a participatory way, as well as to recommend sustainability of the ARCAD project in the future.

3 General comments, project management, quality of leadership

The evaluation committee recognizes the full worth of the ARCAD project whose main objective is the development of an innovating scientific project centred on the processes of domestication of tropical and Mediterranean plants using, on the one hand, new technological and bioinformatic tools such as next generation sequencing and, on the other hand, a deep integration of social and human sciences for the assessment and management of genetic resources.

This project efficiently contributed to the development of common resources for sequencing and genotyping: rationalisation of molecular biology tools for the analysis of genetic material, and bioinformatic platform, bringing together the different partners of ARCAD project.

The project was supported by the Agropolis foundation as a five-year Flagship program funding four scientific sub-projects, two support sub-projects and one training task.
The ARCAD initiative took advantage of the local heritage in terms of scientific knowledge, collections and networks combining research, action and training on the tropical and Mediterranean genetic resources. The project is a major element for the consolidation and development of this material and intellectual capital.

The Committee commends the action of the consortium direction and welcomes its members for the energy invested in the project and the management. Much of the success of the first phase of the project is largely related to this investment. ARCAD is at a crucial moment in its history. Future successes will depend on the ability of young scientists to mobilize for future projects.

4 The three main SP

4.1 Comparative population genomics (SP1)

The aims of the sub-project 1 are (1) to conduct comparative analyses of the effect of domestication on genome evolution in different crop species, (2) to investigate the genomic selective patterns among angiosperm species and possible causes of variation, (3) to investigate in more detail how genes functionally evolve in the different species.

The review team wishes to highlight that it is impressed by the amount of work that is carried out by relevant UMR staff in Montpellier as well as in the South. It also acknowledges the high quality of most of the work and its relevance for the programme as a whole.

The project has generated a unique dataset about crop evolution, domestication and brought new knowledge about the evolution of plant genomes. More than 13 billions sequences have been produced, stored and pre-processed. The review team notes that this has required significant support of biometricians and Bioversity partnership. This is one of the best occasions where collaborations with external organisations has occurred in the project.

The outcomes confirm the potential of genome-wide approach (extrapolated from previous developments in model organisms such as man, mouse and Arabidopsis) in the context of the plant genetic resources, including orphan species in terms of full genome sequencing.

The sub-project takes advantage of the very good local expertise in population genetics. The valorisation of each genetic resource is strength of the project. However, the focus on the population scale is not always fully justified. More explicit hypotheses, more collaboration with external teams working on similar species and an integration of concepts and methods across the different species could add further added value to the sub-project.

4.2 Crop adaptation to climate change (SP2)

SP 2 focused on the genetic and evolutionary mechanisms involved in local adaptation to spatially heterogeneous and temporally variable climatic conditions. The team develop high throughput genome scan on two kinds of samples across climatic and temporal gradients using three model species (African rice, Millets and Medicago) and one single adaptive trait (flowering time). The project compared efficiencies of different innovative methods for detection of selection for genes involved in adaptation along environmental gradients, by using QUANTINEMO simulation approach to generate datasets for comparison. The project showed that methods based on genotype-environment correlations were substantially more powerful to detect selection than differentiation-based methods. This study allowed the formulation of a general guideline for selecting a method to detect footprint of selection. Efficient and strategic partnership with American research teams working on the same topic is appreciated.

These results are very interesting both in terms of benchmarking of the methods of identification of signatures of selection and in terms of identification of candidate genes with a special emphasis on flowering - a trait highly related to resilience to climate change.

As in the previous project, it would be particularly interesting to compare the results obtained by genomic wide approaches to other knowledge on the genetic basis of domestication syndrome in targeted species. A comparison of the results with previous QTL studies would help to generalize the results of the SP2 project. Intended integration with SP3 should lead to fruitful interactions and a better assessment of South realities.
4.3 Cereals in Africa (SP3)

The objectives of SP3 are the comprehensive understanding of wild and cultivated cereal diversity at a continental scale, the investigation of potential diversity hot-spots for cultivated and wild populations to refine in situ conservation approaches and the development of a multi-stakeholder research network on underutilized crops.

The integrative nature of the process is impressive both in terms of intention and methods. Local realities are properly integrated in the SP and choice of species is relevant. The approach is however mainly descriptive. A stronger impact will need a special attention to the drivers of the farmer action (economic but also cultural and social dimensions).

The SP could be a reference in terms of integration of natural sciences and social sciences. Considering the number of datasets and studies, a clear challenge for this SP is the finalisation of the different case studies. A clear planning should be quickly defined in order to avoid half-baked research. From a strategic point of view, it is uneasy to make sense of the diversity of the case studies. The scale of the different case studies is also very heterogeneous.

4.4 Global remarks on the three main SP

The Committee commends the high scientific quality of the results produced by the three SP, which are generally the best state of the art. The three programs have produced a wide variety of innovative results that merit further integration. Most of the research is elegantly built on extant expertise and opportunities. A real effort was produced for extension to new contexts or species. Collaborations between SP are still relatively limited, but all teams seem to be clearly motivated to bring added value through collaboration between SP members.

The multiplicity of thematics and the differences of scales are a real challenge for the future of ARCAD. It will probably require a capacity for making choice driven by a better identification of the specific assets of the members of ARCAD. In order to address these issues, the organisational and motivational leadership observed now will probably evolve towards a more strategic leadership. As ARCAD made the proof of concept of the high level performance of Montpilleran teams, a further step will probably be a improved strategic approach of the research directions with the strengthening of the areas (disciplinary and interdisciplinary) were the added value of the ARCAD members is the highest.

5 The support SP

The mobilisation and/or implementation of support functions within ARCAD are high level and strongly contribute to the quality of the outputs of the project.

5.1 Bioinformatics (SP4)

Considering the topics and ambitions of ARCAD, a full bioinformatic support is required. The implementation of this SP is based on two dimensions: a support to the community in a collaborative approach (based on the Galaxy portal) and the development of original new research topics (such as Greenphyl and Southgreen). Both dimensions are well answered.

The way the structure is organised, the status of the participants to the bioinformatics project (still attached to their original research team or detached to the bioinformatic SP) requires some clarification. The evaluation review has difficulties to understand whether ARCAD is the « maître d’œuvre » of the Bioinformatic platform or only one out of many sponsors and users. The targeted audience of the service is fuzzy. A clear and quick answer to this question is a key element for improving the recognition and international visibility of the bioinformatic output. It will probably require explicit strategic choices from the ARCAD governance.

5.2 Pangenomic study of diversity through the reduction of genome complexity (SP5)

This SP is in a temporal and thematic intermediate state making evaluation rather tricky. Very few outputs are available at this stage. A better positioning in the global scientific and organisational structure is required.
5.3 Towards a DNA bank: Facilities for plants DNA manipulation: purification, quality control, storage and management (SP 6)

The SP 6 was implemented to optimise the processes of production and conservation of nucleic acids required by sub-projects SP 1 to SP 3. The long-term objective is to contribute to a DNA bank for the maintenance of research collections but also for the sharing and distribution of genetic resources to national and international partners. The technical and methodological developments are high levels.

The review team commends the work of ARCAD in developing and refining DNA extraction methodologies. The quality and relevance of methodologies makes available a remarkable workflow taking into account the diversity of species and usages. The laboratory is leader in this domain and the Committee expects that further trainings and other actions will contribute to a wide dissemination of this know-how.

As the DNA bank has two dimensions (provide new data for research and build knowledge for the conservation dimensions), the expectations of ARCAD consortium on these two dimensions should be made explicit in a collaborative but also competitive positioning. Promising partnerships may be considered.

It is recommended that ARCAD should consider the testing of international genebank management system such as GRIN-Global for managing its collection and also establishes linkages with other databases or information system at European (e.g. EURISCO) and global levels (e.g. GENESYS).

The question of germplasm exchange and material transfer and access and benefit sharing agreements are still undeveloped and should be pursued, especially in linking with International Treaty on Plant Genetic Resources for Food and Agriculture. This is becoming increasingly important, as there is a greater need nowadays for sharing germplasm across national boundaries. ARCAD is exactly the right scale to “nourish” activities such as the SP 6 and, on the other way round, SP 6 is a constitutive element of the integrative nature of ARCAD.

5.4 Cryoconservation (SP 7)

SP 7 focuses on cryopreservation research activities on yams and 12 other species and the development, testing and application of cryopreservation protocols for these species. The review team fully recognises the importance of this work in view of the establishment of a Biodiversity Resources Centre (BRC). It recognises the importance of the research work in developing new cryopreserved protocols for their successful cryopreservation of resources, which will subsequently populate the BRC. The activities described have produced some ground-breaking results in the area of cryopreservation research. An example is the work on histological studies on yam shoot tips, which has helped to elucidate the reason for cellular plasmolysis occurring during cryopreservation of yams.

The area of work on ‘cryotherapy’ is an important topic and merits greater attention in future as this work would help not only in reducing the loss of genetic material, but also help in supplying disease free materials. Supporting research in this area would add much value to the BRC as a centre where threatened germplasm could be salvaged using cryotherapy.

Partnerships - This activity is principally led by a single scientist in IRD; however the work has involved a large partnership involving scientists from CIRAD (with histological studies on yam shoot tips), which has helped to elucidate the reason for cellular plasmolysis occurring during cryopreservation of yams, IITA and INRA Guadeloupe.

Training - The project reports that individual training in cryopreservation techniques have been undertaken, the review team feels that with the development of the cryopreservation facilities using the latest state of the art techniques, the ARCAD initiative has the opportunity to develop as a centre of excellence for training in cryopreservation both nationally and internationally. Collaboration with other centres of excellence in cryopreservation should be further explored e.g. with University of KwaZulu-Natal South Africa, USDA National Center for Genetic Resources Preservation Fort Collins USA, National Bureau for Plant Genetic resources (NBPR), India and RDA Genebank South Korea.
5.5 Training (SP 8)

The training part of the project is centred on the evaluation, management and conservation of genetic resources for the tropical and Mediterranean plants.

Training is based, and should be pursued, on the recognized expertise of ARCAD on given plant species and specific techniques such as bioinformatics, DNA analysis, cryoconservation. In terms of scientific disciplines, the strengths of the ARCAD project in a training perspective are population genetics, population genomics, genetics of adaptation, combination of social and biological sciences and implication of stakeholders.

The relevance of the organized Summer schools is high for the targeted public (MSc and PhD thesis) in both South and North location.

For the future, specific attention should be paid to better links with other structures: Eurisco (Europe), Genesys (international). On the strengths (see previous paragraph), the Montpelieran pole is legitimate in terms of expertise and means (collections, infrastructure, knowledge and staff). There is a high potential to develop in and out of the Montpelieran pole.

The growing identity of ARCAD, gained during the first phase of the project, may become more visible by the organisation of seminar and training organised by the ARCAD consortium but as well by the participation of its members to extant activities especially in the Montpelieran context (MSc, doctoral schools,).

6 The infrastructure side of ARCAD

An infrastructure project will be built in 2014 to host conservation and management facilities for seeds, a cryoconservation lab, a DNA bank, an information system and a documentation and communication centre. This new infrastructure project is essential for the conservation of the unique collections of genetic resources of Montpellier and justified by both the long-term heritage on genetic resources and the newly developed expertise where ARCAD is a key element. A clear articulation of this project with other national and international initiatives is crucial as the scope of the project and the community of potential users are wider than the ARCAD project. The challenge is complex and will require a coordinated definition of expectations and will lead to an increased visibility of Montpelier know-how and reinforce the relevance of the investment in ARCAD. This infrastructure is a key element of the sustainability of the ARCAD dynamics. ARCAD is based on a complementarity of scientific and support dimensions and the infrastructure project follows the same lines. The synergy is evident and relevant. A high impact on future research projects and partnerships is expected.

As the evaluation focused on the scientific outcomes of ARCAD, a limited time was devoted to discussion on this infrastructure project. The development of new facilities to host ARCAD activities is considered a necessity to ensure sustainability of the ARCAD initiative. The review team agrees that the facilities would significantly help to integrate the research and adopt common standards for the conservation of biological resources among members of the ARCAD Consortium. While this objective is laudable, it is still unclear on how the management of these facilities will be undertaken. It is recommended that a “management” or “steering committee” be established to oversee the management of such Biodiversity Resource Centre, best based at an independent agency such as the Agropolis Fondation. All relevant members of the ARCAD Consortium should be represented. It should also include a member from a relevant regional (e.g. AEGIS) or international organisation (e.g. CGIAR centre), to provide advice.

7 General conclusion

ARCAD 1.0 has proven to be a new innovative way for the different research team based in Montpellier to work together on common research ideas in a coherent cost effective manner and at the same time represents an important investment of Agropolis Fondation. ARCAD makes the clear demonstration than a multi-institutional project is not only possible but also fruitful and provides a high added value. The evaluation team believes that the proof of concept of such an integrative project has been achieved, although there is room for future improvements, as discussed. The Agropolis Fondation should be credited of this achievement.

Based on the local intellectual and material assets, a new ARCADian identity was built. Considering the investment in the project, the scientific outputs, the national and international visibility, the
committee strongly recommends the support of a new phase of development of the project. The inherent capacity of scientists and the first results paves the way for a promising future for this research structure in term of scientific outcomes, management of genetic resources and training.

Looking ahead for the future, the Evaluation Team proposes ARCAD to take the following issues into account in its future development:

- **Consolidate the achievements of the first phase of the project** through peer-reviewed publications, providing visibility of the results in conferences, websites, journals, magazines, and other media.

- **Strengthen the scientific governance of ARCAD with clear strategic choices** made at the Consortium levels based on the different SP. On the duration of the project, some SP may be more relevant than others and strategic orientations have to be made.

- **Further develop the training dimensions of the project** based on the recognized expertise of ARCAD on assessment and conservation of plant genetic resources. The growing identity of ARCAD, gained during the first phase of the project, may become more visible by the organisation of summer schools, seminar and training organised by the ARCAD consortium.

- **Consider the expansion to new partnerships beyond the boundaries of Montpellier**. The promoters and actors of the project transcend the institutional limits of the complex Montpellieran research community. They demonstrated a capacity of structuration of the research activities in order to deliver original research outcomes. The collaborative effort should open new avenues for a shared and interactive use of multispecies genetic resources as well as to integrate other teams specialised on similar thematics such as CNRS ones.

- **Build on the ARCAD identity**. Based on the Montpelieran intellectual and material assets, a new ARCADian identity was built bringing fresh air and new motivations to the community. Considering the investment in the project, the scientific outputs, the national and international visibility, we do hope than a new phase will open for built on this first steps. The inherent capacity of scientists and the first results paves the way for a promising future for this research structure in term of scientific outcomes, management of genetic resources and training.
8 Annex 1: Review criteria

8.1 General criteria for flagship programs

- Quality, originality, innovativeness and relevance of research and capacity building activities;
- Quality and relevance of local, national and international partnerships involved;
- Extent of interactions and interdisciplinarity developed
  - Integration (from genes to systems, up to the final use of products)
  - Inter-disciplinary approach (biological sciences, engineering and social sciences)
  - Interactions between temperate, Mediterranean and tropical issues
- Contribution to international attractiveness and visibility
- Quality and relevance of any output and deliverables to date; contribution to socio-economic and sustainable development issues
- Adequacy of human and financial resources; value addition of the financial support from Agropolis Fondation as compared to other sources of funding
- Quality and effectiveness of project management; quality of leadership
- Leverage effect of the project in terms of generation of new partnerships and projects, and complementary resources
- Relevance of the FP development perspectives in terms of scientific objectives and partnership.

8.2 Specific criteria for ARCAD

- Added value of ARCAD in terms of structuring effect of the Agropolis scientific community working on agrobiodiversity theme;
- Relevance and quality of capacity building activities (students trained, post-doctoral fellow recruited, training sessions organized);
- Role and position of ARCAD in the national system of plant genetic resources conservation and analysis, as well as in the European and international environments;
- Ways for the positioning of the future resources center towards the scientific strategy of the Agropolis research units and institutions.
9  Annex 2 : Composition of the review committee

The review committee comprised three persons:

Philippe Baret, Professeur, Université catholique de Louvain (Belgium)
Joël Cuguen, Professeur, Université de Lille I
Ehsan Dulloo, Leader, Conservation and Availability Programme, Bioversity International (Italy)

Observers attended the different meetings:

Daniel Barthélemy and Jean-Louis Noyer, CIRAD
Anne-Françoise Adam-Blondon, INRA
Marie-Christine Cormier-Salem, IRD and Scientific council of Agropolis Fondation
Claire Neema, Montpellier SupAgro
Mamadou Billo Barry, IRAG, Guinée