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Working Paper

Sustainable Agricultural Development of Highlands in Central, West Asia and North Africa

Elements of a Research Strategy and Priorities

Synthesis of Regional Expert Meeting on Highland Agriculture
November 2011, Karaj, Iran.

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Feedback: ICARDA welcomes comment on and feedback on this publication. Please visit icarda.org/ to share your views and ideas.

Key words: Highlands, mountains, ICARDA, CWANA, sustainable development, natural resources, climate change, diversification

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CONTENTS

Executive Summary

The objective of this report is to review the current status, constraints and potential of highlands in Iran, Morocco and Turkey and to define elements of a research strategy and ICARDA's research priorities for sustainable agricultural development in the highlands of the Central and West Asia and North Africa (CWANA) Region. The highlands of Iran, Morocco and Turkey are seen as three platforms to review and assess the potential and constraints facing sustainable agricultural development and help prepare collaborative regional research projects on highlands of the region.

The report presents a synthesis of the results of a Regional Expert Meeting on Highland Agriculture held in November 2011 in Karaj, Iran. The meeting convened working groups on:

- Natural resources management and climate change
- Socio-economic and policy issues
- Diversification and integrated production systems

A review team proposed research priority areas and received comments and feedback on the highland research priorities from leaders of national agricultural systems from participating countries and other participants from advanced research institutes and international organizations. The working groups' recommendations are included here.

The authors hope that this comprehensive review of highlands in Iran, Morocco and Turkey, and the resulting proposed elements for an agricultural research strategy and the priorities for highland agriculture will provide useful background information and a scientific framework to enhance collaborative research projects and more investment for sustainable agricultural development of the highlands in the CWANA region.

Introduction and background

Highland and mountain agriculture play an important role in enhancing food security and environmental sustainability in many countries of the world. Since the United Nations Conference on Environment and Development in Rio in 1992, the international community has become more aware of the urgent need to enhance their collaboration on sustainable development of highland and mountainous regions of the worlds. The studies carried out since the Rio meeting demonstrated the importance role that the mountain and highland regions could play in alleviating poverty, enhancing food security, protecting unique natural resources, reducing the risk of floods and protecting the siltation of dams throughout the world. Presently, 12% of the world population lives in mountainous and highland regions from which, 80% live below the poverty line, 37.5% are food insecure and around 20% are hungry. This also reaffirms the importance of sustainable development of highlands and mountainous regions on food security and poverty alleviation in many areas of the world.

International Center for Agricultural Research in the Dry Areas (ICARDA) is mandated to enhance research activities in partnership with national agricultural research systems to generate technologies for sustainable agricultural development of highland areas in the CWANA region. But, due to harsh climatic conditions and low accessibility in many countries, highlands have not yet received due attention from donors and international and regional research communities. This study is commissioned by ICARDA to assess the current status of agricultural research and technology development in the highlands of 3 countries of Iran, Morocco and Turkey, as case studies to review the highlands in various agro ecological zones, and to propose elements of a research strategy and research priority areas for sustainable agricultural development in highlands of the CWANA region.

According to the geographical information system studies done by ICARDA, highlands constitute about 27% of the total land area of the CWANA region and make up a large portion of agricultural land in Afghanistan, Algeria, Armenia, Azerbaijan, Iran, Georgia, Kirgizia, Morocco, Pakistan, Tajikistan, and Turkey. Highlands, as defined in this report, are areas with elevation of more than 800 meter above the sea level and rugged terrain with cool to extremely cold

ICARDA's partnerships for developing highlands agriculture

The International Center for Agricultural Research in the Dry Areas (ICARDA) places a special emphasis on enhancing agricultural research and developing suitable technologies for sustainable agricultural development of the highlands in Central, West Asia and North Africa.

In 1978 ICARDA, at an early stage of its inception, planned to focus its research activities in two main research stations – one in a low-latitude area and the other in a highland region of West Asia and North Africa. Due to unforeseen political changes in the region and lack of financial resources, the establishment of a main research station for the highland regions did not take place.

Since then, in close collaboration and partnership with the countries with vast highland areas – including Afghanistan, Azerbaijan, Georgia, Iran, Morocco, Pakistan, Kirgizia, Tajikistan and Turkey – considerable research has been done on highland agriculture. Due to the harsh and marginal environmental conditions, socio-economic constraints and lack of comprehensive policies, in these agro-ecosystems, highlands areas have not yet received due attention in spite of their important role in improving food security and environmental sustainability in the region and beyond.

winter. Agriculture is mainly based on dryland production system with winter and facultative wheat and barley as the main crops. In many rural areas still traditional small ruminants –pastoral production system is a very common practice. Also, crop production system based on wheat-wheat or wheat-fallow rotation is predominant production systems under rainfed condition. However, limited areas in moderate to cool temperature regions are under cultivation of wheat or barley in rotation with food legumes.

Highlands are rich in agro-biodiversity and genetic resources which are being increasingly threatened by overgrazing and urban expansion. Highland areas are also the main source of water resources required for agriculture, industries and domestic use of increasing population living in the cities located at the downstream. However, highlands in many countries have not yet been given due attention by policy and decision makers and are generally facing high rate of rural poverty, low agricultural productivity, rapid rural migration, frequent drought and increasing water shortages which are also being exacerbated by degradation of natural resources and the impact of climate change.

Soils in highlands studied are usually low in nitrogen and organic carbon content (less than 0.6 percent) and generally need basal or topdressing application of N-fertilizer for viable and economic agricultural production. Soils are mostly deficient in micronutrients such as Fe, Zn and Cu and are usually calcareous with calcium carbonate equivalent of more than 15 percent. The available potassium content is usually medium to high and the amount of available P is variable depending on the prevalent crop production system. Water erosion as sheet or rill is very common on steep slope cultivated land. In many highland regions of the 3 countries reviewed, lack of a holistic policy, adequate investment and generation of suitable technologies to alleviate rural poverty, promote employment, enhance agricultural productivity and diversification, improve utilization of natural resources (water, soils, rangelands, forests and biodiversity) and alleviate the impact of climate change are the major issues to be addressed .

In Iran and Turkey where more than 70% of the territory is located in highland regions, many national and provincial research institutes or centers are involved in conducting agricultural research. But, in Morocco where highlands constitute about 40% of the total land area, the institutions conducting agricultural research activities in highlands are limited. However, in all 3 countries, no specific development policies for highlands have been formulated. Most of the technologies developed are tailored to enhancing agricultural production under irrigated condition and achievements made in developing new high yielding cultivars of crops such as bread wheat, barley, maize, sugar beet, potato, forages and other crops under high input agriculture and irrigated faming systems are relatively more prominent.

In many highland areas of the 3 countries studied, the yield gaps between the research stations and the farmers' fields are still relatively high and adoption rate of improved cultivars of crops and new agronomic practices are low, particularly under dryland farming system. Furthermore, there are still many research and technological gaps to be dealt with in dryland areas, particularly in cold to very cold highland regions.

Generally, a large number of data and knowledge on the highland ecosystems and their communities are available, however, syntheses are still rare, data is dispersed and results are limited to specified localities. There are little integrated interdisciplinary approaches and generally little local community participation to the conception and implementation of research programs. Also, there is still a lack of knowledge and research gaps on integrated natural resource management, i.e. water, soil, range and biodiversity as well as on social and economic issues. Lack of information and adequate awareness on the effect of climate change and increasing drought on agricultural productivity and livelihoods of the inhabitants are very common in many regions. Highlands are generally suffered from a lack of holistic policy and research assessment criteria. For example, many studies on soil erosion and its dynamics have been carried out in Iran, Turkey and Morocco, but they mostly need to be articulated by elaboration of specific models for evaluating arable land losses and a system of monitoring and assessment of its dynamics on soil productivity. Although, there have been many attempts to answer question relative to managing rangelands, there are still very limited research driven projects on the ground to rehabilitate rangelands in various agro-ecological zones and to promote their sustainable utilization taken in to account the potential carrying capacity.

Highlands research and technology areas that need more attention

1. Developing suitable crop varieties of wheat, barley and chickpea for cold to very cold highland regions.
2. Developing suitable technologies for enhancing conservation agriculture under various farming systems prevalent in the cold to very cold highlands.
3. Promoting diversification of production systems to increase income of rural communities and small farmers, i.e. inclusion of horticulture, vegetables, medicinal and herbal plants, honey bees, etc into their farming system.
4. Enhancing integrated natural resource management, i.e. soil, water, range, biodiversity, etc and alleviating the impact of climate change on agricultural productivity, natural resources and livelihoods of the inhabitants.
5. Enhancing soil and water conservation practices in various farming systems as well as adaptation measures to combat frequent drought and increasing water scarcity.
6. Promoting integrated production systems such as crop -range- livestock production system.
7. Enhancing farmer's income and access to local and regional markets and trade.
8. Resolving socio-economic constraints facing adoption of available technologies by small resource farmers and herders.

Moreover, developing elements of a research strategy for highlands of the region is very essential to clearly define the research priorities and to strengthen partnership among all stakeholders at the regional and international level. The main goal of the research strategy in the highlands should be to improve agricultural productivity while preserving natural resources. It should also promote integrated technical, institutional and policy options that are effective for increasing farmer's income and improving their livelihoods resiliency. For this purpose, it should also improve the ability of the actors in the highlands to adapt to changing institutional, economic and environmental conditions.

Therefore, through the course of this study, elements of a research strategy for strengthening national, regional and international collaborative research projects and enhancing agricultural productivity as well as promoting sustainable use of highland resources have been developed. Also, a set of research priorities areas for 2012-2016 on (i) natural resource management and climate change (ii) socio-economic and policy and (iii) integrated and diversified production system have been defined based the outputs and recommendations of the 3 Parallel Working Groups organized during The 1st Regional Expert Meeting on Highland Agriculture held in Iran on 19-21 November 2011. Defining the research priority areas should be an evolving process as new and important issues may arise from stakeholder demand or from the analysis of research results themselves and, therefore, the process should be updated regularly.

In the end , it is strongly recommended that ICARDA and the NARSs involved as well as the relevant international agricultural research centers affiliated to CGIAR, advanced research institutes and international organizations and donors undertake crucial and concerted efforts in mobilizing all necessary human and institutional resources for successfully implementing t collaborative research projects aimed for sustainable development of the highland regions in various agricultural zones of the CWANA region.

1. Elements of Highland Research Strategy

1.1. Goals and objectives

The goal of a research strategy in the highlands is to improve agricultural production systems that alleviate poverty while preserving natural resources. It should produce integrated technical, institutional and policy options that are effective for increasing farm income and improving natural resource management. For this purpose it should improve the ability of the actors to adapt to the changing institutional, economic and climatic conditions in highlands.

1.2. Approach and Methods

In order to contribute to poverty alleviation, it is important to understand livelihood strategies of the poor inhabitants of the highlands. Research needs to find solution to the question of poverty alleviation while conserving natural resources. Research need to focus on win-win solutions and when it is not possible it should develop trade-offs between all stakeholders. To address the multiple factors that affect highland development, research should be holistic. However, it needs to focus on the interactions of critical factors and answer specific questions in contextual conditions including economic, social and institutional conditions. The approach should be integrated and should embrace multiple scales of interventions and responses (Campbell, B. M., et al, 2006).

Given the wide diversity of highlands and mountain agriculture and the complexity and complementarities of research domains involved, the adoption of an integrated, multidisciplinary and participatory research-development approach is required that empowers mountain or highland community people (ICARDA, 2007). In order to ensure that highland inhabitants partners are not only passive beneficiaries in research endeavors or project development, research process should be firmly driven by the users of the research results and make sure that research partners' goals and objectives are not loosely defined but share identified problems and joint desire to have an impact (Campbell, B. M., et al, 2006). For that purpose, local communities should participate in the conception, implementation, monitoring and assessment of research results. This strategy should build on the experience of ICARDA which has already developed participatory and community-based approaches of wide application to incorporate user perspectives into technology development and transfer. This increases the efficiency and effectiveness of the agricultural research at the community and national levels (ICARDA, 2007).

To apprehend the complexity of research in highlands, it is necessary:

1. To use cutting-edge science, technology, and advance approaches to complement conventional approaches. Modeling could be a significant tool to apprehend the complexity of the eco-systems in highlands;
2. To exploit remote sensing, geographical information systems (GIS) and databases tools for characterizing and assessing the evolution of highland communities, institutions and natural resources;
3. To promote synthesis, coordination and integration of different research fields;
4. To ensure a better circulation and accessibility of research information. This can be done by using an accessible format for highland communities, managers, medias and the public;

5. Use models to assess the impacts of social, economic and environmental changes on highlands eco-systems.
6. Use holistic approach in designing strategies and projects.

1.3. Scaling up and out research results:

As research is context bound, it is judicious that it can be generalized across a wider set of situations as well as be able to explain the specific context. This requires careful research design in at least 2 levels – at a given site and across sites. Choices of research design and comparative frameworks across sites should enable the understanding of major causal factors, related conditions, and/or demonstrate diversity through case studies. The scaling up should be a part of the research process as any change (technological, institutional and/or policy) is brought about by the configuration and actions of networks of stakeholders in an innovation system for highland development (Campbell, B. M., et al, 2006).

1.4. Strengthening research capacities

1. Competent and committed human resources are key elements for the success of implementing this strategy. The strategy should emphasis on the development of specialized human resources in research disciplines linked to the strategy adopted and on the development of suitable conditions for their productive and constructive engagements in research activities;
2. Critical supports of development and strengthening finance, equipment, and executive authority of research institutions and centers in highland areas;

   Collaboration among official and influential organizations as well as organizations with the capacity to mobilize resources, service providers, technical specialists in relevant aspect of research and development, and the beneficiaries of the interventions should be emphasized (Campbell, B. M. et al, 2006).
3. Avoid research duplication and seek complementarities and synergies within each NARS system and between NARSs and international research centers, in particular ICARDA. This would enable the efficient use of scarce resources available. Indeed research result in one action site could be used by different countries. However, for the partnership to succeed it is necessary to build long term commitment from all partners. This requires precise definition of the research programs and the commitment of each one;
4. Establish (in-site and cross-sites) social networks that foster co-production of knowledge, sharing and exchanges of information and horizontal transfer of relevant technologies on highlands. Research should concentrate on building community-public-private partnerships targeting the generation and application of technologies, access to markets and credit and participation in local development (ICARDA, 2007);
5. Emphasis should be on the necessity of utilization of capacities and facilities available in other research centers including; international agricultural research centers, advance research institutes in developed countries, and development of suitable atmosphere for the expansion of these collaboration on highlands;
6. Research stations should be rearranged or established in different highland conditions from very cold, cold, cool to warm highland zones.

2. Research Priority Areas

The main objectives of highland development are to improve the livelihood of the inhabitants and to enhance environmental sustainability in order to alleviate poverty in the long run. Sustainable development of the highlands faces challenges that are multiple, interrelated and interactive. In order to tackle real highland development problems, research on the highlands should address the complexity of these issues.

A considerable amount of data and knowledge on highland ecosystems and inhabitants can be found. However, available data is scattered and research results are mainly related to local contexts. Synthesis and generalization of the research results and data would be a main priority (ICARDA. 2007).

The first step should be to collect highlands research results and findings to establish the diagnosis of constraints and opportunities. The establishment of a database of available technology in the different highland zones is also a priority. This work should lead to the assessment of the impact of research development and achievements on highland inhabitant livelihood and the evaluation of the technical and socio-economical adaptability of the existing innovations and the reasons behind the low rate of new technologies adoption.

Research priority areas should focus on policy, institutional and technical issues. Research priorities may generally be classified into 1) socio -economic and policy, 2) integrated natural resources management and climate change and 3) integrated and sustainable production systems as suggested by the Working Groups organized in Karaj, Iran on 20-21 November 2011 during the 1st Regional Expert Meeting on Highland Agriculture. Sixty eight participants from the NARS (Iran, India, Morocco, Pakistan Tajikistan and Turkey) and representatives from Europe (Portugal and France) and international organizations, FAO, ICIMOD, CIMMYT and ICARDA attended these Working Groups. The Working Groups reviewed and discussed the research priorities proposed by the review team and presented a list of the revised research priorities on the highland agriculture. The detailed research priorities which were identified by the Working Groups for enhancing collaborative research projects on highland agriculture for 2012-2016 are presented in Appendix1. However, general themes of the research priorities identified by the 3 Working Groups are as follow:

2.1. Natural Resource Management and Climate Change

1. Assessment of the potential and constraints of land, water, biodiversity and other agricultural resource base in various agro-ecological zones by application of GIS technology (maps and data).
2. Agro-ecological characterization, common denominator for activities related to differentiation and characterization of agricultural environments in terms of ecologies and farming/production systems, research and institutional gaps, interpretation in terms of potential and constraints of the identified agro-ecosystems
3. Reconciling human needs for different land uses with needs for ecological services (e.g. protected areas)
4. Review of traditional knowledge on soil, water and biodiversity management and climate change perceptions

5. Assess and evaluate sustainability of land management systems, current land use, traditional land management, current status and threat to agro biodiversity in predominant farming systems.
6. Improving water productivity , soil management and agricultural productivity of rainfed and irrigated farming systems in various agricultural production systems in highlands
7. Assessing the impact of climate change on natural resources and agricultural production systems in the highland regions and generating viable technologies to improve the resiliency of the farming system and adaptation to climate change.
8. Anticipatory research to develop indicators of environmental change for use in benchmark areas and action sites (e.g. changes in irrigated areas, population, changes in snow cover, flowering dates of plants)

2.2. Socio- economic and Policy

1. Preparing a comprehensive data base on socioeconomic condition of various highland agro ecological zones (population , education, emigration, employment, climate, natural resources, farming systems, crops, fruits trees, livestock, non-farm activities, institutions and services , research results and gaps, etc)
2. Study on household economics and returns to technology options
3. Analysis of the policy impact on domestic or export and import subsidies, price support, direct payment, technology introduction, natural resource, marketing , etc
4. Analysis of value chain, access to market, credit and inputs and institutional services
5. Evaluation of ecological, environmental and cultural services
6. Monitoring and out-scaling technology adoption

2.3. Integrated and Diversified Production Systems

The research should be focused more on cold and cool highland zones since they cover more than 75% of the highlands. Five major farming and production systems are identified. 1- Cereal-based farming system (legumes, forages, oil crops, etc) , 2- Horticulture-based system, 3- Rangelands and livestock system, 4- Aquaculture and fisheries system , and 5- Agro-forestry system. The research priorities for 2010-2016 on the first three systems are as following:

2.3.1 Cereal based farming system

- Developing high yielding and adapted germplasm, tolerant to cold, terminal drought, pests and diseases with good quality (wheat, barley, maize, chickpea, lentil, oil crops, feed legumes (alfalfa, vetch, etc.) for various agro -ecological conditions

- Developing of suitable crop management packages for different highland agro-climatic zones and benchmark areas (nutritional requirement, water management, conservation agriculture , organic farming, precision farming, supplemental irrigation, seed system, seed quality control and certification and others)
- Developing IPM of major pests for rainfed and irrigated production system
- Introduction of alternative crops including off-season crops for enhancing diversification of agriculture and income of farmers (triticale, flax, safflower and summer crops including quinoa, amaranth, sorghum, millets and others)

2.3.2 Horticultural based System

- Identification of adapted varieties of fruit trees and Improvement of cultivars/rootstocks of trees suitable for the highlands.
- Improving orchard establishment methods (access to healthy plantlets, planting system; planting distance, irrigation system) and postharvest processing and marketing.
- Developing of orchard management practices (pruning, pollination, mulch, irrigation, fertilizer application, weeds control, and disease and pest management).
- Introduction of suitable techniques for rainfall water harvesting and increasing water productivity.
- Identification and introduction of high value crops (strawberry, cut-flowers, medicinal /ornamental plants,) for generating more income for farmers.

2.3.3. Rangeland and livestock System

- Introduction of suitable forage and range species and development of alternative feed sources and supplementary feeding (nutrients, vitamins, minerals...)
- characterization of native livestock breeds suitable for highlands and development of proper livestock breeding strategies
- Developing guidelines and databases for utilization of crop residues and agricultural by-products in feeding calendars
- Integrated management of crop/rangeland/livestock in highlands and promotion of honey bee production.
- Determination of prevalent diseases and promoting suitable prevention measures
- Survey of livestock management in the nomadic and transhumant systems and increasing their productivity through participatory research approach.
- Grazing management and analysis of trade-offs of crop-residues for better crop/livestock integration

2.3.4 Cross Cutting Issues

- Capacity building of NARS including long and short term (degree and non-degree) education and training courses
- Strengthening Involvement of private sector in ARD, networking and regional collaboration (exchange of visits, regional and international conferences and meetings)
- Developing new approaches and methodologies for the sustainable use of biodiversity and improving the nutritional quality of local foods produced by using the biodiversity

- The research priority areas should be an evolving process as new and important issues may arise from stakeholder demand or from the analysis of research results themselves. The priority areas should be defined from the beginning with the participation of all stakeholders at the regional and the national level. This process should be updated regularly.

3. Expected Impact of Proposed Research on Agricultural Production and Livelihoods in the Highlands

The proposed strategy is expected to produce strategic achievements and impact on highland development. In particular:

3.1 Policy development, economic and institutional reform options:

- Policy options that reconcile income increase with natural resource preservation are identified and options for policy improvement on the sustainability of the environment are defined. This targets to attract private and public investments, to promote technology uptake and support the involvement of communities and resource users, particularly women, in highland development (ICARDA, 2007);
- Economic return to farmers of their existing crops, technologies and animal systems as well as the introduction of new crops, plantations or new technologies are evaluated;
- Value chain analysis for the main highland production such as sheep, goats, apples, olives, almonds, cherries, aromatic and medicinal plants (AMP) and forest products (such as mushrooms) are undertaken;
- Identifying technical, organizational and institutional constraints to improving local products' marketing chains;
- Improving on-farm processing and marketing of mountain originated agricultural products;
- Identifying and assessing promising options for processing and marketing livestock products such as dairy, leather and wool handicrafts;
- Enhancing quality and added value of farm products and linking farmers to both national and international markets (ICARDA, 2007);
- Establishing market chain linkages for highland agricultural products;
- The effectiveness and the fairness of the institutions that manage rangelands and forests are analyzed and options for suitable approaches for improvement and management of rangelands and forests in highland are proposed to policy makers;
- Household economics in highland studied are assessed and options for farmers' incomes improvement are identified.

3.2 Improvement of natural resource management:

- Natural resource preservation and management (soil, water, and biodiversity) are strengthened;
- The dynamics of the ecosystems, agro-climatic characterization of highlands and the assessment of climatic changes impacts on agriculture and natural resources are better understood;
- Inventory, collection and characterization of AMP are undertaken. Some of them, with high value potentials are selected for cultivation and techniques for their productions and their valorizations are developed (Acherkouk, 2007);

- Indicators for biodiversity, ecosystem soils and watershed degradation are built,
- The erosion process is better understood and the effectiveness of the anti-erosion techniques used is assessed;
- The importance of annual species relative to perennial species and the importance of species used by animals relative to the others are evaluated and some species are identified and selected for use in rangeland pastoral improvement and conservation of genetic resources.
- Nutritional value of foods produced from biodiversity of households are improved and made marketable,
- New approaches and methodologies for the sustainable use of biodiversity are improved and adopted,

3.3 An increase in agricultural productivity and productions:

- The increase, the intensification and the diversification of crop production into promising higher value products such as fruits and vegetables are performed;
- Suitable technologies for cropping (cultivars, planting density, irrigation, fertilizer application, weeding and pest management) are introduced and improved;
- Micro irrigation systems are improved and adopted by highland farmers;
- Management of crop and orchard production (nutrition, plant protection, improved trimming techniques…) is improved and adopted by farmers;
- Technical and economic referential for highland zones are developed;
- Input uses productivity and efficiency are increased;
- Animal production systems are categorized, the performance of local animal races are analyzed, and cross breeding is performed;
- Technical references for feeding livestock, suitable control of using pastoral rangelands, and appropriate bought feeds are defined for facing feed deficit and calendar disequilibrium;
- Improvement of small ruminants (sheep and goats) and cattle production;
- Qualitative and quantitative honey production is improved.

3.4 Enhancement of community development:

- Communities and households productive assets: water, local genetic resources, skills, equipments, inputs, access to credit and technical service are improved;
- Vulnerable groups such as women are empowered and differentiated paths for their economic development are identified;
- Highland communities are more aware of the potential of improving their livelihoods while conserving their natural resources;

- Enhancement of Farmers' and communities' information exchange and knowledge; Highland inhabitant income is increased and diversified and their wellbeing is improved.

4.5 Knowledge development:

- Synthesis and generalization of the results and the data available is undertaken
- An information system for monitoring biodiversity, social, economic and technical issues in highlands is developed;
- Significant amounts of background knowledge and empirical information relative to natural resource characteristics, local genetic resources and farming systems dynamics are produced;
- Traditional knowledge is inventoried, documented and associated with modern tools and technologies;
- A consolidated database on community and household constraints and opportunities is developed.

3.6 Enhancement of research capacity:

- The capacity of NARSs in dealing with research development strategies of highlands at the national and regional levels is reinforced;
- Interdisciplinary integration between the various fields involved: natural resource management, crop genetic improvement and institutional capacity building are enhanced (ICARDA, 2007);
- Cooperation and partnerships between NARSs, development agencies, NGOs, farmer organizations, etc. are improved;
- An increase of research result exchange among institutions dealing with highland development (information, methodologies and experiences) is enhanced;
- Better receptivity and acknowledgement of local communities and other stakeholders in participating in the design and testing of research programs as well as the validation of identified technical, institutional, and policy options strengthens research capacity.

4. Recommendations for Successful Implementation of the Research Strategy and Priorities

Development of highlands is not only imperative for poverty alleviation, increasing food security and conserving valuable natural resources such as water , soil , rangelands and biodiversity , but it is also necessary for sustainable development of the economy of the countries involved. Highlands are facing complex challenges which need deep commitment, strong participation and concerted efforts by all stakeholders including government, NGOs, private sector, farmers' organizations, agricultural research centers and development agencies at national, regional and international levels. Formulation of a research strategy and a set of priorities are crucial steps for sustainable agricultural development of highlands. The success of this strategy relies on:

- Close coordination and collaboration among NARSs, ICARDA, FAO, donors and other regional and international organizations involved in highland development;
- Bottom up and participatory approach in selection of research priorities;
- Comprehensive and multidisciplinary research programs;
- Fund raising efforts from international and regional development agencies as well as the governments involved. As the international community and the governments are becoming more and more aware of the importance of highland development on poverty alleviation, increasing food security and conservation of natural resources, many of the international development agencies, donors and the governments are interested in financing sound and relevant research programs in highlands:
- Effective monitoring and evaluation of the research programs during their implementation;
- Up- scaling and out scaling of the of project outputs;
- Impact assessment of the outcomes of the research programs in improving livelihood resiliency of the rural community, increasing agricultural productivity and conservation of the natural resources;

The research strategy should be in accordance with ICARDA's mission and mandates. ICARDA aspires to contribute to the improvement of livelihood of the resource-poor farmers in dry areas of the world by enhancing food security and alleviating poverty through implementing collaborative research programs and strategic partnership for enhance agricultural productivity and income of the rural community while ensuring the efficient and equitable use and conservation of natural resources (ICARDA, 2007).

This review report provides useful and comprehensive information on the definition and geographic distribution of highlands in the CWANA region as well as the current status of natural resources, agricultural production systems, agricultural research institutions, technologies developed and research gaps on highland agriculture in the three countries of Iran, Morocco and Turkey. The report also proposed elements for formulation of a sound research strategy and a set of relevant agricultural research priorities for development of highlands in the CWANA region.

ICARDA and the NARSs involved as well as the relevant IARCs affiliated to CGIAR, ARIs, regional and international organizations and donors should undertake crucial and concerted efforts in mobilizing all necessary resources, i.e. human and financial and use their influence for the success of collaborative programs for highland development. Further discussions and meetings by the relevant stakeholders may be needed to identify the suitable benchmark and action sites in various agro climatic zones of the highlands as well as to agree on the themes and priorities of the collaborative research projects to be implemented in 2012-2016.

5. Research Achievements and Impacts

In Iran and Turkey, since more than 70% of the territory in both countries is located in highlands several research institutes are involved in conducting agricultural research for development in the highlands. Thus, a lot of technologies on crop and livestock production system under irrigated and dryland farming systems as well as natural resource management have been developed. However, achievements in developing new cultivars of crops such as wheat, barley, maize, sugar beet, potato, and other crops under irrigated condition and in high input agriculture are relatively much more common and impressive than under dryland production system prevalent in marginal cold environments of the highland region. Furthermore , the gaps on available technologies to improve the productivity of natural resource such as soil, water, range, agro-biodiversity as well as diversification of production systems and integration of crop- rang- livestock production system are relatively large in these areas.

In Morocco, much of the research has attempted to adapt technologies for lowland and has targeted innovations that could yield benefits in responding to urgent needs of the production system in lowland, for example genetic improvement of crops to enhance productivity and improve their resistance to pests and diseases (Campbell, B.M., et al, 2006). In Morocco, research and development activities undertaken in the 1980s within the Middle Atlas project showed that significant yield increases could be attained by the adoption of a few existing technologies. Research conducted later within the EC supported Mediterranean Highland Project has provided further confirmation that higher yield gains can also be obtained in cereals, legumes and forages when research activities targeting highland environment. Other research activities on livestock and pastures led to similar conclusions (ICARDA, 2003).

However, very limited studies have been carried out on assessing the impact of technologies developed by the NARS or in partnership with international research centers on improving agricultural productivity, sustainable use of natural resource and livelihood resiliency of rural communities in the highlands of the 3 countries.

5.1. Production Technology

In general, research on developing technologies suitable for agricultural development in highlands is not adequate and more investment and initiative is needed. However, more progress has been made to generate technologies suitable for irrigated agriculture in the highlands areas. But more investment and efforts are needed to produce suitable technologies for dryland agriculture in the highlands. The following technologies for crop production in prevalent rainfed farming systems are available in the highlands of Iran and Turkey:

- Suitable sowing depth and dates as well as row spacing for major crops such as bread wheat, durum wheat, barley and food legumes.
- Developing high yielding cultivars of wheat, barley , chickpea and lentil suitable for various agro-ecological zones of irrigated and rainfed agriculture;

- Nitrogen and phosphorous application and their optimum placement in relation to seeds of wheat and barley. Use of supplemental irrigation in increasing yields of wheat, barley and food legumes.
- Early establishment of rainfed crop with single 70mm irrigation increased the yield by over 50%, while applying additional 100 mm of water in the spring almost doubled wheat and barley yield in a highland region of Iran on the upper Karkheh Revive Basin.
- Foliar application of urea on wheat grain yield;
- Application of Zn- fertilizers in improving yields of cereals in Zn deficient soils in Turkey
- Amendments of cereal seed planters as to simultaneously sow seed and fertilizers;
- Application of biological fertilizers in wheat production;
- Suitable fungicide for controlling wheat common bunt and dwarf bunt (*Tilletia controversa* Kuhn);
- Practicing different tillage systems such as reduced and non-tillage;
- Using sub-soiler and other mechanization techniques for wheat, barley and chickpea;
- Crop residue management in irrigated and rainfed farming systems;
- Suitable crop rotation and integration of food legumes with cereals ;
- Designing and manufacturing special combine for harvesting food legumes;
- Improving straw bailing equipment.

5.2. Breeding and Crop Improvement

There are limited collaborative regional research projects with involvements of the NARS on genetic improvement of crops tolerant to biotic and abiotic stresses for different agro climatic zones of highlands in the region. However, each country has targeted its efforts toward developing suitable crop varieties for its highland zones.

In Iran, for example, an important attempt has been made toward developing suitable high yielding cultivars of main crops. But, considering the vast growing areas of wheat, barley, chickpea and lentil in rainfed agriculture in highland areas, the released cultivars do not meet the requirements of the various highland regions. Achievements made on releasing improved crop varieties in Iran are as following:

Wheat: eleven wheat cultivars have been released over the last 20 years including eight bread wheat and 3 durum wheat cultivars (Tables 6.1 and 6.2). But only five of released cultivars are suitable for moderately cold to cold rainfed highlands agricultural areas, while 72% of rainfed agriculture is in highlands. Azar 2 (a cross between Sardari and an exotic line) was released ten years ago and is adapted to cold to moderately cold areas Rasad (a cross between Sardari and an exotic line) is another newly released cultivar for rainfed highlands. Sardari (landrace) is the mega-cultivar covering almost 80% of the rainfed wheat areas of the highlands followed by Sabalan, and Azar 2 which is grown in about 500,000 hectares in the highlands. Karim and Rijaw bread wheat varieties have been released in 2011 for warm to moderate temperature highland regions of Iran (Table 2).

Barley: So far, only six barley cultivars have been released for rainfed cultivation including three cultivars for lowlands and three cultivars (selected from ICARDA's germplasm) adapted to highlands

(Table 5.3); Sahand (1996), Sararood (1998) and Abidar (2008)). These three cultivars are generally adapted to cold areas, although not for very cold areas.

Chickpea: three cultivars have been released and are adapted to and suitable for warm to cool highlands However, so far no cultivars for fall cultivation in rainfed areas of cold to very cold highlands have been released.

Lentil: Only one cultivar (Kimia) has been newly released for the cold highlands in 2009.

Table 5.1 Crop varieties released for the various dryland areas in the highlands of Iran during 1992- 2011 (DARI, 2012)

Period	Crop	Total varieties released	Varieties released from joint efforts
1992-1996	Spring Wheat and durum wheat	4	Zagros, Niknejad, Gahar and Seimareh (DW)
1997-2005	Barley	4	Izeh, Sahand, Sararood1 and Abidar
	Chickpea	2	Hashem & Arman
	Lentil	1	Ghachsaran
2005-2011	Barley	2	Mahoor and Khoram
	Bread Wheat	5	Rasad, Azar2 , Koohdast , Karim and Rijaw
	Durum Wheat	2	Saji and Dehdasht
	Chickpea	1	Azad
	Lentil	1	Kimia
	Safflower	1	Sina
	Vetch	1	Maragheh

Table 5.2 Bread and Durum wheat cultivars released from ICARDA and CIMMYT germplasms for drylands of Iran, 1995-2011(DARI, 2012)

Cultivar	Growing areas	Origin	Yield (kg/ha)	Year Released	G. H
Zagros (BW)	Warm & Semi-Warm	CIMMYT	3630	1995	S
Niknejad (BW)	Warm & Semi-Warm	CIMMYT	3520	1996	S
Gahar (BW)	Warm & Semi-Warm	CIMMYT	3897	1996	S
Kohdasht (BW)	Warm & Semi-Warm	CIMMYT	3768	2000	S
Seimareh (DW)	Warm & Semi-Warm	ICARDA	3190	1995	S
Dehdasht (DW)	Warm & Semi-Warm	Italy	4015	2007	S
Saji (DW)	Warm, Semi-Warm	ICARDA	2669	2010	S
Karim (BW)	Warm, Semi-Warm and Moderate cold	ICARDA	3594	2011	S
Rijaw(BW)	Moderate and Mild-Cold area	ICARDA	2855	2011	F

Table 5.3 Barley cultivars released by DARI from ICARDA germplasms for the drylands of Iran, 1995-2011(DARI, 2012

Variety	Yield (kg/ha)	Released Areas	Year Released	Growth Habit
Izeh	4372	Warm and Semi Arid areas	1997	S
Sahand	2020	Cold, Mild cold and winter areas	1997	F
Sararood-1	3066	Moderate to mild cold areas	2000	S
Abidar	2138	Cold, Mild cold and winter areas	2005	F
Mahoor	3989	Warm and Semi Arid areas	2009	S
Khoram	3760	Warm and Semi Arid areas	2011	S

During 1990-2008, irrigated wheat productivity in Iran enjoyed a continuous growth of 2% from 2.5 t/ha to 3.8 t/ha and corn grain yield was increased from 3.7 to 7 t/ha. During 2000-2010, Seed and Plant Improvement Institute which is mandated to improve and introduce high yielding cereal varieties suitable for irrigated agriculture released the following high yielding cultivars of bread wheat, durum and barley for highland regions of Iran (SPII 2011).

Bread wheat:

Shahryar in 2001, Pishtaz in 2002, Shiraz in 2002, Tous in 2002, Bahar in 2007, Pishgam in 2008, Sivand in 2009, Parsi in2009 , Orum in 2009, Zare in 2010, Mihan in 2010, Arg in 2009

Durum Wheat:

Arya in 2003, Dena in 2007

Barley:

Nosrat in 2008, Fajr 30 in 2009, Bahman in 2009 and Yousef in 2010

In Morocco, there are several improved released cultivars of wheat, barley, food legumes and other crops developed manly for the lowlands and irrigated agriculture. Very limited crop varieties have been specifically developed for the highlands .The National Institute of Agronomic Research (INRA) and Agronomic and Veterinary Hassan II Institute (IAV Hassan II) are the main public research institutions involved in developing crop varieties for the countries. Table 4 and 5 show bread and durum wheat varieties released during 1984-2010.

Table 4 Bread wheat varieties released in Morocco, 1984-2010 (Nsarrellah, N. 2012)

Variety	Year of release	Main novelty
Jouda	1984	Yield potential. Dryland, early Good bread, LRR
Marchouch	1984	Yield potential. Dryland, early semi dwarf. Wide adaptation, Good bread, LRR sept R
Acsad-59	1985	Yield potential. Dryland, longer season, Good bread , LRR
Sibara	1985	Yield potential. Favorable or irrigated areas, early, Semi dwarf, Good bread, LRR
Saïs	1985	Yield potential. Large adapt, early, Biscuit, LRR
Saba	1987	Yield potential. Favorable areas, early, Good bread, LRR
Kanz	1987	High Yield potential. Large adapt, very early, Good bread, LRR
Achtar	1988	High Yield potential. Large adapt, mid early, Good bread
Baraka	1988	Good Yield potential. Large adapt, very early, Good bread
Khair	1988	Good Yield potential. Large adapt, semi dwarf, mid early, Good bread, LRR
Saada	1988	Good Yield potential. Rainfed dryland adapt, mid early. Good bread, LRR, sept R
Tilila	1989	Good Yield potential. Large adapt, semi dwarf, mid early. Good bread, LRR
Massira	1992	High Yield potential. Rainfed large adapt, mid early. Good bread, Hessian fly tolerant, LRR, sept R
Mehdia	1993	Good Yield potential. Large adapt, mid early. Good bread,
Rajae	1993	Good Yield potential. Large adapt, mid early. Good bread, LRR
Amal	1993	Good Yield potential. Large adapt, mid late. Good bread,
Potam2	1995	Good Yield potential. Large adapt, mid late, Biscuit, Hessian fly resistant, LRR
Sais2	1995	Good Yield potential. Large adapt. mid early. Biscuit, Hessian fly resistant, LRR
Aguilal	1996	Good Yield potential. Large adapt, mid early. Good bread, Hessian fly resistant
Arrihane	1996	Good Yield potential. Large adapt, tall early. Good bread, Hessian fly resistant, LRR, sept R
kharrouba	2010	Good Yield potential. Large adapt, Hessian fly resistant, LRR, Produced by doubled haploid.

Table 5 Durum wheat varieties released in Morocco in 1988-2011(Nsarrellah, N. 2012)

Variety	**Year of release**	**Adaptation zones and other characteristics**
Massa	1988	Wide adaptation, high productivity, good grain quality.
Isly	1988	Wide adaptation, high productivity, Rust resistant
Tensift	1988	Wide adaptation, high productivity
O.Rabia	1988	Wide adaptation, good grain quality
Jawhar	1993	Wide adaptation + irrigated, grain quality
Anouar	1993	Wide adaptation.
Yasmine	1993	Wide adaptation.
Amjad	1995	Wide adaptation
Tarek	1995	Wide adaptation, good color
Ouregh	1995	Wide adaptation, grain color and quality
Marjana	1996	Wide adaptation, grain color and quality
Tomouh	1997	Wide adaptation, dryland, longer season good grain color.
Irden1804	2002	Dryland. HF.* Resistant, good grain quality.
Nassira1805	2002	Dryland. HF. Resistant, good grain quality and color.
Chaoui1807	2003	Dryland. HF. Resistant, good grain quality and color.
Amria1808	2003	Dryland. HF. Resistant, good grain quality and color.
Marouan1809	2003	Dryland. HF. Resistant, good grain quality and color.
Faraj = ICAMORE1	2006	Dryland and favorable areas, HF. And LR. Resistant, septoria resistance. Good grain quality, good color.
PM27	2011	Large adaptation. LR. Resistant, good grain quality, high grain color.

In Turkey, In early 1930's first varieties were developed and provided to the farmers nearby to the research stations, In late 1930's crosses were made among Turkish selected pure lines and also with improved cultivars brought from outside such as Montana . Later in late 1950's, the second group of varieties of wheat and barley were developed. Several of these varieties continued to be planted by farmers till early 2000, such as "*Tokak*" a barley variety, "*Kunduru*" a durum wheat variety and "*Sürak and Sivas*" wheat varieties.

Several wheat varieties were released in 1950's, but they are still planted by many farmers in rainfed winter wheat area in Central Anatolian Plateau (CAP). This region is mainly covered by Ak702 released in 1931 due to its wide adaptation to harsh and poor soil conditions as well as poor agronomic practices by farmers. The other varieties widely accepted and grown by farmers in CAP were Kırac, Bolal and Bezostaya in late 60's and 70's. In mid 1970's "green revolution" came in to effect with a boom in wheat production with introduction of high yielding, so called "Mexican wheat" such as Pitic 62 and Penjamo (Mesut, K. 2012)

In Turkey, along with releasing high yielding wheat and barley varieties, improved agronomic practices which were lately adopted by farmers have given impetus in increasing wheat and barley production in recent years. Wheat production has been raised up to 18 million ton and barley to 5 million ton. Next boom came at the end of 1970's and early 1980's with the release of bread wheat varieties Gerek 79, Cumhuriyet 81 and durum wheat varieties Çakmak 79 and Tunca 79. Next attempt in breeding, especially in wheat came in early 1990's with the release of new generation of varieties such as Gün 91 bread wheat, Kızıltan 91 and Ç-1252 durum wheat varieties After 1990's, breeding program became very effective and many new varieties have been introduced .Today, the most common and widely accepted varieties of bread wheat are Tosunbey, Bayraktar, Sönmez and Demir and durum wheat varieties are Kızıltan 91, Altıntaş and Eminbey (Mesut, K 2012).

By 2011 there are 1848 varieties of field crops, 48% of them released by public research institutes, 5% by universities and 47% by private sector. Over 300 bread and durum wheat cultivars have been released either by public or private sector during the last 40 years. Almost half of the wheat varieties released are adapted to highland climatic conditions. The crop varieties released in 2010 by the public research institutes are given in Table 6

Table 6 Total number and crop species released in Turkey by public research institutes in 2010

Species	No of Variety Released
Common Vetch	2
Bee Grass	1
Barley	1
Sunflower Line	4
Faba Bean	1
Bread Wheat	6
Dried Bean	1
Hungarian Vetch	2
Maize Line	1
Cotton	3
Soy Bean	2
Sesame	1
Triticale	2
Total	**27**

Since 1990, a total of 26 winter wheat cultivars originating from International Winter Wheat Improvement Program, IWWIP (a joint CIMMYT, ICARDA and Turkey initiative) have been released in Turkey (Table 6.7). These varieties have now covered more than 860000 hectors which accounts for about 15 % of total winter wheat areas of the country (Keser, M. 2012). Most widely grown cultivars are Sonmez and Gun91 which cover around 80 % of total area.

Table 7 Wheat varieties released for highlands of Turkey derived from International Winter Wheat Improvement Program (IWWIP) and their estimated planting areas (Keser, M. 2012).

Variety Name	Year released	Estimated area, hectares
KARASU 90	1990	5,000
SULTAN 95	1995	25,000
Kinaci 97	1997	1,000
YILDIZ 98	1998	5,000
GOKSU 99	1999	1
GÜN 91	1999	200,000
CETINEL 2000	2000	1,000
AKSEL2000	2000	0
ALPU 2001	2001	50,000
IZGI	2001	1,000
SONMEZ	2001	500,000
ALPASLAN	2001	5,000
NENEHATUN	2001	3,000
SOYER	2002	1
BAGCI 02	2002	1
SAKIN	2002	5,000
DAPHAN	2002	3,000
YILDIRIM	2002	50,000
CANIK2003	2003	3,000
EKİZ	2004	6,000
OZCAN	2004	500
MÜFİTBEY	2006	5,000
HANLI	2007	100
BESKOPRU	2007	200
NACIBEY	2008	100
AYYILDIZ	2011	1
Total		**868,904**

Large numbers of germplasms of chickpea and lentil have been collected, evaluated and preserved by International Center for Agricultural Research in the Dry Areas (ICARDA) holding the largest collection of cultivated and wild germplasm accessions. The effort that has been spent by ICARDA to study the genetic variation in the world germplasm collection in order to understand local adaptation and to develop specific research programs has been greatly contributed to Turkish national program. Thus genotypes with resistance to various biotic and abiotic stresses received from ICARDA, either directly exploited or used as source of germplasm in national breeding programs. Since 1080s new varieties with good standing ability and, suitability for mechanical harvest have been selected, registered and released in Turkey. The lists of pulses varieties, including chickpea and lentil and related information are given in Tables 6.8 to 6.10.

Table 8 Numbers of varieties of pulses released in Turkey from ICARDA material between 1994 and 2011

Species	Year of Release	Variety Name	Cross/Pedigree
Lentil	1996	SEYRAN 96	ILL-1939
	2001	MEYVECİ 2001	ILL 6972
	2006	ÇAGIL	ILL-5604 X ILL-6015
	2006	ALTINTOPRAK	(80 S 42188 X 76 TA 25) X ILL-223
	2011	ALİDAYI	ILL 5722
Chickpea	1986	ILC482	ILC482
	1991	AKÇİN 91	-
	1992	AYDIN 92	-
	1992	İZMİR 92	-
	1992	MENEMEN 92	-
	1994	DAMLA 89	FLİP 85-7C
	1995	DİYAR-95	(X 80 TH 176/ILC-72 X ILC-215)
	1997	GÖKÇE	FLIP 87-8C
	1998	SARI 98	F85-1C
	2000	İNCİ	FLIP 93-146C
	2001	ÇAGATAY	FLİP 89-7C
	2005	YAŞA-05	FLİP 89-93 C
	2005	IŞIK-05	FLİP 92-36 C
	2009	AZKAN	FLİP 97-107 C
	2009	AKSU	FLIP 98-22C
	2011	HASANBEY	FLIP 98-55C
	2011	SEÇKİN	FLIP 98-63C
Faba Bean	1999	FİLİZ-99	(74 TA 22 x ILB 9) x (S 81080-7)
	2003	KITIK2003	(39 MB x ILB 1799)x(BAL 365x80 Lat.)

Source: *Ministry of Food Agriculture and Livestock, 2011*

Chickpea is an important crop especially in the highlands of Turkey where the total precipitation is over 350 mm. A lot of chickpea cultivars have been released and many of them are originated from ICARDA's materials (Table 6.9). Several varieties now cover most of the chickpea planted area. Though it has been declining in recent years, Gokce is covering 50-60 % of total chickpea planted areas in the country. Gokce is an early, aschocyta and drought tolerant, and high yielding variety. Recently released variety, Damla covers around 10% of the total area. Around 25-30 % of the total area of chickpea plantations is covered by local populations (land races). The main landrace covering most of the area is "*Kirmizi Nohut*" (Red Chickpea), which is used for "*Leblebi*", a special roasted snack made of chickpea that is very common in Turkey and consumed in large quantities. Kirmizi Nohut is very susceptible to Aschocyta and is planted late in order to escape Aschocyta epidemic. This usually causes yield reduction as rainfall is scarce in the late growing stage of the crop. The susceptible of Kirmizi Nohut has been tried to be corrected and although a new cultivar has been recently released for making Leblebi, Kirmizi Nohut land race still covers quite large areas, especially in Northern Transitional Zones of Turkey where rainfall is around 400 mm and altitude of around 500-1000 meter above sea level, masl (Mesut, K. 2012).

Table 9 Chickpea varieties released for low and highlands of Turkey and their main selected characteristics (Keser, M. 2012).

Variety	Year released	Institutional origin	Selected characteristics	**Altitude (masl)**	**Planting region**
ILC482	1986	ICARDA	Aschocyta tolerant, high yielding,	300-600	South Eastern Turkey for fall planting
Akcin91	1991	ICARDA	Aschocyta tolerant, high yielding,	800-1100	Central Anatolia Plateau , spring planting
Aydın92	1992	ICARDA		100-800	spring (fall) planting in Western Transitional Zones of Turkey
Izmir92	1992	ICARDA		100-800	spring (fall) planting in Western Transitional Zones of Turkey
Menemen92	1992	ICARDA		100-800	spring (fall) planting in Western Transitional Zones of Turkey
Diyar95	1995	ICARDA	Aschocyta tolerant, high yielding	300-800	fall planting in Southeastern Turkey
Gokce	1997	ICARDA	Earliness, Aschocyta tolerant (escape), high yielding, drought tolerant	300 -1100	Central Anatolia Plateau spring planting, South Eastern Turkey for fall planting
Sarı98	1998	ICARDA		100-700	spring (fall) planting in Western Transitional Zones of Turkey
Uzunlu	1999	ICARDA	Suitable for machine harvesting	800-1100	Central Anatolia Plateau , spring planting
Cagatay	2001	ICARDA	Aschocyta tolerant, high yielding	600-1000	Northern Trans. Zones, spring planting
Inci	2003	ICARDA	Aschocyta tolerant, high yielding, suitable for machine harvesting	300-700	fall planting in South Turkey
Yasa05	2005	ICARDA	Aschocyta tolerant, high yielding	300-1000	Central Anatolia Plateau spring planting, South Eastern Turkey for fall planting
Isık	2009	ICARDA	Aschocyta tolerant, high yielding	800-1000	Central Anatolia Plateau spring planting
Azkan	2009	ICARDA	Aschocyta tolerant, high yielding	800-1000	Central Anatolia Plateau, spring planting
Aksu	2009	ICARDA	Aschocyta resistant, high yielding, suitable for machine harvesting	300-800	South Eastern Turkey for fall planting

Even though the production is concentrated in low lands of Southeastern Anatolia, lentil is still one of the most important pulses crops in drylands of Turkey. Total lentil production is 447.400 ton with the total area of 234.378 ha in 2010. Domestic production is largely focused on red lentils with the total total production of 422.000 tons and with the total area of 211.508 ha. Southeastern Anatolia produces the biggest portion of red lentils with the area of 207.039 ha and with the production of 415.547 tons in 2010. Lentil production in highland is concentrated in Central Anatolia and Western Transitional Zone. Green lentil production area is almost 23.000 ha and the production is 25.000 tons in average and mainly concentrated in the western part of Central Anatolia and its transitional zones to West and North. Turkish lentil production severely dropped due to severe drought in 2008 and total production was 131.188 tons. Systematic research on lentil and chickpea started recently, compared to other field crops such as wheat and barley. During the last two and a half decades, progress has been made in various aspects of the crop through research. As the result of those research efforts winter sown red lentil varieties have been improved and registered by Central Research Institute for Field Crops. (Table 11). Almost, %80 of the lentil areas covered by the varieties has been developed by Agricultural Research Institute of MİFAL.

Table 11 Lentil varieties selected from ICARDA germplasms and released in low and high lands of Turkey and their selected characteristics.

Variety name	Selected characteristics	**Altitude (masl)**	**Planting region**
MEYVECİ 2001	Big size, tall, spring type, green cotyledon	800-1100	Central Anatolian Plateau and Transitional Zones
ALİDAYI 2011	Big size, spring type, red cotyledon	800-1100	Central Anatolian Plateau and Transitional Zones
SEYRAN 1996	Winter, drought, and lodging resistant, earliness, .high seed yield capacity, short cooking time	300-800	Southeastern Anatolia
ÇAĞIL 2006	Winter and drought resistant, high seed yield capacity, suitable for machinery harvesting, Resistant to *Fusarium oxysporum*-2, earliness.	300-800	Southeastern Anatolia
ALTINTOPRAK 2006	Winter and drought resistant, high yield capacity in the poor environmental conditions, suitable for machinery harvesting, Tolerant to *Fusarium oxysporum*-2 and Earliness	300-800	Southeastern Anatolia
MALAZGİRT 1989	Tolerant to lodging, Earliness, Winter tolerant and drought resistant. red cotyledon color	800-1500	Eastern Anatolia
ERZURUM- 1989	Tolerant to lodging, Earliness, Winter and drought tolerant, yellow cotyledon color.	800-1500	Eastern Anatolia

5.3 Seed Supply

In Iran, as is stated in the crop improvement section, five bread wheat cultivars (Azar 2, Rasad, Homa, Ohadi, and Rijaw) , one durum wheat cultivar (Saji), three barley cultivars (Sahand, Sararood and Abidar), three chickpea cultivars (Hashem, Arman and Azad), one lentil cultivar (Kimia), two safflowe cultivars (Sina and Faraman) and one feed legumes cultivar (Maragheh) have been released for highland rainfed areas over recent years. Therefore, enhancement of multiplication and supply of seed for increasing adoption rate of newly developed and released cultivars is necessary.

More than 10 bread wheat cultivars (Zarrin, Pishtaz, Shiraz, Shahryar, Bahar, Parsi, Sivand, Pishgam, Arg, Mihan, Zare, etc.), two durum wheat cultivars (Dena and Arya), four barley cultivars (Nosrat, Bahman, Yousef and Fajr30), one canola cultivar (Zarfam), two safflower cultivars (Goldasht, Soffeh), two clover cultivars (Nasim and Alborz-1), four beans cultivars (Pak, Sadri, Dorsa, Shokoofa), maize cultivars (SC700, Fajr, Dehghan), two millets cultivars (Shabahang and Bastan), one sunflower cultivar (Farrokh), one potato cultivar (Savalan), one chickpea cultivar (Binalood), two walnut cultivars (Jamal, Damavand), two apple cultivars (Golbahar and Sharbati), two cherry cultivars (Zard90 and Safid90), four appricot cultivars (Maragheh90, Nasiri90, Aybatan and Ordoubad90), four almond cultivars (Araz, Eskandar, Saba and Aydin) and two Hazlnut cultivars (Gerdoui90 and Pashmineh90) have also been released for highland irrigated areas of Iran in recent years(Jallal Kamali, M. R. 2012).

According to the Ministry of Jihad-e-Agriculture policy 50% of required seed for irrigated wheat and 30% of required seed for rainfed wheat in Iran are to be supplied as certified seed. However, practically 50% of required seed for irrigated wheat is supplied as certified seed, but for rainfed wheat this proportion is less than 20% and the set goal is not met. The applied system for supply seed is practiced as follows: breeder seed and foundation seed classes are increased in field stations under the supervisions of concerned breeders. Registered and certified seeds are multiplied through contracts with farmers in irrigated and supplementary irrigated fields and are subsidized based on teh seed quality as premium up to 50% by the government. Nevertheless, major portion of (about 50% for irrigated and more than 80% for rainfed) utilized seed comes from farmers' seed, and the government only supports and facilitates the seed cleaning and treatments, by providing, to some extent, equipments Jallal Kamali, M. R. 2012). For other crops there is no well developed and organized plans/systems for seed increase/propagation and multiplication which demand more supports and facilities form government.

In Morocco, certified seed production is subject to regulations similar to that existing in many developed countries. All crop species that are produced in Morocco are subject to catalogue and certification. The private sector was mainly involved in seed production of vegetable and oil crops but they are now actively started to be also engaged in cereal certified seed production as well.

The number of wheat and barley varieties has been increasing since 1980s. INRA (national agricultural research canter) has several variety development programs (bread wheat, durum wheat, barley, chickpea, lentil, faba bean, etc). INRA presents breeder seeds for catalogue trials and for registration. The new variety is registered if it presents the required stability and homogeneity of traits as well as the performance. The Agronomic and technological performance trials last for two years and may be extended if data collected is not sufficient (as in a dry year).

INRA has a royalty policy based on the sale volume. INRA opens cession call for the private seed companies and is responsible for providing foundation or base seeds. INRA used to produce certified G3 seeds but since 2005 INRA sells only G1 seeds and may produce G2 / G3 or even G4 seeds upon agreement with the relevant company (Nsarrellah, N. 2012). Since certified seed production in Morocco (a drought prone country) suffers from high reject rate, private companies now prefer to buy readymade G4 seed -of varieties registered by foreign companies in Morocco from abroad rather than risking with the high rejection rate during certification in Morocco.

As most of the seed is produced under farmer contracts, this process is a painstaking job when farmers have only small holdings. Nevertheless, several of the INRA registered varieties are holding the majority of the market. Total seed sales were used to be around 60,000 tonnes per year but new measures has increased the sale to near 100,000 tones. On an average, only about 11% of the farmers use are certified wheat seed ,but this varies from less than 10% in the dryland areas to more 20% in the favourable and irrigated areas (BW 13% DW 11% Barley 1%). Barley certified seed sales are very low since this crop species is reserved to drylands. Food legumes certified seeds are produced locally (around 300 tonnes/ year), while 400 tonnes are also annually imported. Most of the seed used is from locally produced common grain.

Concerning the certified wheat seed sold in the highland areas in Morocco, they are mostly INRA registered varieties. They are mainly spring wheat although several facultative winter types were tried but the experiment was abandoned. The total amount of seed sold is about 5000 tons per year and 80% is bread wheat. The bread wheat varieties are Achtar, Kanz, Radia, Arrihane, and durum wheat varieties are Karim, Marzak and Tomouh (Nsarrellah, N. 2012). In highlands areas farmers are still holding to some of the old local cultivars due to high grain quality. Variety registration has been started in 1963 in Turkey when the law on Seed Registration and Certification put in implementation. Since then 2063 varieties for field crops in total in 119 species have been registered (Table 5.6 in the previous section).

Agricultural research institutes have been the leading institutions in variety registration and certified seed production till mid 1980s. After the liberalization of seed sector in 1985 private sector came into game very fast and imported many varieties in many species and have them registered. Universities and other public institutions have been also involved in seed sector and have had registered several varieties. Now a days agricultural research institutes and private sector are the key players in Turkish Seed Sector. In 2006 new Seed Law has put in power and the seed sector gain a new momentum. Considerable portion of the certified seed that have been used by farmers now provided by private sector. General Directorate of Agricultural Enterprises (TİGEM) has been serving in cereal seed system as a key player.

In Turkey, as indicated in the previous section, a total of 26 winter wheat cultivars derived from International Winter Wheat Improvement Program, IWWIP (a Joint CIMMYT/ ICARDA/ Turkey Initiative) have been released for the highlands. These varieties now cover more than 850,000 hectares which accounts for about 15 % of total winter wheat acreage of the country. Most widely grown cultivars of wheat are Sonmez and Gun91 which cover around 80 % of total area of winter wheat varieties derived from IWWIP germplasm. There are around 65 wheat cultivars grown in Turkey and around 60 % of them are winter wheat. Though there are 65 cultivars in the production fields around 25 cultivars covers the

80 % of the wheat acreage. There are about 15 barley cultivars in the production field but, 3 cultivars cover around 75 % of the acreage.

Until 2003 most of the certified (around 98 %) seed in cereals (Wheat and Barley) was supplied by public sector, State Farms in Turkey. Starting in 2003 Turkey started to promote certified seed by separate projects including both private and public sectors. Turkey accepted the Breeders' Right Law in 2004, which regulates the Plant Breeders Rights in breeding and seed production and passed another law called "*Seed Law*" in 2006 that regulates the seed production rules and subsidies for seed production of seed producers and incentives for certified seed use by the farmers. Those two laws affected positively Private Seed Producing enterprises and boomed the number of private companies that enter the seed production business. As an example there were 110 private companies in seed production, only 8 of them had research right in 2002. Same year, in cereal seed production there were only 5 companies and none of them had any research right. There are 538 private companies in total dealing with seed production, 150 of them are holding -research right in 2012. 250 of them were in cereal seed production and 130 of them have been holding research rights. The increase in the number of private companies in cereal seed production was more than 40 times in 7 years(Keser, M. 2012).

About 2.4 millions tons of wheat and barley seed (1.7 mt wheat, 0.7 mt barley) have been used for planting in Turkey each year. Though 2.4 millions of cereal seed has been planted, Turkey made a plan to change certified seed every 3 years. That means that Turkey needs 800 000 mt of certified seed for planting (570 000 mt for wheat, 230 000 mt for barley) each year (Keser, M. 2012) . However, that much of certified seed in one year was not produced at all. While the certified wheat and barley seed sold in 2002 was 40 000 mt, it was 310 000 in 2010 (around 90% of it wheat seed). While the share of the private sector in certified seed of cereal was 2% in 2002, it was 53% in 2010. Private sector is more and more in seed production business in Turkey.

Total certified seed production in 2011 is 633.370 ton. Almost 460.000 ton is belong to cereals. Among cereals both bread and durum wheat is 410.000 and barley is over 48.000 tons. Even though seed production increases rapidly in last 5 years, the use of certified pulses and fodder crops seeds do not increase at the same rate. It is mainly due to that those crops mainly grown in highland by the poor farmers. Along with others there have been considerable amount of subsidies to the use of certified seed of those crops, still expected increase have not been achieved. The reason seems that the new varieties of fodder crops and pulses are not higher yielding than the varieties farmers have been using.

5.4 Natural Resource Management

Research efforts on natural resource management in highlands vary from one country to another. In Iran, rangelands consist of about 86.0 million hectares (53% of the country) with varied vegetation density (Rezaei S. A. et al 2007). They are the main source of feed for livestock of peasants and nomads. The livelihood of more than 900,000 people (peasants and nomads) depends on forages in rangelands for feeding livestock (generally sheep and goats). At present, forage production capacity in rangelands is about 10.7 million tons equal to 5.88 tons of T. D. N. (17% forage production capacity in the country), and are very heavily grazed (2.2 times more than permitted). They are exploited in order to feed 83 million livestock units. To overcome this mismanagement and to establish more appropriate technical management strategies for rangelands in Iran, few technical and economic studies have been conducted and guidelines for rangeland management in different climatic zones have been determined. Suitable sizes for the different types of rangelands and climatic zones are presented in Table 12.

Table 12 Suitable size for different types of rangelands and different climatic zones in Iran

Climate	Minimum suitable size for rangelands, ha	
	Very poor to poor	Average to good
Arid with summer rangelands	1235-1540	473-1059
Semi Arid with winter rangelands	673-1420	288-625
Semi Arid with summer rangelands	540-675	265-328
Mediterranean with summer rangelands	625-886	286-625
Mediterranean with winter rangelands	424-685	130-543
Semi-Humid	715-926	227-490
Humid	769--961	202-230

To show these research achievements, more than 10142 rangeland management projects in 24.3 million hectares (27.6% of rangelands in the country) have been developed and 14.5 million hectares of rangelands were given to 144000 farmers and nomads. This has been implemented with the aim of reducing soil erosion in rangelands that have been converted to rainfed cropping. Restoration of 430000 hectares of these rainfed lands is included in the policies of exploration of unsuitable rainfed areas in highlands. Among other research accomplishments these policies have been able to achieve: reduced tillage, non-tillage in sowing practices with retention of crop residues, the determination of suitable crop rotations as measures in soil stability and a reduction of soil erosion in highland areas.

In Morocco, research and natural resource management studies on highlands cover erosion, inventory of biodiversity and institutions. Research on erosion has focused on the occurrence of land losses in space and time, identification of degrading factors (rainfall, geomorphology, nature of soils and vegetation), hydrology of the watersheds and silting up of dams. Measurement of land losses at parcel level, evaluation of turbidity, measuring solid transportation and bathymetry permit a better understanding of the erosion phenomenon. Most studies on erosion apply modeling and cartography techniques, GIS and remote sensing (Ministère Chargé des Eaux et Forêts 2008).

Several studies in Morocco indicated that overgrazing had reduced appetent vegetable species, increased less appetent vegetable species or increased presence of invasive species which have led to the degradation of vegetative coverage. Semi-intensive livestock systems combining livestock activities and agriculture have been recently emerged. These systems promoted a reduction in animal mobility and an increase in animal charge near the sedentary areas as well as an increase in rotation frequency of herds on the best pasturelands (Yessef, M. 2006).

In Turkey nearly all of the native pastures are public lands and used communally. Smaller areas of rangelands are owned privately. Public rangelands can be rented by farmers for grazing purpose only, when the area is not in communal use or there is a relatively low number of livestock, and of course, overgrazing has not been an issue. However, the development of cereal culture displaced common pastures, and as the result of that development, many of the permanent pastures have been converted to agricultural land as cropping area, particularly during an intense conversion period during 1940 to 1960 due to rapid mechanization in Turkey (Bakır, 1971).

Rapid increase in human population has encouraged the conversion of pastures to cultivated land. Simultaneous enlargement in livestock number has concentrated more animals on a smaller area. The mismanagement of pasture lands by overgrazing has resulted in a reduction in the number of pasture species. The rangeland is grazed from early spring to winter as a common practice. The ideal grazing season, which enables pasture species to recover, is between 15 May and 15 September in the Central Anatolian Region (Büyükburç 1983a). As a result of this extended use and overstocking, the grazing capacity of the common land has been dramatically depleted. Socioeconomic constraints often restrict the sustainable use of common lands. Because of traditional and excessive use, rangelands never reach their full productive capacity, and farmers are not aware of the gains that could be obtained by adopting better management techniques (Fırıncıoğlu et al., 1997).

After the start of implementation of Meadow Law in 1998, there has been recovery on pasturelands as area and quality. The first step was to determination of the boundaries of rangelands, followed by vegetation studies and finally improvement of the rangelands for the benefit of communal use on animal husbandry. A almost country wide Project “Development of Pastures and Meadows and Pasture and Forage Crop Production Project” has been started in 2006 with the collaboration of General Directorate of Agricultural Production and Development, General Directorate of Agricultural Research and the Universities. The research institutes and provincial directorates at the local level have been put their effort together for the improvement of rangelands in Turkey. Under that Project, nearly 1000 project have been run at the local level and nearly 1milion ha meadow area subjected to rehabilitation work and almost 100 ha artificial rangeland has been established by 2011. The Project will continue till 2014.

5.5 Added Value Products and Diversification

The value chain analysis which helps to understand the chain of a product from its inception to its final consumption enables policy makers and private sector to take the right action in order to improve the product’s economic performances. The identification of the actors in the sector, the degree of their involvement and the evaluation of their share of the final value of the product allows policy makers to assess the effects of their actions in both the sector and its stakeholders. This enables policy makers to evaluate the impact of their action in contributing to poverty alleviation. However, the applied value chain analysis for highlands is not very common. ICARDA has undergone this method in mountainous zones of Al Haouz in Morocco for olives and cherries. This study has identified recommendations for improving cherry, olive and olive oil competitiveness, for enhancing their marketing, for organizing small and medium farms and SMEs into cooperative unions and for developing good market information system including price monitoring system (Serghini, H and Arrach, R., 2010).

MARA has been implemented a Rural Development Support Project in Turkey in order to support increasing the number and the size of the local processing facilities to help adding value to the products in the rural areas. Within the project between 2006 and 2011, establishment of 3.155 agro-industrial facility have been supported by MARA. Most of those facilities are in highland. Those facilities have been contributing to the local economy and to increase incomes of households since they are processing the local products. The raw materials have been obtained from local farmers and the processed products from those facilities mainly sold in local markets. The facilities include processing units of wheat to bulgur, flour and other products, peeling lentil, processing fruits to juice, jam production etc. and packing any kind of processed, semi processed products, also include seed processing facilities of field and horticultural crops. Thus the local production becomes more valuable and brings some more money for the local producers.

Diversification is an important issue to be considered for improving income generation and livelihood resiliency of rural communities in most of the highland areas. Highlands have a good potential for inclusion of nontraditional crops into the farming systems such as safflower, rapeseeds, vetches, medicinal and herbal plants, vegetables, potato, dry fruits and other activities such as production of honeybee and various livestock by- product, forest by- product, expansion of handicrafts and eco-tourism, etc.

5.6 Technology Transfer

Technology transfer in highlands suffers from the isolation of farmers and from the lack of adequate extension personnel. In Iran, technology transfer, over the last 20 years, has been mainly focused on supporting and introducing the use of cereal deep planters by supplying a limited numbers of these equipments through government financial aids in the form of extension activities and partial subsides to famers. In addition, seed cleaning and seed treatment services for rainfed wheat and barley growers have been part of technology transfer activities. Changing chemical application on sunnpest from aerial to ground application is also among technology transfer activities in highland rainfed areas. The government supplied suitable equipment for spraying sunnpest infected fields. Presently, Ministry of Jihad-e Agriculture is providing technical advice and cheap loans to farmers who are willing to adopt conservation agriculture in the dryland and irrigated faming systems in lowland and highland areas.

In Morocco, there is no specific policy to transfer technologies in highlands. However, many development projects are implemented in the highlands. In the course of these project technologies are being transferred to farmers.

In Turkey, technology transfer activities are carried out in two main channels, namely public institutions, such as research institute and extension services of Provincial Directorate and private sector. There is a new era in Turkey since 1999. Public research institutes and private sector make their own technology transfer activities in order to sell their products and technologies. It ranges from seeds of improved crop varieties, farm machineries, pesticides to chemical fertilizers. Public sector mostly provides information and technologies on suitable agronomical practices as well as financial support to the investment made by farmers.

Ministry of Food Agriculture and Livestock (MİFAL) in Turkey has been providing financial support in the last 6 years under the program of "Rural Development Support". The support is provided on a project base and % 50 of the total cost of the project is subsidized. The main aim of this support is to transfer new processing and value adding technologies to the rural areas of Turkey. In addition, Turkish Agriculture Bank (TAB) provides low or zero interest loans to the farmers on a project base according to the agreement signed between MİFAL and TAB.

This support provides a good basis for the transfer and adoption of new technologies. A subsidy to the use of certified seeds is also one of the key elements that facilitate the adoption of new varieties. Agricultural insurance is also one of the key and effective elements that give new perspectives to the farmers. Half of the total payment for agricultural insurance has been born by government under the agricultural support policy. Private companies involved in promoting new varieties and technologies on application of different fertilizers and chemicals are becoming much more effective and expanding their working area from low land areas to highlands.

A recent study was carried out by a team of scientists consisted of CIMMYT, ICARDA, and Turkish agricultural research institutes and universities on the rate of adoption and impacts of the new varieties. The study aimed to assess the impacts of five improved varieties developed under the national and international programs in both rain-fed and irrigated production conditions in five provinces of Turkey. It specifically evaluated the technical, economic, and social impacts of the varieties on the livelihoods of producers. The findings of the study of Mazid et al (2009) are summarized as below;

The ability of the varieties to produce high yields and their resistance to drought, their ability to fetch good market prices, well-adaptation to local production conditions, frost resistance, and good bread or durum quality are the most important characteristics as indicated by farmers. Few constraints to the adoption of the monitored varieties were identified based on farmers' perceptions. Some farmers perceived that yield of some varieties declining over time while others stressed that some varieties were susceptible to cold or frost and their seeds were expensive, while some others were susceptible to diseases.

Crop biodiversity of wheat, although very high at country or province levels, is somehow very low at the household level. The implication is that biodiversity may be important for variety development purposes in breeding programs but not necessarily at the farm-level.

Adoption intensity of the monitored varieties is highest among the well-off farmers followed by the poor farmers, and the other wealth groups. These varieties are reaching the poor as well as the well-off farmers. Given the high productivity levels of new varieties, they could contribute faster to poverty reduction if promoted on a wider scale to reach more farmers and production systems.

Yield comparisons show that wheat productivity was doubled under rainfed while it increased by 11% in irrigated system following the adoption of the monitored new varieties. The analysis by region indicated that monitored new varieties were only superior in the plateau region under rainfed condition, but other new varieties were superior in the low-land region and in the plateau region under irrigation condition. However, the monitored varieties and other new varieties give higher yields, in average, compared to old-improved varieties in most cases under farmers' conditions.

Overall, the adoption of the monitored new varieties generated a net increase of 18% in total factor productivity of wheat among producers. The increase in productivity is also accompanied by a substantial improvement in yield stability in the respective production systems.

The monitored new varieties performed better than other varieties on average in terms of water productivity. This indicator was estimated at 0.72 kg of grain per millimeter of rain water for monitored varieties compared to 0.73 kg/mm for other new varieties, and 0.46 kg/mm for old-improved varieties. Thus, the monitored new varieties contribute more to risk reduction for farmers as well as better water use efficiency compared to other varieties. In view of the fact that availability of water is a major constraint to production in the dry areas, more efforts should be made to disseminate these varieties in order to save water resources which are very limited.

Some of the monitored new varieties outperform all wheat varieties cultivated by farmers in terms of profitability measured by the gross margin per unit of land, while one of the monitored new variety is the least profitable. Estimated income for adopters of the monitored varieties is the highest (78.772 TRL per household,) and significantly different from that of non-adopters. The contribution of wheat to total household income is 54% for adopters of the monitored varieties as opposed to 46% for adopters of other new varieties, and 37% for adopters of old-improved varieties.

The monitored varieties contribute substantially to poverty reduction in the study area. The analysis by wealth quartiles and by variety classification shows that households which belong to the lowest wealth quartile (poor farmers) increased their per capita income to $14.9 per day through the adoption of the monitored new varieties compared to those in the same wealth quartile using other new varieties ($ 12.6) or old-improved varieties ($10.6).

The distributions of per capita income from the monitored varieties and from the other new varieties stochastically dominate the distribution of income from old-improved varieties, providing evidence of poverty reduction through variety adoption. The policy implication is that if existing government programs to increase wheat production are targeted specifically to the new varieties rural poverty reduction could be achieve faster.

The preliminary estimate was that an increase in national income in 2007 of about 28.8 million Turkish Lira due to adoption of the monitored new varieties in the target areas of the sampled provinces and about 21 million Turkish Lira due to adoption of other new varieties. Therefore, adoption of new improved wheat varieties which released after 1995 increased the national income in 2007 in 5 provinces about 50 million Turkish Lira; about 80% of this increase came from rainfed areas. The increase in the national income can be greater if new wheat varieties adopted and applied by majority of farmers. Adoption of agricultural technologies by farmers depends upon policy makers being aware of improved technologies, upon good linkage between research/extension work, and upon farmers participating in on-farm trials and demonstrations.

5.7 Policy and Socio-economics

Policy and socio-economic studies are usually undertaken along with identification and implementation of development projects in highlands. However, there have been very limited socio-economic and policy studies on highlands of the 3 counties of Iran, Morocco and Turkey.

The studies undertaken on highlands generally include information on production systems, farmers' activities in and outside their farms, structure of land ownership, technologies used by farmers, farmers' equipments, trade and marketing of products and socio-economic infrastructure such as roads, health care facilities, education level of the households, financing services, etc. They are generally based on field surveys. They rarely include cost of production of agriculture and livestock products, rational for farmers' choices of production systems and the reasons for not using some technologies developed by the research institutes. Moreover, the impact of national policy on their livelihoods and activities as well as the effect of national agricultural policies on the sustainable agricultural development of highlands is not unfortunately in the agenda of these studies.

5.8 Institutions

As mentioned earlier, land and natural resources ownership in highlands encompasses different status. Arable lands are usually owned by private sector, forests are state owned and rangelands are owned by state, communities or tribes. The right to use rangelands and forests varies from one country to another and is not clearly defined or practiced. For instance in Morocco, over a variety of forest by products such as dead wood, grazing and collecting forest fruits, members of a community neighboring the forest have the rights to use these resources. However these rights and people who are entitled to utilize thesr resources are not clearly defined. Also, the rules for using rangelands do not limit the number of animals allowed to graze for each community member and the institutions in charge of implementing the rules are not in a position to observe accordingly. Therefore, private appropriation of rangelands by powerful community members is a common practice. The extent of this appropriation is not known with precision.

It is therefore critical to understand the existing patterns of ownership of the natural resources in order to define more clearly the relationship between stakeholders and highland resources This would ensure a better understanding and acceptance of the rights and responsibilities of the stakeholders involved (D.J. Pratt and L. Preston, 1997).

An institutional approach for managing forests and rangelands is indeed necessary to stop the degradation of these resources. Research done by Mashregh and Maghreb and other projects in Morocco has identified the importance of new institutional approaches to the open-access problem on the rangeland. The economic component of this project has documented the difficulties of the present institutional approach with an emphasis on the failure of state control. It has provided some evidence that the institutions controlling open access were not functioning well and therefore, indirectly, that institutional change was a prerequisite for successful technology introduction (Sanders, J.H. and H. Serghini, 2003).

More effective resource management may be achieved through privatization or through secure tenure rights in some cases. However, not all resources can be privatized and individual ownership may also lead to destructive and unsustainable uses (D.J. Pratt and L. Preston., 1997).

Yet having rangelands under state ownership without the capacity to effectively control their use is generally creating an open access to these resources with no constraint on users, stocking rates or measures to ensure pasture improvement and their sustainable utilization. This has lead to an accelerated overgrazing and early grazing and, thus to accelerated loss of pasture and other edible bio-mass, increased rate of soil erosion and resource degradation. In the Moroccan high plateau rangeland users have been organized in cooperative in order to replace the traditional tribal institution by modern ones. It is not clear, however, if this institution has effectively resolve the issue of open access to the natural resources. The active association of local community members in forest management has also been tested in Morocco. The success of this experience has yet to be established. Therefore there is an urgent need of analyzing and assessing the evolution of the institutions in charge of the management of the common resources and the mechanisms for conflict resolution between rangeland user groups.

The sustainable use of biodiversity and rangelands are, maybe, two of the most critical issues of Turkish highland those need to be considered at institutional level. Since biological resources including rangelands are belong to the public, the use of those resources needed to be fairly managed and sustainable used. Different public organizations have different ownership and management authorities on biodiversity and rangelands. Ministry of Environment and Urbanization (MoEU) is responsible from biodiversity as a whole if it is considered at ecosystem level and MİFAL is responsible from the genetic diversity and the genetic resources. Ministry of Forestry and Water Resources (MoFWR) is responsible from the forestry, biodiversity within the forests and water resources, while MİFAL is responsible from rangelands.

There are different nature protection approaches and categories under different laws and organization, such as nature and national parks under MoEU, forest gene management zones under MoFWR etc. Management of rangelands becomes less problem after “Pasture Law” since 1998. The ownership of rangelands stay wit MİFAL but right to use rangelands transferred to legal personality of the villages. The rangelands those have not been used can be rented by private persons or companies to be used for animal husbandry only. Thus, it can be said that the problems have been defined and solutions have been produced in Turkey when the management of rangelands considered. Of course, that does not mean every problem is solved. Still there are many minor problems for the sustainable use of rangelands.

Sustainable use and efficient management of biodiversity is still need to be further developed. Even though there has been traditional approaches that have been developed by local people and been applied since ages, those still need to be re-arranged by legislations and updated. There are some sample of legislative application under the control of MİFAL, MoEU and MoFWR jointly or separately. For example, collections of flowering plants from the nature are under the control of MİFAL, MoEU and if those plants are collected from the forest area MoFWR is also involved. MoFWR is responsible from the plants collected from the forest. There are a draft law called “Nature and Biodiversity Protection Law” expected to be passed from the parliament soon, that will give the authority to the MoEU on biodiversity and is expected to help solving problems of sustainable use of biodiversity.

5.9 Partnership and Collaboration

Research organizations in CWANA countries have developed good collaborative programs and partnerships with their international counterparts.

In Iran, agreement with the International Center for Agricultural Research in the Dry Areas (ICARDA) for scientific and technical assistances and capacity building for dryland agriculture is the most important scientific collaboration on rainfed agriculture in highlands. Establishment of ICARDA-Iran office in Tehran in 1995 has greatly contributed to the progress of various programs. Indeed, conducting training courses at ICARDA and exchange of scientists by Iran and ICARDA as well as conducting joint research activities on highland agriculture based on the agreed biannual workplans have contributed to the progress of the bilateral collaborative programs. Collaboration with 12 Iranian research institutes/centers with ICARDA on genetic improvement of various crops (bread wheat, durum, barley, food legumes and forages), improving water productivity, watershed management, climate change and drought , seed quality and certification, rangeland rehabilitation, biotechnology and others have also been included on the agenda of the collaboration with ICARDA.

In 2007, CIMMYT has also established its office in Iran and is actively cooperating with various Iranian research institutes on wheat and maize improvement. AREEO has also longstanding collaboration with other CGIAR centers such as IRRI and ICRISAT and is an active member of the regional research associations such as AARINENA and APAARI.

In Morocco, the National Agricultural Research Institute (INRA) entertains partnerships with different national and international research and development organizations. At the national level, it cooperates with Agronomic and Veterinary Hassan II Institute in Rabat (IAV Hassan II) and the National School of Agriculture in Meknès. At the international level, INRA is an active partner of international and regional research organization, mainly, CGIAR, ICGEG, AARINENA, RARA, COI and ICRA. It is also a member of regional networks and maintains cooperation with several countries (INRA, 2004).

Turkey has been cooperating with CG Centers for a long time. International Winter Wheat Improvement Program (IWWIP) is a joint activity between Turkey, CIMMYT and ICARDA and has been operational since 1986. .At the beginning, Turkey and CIMMYT initiated a join program on the winter wheat improvement and ICARDA joined the program in 1990. The IWWIP has now become a complete program which primarily targets CWANA winter and facultative wheat(WFW) growing regions but also serving on request all winter wheat breeding programs in the world. IWWIP distributes genetic materials to about 150 collaborators in 50 countries around the world. The breeding activities have been carried out in collaboration with different institutes in Turkey and ICARDA HQ in Syria.

5.10 Capacity Development

Developing human research capacities of the NARSs in CWANA countries are highly important and should be a top priority for international and regional research organizations.

In Morocco, INRA as the main agricultural research organization in 2010 had 190 scientists, 218 technicians and 43 managers. During 2007 3 INRA researchers have successfully obtained their PhD. INRA has recruited during the same year 10 scientists. Moreover, four out of ten Regional Agricultural Research Centers (RARC) affiliated to INRA have research activities related to highlands as an important component of their programs. They are mainly interested in the sustainable utilization and protection of the natural resources as well as improvement and diversification of production systems, particularly for goat production in the highlands (INRA, 2008).

In Iran, extensive human capacity development program for various research institutes was carried out in partnership with ICARDA during 1995-2005.ICARDA contributed to the development of DARI in 1994 and recently supported the establishment of Seed and Plant Certification Research Institute and contributed to development of its human resource capacity .

ICARDA contributed to the training of more than 1250 persons among them 81 researchers who received PhDs from prestigious universities in Europe, Canada, Australia and India. These scientists and researchers are now playing a major role in Iran's agricultural development providing leadership and cutting edge research (ICARDA-AREEO 2012). These achievements could have directly or indirectly contributed to productivity and production enhancement and to Iran's march towards sustainable agricultural development. ICARDA facilitated participation of many Iranian scientists from Dryland Agricultural Research institute and Seed and Plant Improvement Institute in international conferences, workshops and meetings. Since 1996, ICARDA facilitated procurement of equipments and instruments needed for establishing laboratories, particularly for of DARI and its research stations around the country.

5.11 Research and Technology Gaps

Research findings show that only in limited areas such as crop improvement and release of varieties for moderate to cool highlands, there have been good achievements and outcomes in improving agricultural productivity in the highland regions. There are still many gaps to overcome for sustainable and integrated agricultural development, particularly for cold to very cold highlands. Research gaps include the following areas:

1. Development of suitable crop varieties of wheat, barley and chickpea tolerant against cold and drought for cold to very cold highland regions.
2. Development of technologies for conservation agriculture suitable for the cold highlands
3. Soil conservation and improving soil organic content
4. Suitable crop rotation and diversification of agriculture in cold to very cold highlands and overcoming the constraint facing the issue.
5. Diversification of production systems such as inclusion of horticulture, vegetables medicinal and herbal plants, etc

6. Integrated natural resource management and the effects of climate change on highland agriculture.
7. Enhancing water productivity and managing increasing drought and water scarcity
8. Study on socio-economic constraints facing the adoption and application of research findings in dryland farming system
9. Integrated production systems such as crop -range- livestock production.

Research conducted at the national level in highland areas of Maghreb countries is recent and limited in scope. However, more recent research conducted by ICARDA and its partners in highland areas did yield evidence of the real potential for increasing productivity when due consideration is paid to the specificities of these areas (ICARDA and the NARS of Algeria, Morocco and Tunisia, 2007).

On the whole, there exists a large number of data and knowledge on the highland ecosystems, and their human communities. Unfortunately syntheses are rare, data is dispersed and results are limited to specified localities. There are little integrated interdisciplinary approaches and generally little local community participation to the conception and implementation of research programs. Also, there is a lack of knowledge on indicators of early changes in biodiversity, social and economic changes and a lack of policy assessment criteria in highlands. Many researches on erosion have been done in Iran, Turkey and Morocco. But they need to be strengthened by elaboration of specific models for arable land losses and a system of monitoring and assessment of its dynamics. A research program for the development of watersheds is also needed for many highland regions. There have been many attempts to answer question relative to the rangelands. In particular, many explanations which lack research findings have been put forward to clarify rangeland degradation and the partial success of the government policies and projects in rangelands.

About ICARDA and the CGIAR

Established in 1977, the International Center for Agriculture Research in the Dry Areas (ICARDA) is one of 15 centers supported by the CGIAR. ICARDA's mission is to contribute to the improvement of livelihoods of the resource-poor in dry areas by enhancing food security and alleviating poverty through research and partnerships to achieve sustainable increases in agricultural productivity and income, while ensuring the efficient and more equitable use and conservation of natural resources.

ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and serves the non-tropical dry areas for the improvement of on-farm water use efficiency, rangeland and small-ruminant production. In the Central Asia and West Asia and North Africa region, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes, and associated farming system. It also works on improved land management, diversification of production systems, and value-added crop and livestock products.
Social, economic and policy research is an integral component of ICARDA's research to better target poverty and to enhance the uptake and maximize impact of research outputs.

CGIAR is a global research partnership that unites organizations engaged in research for sustainable development. CGIAR research is dedicated to reducing rural poverty, increasing food security, improving human health and nutrition, and ensuring more sustainable management of natural resources, It is carried out by the 15 centers who are members of the CGIAR Consortium in close collaboration with hundreds of partner organizations, including national and regional research institutes, civil society organizations, academia, and the private sector.
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