International Center for Agricultural Research in the Dry Areas

ICARDA

Review Report

Elements of Research Strategy and Priorities for Sustainable Agricultural Development of Highlands in Central, West Asia and North Africa

Edited by
Mohammad. H. Roozitalab, Hassan Serghini,
Abbas Keshavarz,Vehbi Eser and Eddy de-Pauw

International Center
for Agricultural Research
in the Dry Areas

Review Report

Elements of Research Strategy and Priorities for Sustainable Agricultural Development of Highlands in Central, West Asia and North Africa

Edited by
Mohammad. H. Roozitalab, Hassan Serghini,
Abbas Keshavarz,Vehbi Eser and Eddy de-Pauw

Foreword

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. However, 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 through close collaboration and partnership with the countries possessing large areas of highlands such as Afghanistan, Azerbaijan, Georgia, Iran, Morocco, Pakistan, Kirgizia, Tajikistan and Turkey, considerable research activities have been carried out on highland agriculture. Nevertheless, because of the harsh and marginal environmental conditions, socio-economic constraints and lack of comprehensive policies, the highlands have not yet received due attention in spite of their important role in improving food security and environmental sustainability in the region and beyond.

The main objectives 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 CWANA region. The highlands of Iran, Morocco and Turkey were just envisaged as three platforms to review and assess the potential and constraints facing sustainable agricultural development and help preparing collaborative regional research projects on highlands of the region.

A Regional Expert Meeting on Highland Agriculture was organized on 19-21 November 2011 in Karaj, Iran. During this regional expert meeting, three parallel working groups on i) natural resources management and climate change ii) socio-economic and policy and iii) diversification and integrated production system were held to review the research priority areas proposed by the Review Team and to receive comments and feedbacks on the highland research priorities from the NARS leaders as well as other participants from the advanced research institutes and international organizations. The outputs and recommendations of these three parallel working groups have also been incorporated in this Report.

In the end, we hope that this comprehensive review of highlands in 3 countries of Iran, Morocco and Turkey and the proposed elements for agricultural research strategy and the priorities for highland agriculture could provide background information and scientific framework to enhance collaborative research projects and more investment for sustainable agricultural development of the highlands in the CWANA region.

Mohammad H. Roozitalab
Hassan Serghini **Abbas Keshavarz** **Vehbi Eser** **Eddy de-Pauw**

Acknowledgements:

The Review Team would like to express their deep appreciation and gratitude to Dr. M. Solh , Director General, Dr. K. Shideed, Assistant Director General for International Cooperation and Communication and Dr. M. Van Ginkel, Deputy Director General for Research of ICARDA for their guidance and full support throughout the review process. We also wish to sincerely thank Dr. Rachid Serraj and Dr. Ahmad Amri for their kind review of the draft manuscript and providing valuable comments and recommendations on improving the draft report. Our deep appreciation and gratitude are also extended to Dr. Mesut Keser, Dr. N. Nsarrellah and Dr. M. R. Jalal Kamali for providing valuable information on the seed production and crop varieties released in Turkey, Morocco and Iran respectively. We also wish to thank the GIS Unit of ICARDA for providing the maps and the background information on the extent, characteristics and geographic distribution of highlands in Central, West Asia and North Africa, CWANA .We would like also to thank and express our appreciation to Dr. S. A. Rezaei for his support and Ms. Aisel Gharedagli for her assistance in formatting and designing the draft document.

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

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

International Center for Agricultural Research in the Dry Areas (ICARDA)
PO Box 114/5055, Beirut, Lebanon
E-mail: icarda@cgiar.org
www.icarda.org

Table of Contents

Executive Summary

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 world. 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 live 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.

The 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 GIS studies conducted 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 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 farming 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. Some of the more common research and technological areas which need more attention are as following:

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.

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.

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 collaborative research projects aimed for sustainable development of the highland regions in various agricultural zones of the CWANA region.

Chapter 1

Introduction

1. Introduction

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 1992, the international community has become increasingly aware of the urgent need to address highland and mountain development. This summit dedicated chapter 13 to sustainable mountain development and in 1998, the United Nations' General Assembly proclaimed 2002 as the international year of mountains. The increased awareness is particularly due to the numerous studies on highland and mountain development which have been conducted all over the world since the Rio Summit. These studies demonstrate the importance of mountain and highlands for poverty alleviation, preserving natural resources, reducing the risk of floods and for protecting dams from siltation. In fact, 12% of the world population lives in mountainous and highlands regions, of these populations, 80% live below the poverty line, 37.5% are food insecure and almost 20% are hungry (FAO, 2007). Mountains and highlands are also highly importance for the supply of water for drinking, agriculture, energy and industry. Freshwater from highland areas also supports unique ecosystems and biodiversity in both highlands and lowlands. For example, about 70% of surface water in Morocco and more than 95% in Iran originate from the highlands.

The international community is also being more conscious of how fragile highland ecosystems are due to accelerating soil erosion and overexploitation of natural resources. Highland areas are also under heavy pressure from deforestation, expansion of agriculture and tourism and also from increasing demands on their resources in the densely populated urban areas of the lowlands. As population increases in highlands, natural resources such as scattered forests, rangelands and soils deteriorate due to overgrazing and reclaiming land for cultivation. This degradation combined with the isolation of highlands, high rate of illiteracy and poor policies, all lead to an increase in the poverty rate, which in return, leads to a higher degradation of natural resources. The high degradation of natural resources (water, soils, biodiversity, forests and rangelands) is mostly linked to unclear and ambiguous rights and ownership of the inhabitants and the rural communities over these resources. Therefore, highlands need the design of specific development policies.

In light of these predicaments, what strategy might be developed to address these issues? The strategy should mainly aim for the containment of natural resources degradation, poverty alleviation and identification of development levers that strengthen highland comparative advantage. In order to design a sustainable development policy for highlands, it is necessary to assess and better understand the specificities that characterize these areas. These policies should include institutions and processes that are important to achieve sustainable agricultural development in the highlands areas. In particular, a sound sustainable natural resource management plan has to be implemented. This includes clarification of inhabitant rights over the soils, water, rangelands, forest and the clarification of the land status. This clarification will increase the responsibility of the owners.

Highland communities are usually marginalized from economic exchange, access to information and decision making on development process. Most of the stakeholders and highland communities share a common interest in sustainable development. All should be included in the development process from the action identification phase to its execution passing through the management phase. Sustainable solutions are more likely to succeed if they include economic incentives to all stakeholders. Investing in highlands is not only beneficial to the people living in these areas but also to others. The return on investment should include not only the direct return in increasing inhabitant incomes but the full economic value of all resources (i.e. clean air, pure water, wildlife habitat, erosion reduction, reduction of flood risk, …)

The International Center for Agricultural Research in the Dry Areas (ICARDA) is mandated and has been interested to enhance research activities in partnership with national agricultural research systems for generating needed technologies for sustainable agricultural development of the highland areas in CWANA region. But due to harsh environment and low accessibility, highlands have not yet received adequate attention from donors and international or regional research communities.

This review report was commissioned by ICARDA to assess the current status and agricultural research and technology development in the highlands of 3 countries of Iran, Morocco and Turkey as well as to propose elements of a research strategy and priorities for sustainable agricultural development in the highlands of the CWANA region.

Chapter 2

Classification and Characterization of the Highlands of North Africa, West Asia and Central Asia,

An Overview

2.1 General Information

The CWANA region (Fig.2.1), geographical focus of ICARDA's agricultural research programs, constitutes with nearly 22 million km^2, of which 97% experiences at one time or another water shortage for agricultural use, the largest contiguous area of drylands in the world.

Figure 2.1. Geographical extent of the CWANA region (yellow) and countries included in this study (North Africa, West Asia and Central Asia; striped)

Often overlooked is the fact that, within its overall dryland context, this region also has a very high diversity in agro-ecologies and agricultural systems. Climate is the first determinant of agro-ecological diversity. Using the 1979 UNESCO classification system for Arid Zones, by the simple combination of major aridity and temperature regimes, De Pauw (2011) differentiated 65 agro-climatic zones in CWANA. Further subdivision is possible, based on the distribution of precipitation in relation to the inter-annual temperature pattern. Within this highly heterogeneous climatic setting, more diversity in biophysical environments is created by differences in landscapes, soils, geological substrata, surface water and groundwater resources. Irrigation development is the single most important factor in creating artificial agro-ecological niches, areas where natural conditions and production systems show abrupt differences with their surroundings (De Pauw et al., 2000).

Ignoring the complex nature of such diverse agricultural environments has been one of the main reasons why it has been remarkably difficult to transfer research results or lessonslearnt, whether they concern biodiversity management, crop production intensification or diversification, land use optimization or combating land degradation, from one dryland area to another.

Within this diverse dryland region, the highland areas constitute remarkable entities, as these are the areas where the diversity of environments and production systems are most pronounced. They are extremely diverse in their environmental characteristics and therefore, unsurprisingly, hotspots of biodiversity. However, they often also constitute hotspots of poverty, due to converging problems of agricultural development, climatic and soil constraints, shortage of quality agricultural land, poor accessibility, and limited infrastructure and agricultural services affecting market access.

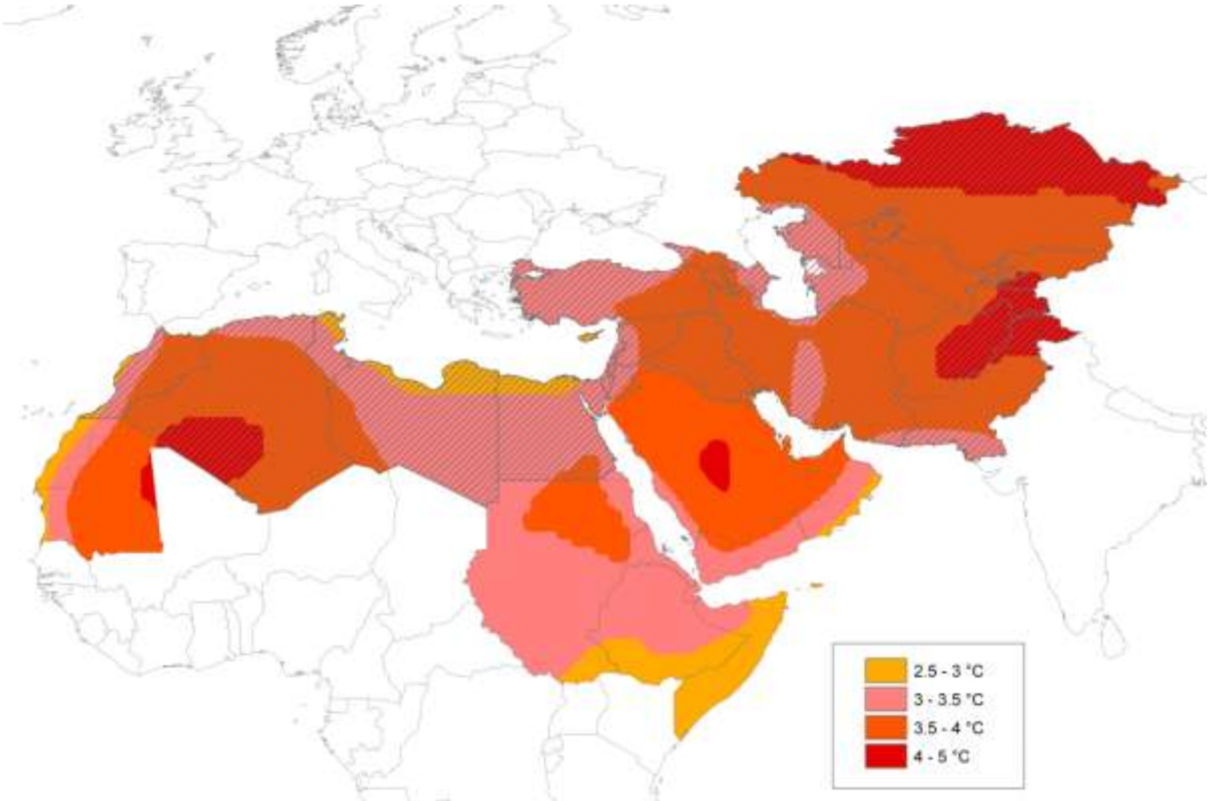

Figure 2.2. Absolute change of mean annual temperature 1980/1999 to 2080/2099, scenario A1b, average of 21 GCMs (compiled by GIS Unit ICARDA, based on partial maps in Christensen et al., 2007)

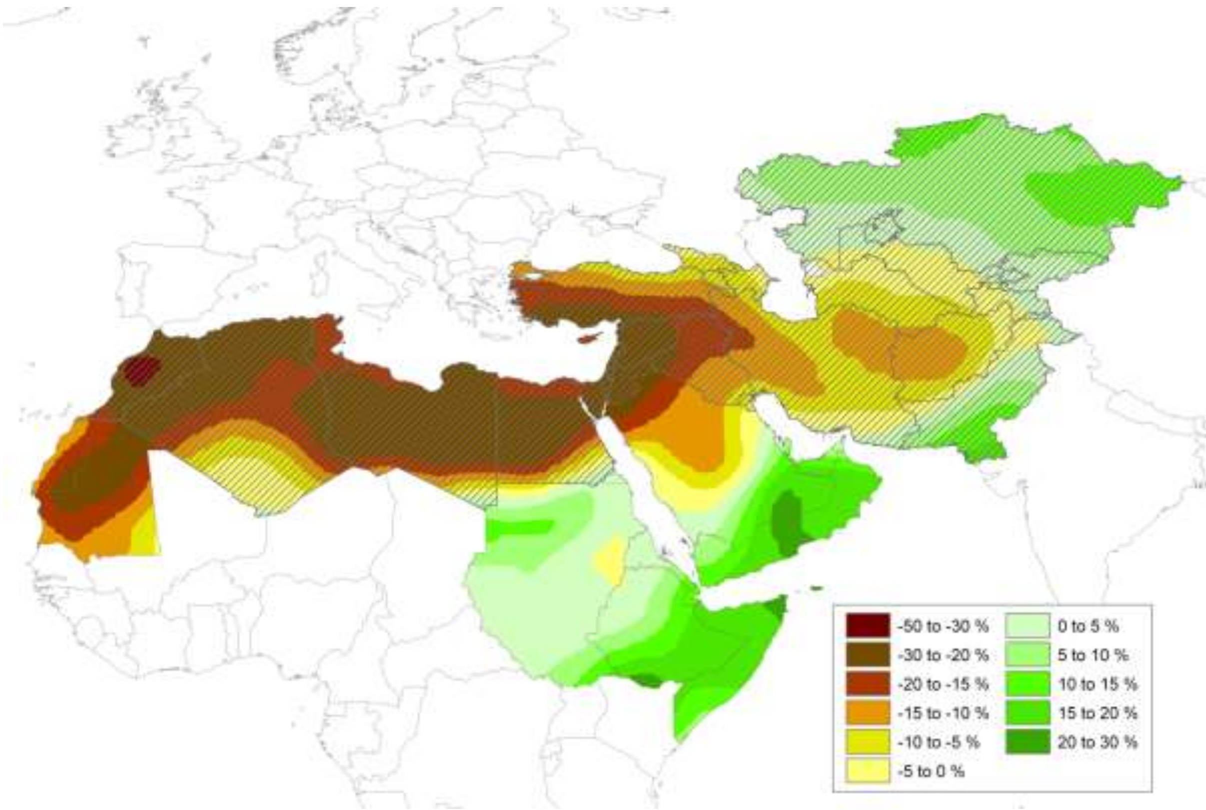

Figure 2.3. Relative change of mean annual precipitation 1980/1999 to 2080/2099, scenario A1b, and average of 21 GCMs (compiled by GIS Unit ICARDA, based on partial maps in Christensen et al., 2007)

Climate change is another potential threat that may affect highland areas in particular. The temperature increases expected by the end of the 21st century for the drylands (Fig.2.2) are in the range 2.5-5°C. Whereas a mild increase in precipitation is projected for the tropical drylands and most of Central Asia, the bulk of CWANA, and particularly the area studied in this chapter, is projected to suffer significant decreases in precipitation (Fig. 2.3). In fact, in terms of precipitation decline, the drylands around the Mediterranean are projected to be one of the most severely affected by climate change in the world.

Despite these problems, the highlands are also areas where potential for agricultural development is considerable, provided appropriate crop varieties and agricultural technologies are targeted to their very diverse conditions. However, the knowledge base for doing so is inadequate for most global highlands in general, and this is certainly the case for highlands in dryland environments. While information about these areas is suboptimal and scattered, whatever exists has not been used well. The problem in distilling a coherent and comprehensive picture of the diversity of agricultural environments of the dryland highlands has been mostly one of bringing diverse datasets together in an integrated framework that allows comparing them across a wide range of conditions in a consistent spatial and descriptive framework.

It is particularly in this context of available but scattered information that Geographic information systems (GIS) have great potential to serve as an integrating platform for capturing knowledge on the highlands. Using GIS technology and spatial data available at either national or international level, we can develop a spatial framework for the rapid classification and characterization of the agricultural environments of the highlands, and define extrapolation domains for agricultural technologies developed at experimental stations.

The geographical focus of this study is on the non-tropical part of the CWANA region covering North Africa, West and Central Asia (Fig. 2.4). The tropical areas of Sub-Sahara Africa that are part of CWANA as well as the hyper-arid Arabian Peninsula are excluded. The studied part of the CWANA region is henceforth designated as 'study area'.

Apart from their common elevation features and non-tropical climates, these areas show great diversity in their climatic and terrain characteristics. The landscape either consists of dissected terrain (mountains or hills) or plains within mountain ranges. Agriculture is mainly based on rainfed farming systems with winter wheat and winter barley varieties as the main crops in cold to extremely cold highlands. For the purpose of this study highlands in desert areas (with hyper-arid moisture regime) are mentioned but otherwise not given much attention as their potential for agricultural use is limited to small pockets where some water resources exist for oasis-type agriculture.

In this introductory chapter a simple approach has been adopted for defining a consistent spatial framework for region-wide agro-ecological characterization, and for characterizing the different parts of the highlands.

This approach has three elements:

- Identification of the highlands
- Differentiation based on key characteristics
- Characterization based on secondary spatial datasets

2. 2 Identification of highlands

Highlands are defined in this report as **areas with elevation of more than 800 meter above sea level.** The advantages of this definition are simplicity and consistency. With the availability of global digital elevation models (DEM) the criterion allows accurate mapping and can be applied globally (Fig.2.4).

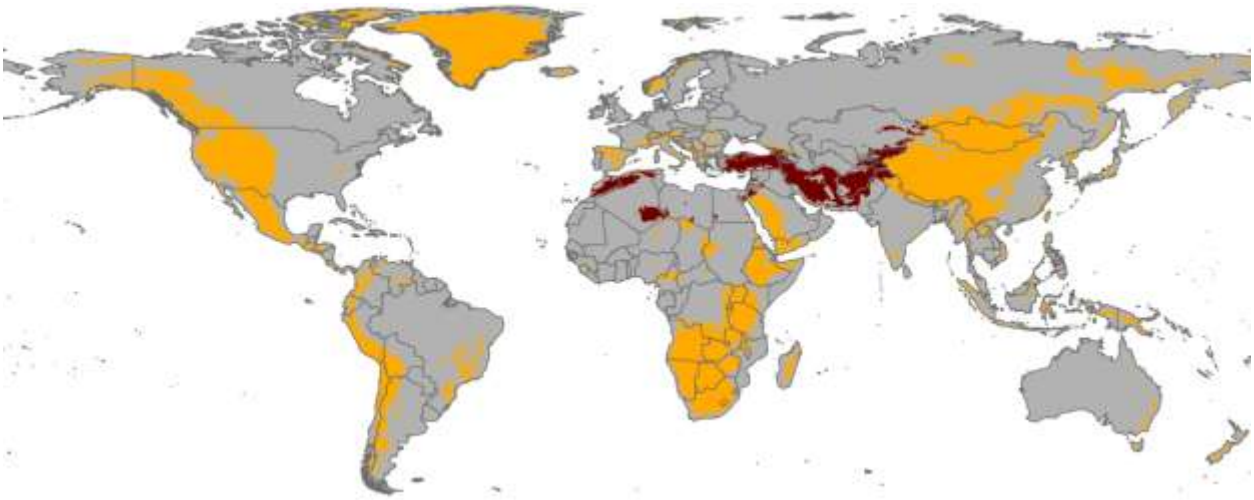

Figure 2.4. Distribution of global (orange) and study area highlands (brown) as defined by the 800 m elevation limit

Against the use of this definition one might argue that in some parts of the world the 800 m limit would certainly be appropriate to distinguish high-elevation areas, whereas in other parts the limit might be considered as too high or too low. Certainly, the 800 m boundary is a compromise which matches quite well with the perceptions of our own study area, and the global relevance of an altitude-based threshold of 800 m to differentiate highlands from 'lowlands' could be questioned. It is also true that the areas delineated by a simple elevation criterion **are not homogenous** in their environmental characteristics.

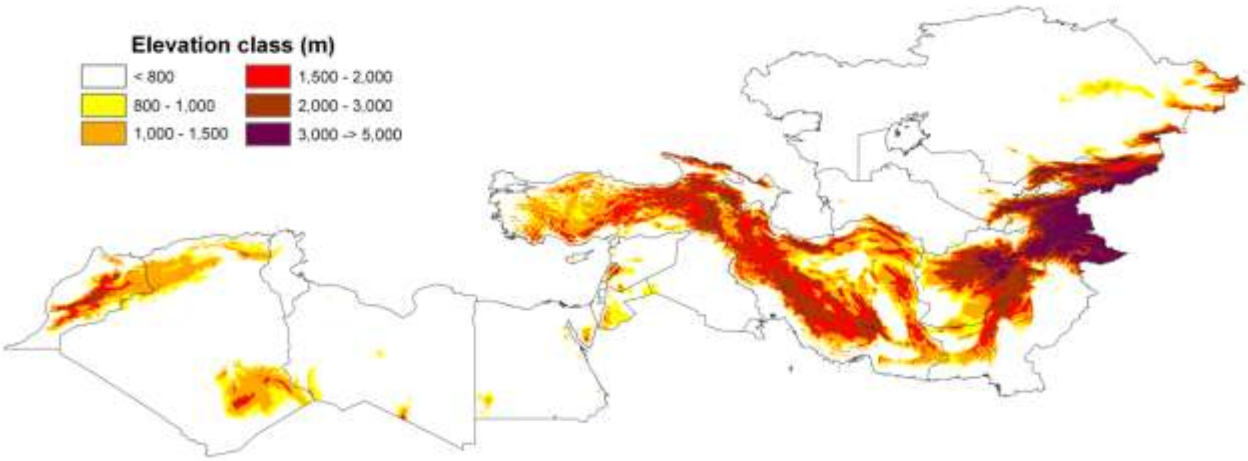

Figure 2. 5. Elevation differences within the studied highlands of the CWANA region

This is already evident from Figure 2. 5, which shows the diversity in elevation zones of the highlands in the study area of the region..

On the other hand, no elevation criterion is capable in its own right of capturing the diversity of the highlands without resorting to the use of extra criteria and limits, based on climate, relief etc. But adding these criteria would already constitute a form of **characterization** rather than definition. In our approach we opted for a simple definition that encompasses all kinds of highlands and recognizes that, after definition, a stage of characterization is needed in which any other relevant characteristics can be incorporated (e.g. topography, climate, soils, land use etc.).

Highlands, as defined above, constitute about 28% of the study area (4,030,000 km^2), and cover large areas in many countries of this region, underscoring their importance (Table 2.1).

Table 2 .1 Highlands in the countries of the study area

Sub-region	Country	Land area (sq.km)[1]	Highland (sq.km)	Highland (%)
Caucasus	Armenia	28,203	27,619	98
Caucasus	Azerbaijan	82,629	25,648	31
Caucasus	Georgia	69,700	43,541	62

[1] Source of country areas: http://en.wikipedia.org/wiki/List_of_countries_by_area

Central Asia	Kazakhstan	2,699,700	212,373	8
Central Asia	Kyrgyzstan	191,801	185,366	97
Central Asia	Tajikistan	141,510	121,906	86
Central Asia	Turkmenistan	469,930	9,465	2
Central Asia	Uzbekistan	425,400	36,598	9
North Africa	Algeria	2,381,741	482,795	20
North Africa	Egypt	995,450	31,708	3
North Africa	Libya	1,759,540	50,294	3
North Africa	Morocco	446,300	217,571	49
North Africa	Tunisia	155,360	5,574	4
West Asia	Afghanistan	652,230	511,342	78
West Asia	Iran	1,531,595	1,118,571	73
West Asia	Iraq	437,367	26,190	6
West Asia	Jordan	88,802	43,278	49
West Asia	Lebanon	10,230	6,266	61
West Asia	OPT[2]: Gaza_Strip	360	0	0
West Asia	OPT: West_Bank	5640	399	7
West Asia	Pakistan	770,876	312,148	40
West Asia	Syria	183,630	19,724	11
West Asia	Turkey	769,632	540,000	70

2.3. Differentiation of highlands based on key characteristics

The very diverse highlands of the study area can be differentiated on the basis of ecologically relevant key characteristics, of which the most important are temperature, relief and aridity. A fairly complex stratification of the highlands into ecologically more homogeneous groups can quickly be obtained by applying in a GIS environment some simple rules, using publicly available global datasets on climate and topography, as follows:

[2] OPT: Occupied Palestinian Territories

- Rule 1 for differentiating highlands: *highlands are 'colder' than lowlands*
- Rule 2 for differentiating highlands: *highlands contain diverse landforms*
- Rule 3 for differentiating highlands: *Highlands have diverse moisture regimes*

Rule 1: highlands are 'colder' than lowlands

Using publicly available spatial climatic datasets (De Pauw, 2008) it is relatively easy to make a classification of the highlands according to their 'coldness' characteristics and to map these coldness classes across the region. The measure of coldness used is the *annual accumulated cold units (AACU)*, which can be defined as 'the total amount of degrees Celsius below zero, based on the daily minimum temperature, summed over the entire year'.

The AACU can be calculated either using daily data (equation 1), or, more commonly, using monthly data (equation 2) and is expressed in degree days units:

$$\sum_{d=1}^{365} (if\ Tmin_d > 0{,}0, -Tmin_d)$$

$$\sum_{m=1}^{12} (if\ Tmin_m > 0{,}0, -Tmin_m * ND_m)$$

with d: day number; m: month number; Tmin: minimum temperature of day d or month m; ND: number of days in month m

Based on the AACU levels, coldness classes can be distinguished. In order to retain simplicity, in this study we distinguish five coldness classes as follows:

- Class 1: AACU ≤ 1
- Class 2: AACU >1 – 500
- Class 3: AACU >500 – 1200
- Class 4: AACU >1200 – 2500
- Class 5: AACU >2500

These coldness classes correspond roughly with the following situations:

Cold Zone 1 (AACU ≤ 1): 'warm' highlands

No frost risk; highlands with 'mild' or 'warm' winters.

The warm highlands constitute about 24% of the highlands of the study area.

Cold Zone 2 (AACU >1 – 500): 'cool' highlands

Light frost endemic; only adapted crops and plants are required

The cool highlands constitute about 36% of the highlands of the study area.

Cold Zone 3 (AACU >500 – 1200): 'cold' highlands

Severe winters with endemic frost; cold tolerance in crops and plants is required

The cold highlands constitute about 18% of the highlands of the study area.

Cold Zone 4 (AACU >1200 – 2500): 'very cold' highlands

Very cold winters and cool to mild summers; biomass productivity potential is reduced; frontier for breeding cold-resistant crops.

The very cold highlands constitute about 11% of the highlands of the study area.

Cold Zone 5 (AACU >2500): extremely cold' highlands

Very cold climates resulting in strongly reduced biomass productivity and confined to very high mountain areas.

The extremely cold highlands constitute about 11% of the highlands of the study area.

As the above figures and the map in Figure 2.6 indicate, it is obvious that all 5 coldness zones are important in the study area and that therefore it is important to accept that each zone will need to be managed differently in accordance with the ecological limits imposed by their coldness characteristics.

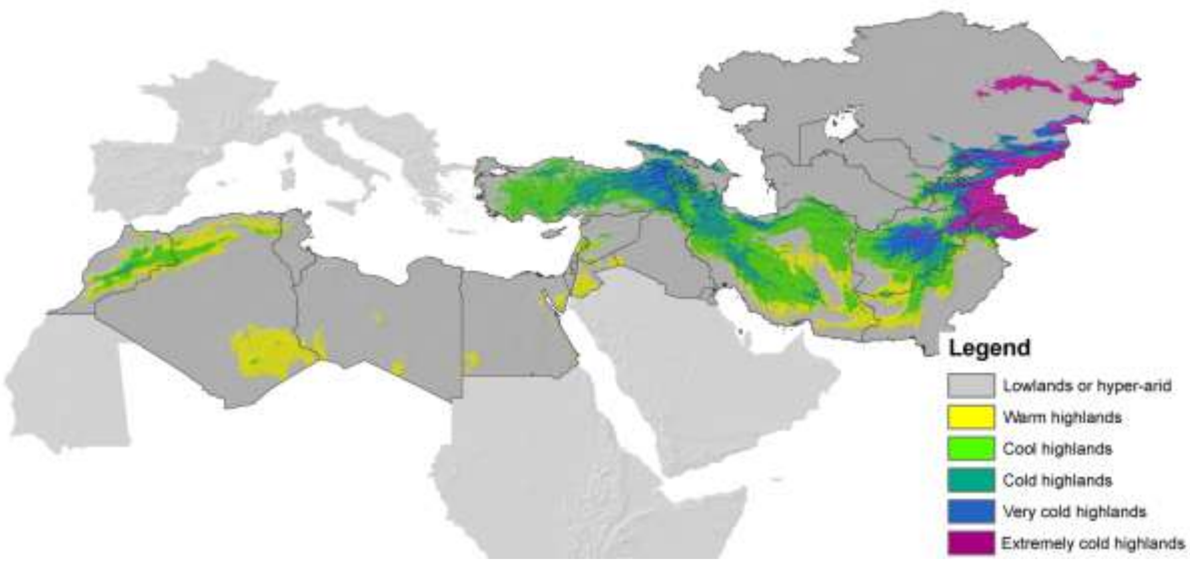

Figure 2.6 Distribution of coldness zones in the highlands of the study area

Rule 2: highlands contain diverse landforms

The measure used to differentiate the highlands according to terrain characteristics into landforms at regional scale is the degree of dissection, or 'ruggedness' , which can be easily mapped in a GIS using a digital elevation model (DEM). The DEM used is extracted from the global DEM SRTM30[3] and the ruggedness characteristic is calculated and classified from this DEM using a simple neighborhood function in GIS software as follows:

Landform 1: 'Plain-like' highlands

These are calculated as the contiguous areas in which the maximum elevation difference between neighboring pixels is less than 50 m. They represent those parts of the highlands that have a low degree of dissection and are characterized by flat or undulating relief. Plain-type highlands occupy about 26% of the STUDY AREA region.

Landform 2: 'Hilly' highlands

These are calculated as the contiguous areas in which the maximum elevation difference between neighboring pixels is 50-300 m. They represent those parts of the highlands that have a moderate to high degree of dissection and are characterized by rolling or steep relief. Hilly highlands occupy about 48% of the STUDY AREA region.

Landform 3: 'Mountainous' highlands

These are calculated as the contiguous areas in which the maximum elevation difference between neighboring pixels is more than 300 m. They represent those parts of the highlands that have a very high degree of dissection and are characterized by very steep to near vertical relief. Mountainous highlands occupy about 26% of the STUDY AREA region.

---

[3] SRTM30 Digital Elevation Model (http://topex.ucsd.edu/WWW_html/srtm30_plus.html)

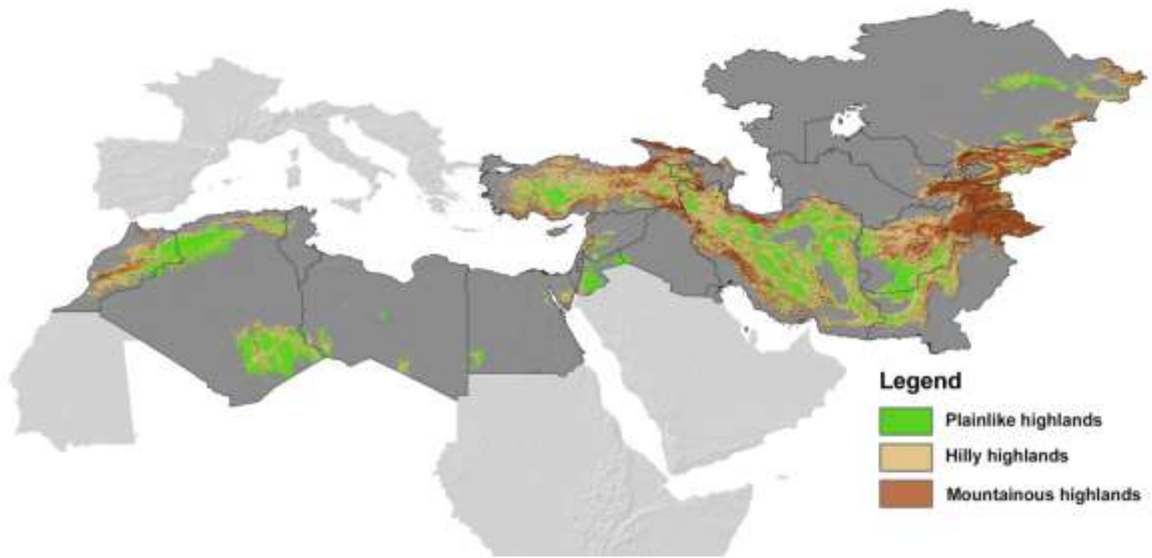

Figure 2 .7. Distribution of relief classes in the highlands of the study area

From the above figures and the map in Figure 2.7 it is clear that these three relief classes are important in the highlands of the study area and that land management will have to take into consideration the particular opportunities and risks that are associated with the slope patterns in each of the relief classes. Plains have the advantage of suitable topography for agriculture, whereas erosion is a particular risk in the hilly and mountainous highlands, a risk that can be exacerbated by the lithological properties of the local geology and precipitation patterns and is therefore very site-specific. On the positive side, hilly and mountainous highlands also offer opportunities for diversified land use patterns by exploiting micro-climatic conditions, particularly related to differences in thermal regime arising from different slopes and slope orientations, as well as possibilities for water harvesting.

Rule 3: Highlands have diverse moisture regimes

The general moisture regime of the highlands can be expressed by a simple measure, the *aridity index*, which is the ratio of the annual precipitation to annual potential evapo-transpiration. It is therefore particular to this system that in the definition of the moisture regime not only the water supply (precipitation) is considered, but also the water demand (evapo-transpiration). The following aridity index classes, borrowed from UNESCO (1979), were extracted from a study covering Eurasia (De Pauw, 2008) and mapped for the Highlands of the study area (Fig. 2.8):

Moisture regime 1: Hyper-arid (Aridity index <0.03)

This aridity class is characterized by very low and irregular rain, which may fall in any season, and is present in about 8% of the Highlands of the study area.

Moisture regime 2: Arid (Aridity index 0.03 – <0.2)

This aridity class is characterized by annual rainfall of 80-200 mm (in areas with winter rainfall) up to 200-350 mm (in areas with summer rainfall) and is present in about 30% of the Highlands of the study area. Inter-annual rainfall variability is 50-100 percent.

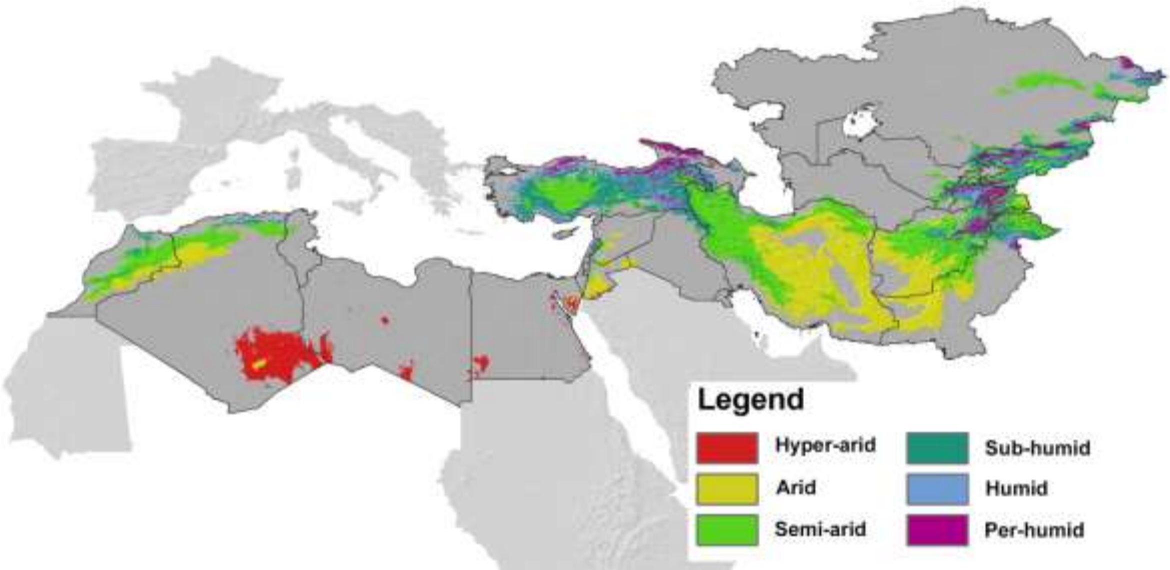

Figure 2.8. Aridity patterns in the highlands of the study area

Moisture regime 3: Semi-arid (Aridity index 0.2 – <0.5)

In winter rainfall areas this aridity index range corresponds roughly with a mean annual rainfall from 200-250 mm to 450-500 mm, in summer rainfall areas with a mean annual rainfall from 300-400 mm to 700-800 mm. This aridity class is characterized by high inter-annual rainfall variability (25-50 percent) and is present in about 33% of the Highlands of the study area.

Moisture regime 4: Sub-humid (Aridity index 0.5 – <0.75)

The inter-annual rainfall variability is less than 25 percent. This aridity class is present in about 15% of the highlands of the study area.

Moisture regime 5: Humid (Aridity index 0.75 – 1.0)

This aridity class is present in about 7% of the highlands of the study area.

Moisture regime 6: Per-humid (Aridity index above 1.0)

This aridity class is present in about 7% of the highlands of the study area.

It is to be noted that since the aridity index represents a ratio between a water supply term and a water demand term, a low aridity index can be the result of either a low rainfall-moderate potential evapo-transpiration or high rainfall- very high potential evapo-transpiration combination. Conversely - and this is usually the case in the highlands of the study area – a high ratio (humid and per-humid classes) is the consequence of a combination of moderate to high rainfall with low to very potential evapo-transpiration at higher elevations, where temperatures are very low and precipitation is mostly in the form of snowfall.

Putting the pieces together

The huge diversity of the Highlands of the study area becomes particularly obvious when overlaying the basic themes: aridity classes, accumulated annual cold unit classes and relief classes. The combination of the three themes generates 74 new classes, encompassing widely different moisture and thermal regimes and landscapes. Of these, 25 classes (Table 2.2) make up 80% of the Highlands of the study area, the remaining 49 classes total 20% of these highlands.

Table 2.2. Classification of highlands in the study area on the basis of aridity, coldness and landforms

Description	Percent	sq.km
Arid, cool, hilly highlands	7.97	321,114
Semi-arid, cool, hilly highlands	7.29	293,936
Arid, cool, plain-like highlands	7.26	292,702
Semi-arid, cold, hilly highlands	6.07	244,654
Arid, warm, plain-like highlands	6.03	242,884
Arid, warm, hilly highlands	5.52	222,537
Hyper-arid, warm, plain-like highlands	4.28	172,283
Semi-arid, cool, plain-like highlands	3.26	131,473
Hyper-arid, warm, hilly highlands	2.91	117,272
Sub-humid, cool, hilly highlands	2.87	115,773
Per-humid, extremely cold, mountainous highlands	2.60	104,861
Sub-humid, cold, hilly highlands	2.52	101,494
Semi-arid, cold, mountainous highlands	2.40	96,743

Semi-arid, cool, mountainous highlands	2.11	84,835
Semi-arid, warm, hilly highlands	1.83	73,719
Sub-humid, cold, mountainous highlands	1.78	71,547
Semi-arid, very cold, hilly highlands	1.77	71,135
Per-humid, very cold, mountainous highlands	1.72	69,366
Sub-humid, extremely cold, mountainous highlands	1.46	58,975
Semi-arid, warm, plain-like highlands	1.42	57,301
Sub-humid, cool, mountainous highlands	1.41	56,854
Sub-humid, very cold, mountainous highlands	1.41	56,752
Semi-arid, extremely cold, hilly highlands	1.40	56,218
Sub-humid, very cold, hilly highlands	1.39	55,919
Semi-arid, extremely cold, mountainous highlands	1.38	55,428
Humid, very cold, mountainous highlands	1.32	53,310
Semi-arid, cold, plain-like highlands	1.32	53,310
Semi-arid, very cold, mountainous highlands	1.29	51,848
Humid, extremely cold, mountainous highlands	1.15	46,268
Semi-arid, extremely cold, plain-like highlands	1.12	45,146
Humid, cold, mountainous highlands	1.10	44,447
Arid, cool, mountainous highlands	1.05	42,259
Humid, cold, hilly highlands	0.95	38,303
Sub-humid, extremely cold, hilly highlands	0.90	36,280
Humid, very cold, hilly highlands	0.78	31,278
Arid, warm, mountainous highlands	0.73	29,569
Humid, cool, hilly highlands	0.69	27,858
Per-humid, cold, mountainous highlands	0.63	25,268
Per-humid, very cold, hilly highlands	0.60	24,045

Figure 2.9 contains the overview map of the Highlands of the study area, classified in accordance with the above three tier system based on aridity class, coldness class and major landform class. In order to get a better picture of the diversity of these highlands, more detailed maps are provided for different parts of the highlands in Figures 2.10-2.17.

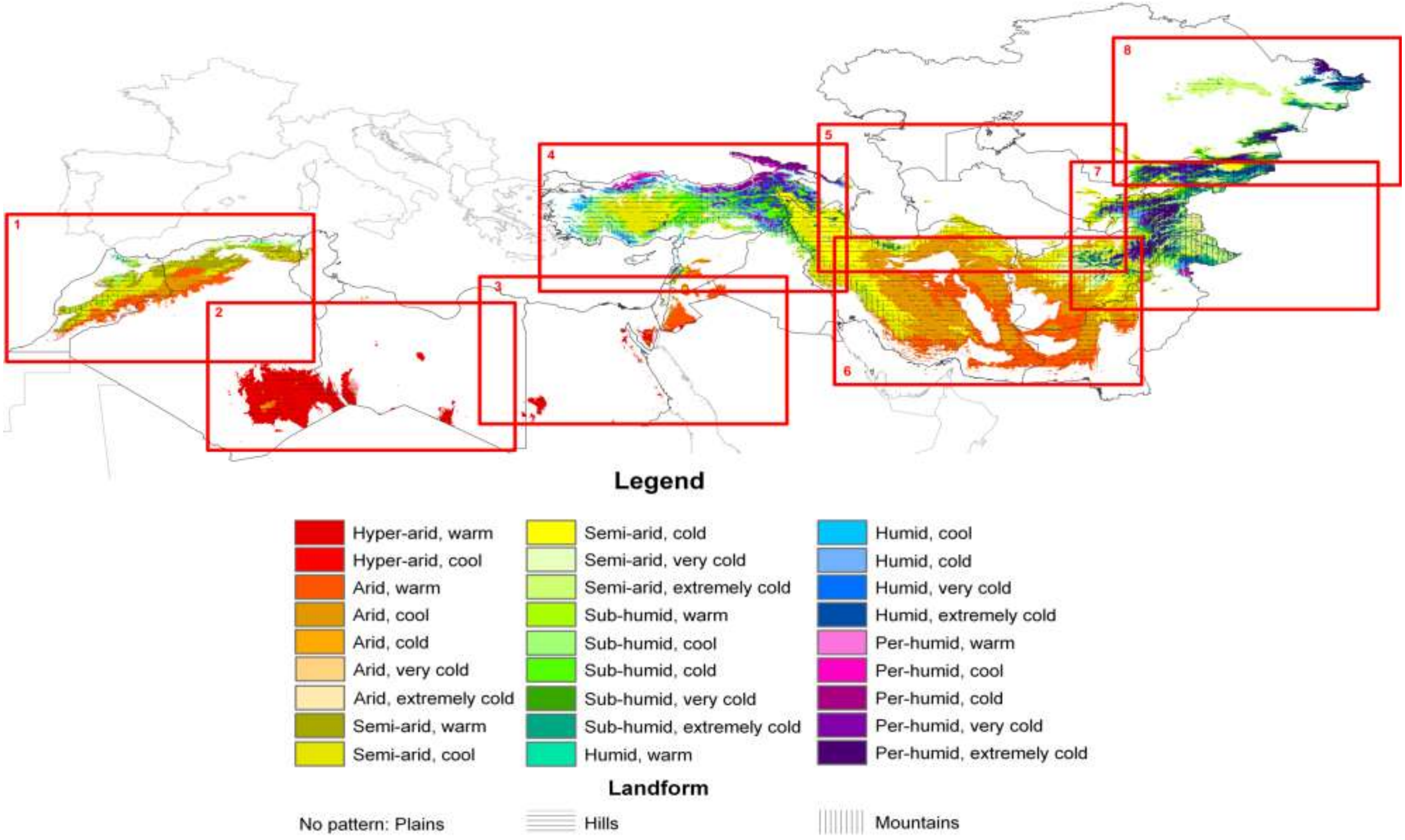

Figure 2.9 Distribution of highlands of the study area classified according to aridity regime, degree of coldness and major landforms. The red rectangles indicate the extent of the enlarged maps shown in Figures 2.10 -2. 17.

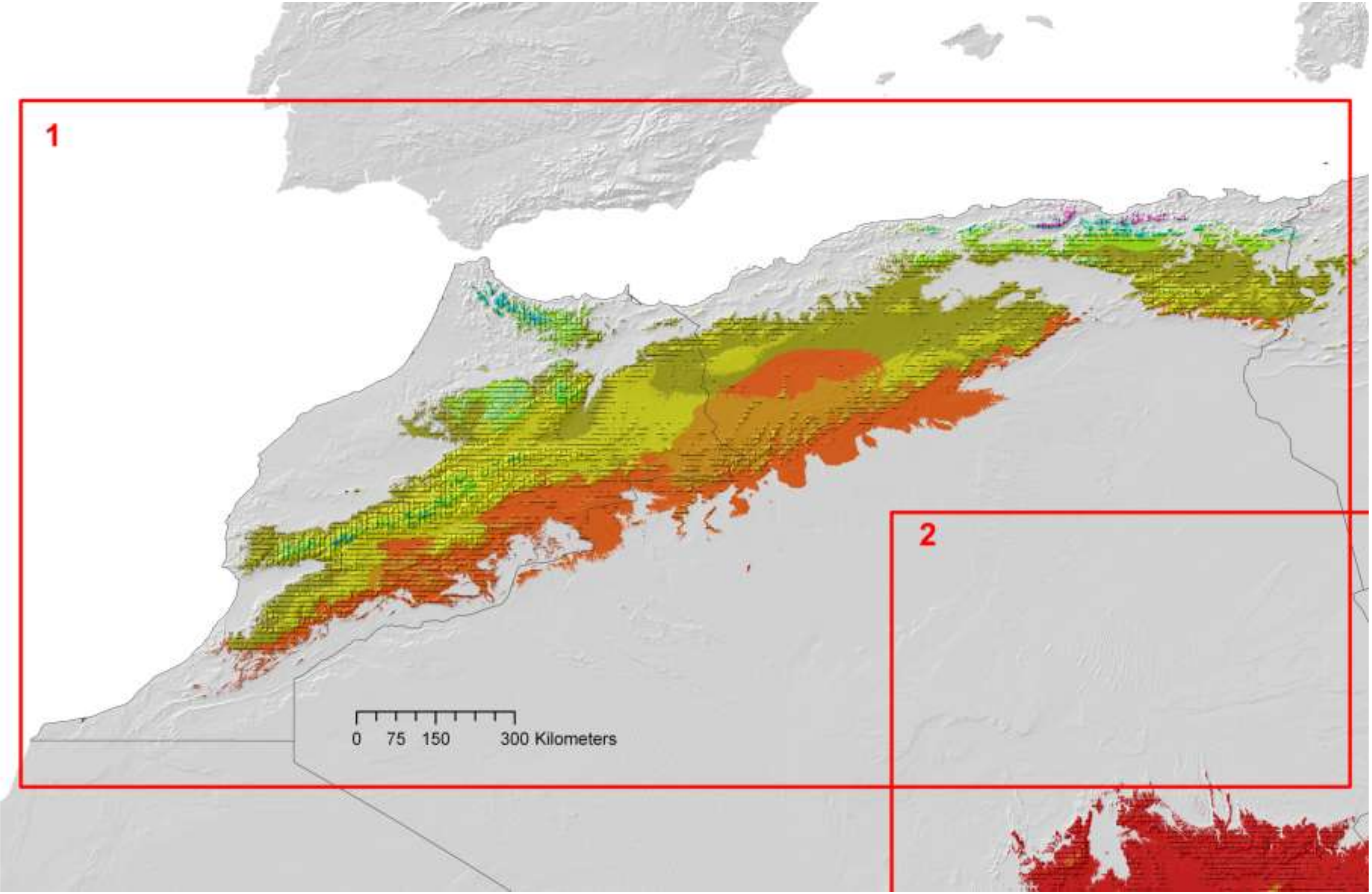

Figure 2.10 Distribution of highlands of the study area in Map Sheet 1 classified according to aridity regime, degree of coldness and major landforms.

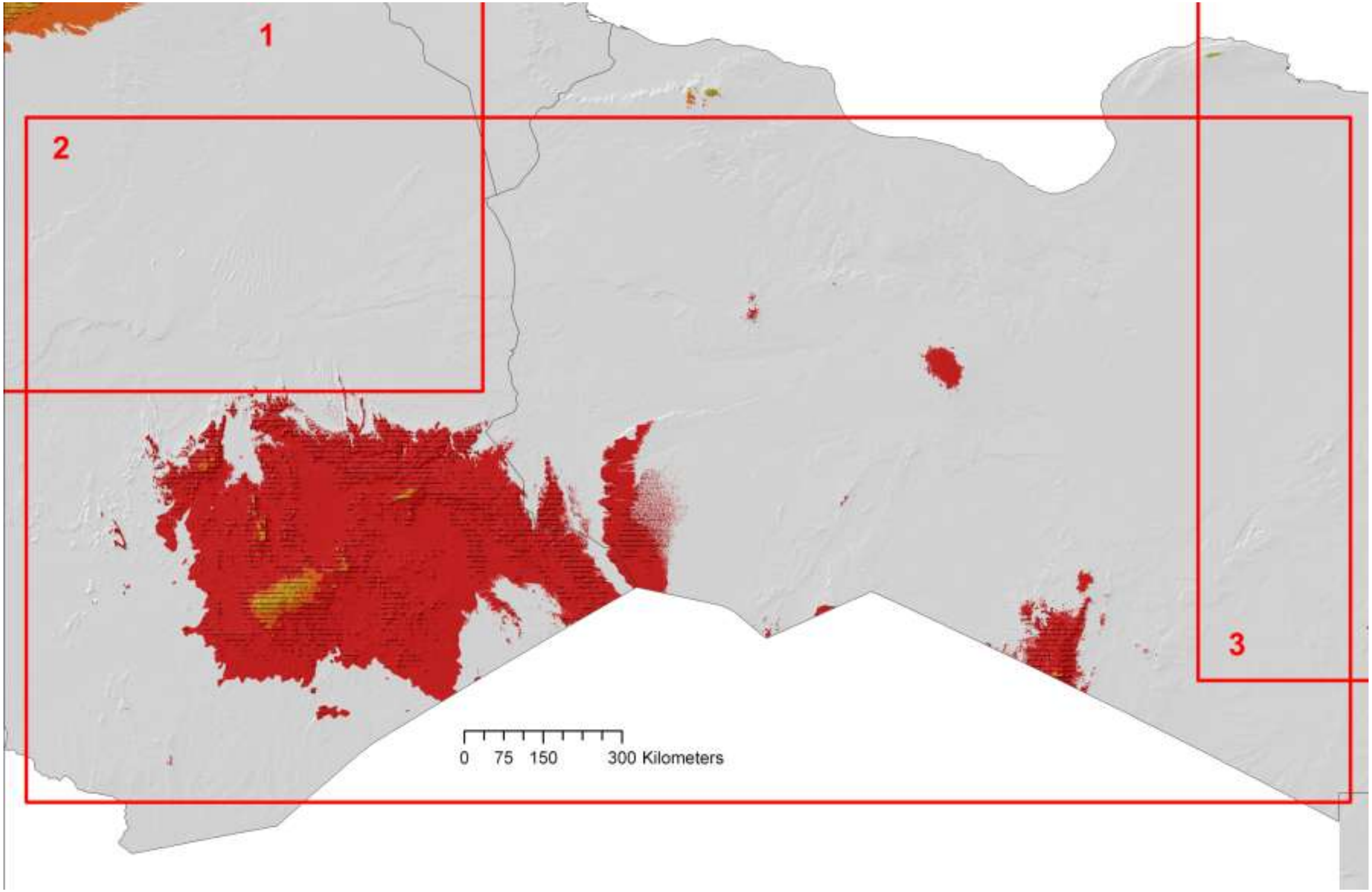

Figure 2.11 Distribution of highlands of the study area in Map Sheet 2 classified according to aridity regime, degree of coldness and major landforms.

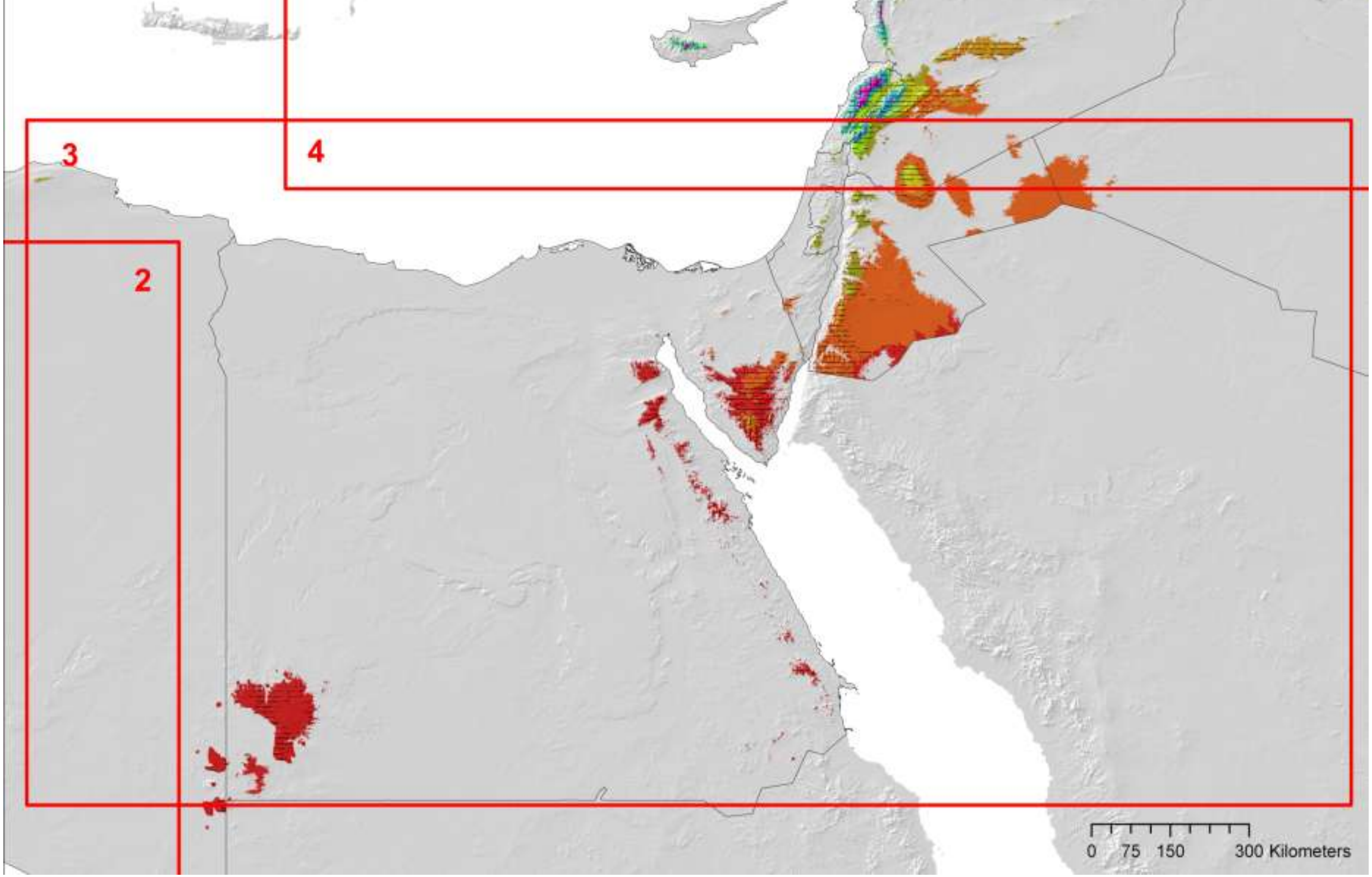

Figure 2.12. Distribution of highlands of the study area in Map Sheet 3 classified according to aridity regime, degree of coldness and major landforms.

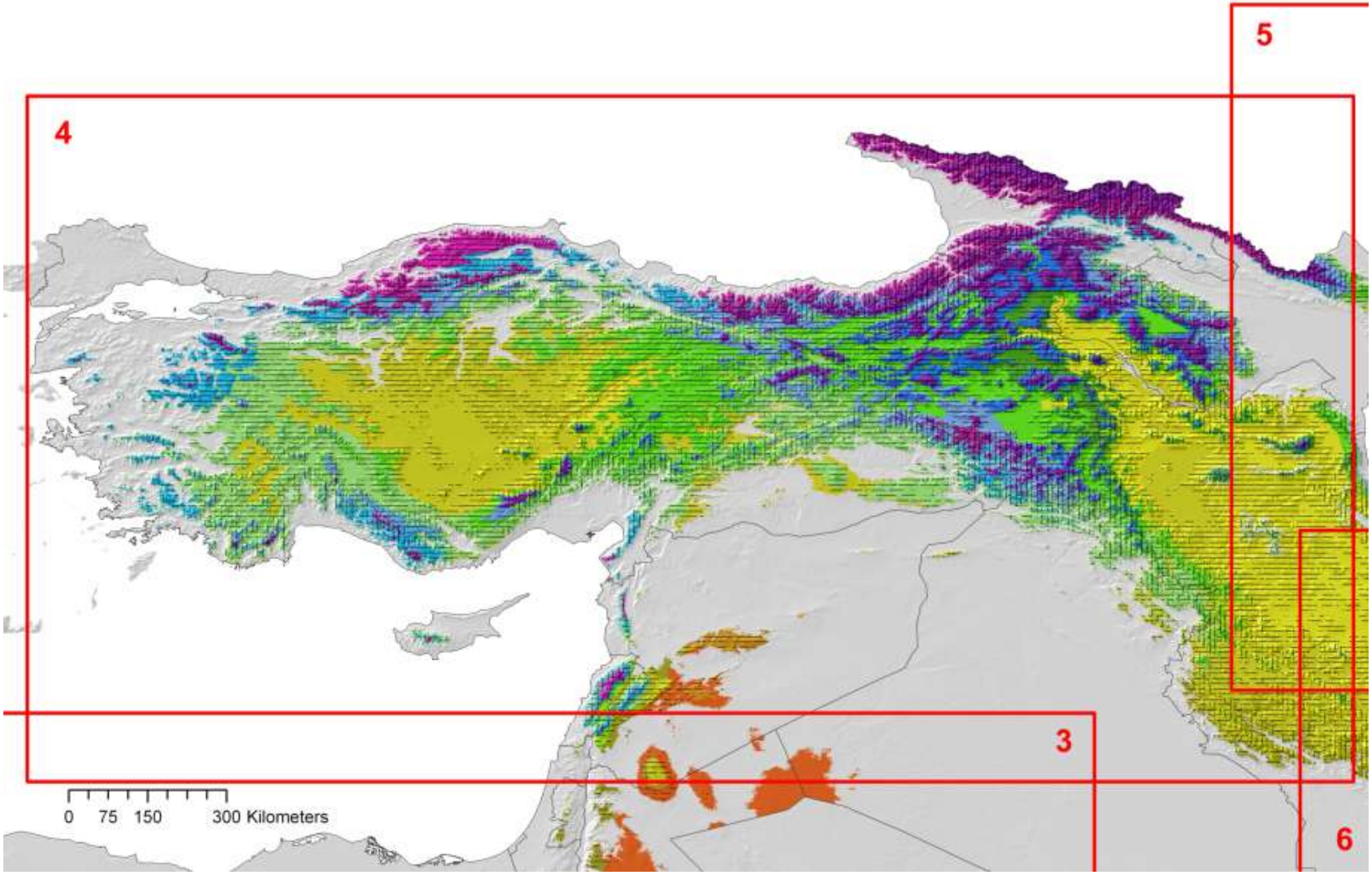

Figure 2.13 Distribution of highlands of the study area in Map Sheet 4 classified according to aridity regime, degree of coldness and major landforms.

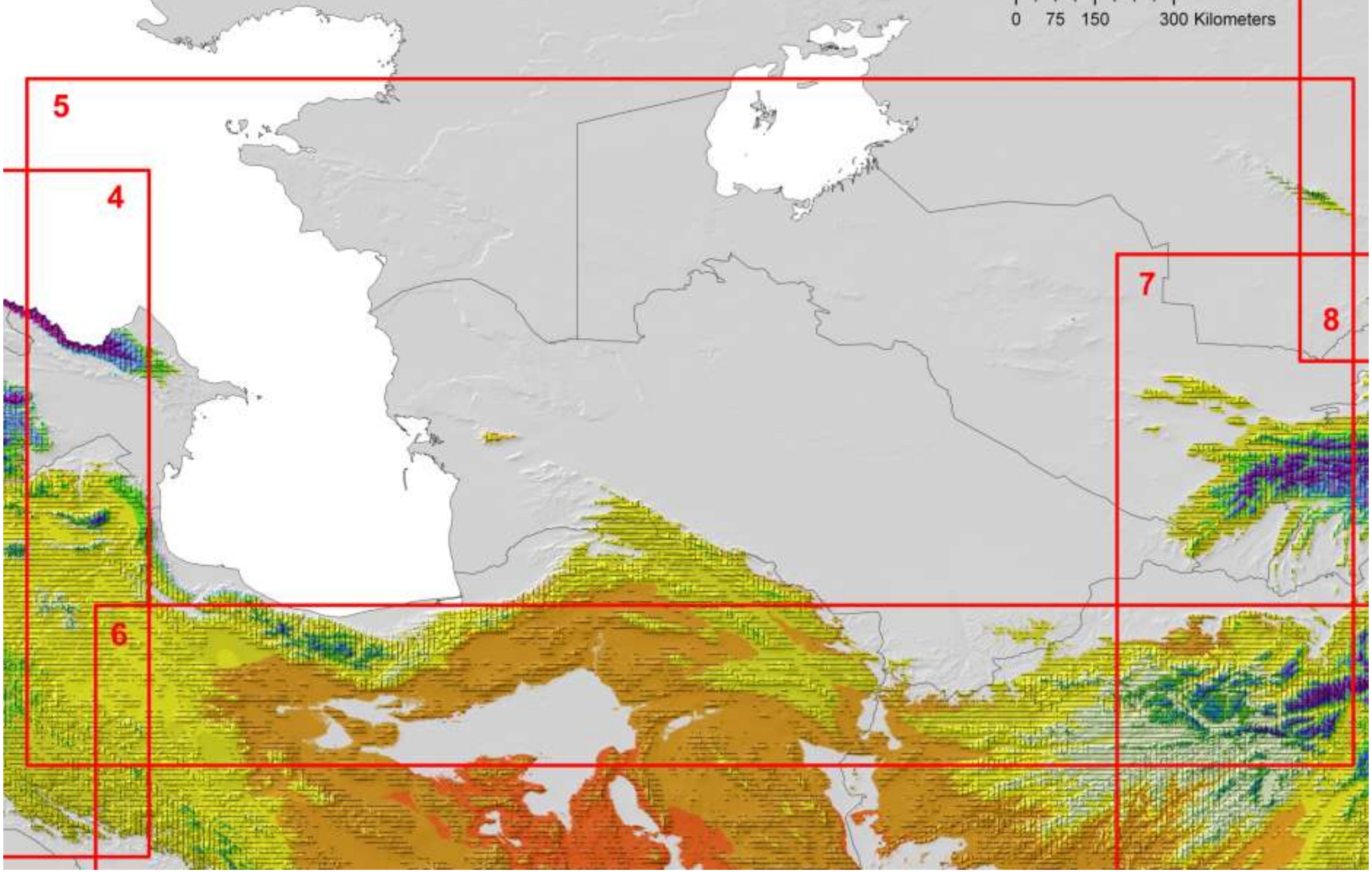

Figure 2.14 Distribution of highlands of the study area in Map Sheet 5 classified according to aridity regime, degree of coldness and major landforms.

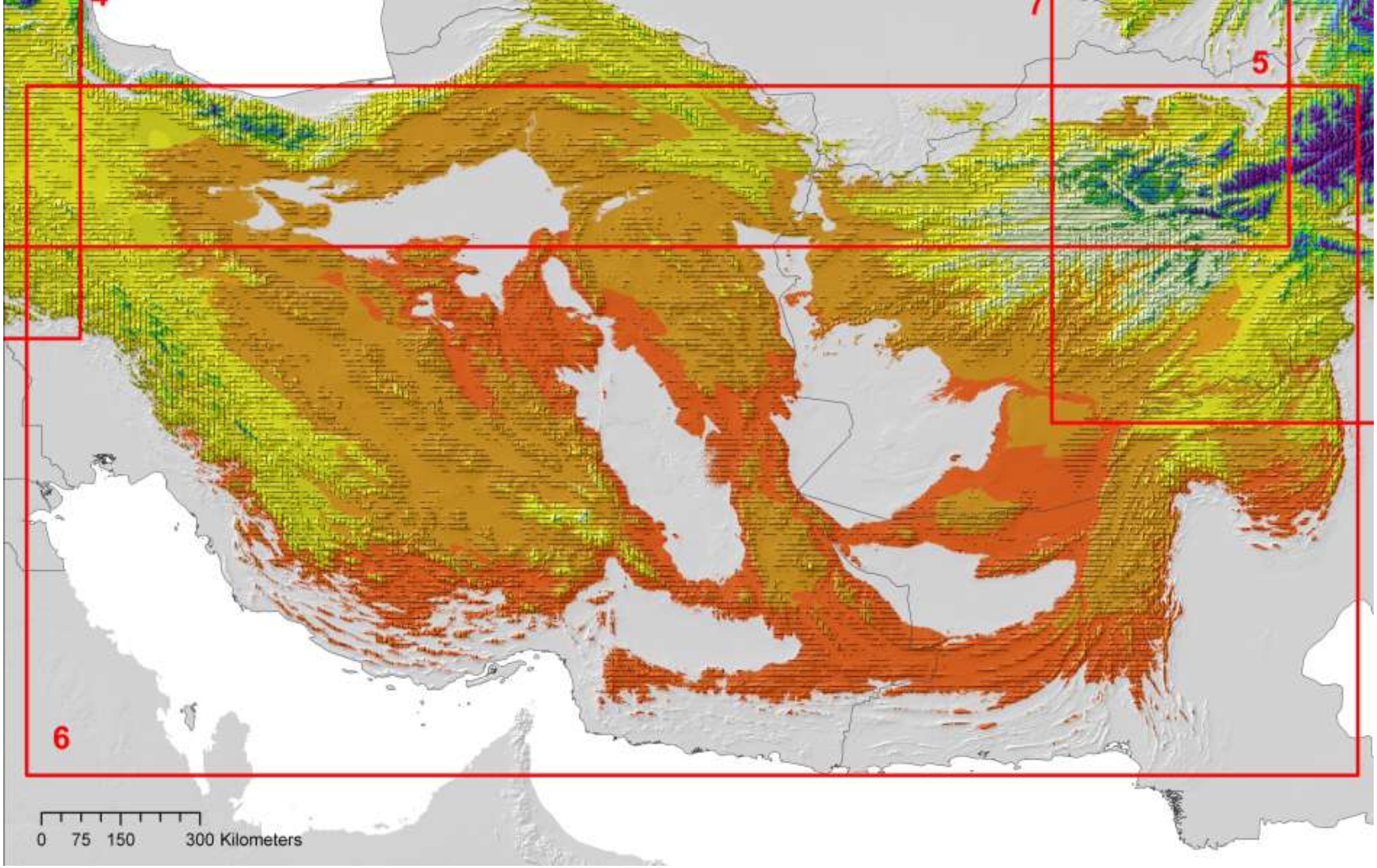

Figure 2.15 Distribution of highlands of the study area in Map Sheet 6 classified according to aridity regime, degree of coldness and major landforms.

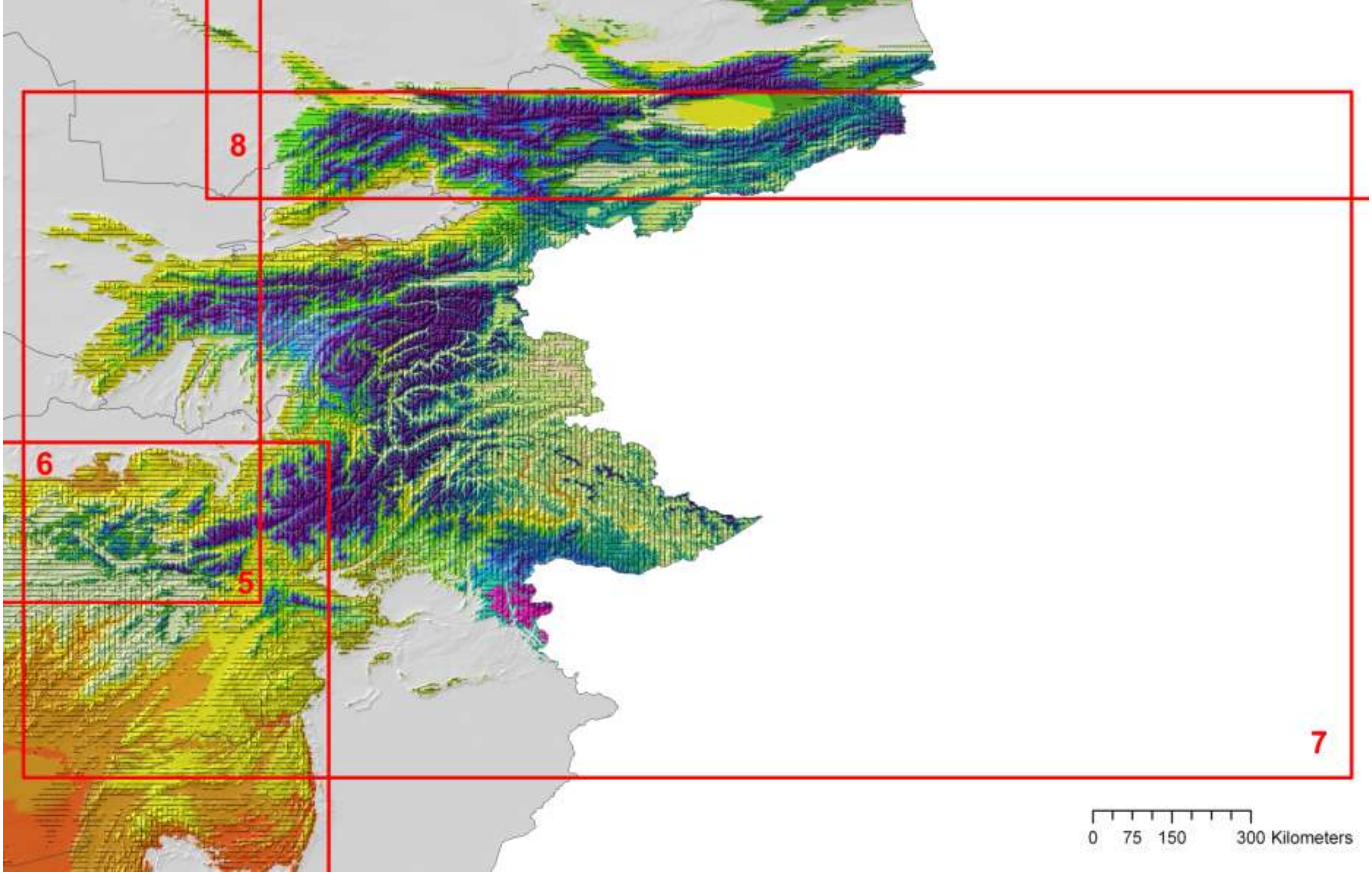

Figure 2.16 Distribution of highlands of the study area in Map Sheet 7 classified according to aridity regime, degree of coldness and major landforms.

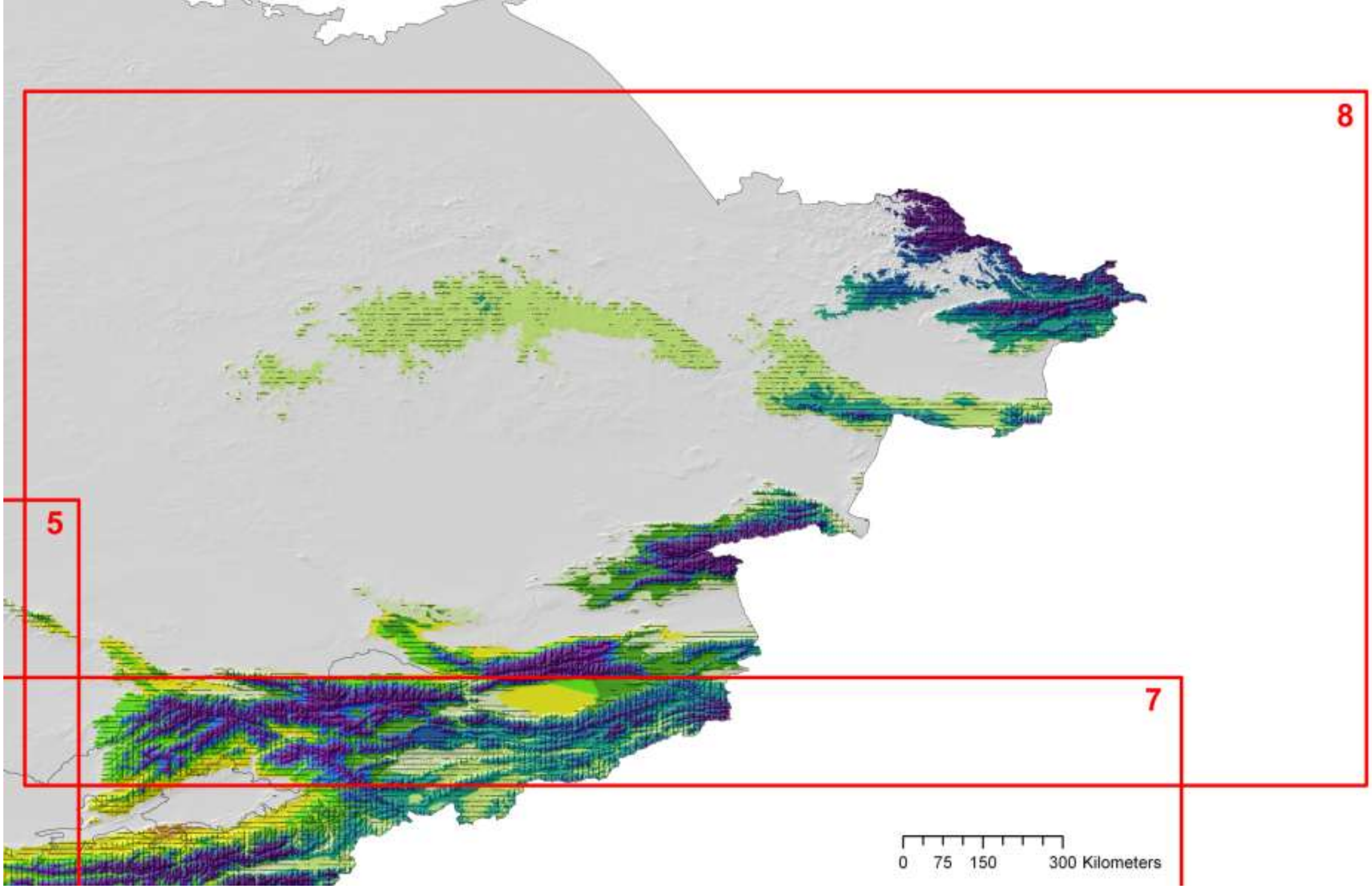

Figure 2.17 Distribution of highlands of the study area in Map Sheet 8 classified according to aridity regime, degree of coldness and major landforms.

2..4. Characterization of highlands

In the previous sections was explained how highlands were defined and differentiated using spatial datasets available in the public domain. In this section is discussed how each highland zone can be characterized by means of other spatial datasets. This process is schematized in Figure 2.18.

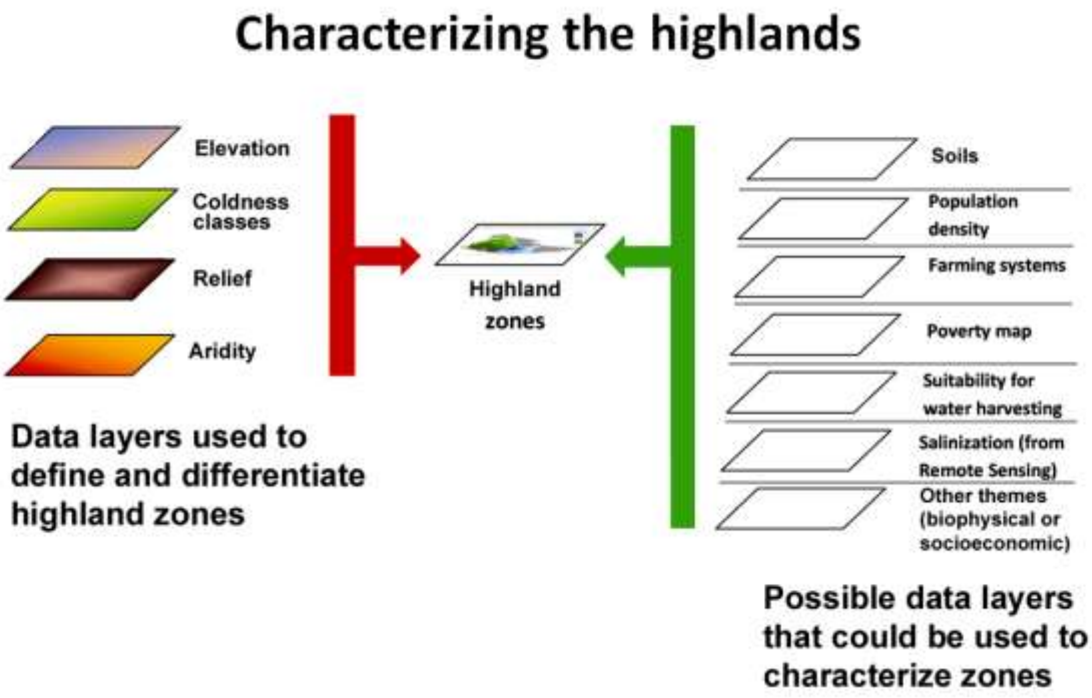

Figure 2.18. Using thematic spatial datasets to characterize different highland zones

2.4.1. Characterization tables

A very effective way to characterize the different highland zones is by means of histograms that provide the relative importance of each thematic class inside each highland zone. These so-called *characterization tables* can be prepared for any spatial dataset that is considered relevant and sufficiently reliable to provide meaningful information. The spatial datasets could cover themes related to the quality of the natural resource base, such as soils, salinity, growing periods, land suitability etc., but also socio-economic themes, such as poverty, farming systems, population, and others. Several example themes are shown in Figure 2.16. In fact, any theme that can be presented as spatial data can be used, as long as the particular theme is relevant to the research questions to be addressed, sufficiently reliable and at a level of detail that makes sense to differentiate by highland zone.

In the following pages are presented some examples of thematic characterizations, converting thematic maps into synthesis characterization tables.

Table 2.3 provides the summary table for the theme 'soil constraints', for which the spatial extent is shown in Figures 2.19a and 2.19b.

Table 2.4 provides the summary table for the theme ‘length-of-moisture-limited growing period’, for which the spatial extent is shown in Figures 2.20a and 2.20b.

Table 2.5 provides the summary table for the theme ‘land use/land cover’, for which the spatial extent is shown in Figures 2.21a and 2.21b.

Table 2.6 provides the summary table for the theme ‘farming systems’, for which the spatial extent is shown in Figures2.22a and 2.22b.

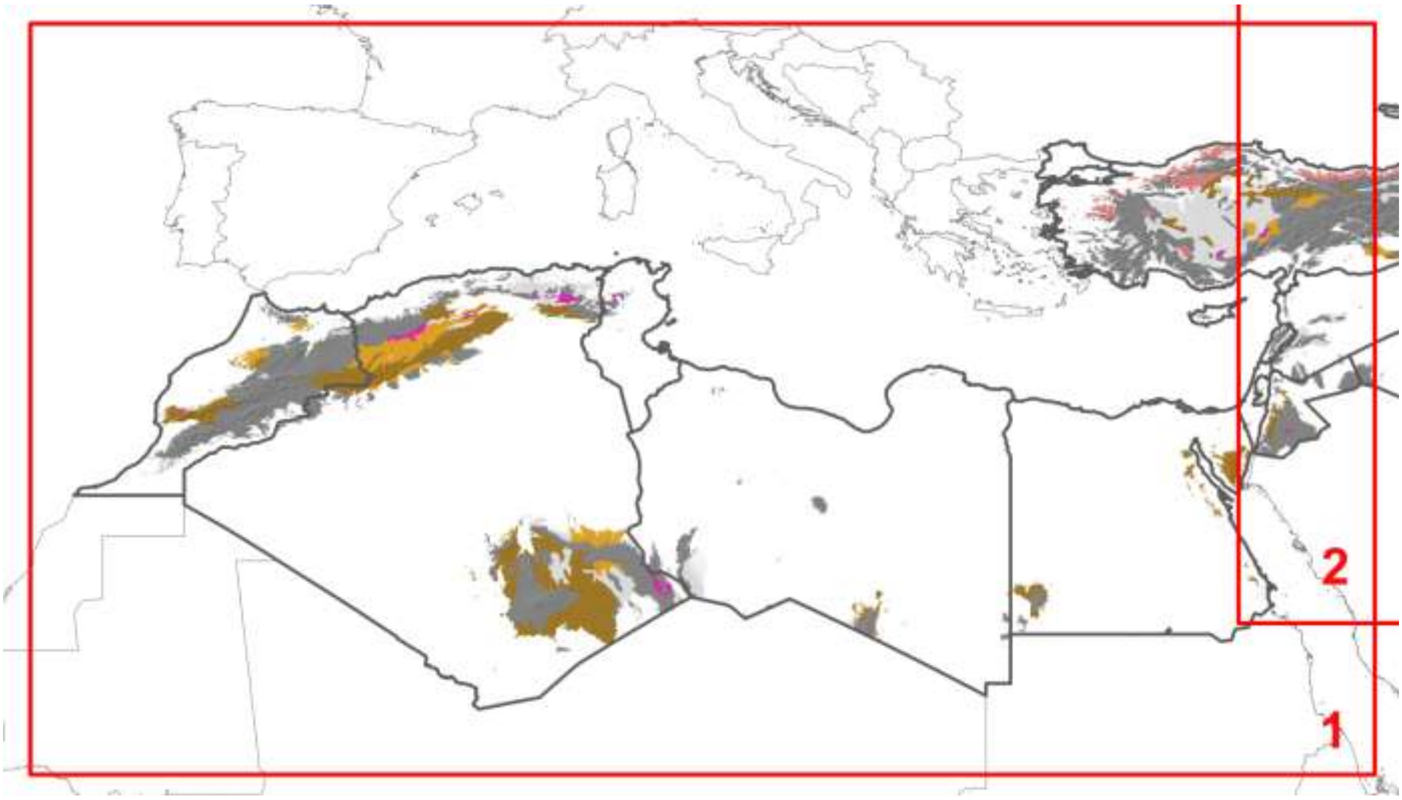

Figure 2.19a. Presence of soil constraints in highlands of the study area (Map sheet 1)

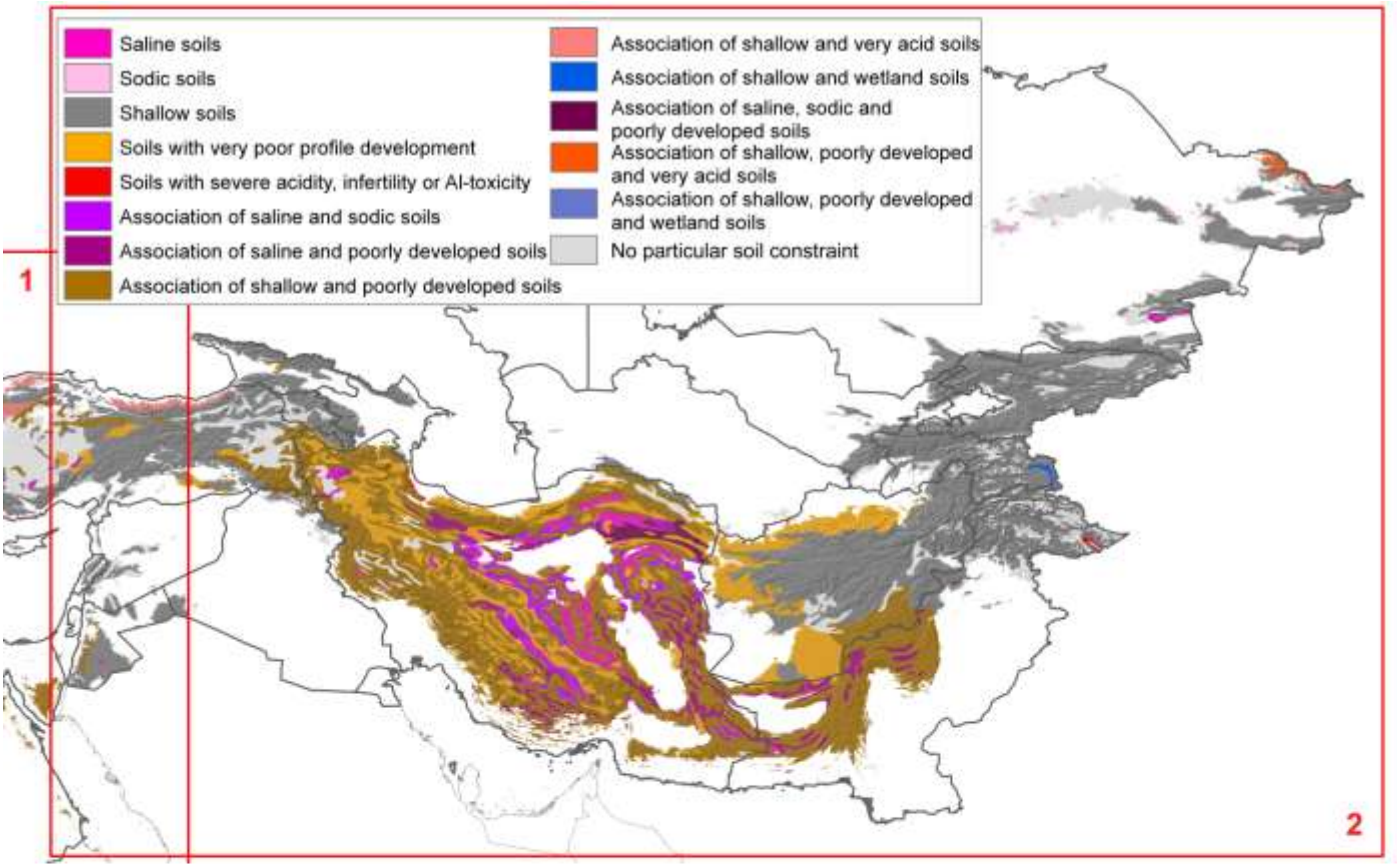

Figure 2.19b Presence of soil constraints in highlands of the study area (Map sheet 2)

Table 2.3a. Distribution of soil constraint categories in different highland zones

Highland zone description	% of HL	sq.km	Soil constraint class (%)(*)														Sum
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	
Arid, cool, hilly highlands	7.97	321,059	3	3	0	8	17	0	5	6	55	0	0	2	0	0	97
Semi-arid, cool, hilly highlands	7.29	293,886	21	0	0	30	12	0	0	1	33	0	0	2	0	0	79
Arid, cool, plain-like highlands	7.26	292,652	3	13	0	5	32	0	14	9	22	0	0	2	0	0	97
Semi-arid, cold, hilly highlands	6.07	244,612	7	0	0	24	21	0	0	1	45	0	0	1	0	0	93
Arid, warm, plain-like highlands	6.03	242,843	1	5	0	32	17	0	5	12	28	0	0	0	0	0	99
Arid, warm, hilly highlands	5.52	222,499	0	2	0	15	7	0	3	8	65	0	0	0	0	0	100
Hyper-arid, warm, plain-like highlands	4.28	172,254	14	1	0	40	3	0	0	0	43	0	0	0	0	0	86
Semi-arid, cool, plain-like highlands	3.26	131,450	44	3	0	22	12	0	2	4	12	0	0	1	0	0	56
Hyper-arid, warm, hilly highlands	2.91	117,252	13	1	0	45	9	0	0	0	32	0	0	0	0	0	87
Sub-humid, cool, hilly highlands	2.87	115,753	12	0	0	76	1	0	0	0	8	3	0	0	0	0	88
Per-humid, extremely cold, mountainous highlands	2.60	104,843	16	0	0	80	0	0	0	0	0	0	0	0	3	0	84
Sub-humid, cold, hilly highlands	2.52	101,477	16	0	0	64	4	0	0	0	15	1	0	0	0	0	84
Semi-arid, cold, mountainous highlands	2.40	96,727	4	0	0	34	13	0	0	0	47	0	0	1	0	0	96
Semi-arid, cool, mountainous highlands	2.11	84,820	7	0	0	30	9	0	0	1	52	0	0	1	0	0	93
Semi-arid, warm, hilly highlands	1.83	73,706	13	2	0	51	6	0	0	0	28	0	0	0	0	0	87
Sub-humid, cold, mountainous highlands	1.78	71,535	6	0	0	71	2	0	0	0	20	0	0	0	0	0	94
Semi-arid, very cold, hilly highlands	1.77	71,122	13	1	0	76	6	0	0	0	5	0	0	0	0	0	87

Per-humid, very cold, mountainous highlands	1.72	69,354	4	0	0	90	0	0	0	0	5	1	0	0	0	0	96
Sub-humid, extremely cold, mountainous highlands	1.46	58,965	17	0	0	82	0	0	0	0	0	0	0	0	0	0	83
Semi-arid, warm, plain-like highlands	1.42	57,291	16	7	0	45	14	0	0	0	18	0	0	0	0	0	84
Sub-humid, cool, mountainous highlands	1.41	56,845	6	0	0	80	2	0	0	0	11	0	0	0	0	0	94
Sub-humid, very cold, mountainous highlands	1.41	56,743	6	0	0	74	4	0	0	0	17	0	0	0	0	0	94
Semi-arid, extremely cold, hilly highlands	1.40	56,208	38	0	10	53	0	0	0	0	0	0	0	0	0	0	62
Sub-humid, very cold, hilly highlands	1.39	55,909	25	2	0	57	2	0	0	0	14	0	0	0	0	0	75
Semi-arid, extremely cold, mountainous highlands	1.38	55,419	24	0	0	73	0	2	0	0	0	0	1	0	0	0	76
Humid, very cold, mountainous highlands	1.32	53,301	7	0	0	84	1	0	0	0	9	0	0	0	0	0	93
Semi-arid, cold, plain-like highlands	1.32	53,300	27	0	0	12	32	0	0	3	26	0	0	0	0	0	73
Semi-arid, very cold, mountainous highlands	1.29	51,840	5	0	0	79	5	1	0	0	11	0	0	0	0	0	95
Humid, extremely cold, mountainous highlands	1.15	46,260	14	0	0	84	0	0	0	0	0	1	0	0	1	0	86
Semi-arid, extremely cold, plain-like highlands	1.12	45,138	56	0	12	32	0	0	0	0	0	0	0	0	0	0	44
Humid, cold, mountainous highlands	1.10	44,439	5	0	0	78	1	0	0	0	13	3	0	0	0	0	95

Table 2.3a. continued

Highland zone description	% of HL	sq.km	Soil constraint class (%)(*)														Sum
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	
Arid, cool, mountainous highlands	1.05	42,252	3	2	0	11	10	0	2	4	67	0	0	0	0	0	97
Humid, cold, hilly highlands	0.95	38,297	7	0	0	72	2	0	0	0	8	11	0	0	0	0	93
Sub-humid, extremely cold, hilly highlands	0.90	36,273	11	0	0	89	0	0	0	0	0	0	0	0	0	0	89
Humid, very cold, hilly highlands	0.78	31,272	21	0	0	68	0	0	0	0	10	0	0	0	0	0	79
Arid, warm, mountainous highlands	0.73	29,564	0	0	0	10	2	0	1	7	80	0	0	0	0	0	100
Humid, cool, hilly highlands	0.69	27,853	7	0	0	70	0	0	0	0	1	21	0	0	0	0	93
Per-humid, cold, mountainous highlands	0.63	25,263	2	0	0	77	0	0	0	0	7	13	0	0	0	0	98
Per-humid, very cold, hilly highlands	0.60	24,040	10	0	0	81	0	0	0	0	8	1	0	0	0	0	90
Humid, cool, mountainous highlands	0.51	20,498	6	0	0	74	1	1	0	0	4	15	0	0	0	0	94
Arid, cold, hilly highlands	0.50	20,105	4	2	0	34	7	0	0	2	52	0	0	0	0	0	96
Humid, extremely cold, hilly highlands	0.49	19,843	6	0	0	88	0	0	0	0	0	3	0	0	3	0	94
Per-humid, extremely cold, hilly highlands	0.41	16,475	9	0	0	71	0	0	0	0	0	2	0	0	18	0	91
Sub-humid, cold, plain-like highlands	0.39	15,610	59	0	0	31	8	0	0	0	3	0	0	0	0	0	41
Semi-arid, warm, mountainous highlands	0.38	15,315	8	1	0	35	3	0	0	0	53	0	0	0	0	0	92
Sub-humid, warm, hilly highlands	0.35	14,299	41	0	0	47	11	0	0	0	0	0	0	0	0	0	59
Sub-humid, cool, plain-like highlands	0.35	14,047	22	0	0	69	2	0	0	0	6	1	0	0	0	0	78
Per-humid, cool, mountainous highlands	0.33	13,297	17	0	0	48	0	0	0	0	3	32	0	0	0	0	83
Per-humid, cold, hilly highlands	0.31	12,623	2	0	0	59	1	0	0	0	9	30	0	0	0	0	98

Arid, cold, mountainous highlands	0.27	10,840	5	1	0	45	9	0	0	1	38	0	0	0	0	0	95
Semi-arid, very cold, plain-like highlands	0.25	10,174	50	3	0	46	0	0	0	0	0	0	0	0	0	0	50
Per-humid, cool, hilly highlands	0.22	8,911	14	0	0	41	0	0	0	0	3	41	0	0	0	0	86
Sub-humid, very cold, plain-like highlands	0.21	8,301	42	3	0	53	0	0	0	0	2	0	0	0	0	0	58
Hyper-arid, warm, mountainous highlands	0.21	8,259	8	1	0	25	20	0	0	0	47	0	0	0	0	0	92
Arid, cold, plain-like highlands	0.19	7,712	22	0	0	24	8	0	0	0	46	0	0	0	0	0	78
Sub-humid, warm, mountainous highlands	0.13	5,159	15	0	0	77	7	0	0	0	0	1	0	0	0	0	85
Humid, warm, hilly highlands	0.13	5,079	44	0	0	56	0	0	0	0	0	0	0	0	0	0	56
Humid, warm, mountainous highlands	0.11	4,253	35	0	0	62	0	0	0	0	0	2	0	0	0	0	65

Notes: Soil constraint classes: 0 (no constraint); 1 (saline soils); 2 (sodic soils); 3 (shallow soils); 4 (soils with very poor profile development); 5 (soils with severe acidity, infertility or Al-toxicity); 6 (association of saline and sodic soils); 7 (association of saline and poorly developed soils); 8 (association of shallow and poorly developed soils); 9 (association of shallow and very acid soils); 10 (association of shallow and wetland soils); 11 (association of saline, sodic and poorly developed soils) ; 12 (association of shallow, poorly developed and very acid soils); 13 (association of shallow, poorly developed and wetland soils); Sum: total percentage of areas covered by various soil constraints

Table2. 3b. Distribution of soil constraint categories in the highlands of different countries

Country	Highland area (sq.km)	Highland area (%)	Soil constraint class														Sum
			0	1	2	3	4	5	6	7	8	9	10	11	12	13	

Afghanistan	511,342	78	6	0	0	61	26	0	0	0	7	0	0	0	0	0	94
Algeria	482,795	20	10	3	0	39	13	0	0	0	35	0	0	0	0	0	87
Armenia	27,619	98	23	0	0	74	3	0	0	0	0	0	0	0	0	0	77
Azerbaijan	25,648	31	4	0	0	88	6	0	0	0	3	0	0	0	0	0	96
Cyprus	686	7	0	0	0	100	0	0	0	0	0	0	0	0	0	0	100
Egypt	31,708	3	3	0	0	18	0	0	0	0	79	0	0	0	0	0	97
Georgia	43,541	62	6	0	0	91	0	0	0	0	3	0	0	0	0	0	94
Iran	1,118,571	73	3	6	0	0	18	0	7	7	57	0	0	2	0	0	91
Iraq	26,190	6	17	0	0	61	0	0	0	0	22	0	0	0	0	0	83
Jordan	43,278	49	0	1	0	88	0	0	0	0	11	0	0	0	0	0	99
Kazakhstan	212,373	8	32	1	4	59	0	0	0	0	0	1	0	0	3	0	67
Kyrgyzstan	185,366	97	14	0	0	86	0	0	0	0	0	0	0	0	0	0	86
Lebanon	6,266	61	23	0	0	77	0	0	0	0	0	0	0	0	0	0	77
Libya	50,294	3	28	1	0	58	1	0	0	0	12	0	0	0	0	0	71
Morocco	217,571	49	3	0	0	75	4	0	0	0	17	0	0	0	0	0	97
OPT: West Bank	399	7	0	0	0	100	0	0	0	0	0	0	0	0	0	0	100
Pakistan	312,148	40	12	0	0	31	1	0	0	8	47	0	0	0	0	0	87
Syria	19,724	11	34	0	0	66	0	0	0	0	0	0	0	0	0	0	66
Tajikistan	121,906	86	16	0	0	82	0	0	0	0	0	0	2	0	0	0	84
Tunisia	5,574	4	2	10	0	88	0	0	0	0	0	0	0	0	0	0	88

Turkey	540,000	70	27	0	0	54	3	0	0	0	9	6	0	0	0	0	73
Turkmenistan	9,465	2	30	2	0	62	3	0	0	0	2	0	0	0	0	0	68
Uzbekistan	36,598	9	27	0	0	73	0	0	0	0	0	0	0	0	0	0	73
Weighted total			*11.9*	*2.1*	*0.3*	*41.6*	*10.2*	*0.1*	*2.0*	*2.7*	*27.4*	*1.0*	*0.1*	*0.6*	*0.2*	*0.0*	*88*

Note: constraint classes have the same meaning as in table 3a. Sum: total percentage of areas covered by various soil constraints

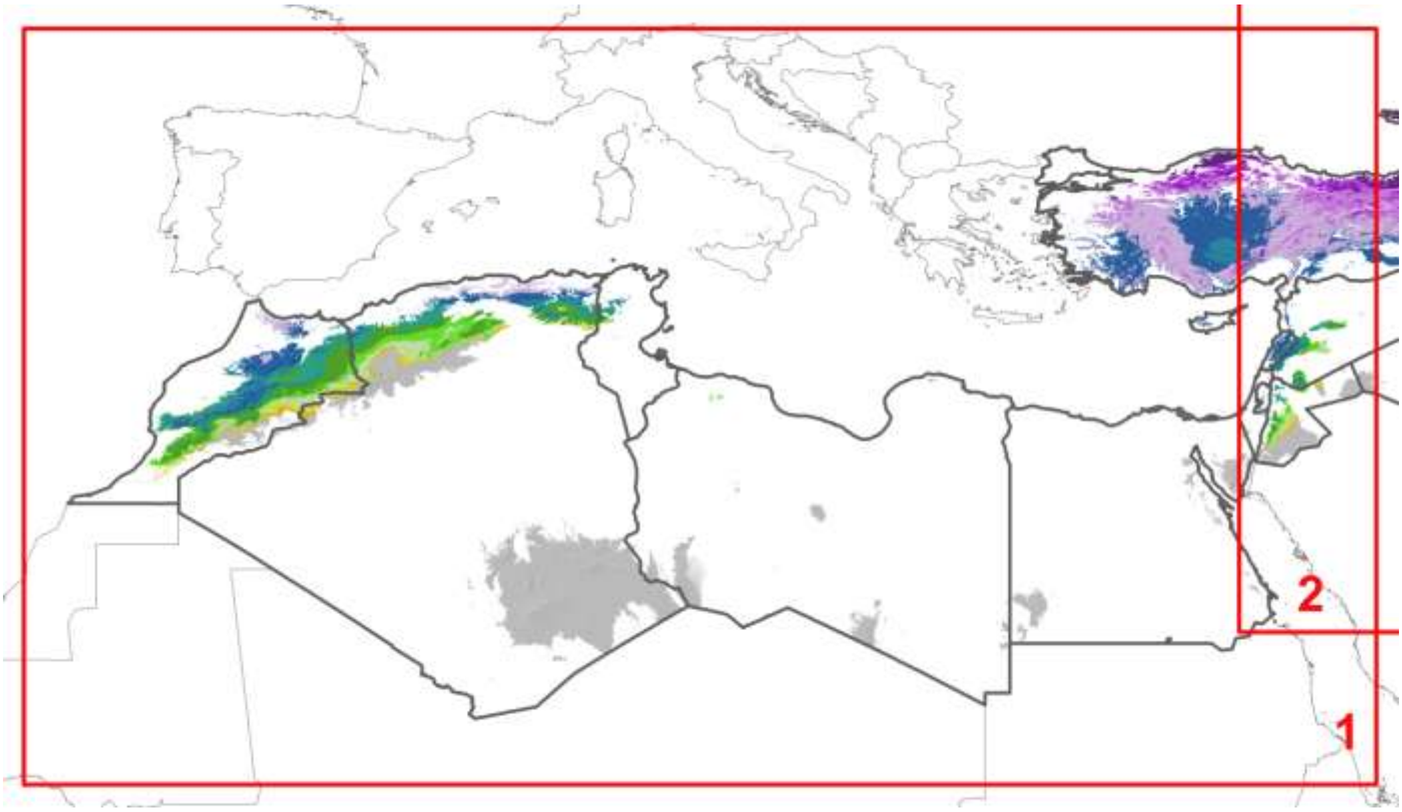

Figure 2.20a Duration of the moisture-limited growing period in highlands of the study area (Map sheet 1)

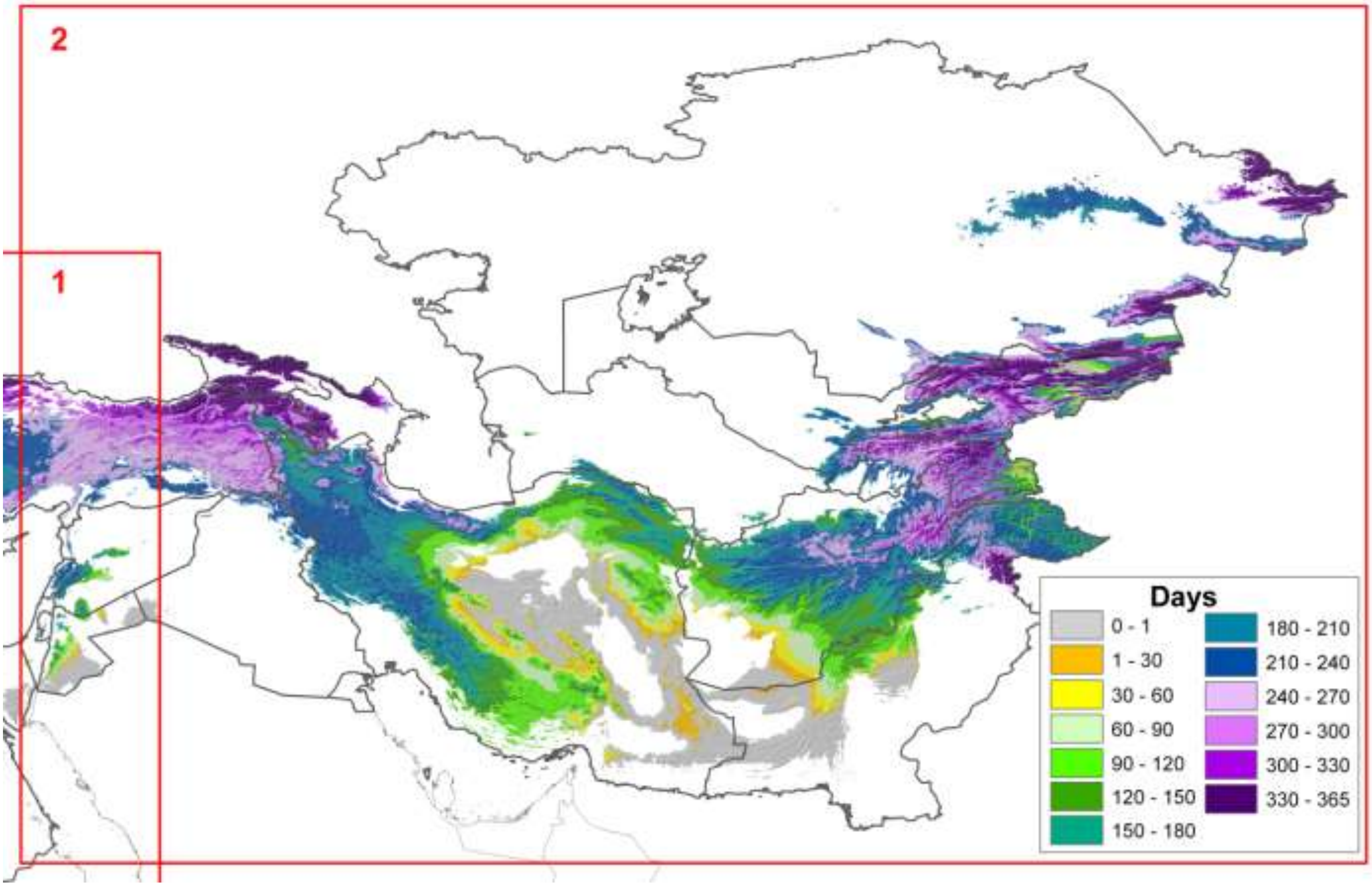

Figure 2.20b Duration of the moisture-limited growing period in highlands of the study area (Map sheet 2)

Table 2.4a. Distribution of growing period length classes in different highland zones

Highland zone description	% of HL	sq.km	Growing period length class (days)												
			0 - 1	1 - 30	30 - 60	60 - 90	90 - 120	120 - 150	150 - 180	180 - 210	210 - 240	240 - 270	270 - 300	300 - 330	330 - 365
Arid, cool, hilly highlands	7.97	321,059	21	8	10	15	27	17	2	0	0	0	0	0	0
Semi-arid, cool, hilly highlands	7.29	293,886	0	0	0	0	4	16	26	23	25	4	0	0	0
Arid, cool, plain-like highlands	7.26	292,652	19	7	14	24	23	13	0	0	0	0	0	0	0
Semi-arid, cold, hilly highlands	6.07	244,612	0	0	0	0	1	7	16	33	36	7	0	0	0
Arid, warm, plain-like highlands	6.03	242,843	70	8	6	9	6	1	0	0	0	0	0	0	0
Arid, warm, hilly highlands	5.52	222,499	72	5	5	6	9	3	0	0	0	0	0	0	0
Hyper-arid, warm, plain-like highlands	4.28	172,254	100	0	0	0	0	0	0	0	0	0	0	0	0
Semi-arid, cool, plain-like highlands	3.26	131,450	0	0	0	0	3	19	22	21	29	6	0	0	0
Hyper-arid, warm, hilly highlands	2.91	117,252	100	0	0	0	0	0	0	0	0	0	0	0	0
Sub-humid, cool, hilly highlands	2.87	115,753	0	0	0	0	0	0	0	2	38	49	10	1	0
Per-humid, extremely cold, mountainous highlands	2.60	104,843	0	0	0	0	0	0	0	0	1	7	14	21	58
Sub-humid, cold, hilly highlands	2.52	101,477	0	0	0	0	0	0	0	0	10	56	31	2	1
Semi-arid, cold, mountainous highlands	2.40	96,727	0	0	0	0	2	8	17	32	35	6	1	0	0
Semi-arid, cool, mountainous highlands	2.11	84,820	0	0	0	0	3	13	23	35	23	2	0	0	0
Semi-arid, warm, hilly highlands	1.83	73,706	0	0	1	2	11	23	29	23	11	0	0	0	0
Sub-humid, cold, mountainous highlands	1.78	71,535	0	0	0	0	0	0	0	4	33	39	19	4	1

Semi-arid, very cold, hilly highlands	1.77	71,122	2	0	0	0	1	5	4	16	62	10	0	0	0
Per-humid, very cold, mountainous highlands	1.72	69,354	0	0	0	0	0	0	0	0	1	8	18	18	55
Sub-humid, extremely cold, mountainous highlands	1.46	58,965	0	0	1	1	1	1	3	11	26	20	12	9	15
Semi-arid, warm, plain-like highlands	1.42	57,291	1	1	1	5	26	32	23	8	3	0	0	0	0
Sub-humid, cool, mountainous highlands	1.41	56,845	0	0	0	0	0	0	0	7	46	35	9	2	0
Sub-humid, very cold, mountainous highlands	1.41	56,743	0	0	0	0	0	0	0	3	28	38	20	7	3
Semi-arid, extremely cold, hilly highlands	1.40	56,208	0	0	1	1	2	6	5	25	50	7	1	0	0
Sub-humid, very cold, hilly highlands	1.39	55,909	0	0	0	0	0	0	0	1	11	35	39	7	5
Semi-arid, extremely cold, mountainous highlands	1.38	55,419	1	0	1	1	4	11	22	32	15	7	3	1	1
Humid, very cold, mountainous highlands	1.32	53,301	0	0	0	0	0	0	0	0	6	23	30	22	18
Semi-arid, cold, plain-like highlands	1.32	53,300	2	1	0	2	3	9	26	29	21	8	0	0	0
Semi-arid, very cold, mountainous highlands	1.29	51,840	1	0	0	0	0	3	11	26	46	11	1	0	0
Humid, extremely cold, mountainous highlands	1.15	46,260	0	0	0	0	0	0	1	2	10	18	12	13	43
Semi-arid, extremely cold, plain-like highlands	1.12	45,138	0	0	0	0	1	1	1	48	46	3	0	0	0

Table2. 4a. (continued)

Highland zone description	% of HL	sq.km	Growing period length class (days)												
			0 - 1	1 - 30	30 - 60	60 - 90	90 - 120	120 - 150	150 - 180	180 - 210	210 - 240	240 - 270	270 - 300	300 - 330	330 - 365
Humid, cold, mountainous highlands	1.10	44,439	0	0	0	0	0	0	0	0	6	36	27	16	15
Arid, cool, mountainous highlands	1.05	42,252	23	9	10	14	25	16	3	0	0	0	0	0	0
Humid, cold, hilly highlands	0.95	38,297	0	0	0	0	0	0	0	0	1	27	38	20	13
Sub-humid, extremely cold, hilly highlands	0.90	36,273	0	0	0	0	0	0	1	3	12	39	16	12	17
Humid, very cold, hilly highlands	0.78	31,272	0	0	0	0	0	0	0	0	1	6	38	32	23
Arid, warm, mountainous highlands	0.73	29,564	45	5	6	14	23	7	1	0	0	0	0	0	0
Humid, cool, hilly highlands	0.69	27,853	0	0	0	0	0	0	0	1	9	40	30	13	8
Per-humid, cold, mountainous highlands	0.63	25,263	0	0	0	0	0	0	0	0	1	8	7	12	73
Per-humid, very cold, hilly highlands	0.60	24,040	0	0	0	0	0	0	0	0	0	2	13	19	66
Humid, cool, mountainous highlands	0.51	20,498	0	0	0	0	0	0	0	0	13	44	19	12	12
Arid, cold, hilly highlands	0.50	20,105	0	0	2	6	22	50	19	1	0	0	0	0	0
Humid, extremely cold, hilly highlands	0.49	19,843	0	0	0	0	0	0	0	0	2	6	7	14	71
Per-humid, extremely cold, hilly highlands	0.41	16,475	0	0	0	0	0	0	0	0	0	1	6	8	85
Sub-humid, cold, plain-like highlands	0.39	15,610	0	0	0	0	0	0	0	0	1	69	29	1	0
Semi-arid, warm, mountainous highlands	0.38	15,315	0	0	1	1	6	19	35	31	7	0	0	0	0
Sub-humid, warm, hilly highlands	0.35	14,299	0	0	0	0	0	0	0	9	63	27	0	0	0
Sub-humid, cool, plain-like highlands	0.35	14,047	0	0	0	0	0	0	0	0	41	57	2	0	0

Per-humid, cool, mountainous highlands	0.33	13,297	0	0	0	0	0	0	0	0	3	4	4	13	75
Per-humid, cold, hilly highlands	0.31	12,623	0	0	0	0	0	0	0	0	1	7	10	38	44
Arid, cold, mountainous highlands	0.27	10,840	1	1	6	9	23	39	19	2	0	0	0	0	0
Semi-arid, very cold, plain-like highlands	0.25	10,174	6	0	0	0	1	8	6	11	49	19	0	0	0
Per-humid, cool, hilly highlands	0.22	8,911	0	0	0	0	0	0	0	0	4	2	7	19	68
Sub-humid, very cold, plain-like highlands	0.21	8,301	0	0	0	0	0	0	0	4	4	31	48	11	2
Hyper-arid, warm, mountainous highlands	0.21	8,259	100	0	0	0	0	0	0	0	0	0	0	0	0
Arid, cold, plain-like highlands	0.19	7,712	0	0	0	0	3	85	12	0	0	0	0	0	0
Sub-humid, warm, mountainous highlands	0.13	5,159	0	0	0	0	0	0	0	8	46	41	4	0	0
Humid, warm, hilly highlands	0.13	5,079	0	0	0	0	0	0	0	4	28	40	7	12	9
Humid, warm, mountainous highlands	0.11	4,253	0	0	0	0	0	0	0	4	26	41	6	10	14

Table 2.4b. Distribution of growing period length classes in the highlands of different countries

Country	Highland area (sq.km)	Highland area (%)	Growing period length class (days)												
			0 - 1	1 - 30	30 - 60	60 - 90	90 - 120	120 - 150	150 - 180	180 - 210	210 - 240	240 - 270	270 - 300	300 - 330	330 - 365
Afghanistan	511,342	78	3	2	3	6	6	13	15	13	22	9	4	2	0
Algeria	482,795	20	66	2	2	4	7	6	5	3	3	2	0	0	0
Armenia	27,619	98	0	0	0	0	0	0	6	3	6	8	19	18	40
Azerbaijan	25,648	31	0	0	0	0	0	3	3	3	4	9	17	20	42
Cyprus	686	7	0	0	0	0	0	0	0	11	79	10	0	0	0
Egypt	31,708	3	100	0	0	0	0	0	0	0	0	0	0	0	0
Georgia	43,541	62	0	0	0	0	0	0	0	0	0	0	2	4	94
Iran	1,118,571	73	22	4	5	8	14	11	9	14	11	2	1	0	0
Iraq	26,190	6	20	0	0	0	0	0	0	10	62	8	0	0	0
Jordan	43,278	49	65	3	6	8	9	5	3	2	0	0	0	0	0
Kazakhstan	212,373	8	0	0	0	0	0	1	1	16	27	17	7	4	27
Kyrgyzstan	185,366	97	2	1	1	1	2	3	3	5	11	14	13	13	32
Lebanon	6,266	61	0	0	0	0	0	0	0	45	51	3	1	0	0
Libya	50,294	3	98	0	0	0	1	0	0	0	0	0	0	0	0
Morocco	217,571	49	8	3	5	8	8	20	19	12	14	3	0	0	0
OPT: West Bank	399	7	0	0	0	0	0	0	9	91	0	0	0	0	0
Pakistan	312,148	40	35	3	3	4	8	9	7	11	10	5	2	1	3

Syria	19,724	11	1	0	2	10	12	23	18	22	9	1	0	0	0
Tajikistan	121,906	86	0	1	1	1	3	5	3	6	15	22	15	16	12
Tunisia	5,574	4	1	0	2	2	9	24	30	24	3	5	0	0	0
Turkey	540,000	70	0	0	0	0	0	0	0	2	25	37	22	8	6
Turkmenistan	9,465	2	0	0	0	0	2	15	46	32	5	0	0	0	0
Uzbekistan	36,598	9	0	0	0	0	1	0	5	24	36	17	8	5	4
Weighted total			*19.4*	*2.1*	*2.7*	*4.4*	*6.6*	*7.6*	*7.0*	*9.5*	*14.7*	*10.5*	*5.8*	*3.3*	*6.5*

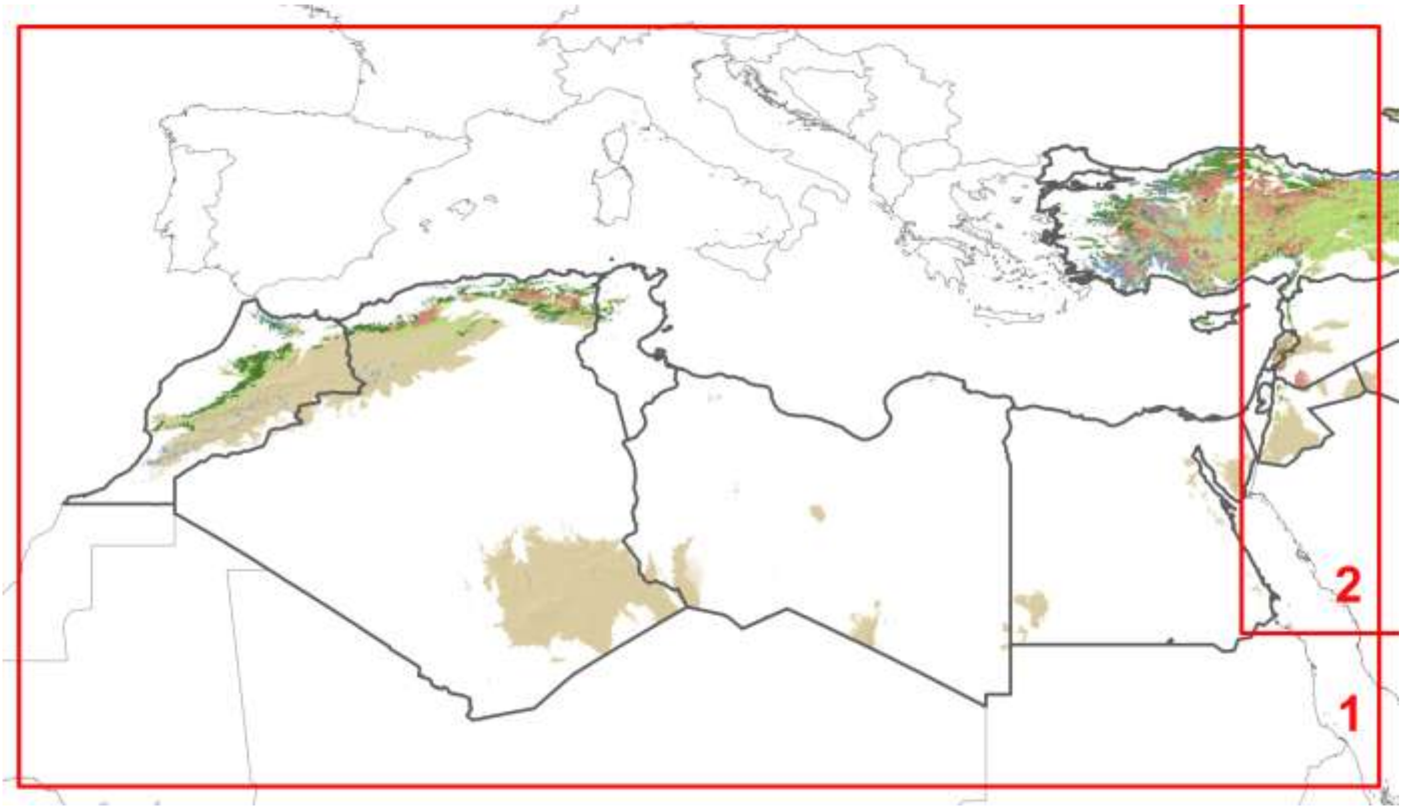

Figure 2.21a Land use/land cover classes in highlands of the study area (Map sheet 1)

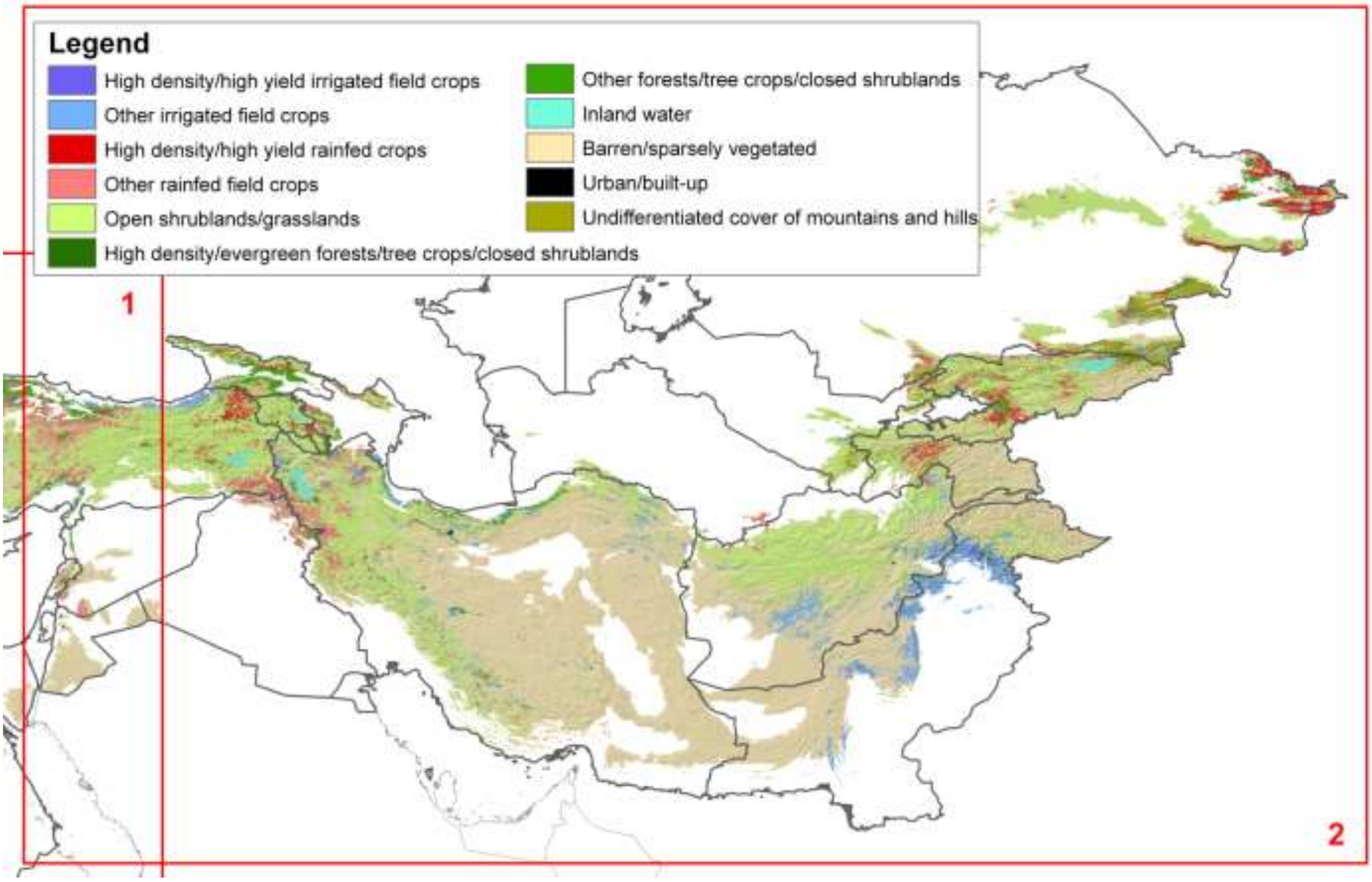

Figure 2.21b Land use/land cover classes in highlands of the study area (Map sheet 2)

Table 2.5a. Distribution of land use/land cover classes in different highland zones

Highland zone description	% of HL	sq.km	Land use/land cover category										
			1	2	3	4	5	6	7	8	9	10	11
Arid, cool, hilly highlands	7.97	321,059	0	4	0	0	4	0	0	0	92	0	0
Semi-arid, cool, hilly highlands	7.29	293,886	0	7	0	8	41	3	1	0	38	0	0
Arid, cool, plain-like highlands	7.26	292,652	0	6	0	1	4	0	0	0	89	0	0
Semi-arid, cold, hilly highlands	6.07	244,612	0	4	0	8	56	0	1	0	31	0	0
Arid, warm, plain-like highlands	6.03	242,843	0	2	0	1	2	0	0	0	96	0	0
Arid, warm, hilly highlands	5.52	222,499	0	2	0	0	5	0	0	0	93	0	0
Hyper-arid, warm, plain-like highlands	4.28	172,254	0	0	0	0	0	0	0	0	100	0	0
Semi-arid, cool, plain-like highlands	3.26	131,450	0	7	0	15	30	0	3	6	38	0	0
Hyper-arid, warm, hilly highlands	2.91	117,252	0	0	0	0	0	0	0	0	100	0	0
Sub-humid, cool, hilly highlands	2.87	115,753	0	10	0	26	40	5	11	1	6	0	0
Per-humid, extremely cold, mountainous highlands	2.60	104,843	0	1	3	3	17	0	1	0	62	0	12
Sub-humid, cold, hilly highlands	2.52	101,477	0	2	2	22	63	0	6	0	2	0	2
Semi-arid, cold, mountainous highlands	2.40	96,727	0	8	0	4	53	0	3	0	30	0	1
Semi-arid, cool, mountainous highlands	2.11	84,820	0	11	0	4	41	3	4	0	35	0	0
Semi-arid, warm, hilly highlands	1.83	73,706	0	12	0	9	23	15	3	0	39	0	0
Sub-humid, cold, mountainous highlands	1.78	71,535	1	9	2	17	55	0	4	0	9	0	3
Semi-arid, very cold, hilly highlands	1.77	71,122	0	2	0	5	70	0	1	0	18	0	3

Per-humid, very cold, mountainous highlands	1.72	69,354	0	5	5	5	56	0	1	0	18	0	10
Sub-humid, extremely cold, mountainous highlands	1.46	58,965	0	0	4	5	26	0	1	0	55	0	9
Semi-arid, warm, plain-like highlands	1.42	57,291	0	2	0	16	26	2	2	0	52	0	0
Sub-humid, cool, mountainous highlands	1.41	56,845	0	8	4	10	55	0	3	0	15	0	5
Sub-humid, very cold, mountainous highlands	1.41	56,743	2	21	0	21	33	5	11	0	6	0	0
Semi-arid, extremely cold, hilly highlands	1.40	56,208	1	4	4	11	60	0	6	0	6	0	9
Sub-humid, very cold, hilly highlands	1.39	55,909	0	0	2	7	71	0	3	0	16	0	1
Semi-arid, extremely cold, mountainous highlands	1.38	55,419	0	0	1	1	15	0	0	0	81	0	1
Humid, very cold, mountainous highlands	1.32	53,301	0	6	4	11	56	0	1	0	10	0	11
Semi-arid, cold, plain-like highlands	1.32	53,300	0	4	0	8	47	0	3	11	26	1	0
Semi-arid, very cold, mountainous highlands	1.29	51,840	0	3	0	2	57	0	1	0	35	0	1
Humid, extremely cold, mountainous highlands	1.15	46,260	0	1	6	6	23	0	2	0	48	0	14
Semi-arid, extremely cold, plain-like highlands	1.12	45,138	0	0	0	4	90	0	0	1	4	0	0

Table2. 5a (continued)

Highland zone description	% of HL	sq.km	Land use/land cover category (*)										
			1	2	3	4	5	6	7	8	9	10	11
Humid, cold, mountainous highlands	1.10	44,439	0	7	4	19	57	0	8	0	2	0	2
Arid, cool, mountainous highlands	1.05	42,252	0	9	0	0	4	0	1	0	86	0	0
Humid, cold, hilly highlands	0.95	38,297	0	3	5	24	49	0	17	1	1	0	1
Sub-humid, extremely cold, hilly highlands	0.90	36,273	0	1	12	13	40	0	9	0	18	0	7
Humid, very cold, hilly highlands	0.78	31,272	0	2	15	8	67	0	2	0	1	0	5
Arid, warm, mountainous highlands	0.73	29,564	0	8	0	0	9	0	0	0	83	0	0
Humid, cool, hilly highlands	0.69	27,853	3	15	1	19	12	13	36	0	2	0	0
Per-humid, cold, mountainous highlands	0.63	25,263	4	11	10	6	45	0	22	0	2	0	0
Per-humid, very cold, hilly highlands	0.60	24,040	0	2	19	6	63	0	2	0	2	0	4
Humid, cool, mountainous highlands	0.51	20,498	5	25	1	16	21	10	22	0	1	0	0
Arid, cold, hilly highlands	0.50	20,105	0	9	0	0	9	0	0	0	81	0	0
Humid, extremely cold, hilly highlands	0.49	19,843	0	0	24	16	19	0	20	1	11	0	9
Per-humid, extremely cold, hilly highlands	0.41	16,475	0	1	17	12	20	0	7	0	27	0	15
Sub-humid, cold, plain-like highlands	0.39	15,610	0	1	4	7	54	0	2	29	1	0	0
Semi-arid, warm, mountainous highlands	0.38	15,315	0	19	0	1	21	14	1	0	43	0	0
Sub-humid, warm, hilly highlands	0.35	14,299	0	6	0	38	35	3	3	10	6	0	0
Sub-humid, cool, plain-like highlands	0.35	14,047	1	14	0	16	14	35	17	0	3	0	0

Per-humid, cool, mountainous highlands	0.33	13,297	12	24	4	4	16	3	38	0	0	0	0
Per-humid, cold, hilly highlands	0.31	12,623	5	6	4	11	20	0	52	0	1	0	0
Arid, cold, mountainous highlands	0.27	10,840	0	13	0	0	12	0	2	0	72	0	0
Semi-arid, very cold, plain-like highlands	0.25	10,174	1	9	0	5	59	0	2	4	19	1	0
Per-humid, cool, hilly highlands	0.22	8,911	11	8	1	14	4	1	61	0	0	0	0
Sub-humid, very cold, plain-like highlands	0.21	8,301	4	15	12	8	41	0	13	3	3	1	1
Hyper-arid, warm, mountainous highlands	0.21	8,259	0	0	0	0	0	0	0	0	100	0	0
Arid, cold, plain-like highlands	0.19	7,712	0	5	0	0	10	0	0	2	82	0	0
Sub-humid, warm, mountainous highlands	0.13	5,159	1	42	0	5	6	33	7	1	4	0	0
Humid, warm, hilly highlands	0.13	5,079	3	34	0	14	4	26	18	0	0	0	0
Humid, warm, mountainous highlands	0.11	4,253	3	41	0	12	4	26	14	0	0	0	0

(*): Land use/land cover class 1: High density/high yield irrigated field crops; class 2: Other irrigated field crops; class 3: High density/high yield rainfed crops;

class 4: other rainfed field crops; class 5: Open shrublands/grasslands; class 6: High density/evergreen forests/tree crops/closed shrublands; class 7: Other forests/tree crops/closed shrublands; class 8: Inland water; class 9: Barren/sparsely vegetated; class 10: Urban/built-up; class 11: Undifferentiated cover of mountains and hills

Table 2.5b. Distribution of land use/land cover classes in the highlands of different countries

Country	Highland area (sq.km)	Highland area (%)	Land use/land cover category (*)										
			1	2	3	4	5	6	7	8	9	10	11
Afghanistan	511,342	78	0	9	0	1	40	0	0	0	50	0	0
Algeria	482,795	20	0	1	0	4	7	4	2	0	82	0	0
Armenia	27,619	98	0	0	7	0	78	0	8	5	0	1	0
Azerbaijan	25,648	31	2	2	6	17	54	0	16	0	3	0	0
Cyprus	686	7	0	1	0	0	5	55	38	0	1	0	0
Egypt	31,708	3	0	0	0	0	0	0	0	0	100	0	0
Georgia	43,541	62	2	0	12	0	48	0	33	0	5	0	0
Iran	1,118,571	73	0	3	0	4	23	0	2	1	67	0	0
Iraq	26,190	6	0	3	0	55	10	0	10	0	21	0	0
Jordan	43,278	49	0	0	0	1	4	0	0	0	94	0	0
Kazakhstan	212,373	8	0	1	9	12	50	0	7	0	6	0	14
Kyrgyzstan	185,366	97	0	1	3	10	45	0	3	4	24	0	9
Lebanon	6,266	61	0	5	0	30	39	0	6	0	19	0	0
Libya	50,294	3	0	0	0	0	0	0	0	0	100	0	0
Morocco	217,571	49	0	5	0	1	7	10	1	0	75	0	0
OPT: West Bank	399	7	0	12	0	15	56	0	0	0	13	4	0
Pakistan	312,148	40	1	18	0	0	7	1	0	0	73	0	0

Syria	19,724	11	0	1	0	16	6	0	4	0	72	0	0
Tajikistan	121,906	86	0	0	2	7	28	0	0	1	57	0	5
Tunisia	5,574	4	1	12	0	9	26	20	8	0	23	0	0
Turkey	540,000	70	1	7	3	20	51	2	9	2	5	0	0
Turkmenistan	9,465	2	0	0	2	18	61	0	0	0	14	0	5
Uzbekistan	36,598	9	0	2	1	5	65	0	0	0	11	0	16
Weighted total			*0.3*	*5.1*	*1.4*	*6.8*	*28.8*	*1.3*	*3.2*	*0.7*	*50.6*	*0.1*	*1.7*

Note: land use/land cover classes have the same meaning as in table 5a.

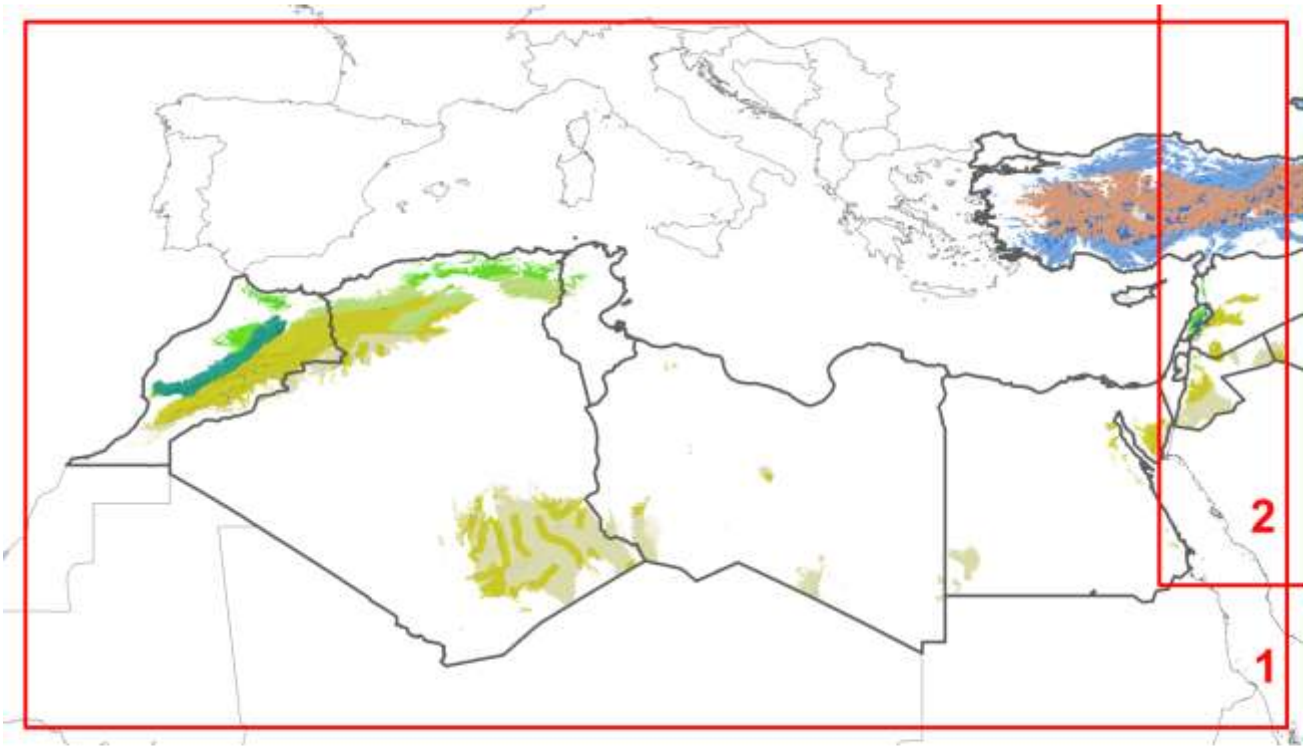

Figure 2.22a Farming system categories in highlands of the study area (Map sheet 1)

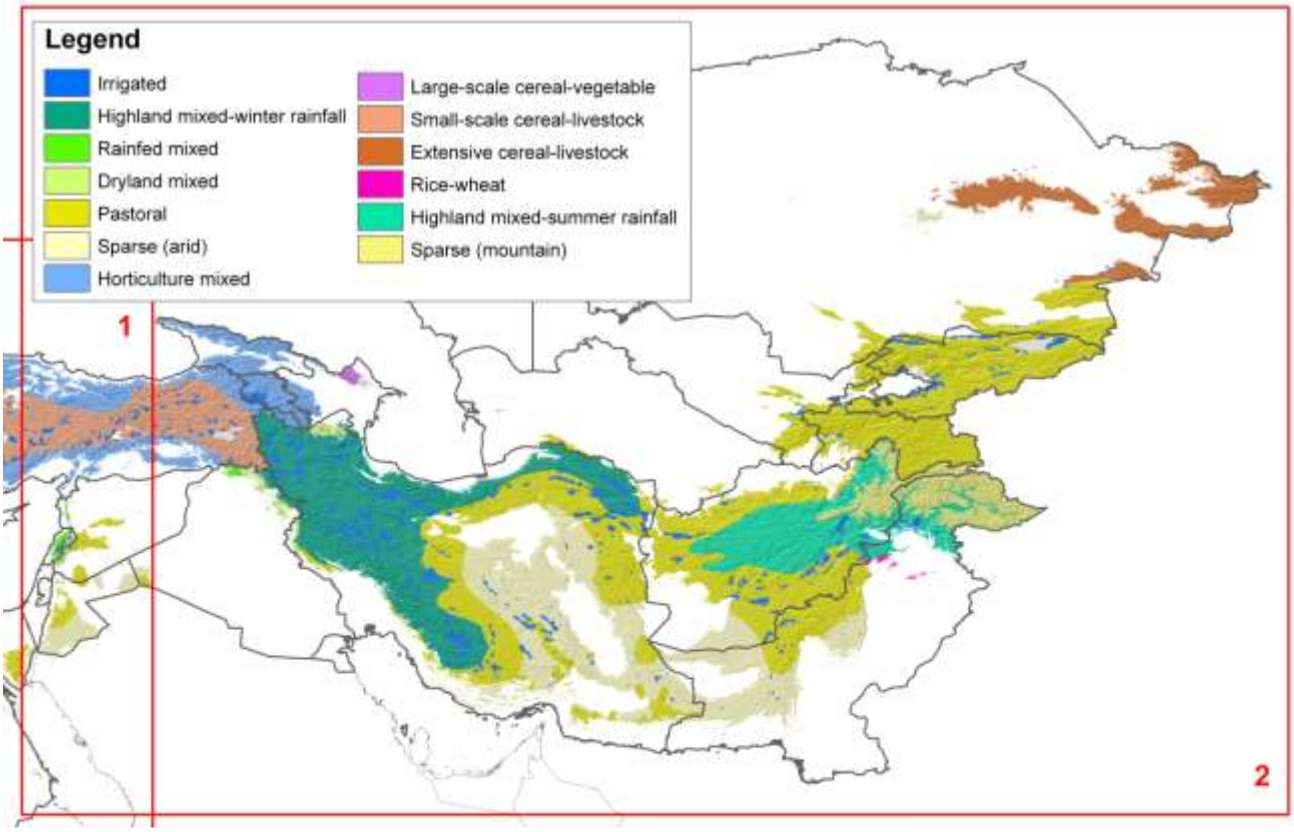

Figure 2.22b Farming system categories in highlands of the study area (Map sheet 2)

Table 2.6a. Distribution of farming systems in different highland zones

Highland zone description	% of HL	sq.km	Farming system categories (*)												
			1	2	3	4	5	6	7	8	9	10	11	12	13
Arid, cool, hilly highlands	7.97	321,059	2	7	0	1	58	32	0	0	0	0	0	1	0
Semi-arid, cool, hilly highlands	7.29	293,886	7	29	1	6	36	1	4	0	14	0	0	3	0
Arid, cool, plain-like highlands	7.26	292,652	14	5	0	1	59	21	0	0	0	0	0	0	0
Semi-arid, cold, hilly highlands	6.07	244,612	9	48	0	1	26	1	3	0	5	0	0	7	0
Arid, warm, plain-like highlands	6.03	242,843	2	0	0	1	32	65	0	0	0	0	0	0	0
Arid, warm, hilly highlands	5.52	222,499	1	2	0	1	30	66	0	0	0	0	0	0	0
Hyper-arid, warm, plain-like highlands	4.28	172,254	0	0	0	0	32	68	0	0	0	0	0	0	0
Semi-arid, cool, plain-like highlands	3.26	131,450	24	17	0	5	21	0	3	0	29	0	0	0	0
Hyper-arid, warm, hilly highlands	2.91	117,252	0	0	0	0	27	73	0	0	0	0	0	0	0
Sub-humid, cool, hilly highlands	2.87	115,753	6	5	5	3	5	0	39	0	35	0	0	2	0
Per-humid, extremely cold, mountainous highlands	2.60	104,843	0	0	0	0	63	0	1	0	0	10	0	1	24
Sub-humid, cold, hilly highlands	2.52	101,477	6	7	0	0	15	0	17	0	51	0	0	2	0
Semi-arid, cold, mountainous highlands	2.40	96,727	3	48	0	1	26	2	1	0	1	0	0	17	1
Semi-arid, cool, mountainous highlands	2.11	84,820	3	51	0	4	24	3	2	0	1	0	0	12	0
Semi-arid, warm, hilly highlands	1.83	73,706	2	15	18	38	19	1	0	0	0	0	3	5	0
Sub-humid, cold, mountainous highlands	1.78	71,535	4	6	0	0	32	1	0	0	0	4	0	52	0

Semi-arid, very cold, hilly highlands	1.77	71,122	3	21	0	1	26	0	12	0	18	0	0	18	1
Per-humid, very cold, mountainous highlands	1.72	69,354	0	0	0	0	36	0	31	2	15	0	0	3	11
Sub-humid, extremely cold, mountainous highlands	1.46	58,965	0	0	0	0	50	1	0	0	0	9	0	3	36
Semi-arid, warm, plain-like highlands	1.42	57,291	1	1	10	47	39	0	0	0	0	0	0	0	0
Sub-humid, cool, mountainous highlands	1.41	56,845	2	17	0	0	42	0	2	0	4	1	0	21	11
Sub-humid, very cold, mountainous highlands	1.41	56,743	5	12	4	7	6	0	35	0	12	0	0	19	0
Semi-arid, extremely cold, hilly highlands	1.40	56,208	1	0	0	0	24	5	0	0	0	66	0	0	4
Sub-humid, very cold, hilly highlands	1.39	55,909	4	8	0	0	44	0	5	0	18	5	0	15	0
Semi-arid, extremely cold, mountainous highlands	1.38	55,419	0	0	0	0	33	1	0	0	0	2	0	2	62
Humid, very cold, mountainous highlands	1.32	53,301	1	5	0	0	48	0	7	0	16	0	0	11	12
Semi-arid, cold, plain-like highlands	1.32	53,300	1	11	0	0	19	1	0	0	0	1	0	55	11
Semi-arid, very cold, mountainous highlands	1.29	51,840	31	39	0	0	22	0	2	0	6	0	0	1	0
Humid, extremely cold, mountainous highlands	1.15	46,260	0	0	0	0	54	0	0	0	0	16	0	3	27
Semi-arid, extremely cold, plain-like highlands	1.12	45,138	1	0	0	0	6	7	0	0	0	86	0	0	0

Table 2.6a. (continued)

Highland zone description	% of HL	sq.km	Farming system categories (*)												
			1	2	3	4	5	6	7	8	9	10	11	12	13
Humid, cold, mountainous highlands	1.10	44,439	2	1	1	1	19	0	31	3	31	0	0	9	1
Arid, cool, mountainous highlands	1.05	42,252	1	6	0	0	44	45	0	0	0	0	0	3	0
Humid, cold, hilly highlands	0.95	38,297	3	0	0	1	6	0	54	1	33	0	0	1	0
Sub-humid, extremely cold, hilly highlands	0.90	36,273	0	0	0	0	36	0	0	0	0	52	0	5	7
Humid, very cold, hilly highlands	0.78	31,272	2	3	0	0	20	0	24	0	45	1	0	4	0
Arid, warm, mountainous highlands	0.73	29,564	1	4	0	0	30	65	0	0	0	0	0	0	0
Humid, cool, hilly highlands	0.69	27,853	3	0	3	2	5	0	60	0	25	0	0	1	0
Per-humid, cold, mountainous highlands	0.63	25,263	0	0	1	0	2	0	80	1	10	0	0	4	1
Per-humid, very cold, hilly highlands	0.60	24,040	1	0	0	0	10	0	54	0	33	0	0	1	2
Humid, cool, mountainous highlands	0.51	20,498	2	2	8	2	7	0	57	1	11	0	0	10	0
Arid, cold, hilly highlands	0.50	20,105	2	18	0	0	47	15	0	0	0	0	0	17	0
Humid, extremely cold, hilly highlands	0.49	19,843	0	0	0	0	25	0	0	0	0	66	0	6	3
Per-humid, extremely cold, hilly highlands	0.41	16,475	0	0	0	0	42	0	1	0	0	46	0	1	9
Sub-humid, cold, plain-like highlands	0.39	15,610	2	46	4	9	20	2	0	0	0	0	3	12	0
Semi-arid, warm, mountainous highlands	0.38	15,315	4	0	83	5	0	0	5	0	0	0	0	2	0
Sub-humid, warm, hilly highlands	0.35	14,299	15	2	2	0	1	0	30	0	49	0	0	0	0
Sub-humid, cool, plain-like highlands	0.35	14,047	0	1	6	0	0	0	71	1	1	0	0	20	0

Per-humid, cool, mountainous highlands	0.33	13,297	20	1	0	0	8	0	19	0	52	0	0	0	0
Per-humid, cold, hilly highlands	0.31	12,623	1	0	1	0	0	0	89	0	9	0	0	0	0
Arid, cold, mountainous highlands	0.27	10,840	1	8	0	0	41	21	0	0	0	0	0	29	0
Semi-arid, very cold, plain-like highlands	0.25	10,174	12	0	0	0	74	0	0	0	0	3	0	11	0
Per-humid, cool, hilly highlands	0.22	8,911	0	0	5	0	0	0	87	0	1	0	0	6	0
Sub-humid, very cold, plain-like highlands	0.21	8,301	0	0	0	0	55	45	0	0	0	0	0	0	0
Hyper-arid, warm, mountainous highlands	0.21	8,259	20	0	0	0	50	0	13	0	14	3	0	1	0
Arid, cold, plain-like highlands	0.19	7,712	29	13	0	0	54	2	0	0	0	0	0	2	0
Sub-humid, warm, mountainous highlands	0.13	5,159	6	0	57	2	0	0	13	0	0	0	0	21	0
Humid, warm, hilly highlands	0.13	5,079	7	0	55	0	0	0	11	0	0	0	4	23	0
Humid, warm, mountainous highlands	0.11	4,253	3	0	51	0	0	0	13	0	0	0	1	30	0

(*) 1: Irrigated; 2: Highland mixed-winter rainfall; 3: Rainfed mixed; 4: Dryland mixed; 5: Pastoral; 6: Sparse (arid); 7: Horticulture mixed; 8: Large-scale cereal-vegetable; 9: Small-scale cereal-livestock; 10: Extensive cereal-livestock; 11: Rice-wheat; 12: Highland mixed-summer rainfall; 13: Sparse (mountain)

Table 2.6b. Distribution of farming systems in the highlands of different countries

Country	Highland area (sq.km)	Highland area (%)	Farming systems category (*)												
			1	2	3	4	5	6	7	8	9	10	11	12	13
Afghanistan	511,342	78	5	0	0	0	44	5	0	0	0	0	0	36	10
Algeria	482,795	20	0	0	7	17	34	43	0	0	0	0	0	0	0
Armenia	27,619	98	15	0	0	0	0	0	85	0	0	0	0	0	0
Azerbaijan	25,648	31	4	5	0	2	0	0	70	20	0	0	0	0	0
Egypt	31,708	3	0	0	0	0	50	50	0	0	0	0	0	0	0
Georgia	43,541	62	1	0	0	0	0	0	97	2	0	0	0	0	0
Iran	1,118,571	73	9	37	0	1	27	27	0	0	0	0	0	0	0
Iraq	26,190	6	0	29	14	37	8	12	0	0	0	0	0	0	0
Jordan	43,278	49	0	0	0	2	25	73	0	0	0	0	0	0	0
Kazakhstan	212,373	8	1	0	0	0	37	3	0	0	0	60	0	0	0
Kyrgyzstan	185,366	97	8	0	0	0	91	1	0	0	0	0	0	0	0
Lebanon	6,266	61	17	0	52	30	0	0	0	0	0	0	0	0	0
Libya	50,294	3	0	0	0	0	10	90	0	0	0	0	0	0	0
Morocco	217,571	49	0	22	10	4	57	7	0	0	0	0	0	0	0
OPT: West Bank	399	7	0	0	0	100	0	0	0	0	0	0	0	0	0
Pakistan	312,148	40	2	0	0	0	22	37	0	0	0	0	1	13	26
Syria	19,724	11	1	0	6	14	77	2	0	0	0	0	0	0	0

Tajikistan	121,906	86	2	0	0	0	98	0	0	0	0	0	0	0	0
Tunisia	5,574	4	0	0	29	67	4	0	0	0	0	0	0	0	0
Turkey	540,000	70	7	0	0	0	0	0	37	0	56	0	0	0	0
Turkmenistan	9,465	2	0	10	0	0	85	6	0	0	0	0	0	0	0
Uzbekistan	36,598	9	6	0	0	0	94	0	0	0	0	0	0	0	0
Weighted total			*4.9*	*11.7*	*1.4*	*2.7*	*33.1*	*18.5*	*7.3*	*0.1*	*7.8*	*3.7*	*0.1*	*5.5*	*3.3*

<u>Note</u>: farming systems classes have the same meaning as in table 6a.

2.4.2 Soil constraints

As Table 2.3a indicates, all highland zones in the study area suffer from severe soil constraints (from a minimum of 44% to a maximum of 100%). While this is an estimate based on a low-resolution dataset[4], the overall picture is not surprising as it points to a well-known predicament of highland areas. By far the most important constraint is the presence of shallow soils. Shallow soils occur in all highland zones, although in variable proportions in each zone, and overall more than 70% of the highlands is affected.

The second major soil constraint is poor profile development, meaning that for affected soils their potential for agriculture is much reduced. The poor profile development is, together with shallow depth, usually the consequence of processes that are common in dissected topography with unprotected soil cover and low soil formation rates by lower temperatures than is the case in lowland areas.

There is little variation between individual countries in the dominance of the key constraints of shallow depth and poor profile development (Table 2.3b). However, some countries have higher proportions of highland areas without major soil constraints, e.g. Armenia, Kazakhstan, Lebanon, Libya, Syria, Turkey, Turkmenistan, Uzbekistan. However, before drawing premature conclusions, it is useful to remember that the soil information used for the characterization of the highlands is derived from a global generalized database (FAO, 1995) and is therefore of an indicative character.

2.4.3 Growing periods

Analysis of Table 2.4a indicates that nearly 65% of the highlands of the study area have a moisture-limited growing period of more than 120 days, which is adequate for crop production. Nearly 9% of the highlands has a moisture-limited growing period between 120-150 days, 16% has a growing period between 150-210 days, and 40% has a growing period exceeding 7 months. Thus moisture availability in highlands is generally better as compared to lowland areas, although this higher potential for agricultural use can obviously not compensate the soil-related constraints. Moreover, as indicated earlier, coldness is a key constraint that restricts the available growing period for crops, irrespective of the better moisture availability.

Looking at the growing period patterns in the highlands of individual countries (Table 2.4b), greater variations in growing period length can be observed between individual countries. Countries with very small growing periods in their highland areas include Algeria, Egypt, Jordan, and Libya. By contrast, more than 85% of areas in the Caucasus have growing periods of 8 months or more, whereas the Central Asian countries (with the exception of Turkmenistan) at least 70% of the highlands have growing periods of 7 months or more. In

[4] Source: http://crp11.icarda.cgiar.org/crp/public/files/maps/08-Main%20global%20Soil%20constraints_A0.pdf

other countries the range of growing periods is large but in most cases adequate to support a short-maturing crop variety, if low temperature is not a limiting factor.

2.4.4 Land use/land cover

Table 5a indicates that two land cover types dominate the highlands: open shrub land/grasslands (29%) and the barren/sparsely vegetated cover (50%). Agriculture (both irrigated and rainfed) is estimated to be practiced in about 13% of the Highlands of the study area. This low occupancy of land for agricultural use and high presence of natural vegetation is of course consistent with the severe soil constraints and climatic limitations as well.

The countries with the highest proportions of irrigated field crops in their highland areas are the West Bank, Pakistan and Tunisia. Azerbaijan, Iraq, Kazakhstan, Lebanon, Turkmenistan and Uzbekistan have more than 20% of their highlands under rainfed crops (Table 2.5b).

As in the case of soil information, land use/land cover information at country level is derived from a regional mapping of land use/land cover (Celis et al., 2007) and somewhat outdated, as it refers to the period 1993. Follow-up studies are needed to characterize in more detail land use/land cover in the highland areas.

2.4.5 Farming systems

As indicated by Table 2.6a, pastoral systems are the most important ones in the Highlands of the study area (33%), followed by horticulture-mixed systems (18%), and small-scale cereal livestock systems (8%).

Summary descriptions of these systems are provided in the following paragraphs.

Pastoral systems: systems based on the mobility of flocks and herds moving between more humid and drier areas, with the availability of grazing and water. Range resources under a wide precipitation range (typically 100-400 mm) are accessed.

Horticulture-mixed (a.k.a. 'Rainfed mixed'): highly diversified systems, with a wide range of rainfed crops, including tree crops (olives, fruits and nuts) and field crops (mainly wheat, barley, lentils, chickpeas, potatoes, sugar beet and faba beans). Terracing is common in hilly areas. Seasonal interaction with livestock, mainly sheep and goats, and use of crop residues and other fodder are common features.

Small-scale cereal livestock systems (a.k.a. ' Dryland mixed'): less diverse than the rainfed mixed systems, with barley and wheat as main crops grown in alternation with single or double-season fallows or with legumes (lentil, chickpea).

Interactions with small livestock systems mainly take the form of barley and stubble-grazing and are stronger than in the previous system.

Sparse (arid): dry-end pastoral systems confined to very arid areas and limited to opportunistic grazing following rainstorms.

Between individual countries the highland farming systems show considerable variation (Table 2.6b). However, the farming systems map, derived from Dixon et al. (2001)[5] is the most general map of those used in this chapter and therefore needs to be interpreted with considerable care: the risk of errors in the delineation of these systems due to overlaying a high-resolution layer (the highlands boundary) with a low-resolution layer (the farming systems) is particularly high. Further characterization studies of these systems are an absolute must.

2.4.6 Characterization plots

The GIS techniques used at the regional scale allow also to extract country-specific profiles by plotting the corresponding values of two (or maximum three) relevant characterization themes. Figures 2.23-2.26 illustrate for a randomly selected sample of sites in each country of the study area the site-specific relationship between aridity index (x-axis) and annual accumulated cold units (y-axis). These graphs are useful GIS-derived visualization tools and help to gain further insights in how much highlands in the various countries are similar or divergent, either within or between countries.

[5] Source: http://crp11.icarda.cgiar.org/crp/public/files/maps/Farming_Systems_CWANA.pdf

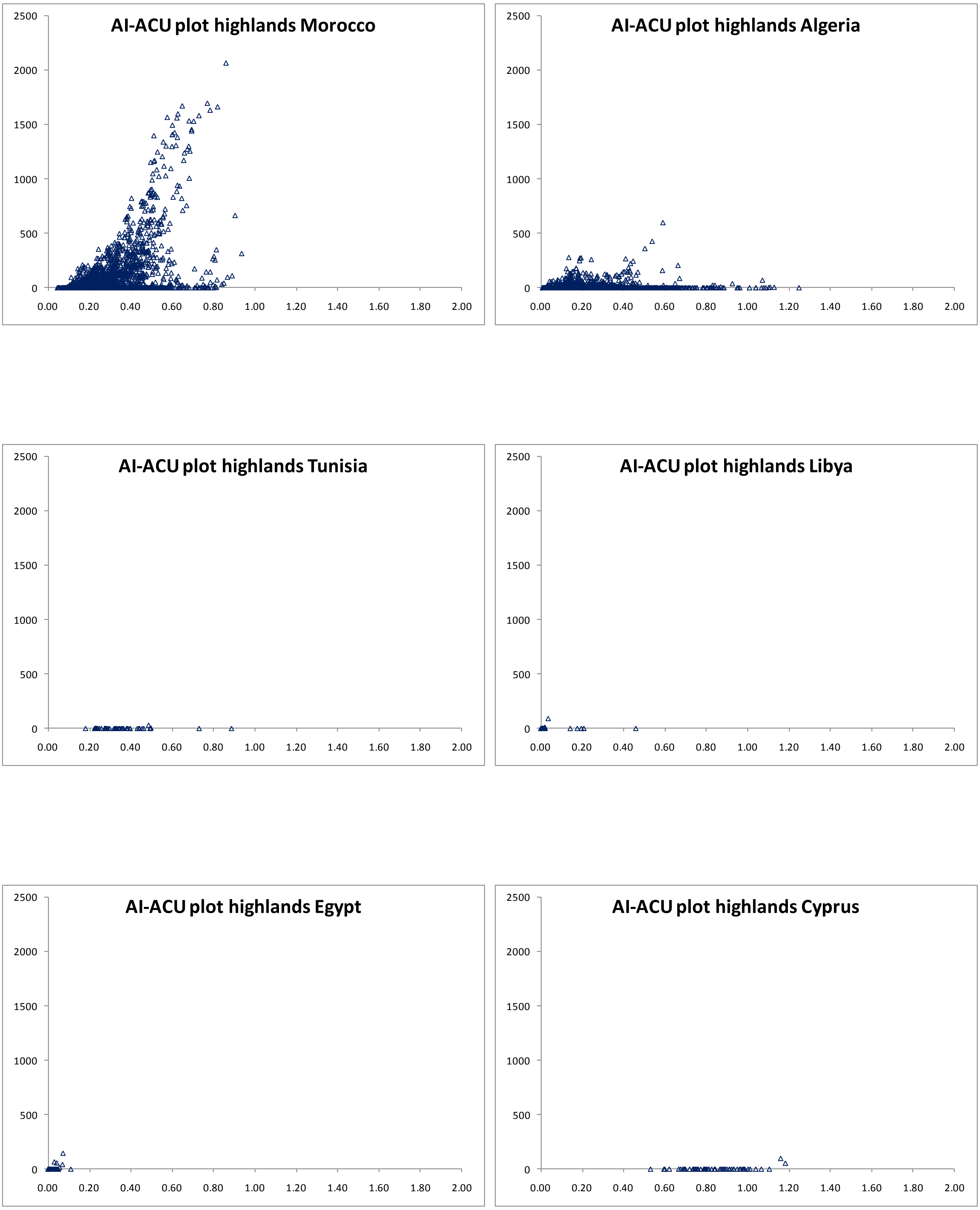

Figure 2.23 Plots of aridity index (x-axis) versus accumulated cold units (y-axis) for highland areas in Morocco (top left), Algeria (top right), Tunisia (middle left), Libya (middle right), Egypt (bottom left) and Cyprus (bottom right)

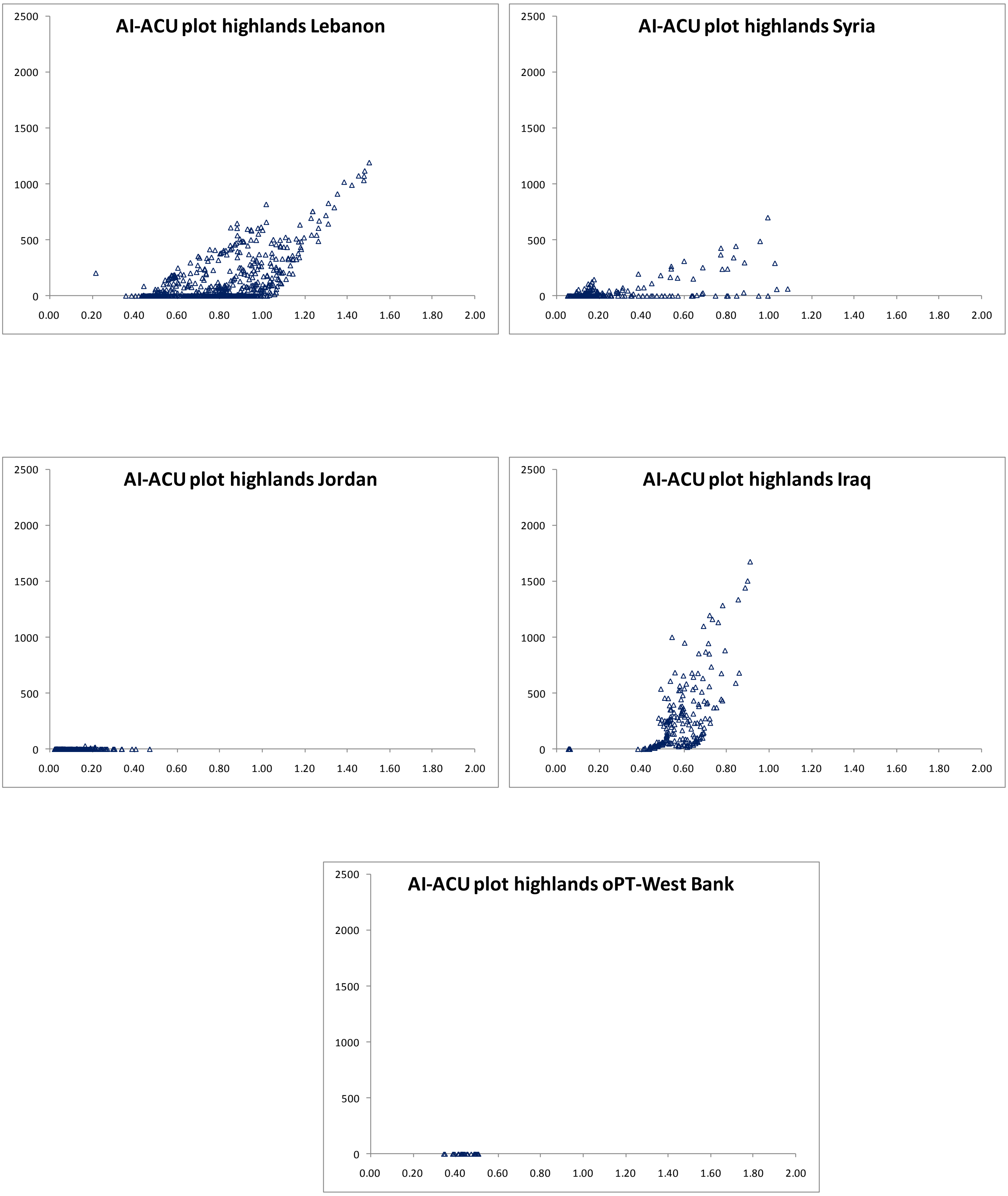

Figure2. 24. Plots of aridity index (x-axis) versus accumulated cold units (y-axis) for highland areas in Lebanon (top left), Syria (top right), Jordan (middle left), Iraq (middle right), and West Bank (bottom)

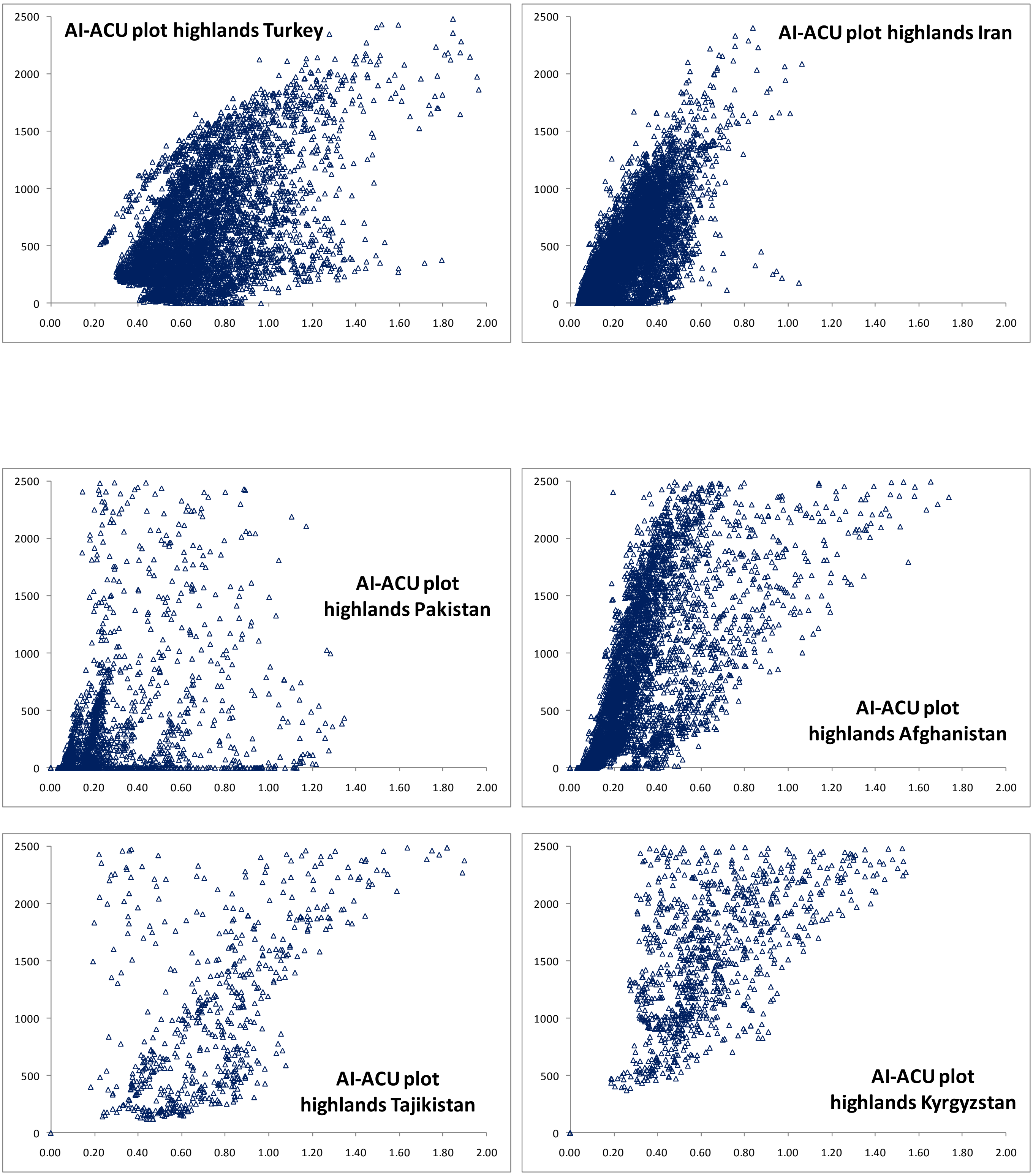

Figure2. 25. Plots of aridity index (x-axis) versus accumulated cold units (y-axis) for highland areas in Turkey (top left), Iran (top right), Pakistan (middle left), Afghanistan (middle right), Tajikistan (bottom left) and Kyrgyzstan (bottom right)

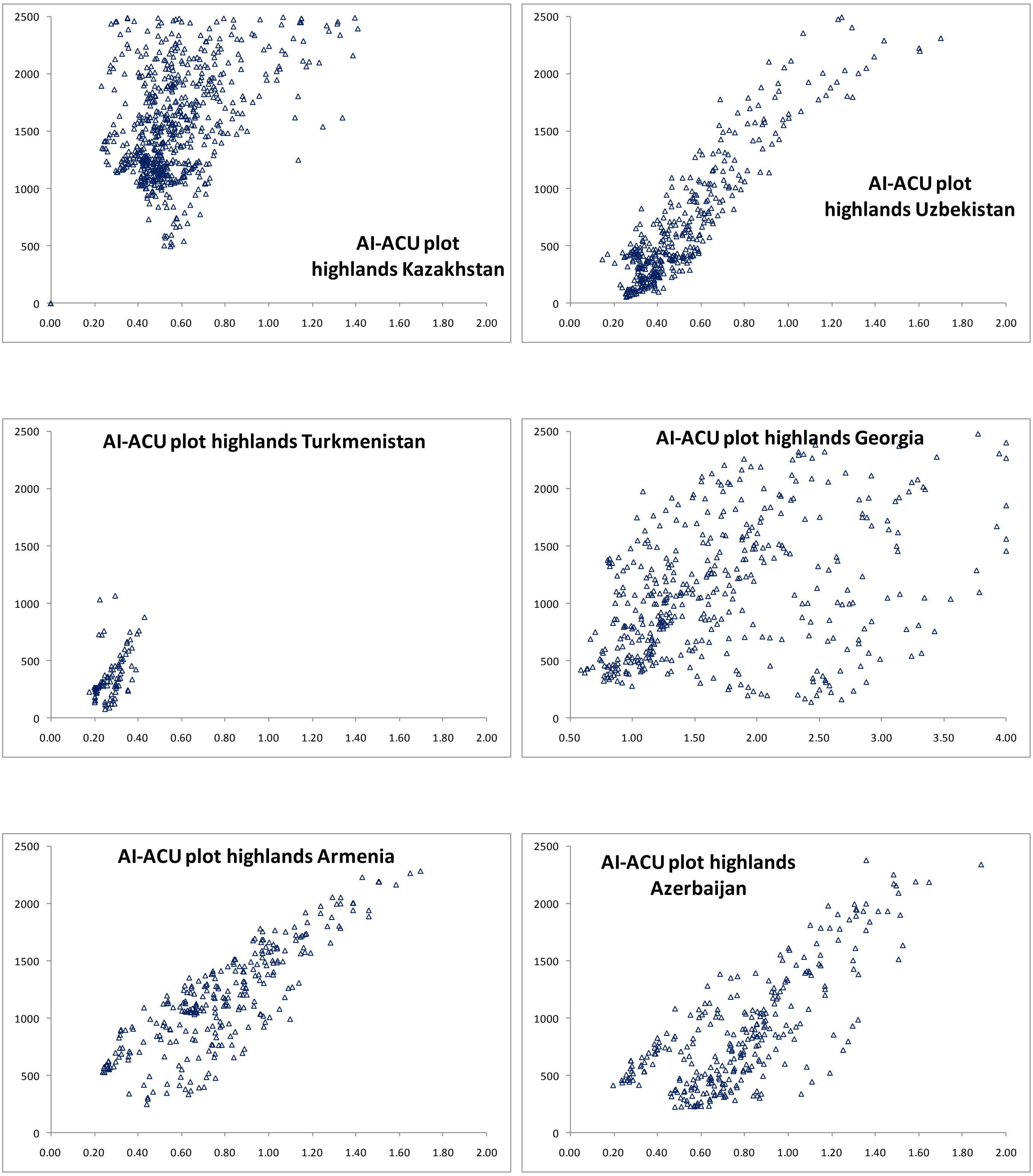

Figure 2.26 Plots of aridity index (x-axis) versus accumulated cold units (y-axis) for highland areas in Kazakhstan (top left), Uzbekistan (top right), Turkmenistan (middle left), Georgia (middle right), Armenia (bottom left) and Azerbaijan (bottom right)

2.5 Synthesis from the initial characterization studies

Using the above and additional spatial datasets for characterization, the initial assessment points to the relevance of 'coldness' as the key feature for differentiating the highlands of the study area at the regional scale in terms of agricultural potential. The 5 general categories differentiated and mapped in Figure 2.4 form a good basis to make a broad synthesis as follows:

1. Extremely cold highlands (HL5). The moisture regime ranges from semi-arid to per-humid. The mean temperature of the coldest month is less than -8°C, and the mean annual temperature is invariably below 5°C. These areas are not suitable for dry land cultivation due to a very short growing period and extreme cold. This zone covers about 15% of the highlands that are not hyper-arid, and is most prominent in the Tien-Shan and Pamir mountains of Central Asia.

2. Very cold highlands (HL4). The moisture regime may range between semi-arid to per-humid, but is in the majority either semi-arid or sub-humid. The mean temperature of the coldest month is mostly below -8°C, but with a substantial minority of areas in the range -8°C-0°C. The mean annual temperature is mostly below 5°C, but with a substantial minority of areas in the range 5-10°C. The growing period is very short due to extreme cold in the winter and early spring and terminal drought in the summer, therefore cold tolerant crop varieties such as winter wheat and winter barley varieties are needed. Food legumes are planted by farmers in the spring with very low yields due to extreme cold in the winter. This zone covers about 14% of the highlands that are not hyper-arid. Representative for this zone are the mountains and plateaus of eastern Anatolia, most of Armenia, the northwest part of Iran (Ardabil region) and parts of Kirghizstan, Tajikistan and Afghanistan.

3. Cold highlands (HL3). The moisture regime is mostly semi-arid or sub-humid. The mean temperature of the coldest month is in the range -8°C to 0°C. The mean annual temperature is mostly in the range 5-10°C, with a substantial minority in the range 10-15°C. The growing period is also short and cold tolerant crop varieties with tolerant to terminal drought such winter wheat and winter barley varieties are needed. Food legumes are planted by farmers in the spring with low yields. This zone covers nearly 25% of the highlands that are not hyper-arid. Representative for this zone are northwest and western part of Iran, the Central Anatolian Plateau in Turkey, parts of Azerbaijan and Armenia, and the highest parts of the Atlas mountain range in Morocco.

4. Cool highlands (HL2). Nearly 50% of this zone is arid, the remainder semi-arid or sub-humid. The mean temperature of coldest month is in the range 0-5°C, with some areas colder (-8-0°C) and some warmer (5-10°C). The mean annual temperature is in the range 10-20°C. The facultative wheat varieties and food legumes planted in the fall are dominant crops at the farmer fields. This zone covers nearly half of the highlands that are not hyper-arid, and is represented by Kermanshah and Kurdistan in Iran, parts of western Pakistan, parts of Tajikistan, and most of the Atlas mountains in Morocco.

5. Warm highlands (HL1). This zone is mostly arid, with a substantial minority semi-arid. The mean temperature of the coldest month is mostly in the range 5-10°C, hence serious winter frost winter is unlikely. The mean annual temperature is mostly in the range 15-20°C. Facultative and spring wheat varieties and food legumes planted in the fall are very common in farmers fields. This zone occupies less than 1% of the highlands that are not hyper-arid, and occurs in southwestern Iran (Lorestan) and parts of Pakistan.

2.6 Summary and conclusions

This exploratory assessment of the CWANA highlands was confined to those located in North Africa, West Asia and Central Asia. Excluded from the assessment were the highlands of the Arabian Peninsula and the highlands of the tropical parts of CWANA in sub-Sahara Africa. Still, with about 4,000,000 km^2 this is a very large area representative of the non-tropical dryland highlands. The following observations summarize this introductory chapter.

1. A simple approach relying on the power of GIS and the availability of global spatial datasets has been adopted for defining a consistent spatial framework for region-wide agro-ecological characterization of the highlands of dryland areas. This approach has three elements:

- Identification/definition of the highlands;
- Differentiation leading to reduction of complexity based on key characteristics;
- Characterization based on secondary spatial datasets.

2. The straightforward definition of highlands on the basis of a simple elevation criterion (‘areas with elevation of more than 800 meter above sea level’) takes away the confusion that has beset targeting agricultural research, as it allows accurate mapping at global level. At the same time it is recognized that an elevation-based definition lumps together highland areas that can be extremely diverse, and that therefore agricultural development of highlands in any particular locality necessitates their characterization in terms of biophysical and socio-economic features.

3. A rapid overview of the diversity of the dryland highlands can be obtained by classification into ecologically more homogeneous zones on the basis of relevant key characteristics, of which the most important are temperature, relief and aridity. These factors can be mapped with reasonable accuracy in a GIS environment, using publicly available global datasets on climate and topography, leading to a rapid but fairly complex stratification of the highlands.

4. To apply a first principle that highlands can primarily be differentiated based on their ‘coldness’ characteristics, temperature data were converted into five coldness classes using the concept of *annual accumulated cold units (AACU)*.

5. Recognizing that terrain characteristics, particularly slopes, are a key factor that accounts for the complexity of the highlands, a simple measure of ‘ruggedness’ applied in a GIS on a global DEM allowed to differentiate consistently three landform classes.

6. Finally, in a dryland context classification of the moisture regime is a must and the aridity index is the measure that combines both simplicity and consistency, as it allows to compare areas with different water supply (from precipitation) and demand (from evapotranspiration) situations. On the basis of the aridity index six aridity classes were differentiated.

7. The combination of these three themes (coldness classes, landforms and aridity classes) generates 74 new classes, encompassing widely different moisture and thermal regimes and landscapes. Of these, 25 classes make up 80% of the Highlands of the study area, the remaining 49 classes total 20% of these highlands.

8. A very effective way to characterize the different highland zones is by means of characterization tables, which offer syntheses for any spatial dataset that is considered relevant and sufficiently reliable to provide meaningful information.

In this chapter some ideas have been worked out demonstrating how GIS techniques applied to publicly available spatial datasets can be used to identify, map, classify and characterize an ecologically very diverse but poorly known part of the drylands of the world. The characterization tables and plots provided as examples illustrate the process of how summary information for each of the differentiated highland zones can be quickly extracted through GIS procedures by overlaying them with new spatial datasets.

As a final conclusion it is useful to stress that the goals of this study have been limited: to provide an initial exploration of the Highlands of the study area, using widely available but fairly general and therefore imperfect data. Particularly the datasets on soils, land use/land cover and farming systems require either updating or much more detailed assessments. *Further characterization studies of different parts of the highlands are thus prerequisites for their development.* The three case studies in this report of the highlands of Iran, Morocco, and Turkey, provide examples of characterization studies focusing on individual countries and, as they tap into national and sub-national information sources, attain much more depth. For specific development projects even more detailed surveys will be required.

Chapter 3

Highlands of Iran, Morocco and Turkey

Highlands of Iran, Morocco and Turkey were selected in this review as 3 case studies to review in detail the characteristics and diversity of theses highlands in the CWANA region as well as to assess their potential and constraints for sustainable agricultural development. The other aims of the review were also to evaluate the current state of agricultural research and technology development in these countries and to propose elements of a research strategy and define research priorities for sustainable agricultural development of the highlands in the CWANA region. It is envisioned that similar studies could also be carried out in other countries with significant highland coverage.

3.1. Highlands of Iran

Iran is situated in the southern part of temperate regions of the northern hemisphere. Iran is located on the arid and desert belt regions of the world and deserts of Iran are among the driest areas on the earth. However, the climatic conditions in Iran are very diverse. There is no tropical warm humid weather, and freezing climatic conditions are found in very small scale at the high summits of mountain ranges, Generally, the average elevation of Iran is 1500 meters above sea level, and more than 50% of the country is of elevation of 1000 meters above sea level, Figure 1 (De Pauw, E., A. Ghaffari and V. Ghasemi. 2004). 56% of the country is mountainous and the remaining are plains. The main plains are situated in central part and the average of their altitude exceeds 1000 meters above sea level. The highest desert plain in Iran is Ibrahim-Abad plain in Sirjan (in the south Zagros) with 1710 meters and the lowest plain is Loot plain with 187 meters elevations above sea level, respectively.

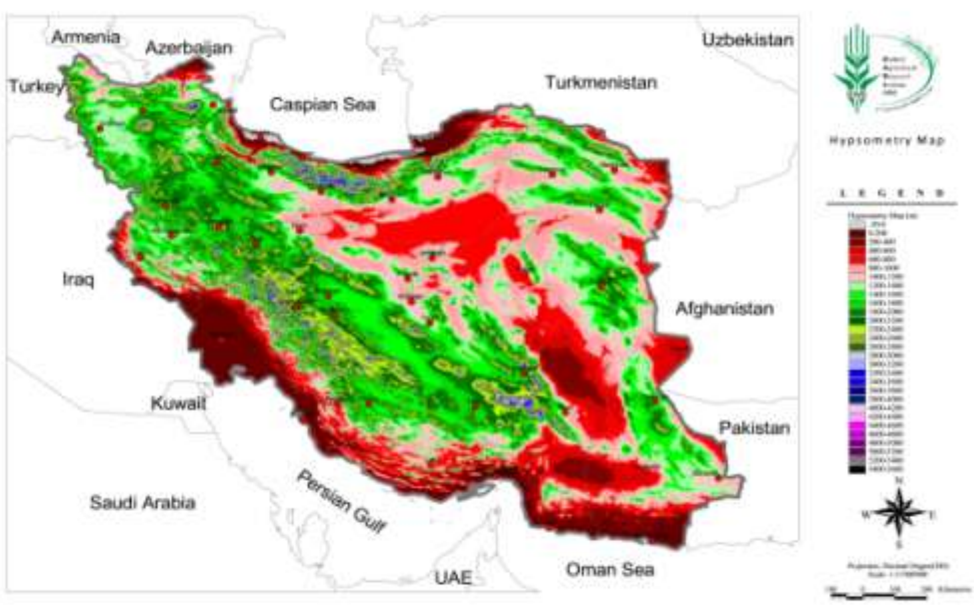

Figure 3.1 Highlands and Hypsometry Map of Iran

Highland agriculture in Iran is mostly categorized as semi-arid according to the moisture index with an average annual precipitation of 250 to 600mm. Generally, agriculture in highlands is mostly situated in the central Zagros mountain range rather than in the Alborz mountain range. The relation between precipitation and elevation and air masses influences agricultural highlands, hence, the amount of precipitation is proportionally increased as we approach higher altitudes. Agricultural highlands start from Shirvan with about 1000 m elevation and 260 mm average annual precipitation (northern-east of Iran) and 1250 m elevation and 270 mm average annual precipitation in Qazvin (120 Km west Tehran) regions and are extended to areas with 2300 m elevation and more than 400 mm average annual precipitation in central Zagros mountain range (De Pauw, E., A. Ghaffari and V. Ghasemi. 2004). Precipitation distribution pattern in these regions also varies in different seasons. For example: in the north-west of Iran, 23% of precipitation is received in autumn, 27% in winter, 43% in spring and the remaining 7% in summer. This precipitation distribution pattern in the western part of the country is 25.5% 48% and 27% in autumn, winter, and spring seasons, respectively. In other areas (Alborz and Khorasan), the precipitation distribution pattern is also 24% in autumn and 32% in winter, 36% in spring and the remaining 8% in summer. Average annual precipitation in these areas is very variable.

Agricultural highlands in Iran are generally classified as semi-arid based on the moisture index-using UNSECO methodology, however, modified De Martin moisture index classifies them into semi-arid, Mediterranean and semi-humid areas. Highland agricultural areas in East Azarbayjan, Zanjan, Hamadan, Qazvin, Markazi provinces with average annual precipitation of 300-400 mm are in the semi-arid moisture index, some areas in Ardabil, Kermanshah, West Azarbayjan, Kordestan, Lorestan Chehar Mahal-e-Bakhtiari (Broojen and Adl) with average annual precipitation of 400-600 mm are in the Mediterranean moisture index, and some specific areas (e.g. Qeidar, Beijar, and some parts in Ardabil and West Azarbayjan provinces) with average annual precipitation of more than 600mm (sometimes 800mm) are in the semi-humid areas. However, small areas in agricultural highlands in Hamadan, Markazi, Northern Khorasan provinces) with average annual precipitation of 250-300mm are a part of more severe aridity index. The Yasouj region with average annual precipitation more than 900mm is in the humid moisture index. Another aspect of precipitation distribution pattern in agricultural highlands in Iran is its seasonal variability in the amount of precipitation as the frequency of abnormal years for precipitation in different years and regions is quite high (Table 3.1).

Table 3.1 Frequency of normal and abnormal years for precipitation in a period of 20 years

Region/Plateau	Normal	> Normal	Dry years	Very dry years
Central Plateau	13	3	3	1
North-West	11	5	2	2
West	9	5	5	1

As could be interpreted from the Table 3.1, the risk of reduction in precipitation varies in different regions, but the risk of drought is higher in the western part of the country with Mediterranean moisture index (400-600 mm annual precipitation).

Thermal indices in these regions also differ in different seasons. Temperature is a very important environmental factor and plays a significant role in growth and plant development. For instance, growth of most of the crop plants species is slowed down or negligible in temperatures inferior to +5 °C. In agricultural highlands, winter temperature regimes are different, but the summer is almost similar. In UNESCO methodology, winters in these regions are described as "*cold*" or "*cool*". However, in modified De Martin classification, these regions are defined as "*very cold*" and "*cold*". In very cold regions, there are about 120 days with temperatures below 0°C (begins in autumn), and the average daily temperature in the coldest month of the year is less than -7°C. In cold regions the average daily temperature in the coldest month of the year varies between 0°C and -7°C. Considering summer temperature regimes in agricultural highlands, most of these areas are classified as warm regions (UNESCO classification) and the average daily temperatures in the warmest month of the year varies between 20°C and 30°C. Some specific areas in higher altitudes or regions situated in the fringe of high summits are of rather temperate temperatures, e.g.; Broujen and Adl as well as high altitudes in Hashtrood, Ardabil, and Sarab.

The rainfall in autumn, in very cold regions, is not less than 115mm and in some areas approaches 220 mm. This rainfall, in cold regions, is not less than 155mm and in some areas approaches 250 mm. In very cold regions, this amount of rainfall is essentially adequate for sowing and the establishment of rainfed crops, however, the average temperature in the third month of autumn approaches to 2.5-4 °C, and in some areas even 0 °C. The average temperature in the third month of autumn, in cold regions, is about 5-6 °C. It is concluded that the last month and in some areas the second month of autumn are not considered as favorable periods for crops establishment and growth. Therefore, low temperatures in the two last months of autumn in very cold regions and one last month of autumn in cold regions are usually considered as winter season. Since sowing date in rainfed agriculture is correspondent with the first effective opening rain (for sowing, germination and emergence), the untimely occurrence of this rainfall would not provide enough favorable growth period for early growth of autumn sown crops.

A glance at climatic conditions in spring season also implies that following the freezing season (usually in March), temperatures in April and May increase rapidly. Average temperature in March is 3-5°C in very cold regions, and 4-7°C in cold regions, average temperatures in April and May are 16-20 °C and 18-23 °C in the very cold and cold regions, respectively. Average rainfall in this season is 60-120 mm in very cold regions and 85-140 mm in cold regions. These averages are correspondent to most of the agricultural highlands; however, there are also some exceptions. In the summer, temperatures increase as the absolute maximum temperatures of warm days in July and August, in both regions, exceeds 38 °C.

3.2. Highlands of Morocco

Highland areas in the Maghreb countries cover about 25 million hectares, of which 60% is located in Morocco, 32% in Algeria, and 8% in Tunisia. These areas have different geographical characteristics (extent, altitude and landscape) and the climate is highly diverse ranging from humid in the north to desert in the south with arid and semi-arid climate in between with high variability in rainfall and prevailing drought (ICARDA and the NARS of Algeria,2007). Highlands in Maghreb constitute a barrier that protects the plains from the Saharan aridity and a water tower that provide water resource for their irrigation(Figure 3.2)

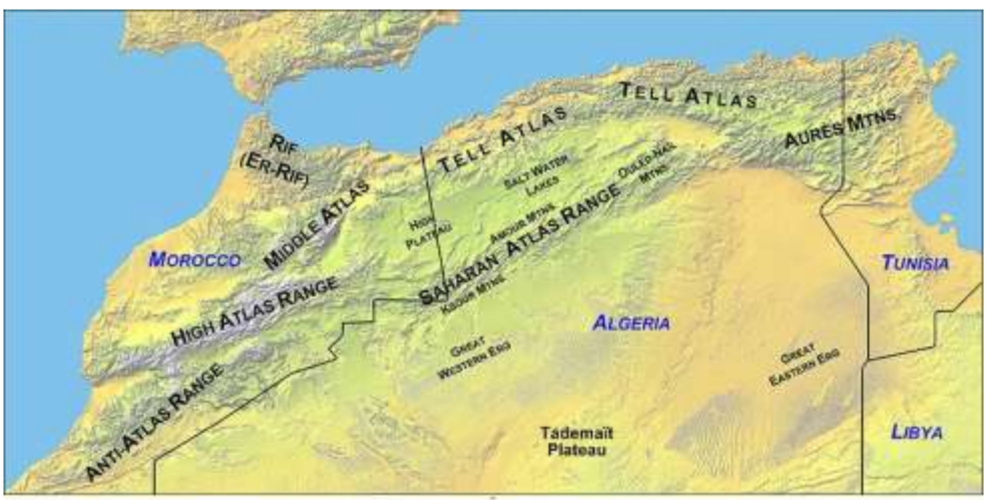

Figure 3.2 Rif and Atlas Mountains in the Maghreb Countries

Moroccan Mountains cover 26% (190 000 Km^2) of the national territory and they host 30% of the total population with a higher population density than the country average (40 vs. 37/ Km^2). 35% of arable land is in these areas. 62% of the total forest areas are in the mountains. Two agro ecological zones can be distinguished:

1. Humid mountains with 400-600 mm rain;
2. Arid mountains with 300 mm of rain.

The aridity increases from north to south and from oust to east. Rain fluctuation is becoming structural (50% of the years between 1995 and 2005 are drought years) (Herzenni, A. 2006).

Moroccan Highlands have a large ecological diversity between the set of mountains (3 in the Haut Atlas, 3 in the Middle Atlas, 3 in the Rif and 2 in the Anti-Atlas) but also amongst each set of mountains: diversity from one valley to another and large differentiation along the altitude and the orientation of the versants. This diversity creates ecological niches. The spread of the mountains from the Mediterranean Sea to the Sahara creates bio-climatic differentiation where humidity spread from hyper humid on the crest and on the Atlantic side of the Rif to the south side of the Anti- Atlas (proximity of the Sahara).

3.3. Highlands of Turkey

Turkey is located in the eastern Mediterranean and a bridge between the continents of Europe and Asia and located between 36º-42° N and 26°-45° E. Total land area is 785.347 km^2 (TurkStat, 2010), of which 761.361 km^2 are in Asia and 23.986 km^2 in Europe. Wetlands, rivers, lakes, and dams in total are 13.959 km^2 and land area is 771.388 km^2. The Asian part is called "*Anatolia*" and the European part "*Thrace*". The country is roughly rectangular and measures about 1 600 km from east to west, and about 600 km from north to south (Figure 3.3).

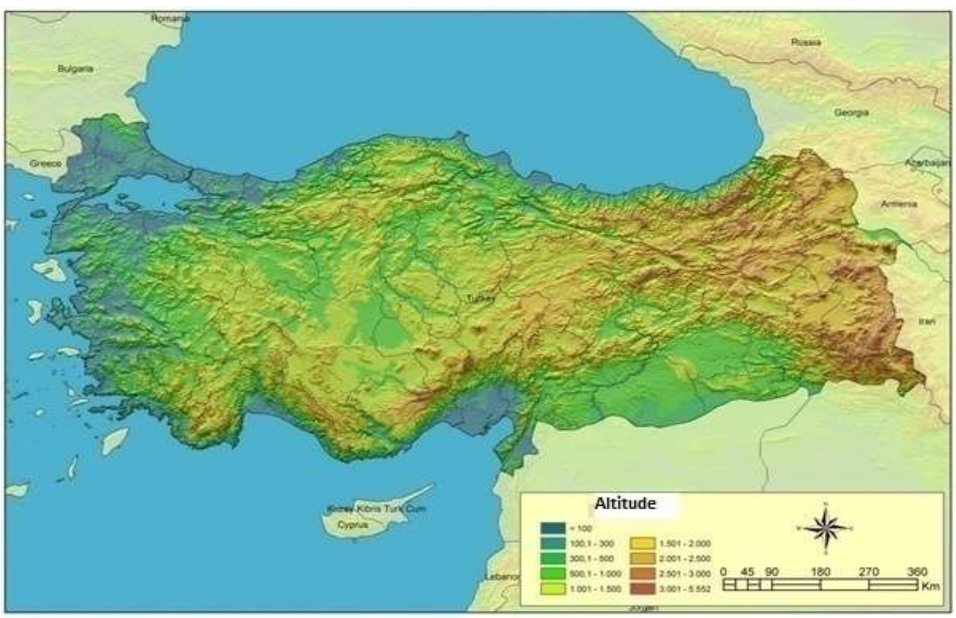

Figure 3.3 Highlands and the Altitute Map of Turkey

Turkish landscape stretching from west to east resembles a high plateau with a 1,141m average elevation. It is for the most part a mountainous country, and true lowlands are restricted to the coastal fringes. Roughly 25 percent of the total area has an altitude of over 1,219m, and less than 20 percent is positioned below 450m. Mountain peaks go above 2,250m in many places, particularly in the Eastern Anatolian Region. Steep slopes are common throughout the country, while flat or gently sloping land makes up barely one-sixth of the total area. Since Turkish landscape has the combined characteristics of three old continents (Europe, Africa, and Asia), ecological and biological diversity surpass any other place along the 40^{o}N latitude in the region. For example, at the large scale, there are three phytogeographic regions such as the Mediterranean, Euro-Siberian and Irano-Turanian phytogeographic regions which are the indication of diverse climate and topography of the country (Kaya and Raynal, 2001).Highlands with elevation of more than 800 masl covers about 70 % of the Turkish territory and start from inner Aegean region from the west and stretches to the eastern border of the country and it extends from the mountains that goes parallel to the Black Sea in the north to the Taurus Mountain chain and parallel to Mediterranean sea in the south.

Major causes of topographic diversity in Turkey are due to the tectonic movements of the recent geologic periods and the accumulation of volcanic products, which have created an elevated mass with an average altitude of 1141m. Most mountain ranges extend from west to east and great ranges appear in forms of arches. The Taurus Mountains in the south can be considered as a good example of this type. The highlands and basins among the mountains have formed similar geomorphologic features.

The Turkish landscape encompasses a vast variety of diversity in topography, climate, and natural resources. From east to west, one will encounter rugged snow-capped mountains with long cold winters and long cool summers in the east to barren bedrocks and endless wheat fields of dry steppes with rolling hills in the Central Anatolia to fertile valleys between cultivated mountain–foot hills reaching lacelike shores of the Aegean Sea with warm climate in the west. The north-south cross section begins with the lush, temperate zone of the Black Sea coast with mountain ranges facing coastal lines which are mostly cultivated with hazelnuts, some corn and tea. The high elevation northern Anatolian Mountains include intact forest ecosystems and biodiversity rich high rangelands, which are characteristics of the northern Turkey. To the south from the Black Sea, vast Konya plain in the central Anatolia and magnificent Taurus Mountains covered with conifer forest followed by the field of cotton and banana plantation in the Mediterranean Region are present with the nice Mediterranean climate.

Chapter 4

Current Situation

4. Current Situation

4.1. Natural Resources

4.1.1. Soils

Soils of the highlands in Iran are generally classified in the Entisols and Inceptisols orders with little soil profile development. Soil surface basically consists of a thin ochric epipedon with low organic matter content of less than 1 percent. Cambic and calcic horizons are the prevalent subsurface horizons in many soils. The soils developed on the alluvial and colluvial fans and piedmont plains are mainly classified in the Orthent suborder (Xerorthents and Ustorthents) and the soils formed on the alluvial and flood plains are generally classified in the Fluvent suborder (Xerofuvents and Ustifluvents) with loamy to finer soil textures. The Inceptisols are developed on stable land forms, old terraces and piedmont plains and are usually classified in Calcixerepts, Haploxerepts and Haplustepts great groups with calcic and cambic horizons. The dominant soil moisture regime of highlands in Iran under rainfed agriculture is Xeric. But, Ustic moisture regime is mainly present in the south and south western Iran. The dominant soil temperature regimes in the highlands are mesic and thermic (Banaei, M. H. 1998).

The soils of Iran including in the highland regions are usually N deficient with low organic carbon content (less than 0.6 percent) and needs basal and topdressing application of N-fertilizer for viable and economic agricultural production. In highlands, water erosion as sheet or rill is very common on steep slope cultivated land on which appropriate soil tillage practices , management of crop residue and proper crop rotation are not practiced. Soils are usually calcareous with calcium carbonate equivalent of more than 25 percent. The available potassium content is usually medium to high and the amount of available P in soils is variable depending on the history and rate as well as frequency of application of P-fertilizes in the previous years. Highland soils developed on the steep slope landscapes are usually shallow with calcic horizons or calcareous sub-surface horizons close to the soil surface.

Deficiency of micronutrients such as Fe, Zn and Cu has been reported in many soils in Iran and application of Fe, Zn and Cu fertilizers of organic compounds are common in many orchards such as apples and cherries under irrigation condition. However, no concrete research data are available on the need for application of micronutrients for improving cereals and food legume production under the rainfed condition.

Soil in the highlands of Morocco and the Atlas Mountains are usually rich in calcium and magnesium content and are characterized either by an intensive erosion or by underlying geologic materials relatively more resistance to weathering process or by recent deposits of alluvial or colluvial sediments which inhibit soil development and formation of well developed soils. The soils under dryland agriculture are basically less developed and are generally young soils classified in Inceptisols and Entisols orders. The soils developed on the steep slope in the

Rif and Anti Atlas Mountains are usually shallow with thin Ochric epipedon in the surface. Soil organic matter content of the cultivated soils in the highlands and mountainous areas is generally lower than 1 percent. The mountainous soils in Morocco are generally subject to water erosion because of their steepness, the harsh climatic condition and the nature of their substratum. These natural phenomena are further aggravated by human activities. Indeed, the extent of arable land relative to the rural population is becoming increasing lower by time. This leads to an overexploitation of natural resources, particularly soil resources. In order to plant cereals, farmers tend to encroach forest and rangelands. They also tend to practice production techniques that are not conserving soils (heavy tillage, monoculture, plowing along the slope, etc).

In Turkey, soils classified into Entisols, Inceptisols and Alfisols orders are dominant in the highland regions. The major Soil Great Groups are Xerorthents (Regosols), Xerofluvents , Calcixerepts and Haploxerept (Calcisols and Cambisols), Haploxeralfs and Calcixeralfs (Fluvisols) ,Vertisols(Calcixererts) , Calcixerolls and Haploxerolls (Chestnuts and Kastonozems), Arenosols and Acrisols (Özden et al., 2001).

Anatolia has a variety of soil types. Nearly 40% of the land, including the Black Sea coast and most of the northeast, is covered by red and gray brown podzols (Ultisols) and by brown forest soils (Alfisols). The Aegean and Mediterranean coasts are characterized by mountain soils as brown forests (Alfisols), terra rossa (Rhodoxerolls) and rendzina (Rendolls). Chestnut (Calcixerolls) and desert soils (Calcids, Cambids, Torriorthents, and Torrifluvents) are found in Central Anatolia. The southeast has rich Chernozems (Calcixerolls and Haploxerolls) and Chestnut-type (Calcixerolls) soils.

The Turkish soils including the soils of the highlands vary greatly in texture. Most of the soils are alkaline but some neutral and acid soils are also present. The organic matter content of soils is usually low but the soils have relatively high cation exchange capacity. Relatively low electrical conductivity values and sodium content are typical of most Turkish soils including the highland soils, but the amounts of calcium carbonate or calcite are usually high (Sillanpaa, 1982).

Most of the soils in Turkey are alkaline with pH more than 7.5 values, but some neutral and acid soils are also present in some regions where rainfall is comparatively high. With the exception of soils in Marmara and Black Sea Regions, pH value is more than 7.0 in most of the Turkish soils. Large portion of soils in Turkey are calcareous. When the total lands are considered, % 27 of soils are not calcareous, 19% are slightly calcareous, 24% are moderately calcareous, 16% are highly calcareous and 16% are excessively calcareous. The more calcareous soils are developed in the Mediterranean region, while soils of Marmara and Black sea regions have low lime (Eyupoglu, 1999). Total available N and P content of highland soils are very low. The K content of soils corresponds closely to the respective internationally acceptable mean value for soil K (Sillanpaa, 1982). Thus, while N and P fertilizers are usually applied, no significant amounts of K fertilizers have been applied in soils for crop production. Only 5% of the soils are rich in organic matter. Black Sea region including northern transitional highland, due to high rainfall and relatively cool climate, is the richest in organic matter content. On the other hand, highland regions with high temperature and low rainfall like Central Anatolia and Southeastern Transitional highland have low organic matter (Eyupoglu, 1999). Along with the organic matter, micronutrient deficiencies have also been observed in many soils. The most evident and common micronutrient disorders are those due to deficiency of zinc. The levels of iron and manganese are also low. Low boron values occasionally recorded. In general, boron and molybdenum values are normal, but in some areas especially boron is very high. Copper level is around normal and any problem due to shortage or excess of Cu are unlikely (Sillanpaa, 1982).

Zinc (Zn) deficiency is a critical nutritional problem for plants and humans in Turkey. About 14 Mha of cropped land in Turkey are known to be Zn deficient, particularly cereal growing areas of Anatolia (Cakmak, et al. 1999). In Turkey, Based on analysis of 1511 soil samples collected from all provinces of Turkey (Eyupoglu, et al.1994) showed that 50% of the cultivated soils in Turkey are Zn deficient. These Zn-deficient areas are equivalent to 14 million hectare of cultivated land in Turkey, including highlands. Deficiency of Zn in soils on such a large scale and thus in food has been suggested to be one of the major causes of the widespread occurrence of Zn deficiency in humans in Turkey (Cakmak et al., 1996). Zn deficiency problem was recognized as a critical problem for wheat production in Turkey and the total amount of Zn-fertilizers applied in Turkey is now at a record level of 300,000 tons per year.

4.1.2. Water Resources

Topography and climatic conditions including variation in precipitation and potential evapo-transpiration are significantly different in various agro-climatic zones of Iran. For example: average annual precipitation in central plateau is only 150 mm while annual potential evapo-transpirations in this region are 2700-3000 mm. Only in the north of the country in Caspian coastal strip with a humid climatic condition the average annual precipitation is about 700 mm with annual potential evapotranspiration of 800-1000 mm. Precipitations in the highlands and mountainous areas are the main sources of water in Iran. Surface and deep percolated water in sedimentary rocks, particularly in calcareous formations mainly shape exploitable water resources in the country. The capacity of water resources in agricultural development of Iran with reference to the importance of high elevation regions is summarized in Table 4.1.

Table 4.1 Capacity of water resources in agricultural development with reference to high elevation regions in Iran

Areas	High elevation areas, 1000Km2	Lowlands, 1000Km2	Average annual precipitation mm	Surface water capacity	Under-ground water capacity billion m^3	Irrigated areas, 1000 ha
North-West	88	-	399	8.3	3.6	540
North	101	7	599	16.8	5.3	750
West & South-West	17	3	545	44.2	9.5	1000
North-East	204	130	197	6.2	9.6	1000
Central	77	15	287	3.7	8.0	800
South (Fars)	146	60	287	7.4	7.0	630
Total	**633**	**215**	**-**	**86.6**	**43**	**4720**
% of the country	**38.5**	**13**	**-**	**93**	**97**	**85**

These data indicate that 95% of water resources in Iran are originated from the highlands which irrigate more than 85% of total irrigated land in the country.

Moroccan climate is mainly semi-arid. It has for its northern part a typical Mediterranean climate with mild wet winters and hot dry summers. With the exception of the North-Western region and the mountains, the amount of precipitations is low comparatively to the northern part of the Mediterranean Sea. Precipitation levels diminish from west to east and from north to south. In the northwest, they vary between 500 to 2000 mm per year and reach only 100 mm in the arid zones in the south. The rainy season is generally limited to the October-April period. The end of spring and the entire summer are dry. The other feature of the precipitation in Morocco similar to Iran and Turkey is that it is irregular from year to year. There are torrential rains, especially in mountain and the highland areas that cause devastating floods.

Mountain and highland zones are more humid than the other areas in Morocco. However, the climate in the highland regions varies from humid to sub-humid (in Middle Atlas, Occidental Rif and Pré-Rif), semi-arid (in High Atlas) to arid (in Anti-Atlas). Moroccan highlands generally receive precipitation in the form of snow which constitutes an important reservoir for surface and ground water. Major rivers in Morocco have their sources in these mountainous regions. The most part of the river water is kept behind 104 dams, 27 of which have been built in the highland regions. There are also 26 natural lakes in the highlands.

Nonetheless, it is estimated that one billions m^3 of dam capacity has already been lost due to sedimentation. Watersheds and upstream of the dams cover an area of more than 20 million hectares in Morocco , one quarter of which is in need of immediate watershed management activities. During the past 40 years a small portion has been done within the framework of some development projects.

Turkey is divided into 26 hydrological basins with large differences in specific discharge. Several major rivers in the region originate from Turkey and there are more than 120 natural lakes and 706 artificial lakes. Turkey is a country rich in wetlands, ranking first in this respect among the Middle Eastern and European countries. There are more than 250 wetlands in the country with a total area of approximately one million hectares. Almost 75 wetlands are larger than 100 hectares (TCV, 1995).

By 2010, 262 large dams, mostly rock-fill or earth-fill, and 444 ponds had been constructed in Turkey. In total 706 dams have been completed and put into service for water supply, irrigation, hydropower and flood control (DSI, 2011). The large dams were constructed in large irrigation schemes (>1 000 ha, with 70 percent >10 000 ha), the rest are in the small irrigation schemes (<1 000 ha). The large dams have a total reservoir capacity of almost 200 km^3, whereas the total capacity of all dams is almost 701 km^3.

Total renewable water resources in Turkey are estimated at 227 km^3/year. About 186 km3 is surface water and 69 km3 groundwater, while 28 km3 is considered to be the overlap between surface water and groundwater. Annual usable water potential is estimated at 98 km3/year surface water and 14 km3/year underground water summing up at 112 km^3 / year (Table 4.2) .

In 2010, the total water withdrawal in Turkey was estimated at 46 km^3 / year from which 74 percent for irrigation, 15 percent for municipal purposes and 11 percent for industrial purposes. (Table 4.2). Apart from private initiatives for various purposes, by the end of 2010 the DSI and Special Administrations of Provinces had established irrigation facilities using groundwater to irrigate 505.783 ha of land.

Table 4.2 Water potential and total annual use in Turkey (DSİ, 2011)

Water Potential	
1. Annual Average Rainfall	643 mm/year
2. Annual Total Rainfall	501 billon m^3
3. Annual Total Evapotranspiration	274 billon m^3
4. Renewable Water Resources	227 billion m^3
4.1. Infiltration to underground	41 billon m^3

4.2. Annual Surface Flow	186 billon m^3
5. Usable Surface Water	98 billon m^3
6. Annual Withdrawal Underground Water	14 billon m^3
Annual Total Usable Water	**112 billon m^3**
Annual Water Use	
1. Irrigation	34 billon m^3
2. Home Use	7 billon m^3
3. Industrial Use	5 billon m^3
Annual Total Used Water	**46 billon m^3**
Irrigation	
1. Total irrigable area	25.75 million ha
2. Targeted total irrigated area by 2023	8.5 million ha
3. Currently irrigated area	5.5 million ha
4.1. Through DSİ constructed facilities	3.21 million ha
4.2. Through Special Administration facilities	1.29 million ha
4.3. Through User Owned facilities	1 million ha
Irrigation Methods	
1. Total irrigated area	5.5 million ha
2. Surface Irrigation-83%	4.57 million ha
3. Sprinkler and dripped-17%	0.93 million ha

In the highlands of Turkey, total irrigated area is 959.167 ha. It represents 3.9 % of total agricultural land of Turkey, 13. 8 % of agricultural land in highland and 17.4 % of irrigated land of the country.

4.1.3. Biodiversity and Genetic Resources

- **Highland biodiversity and genetic resources in Iran**

Iran is one of the important countries for conservation of biological diversity in the CWANA region. Iranian plateau with a vast desert in the central areas and two mountain ranges, Zagros in the West and Alborz in the North, comprise a significant portion of the territory. Iran's topography has given rise to four floristic zones, namely: Irano-Touranian, Zagrosian, Hyrcanian, and Khalij-o-Omanian. Most of Iran forest covers are located in Hyrcanian, Arasbaranian and Zagrosian zones.

The following biomes are considered as general vegetation regions across the Country (Department of Environment, 2010).

a) **Irano-Touranian** which covers an area of about 3,452,775 ha with arid and semi arid deserts and plains of central Iran. Regarding topographical conditions and diversity of species, the region is divided into plain and mountainous sub-regions.

Plain sub-region: The central Iranian sector hosts the most typical vegetation of Iran's steppe and desert regions. Dwarf scrub vegetation is common in large areas of the interior of Iran and is very diverse and rich in species; in non-saline areas, a variant with many thorn-cushions is formed. Under extremely arid conditions, a very open variant of the dwarf shrub lands appears, also characteristic of large areas of the Iranian interior; the dominant species are Artemisia siberi, Astragalus gossypius, and others. In areas receiving over 100 mm of rain, other genera such as Pteropyrum, Zygophyllum and Amygdalus can also be found. With regard vegetation of the sand deserts in the interior regions of Iran, among the more characteristic genera are Ephedra, Calligonum, Heliotropum, and others. Endemic shrubs and perennials include Astragalus (Ammodendron) kavirensis Freitag, Heliotropum rudbaricum, and others. Halophytic communities of varying composition are found on the margins of the un-drained salt pans of the central Iranian region, such as the Dasht-e-Kevir. Characteristic genera and species include Aellenia spp., Halocnemum strobilaceum, Haloxylon spp., Salsola spp., and others. The inner parts of the salt pans have almost no vegetation.

Mountainous sub-region: in this sub-region the Juniperus polycar species have been developed. It has dry and cold climate, temperate summer and the annual precipitation of about 400 mm. A variety of fruit trees, medicinal, industrial, and fieldcrop plants are grown in the mountain ecoregions of the Irano-Turanian Zone. Some of the dominating plant species of these regions are among others: Amigdallus scoparia, Onobrychis cornuta, Acantholimon spp., Astragalus spp., Artemisia aucheri, Alleum spp, Bromus tumentellus.

b) **Zagrosian:** with an area of about 4,749,000 ha covers semi-arid Zagros mountain ranges. This ecological zone extends throughout the Zagros Mountain in the west and south. This mountain range parallels the Persian Gulf and consists of numerous parallel ridges, with the highest peaks exceeding 4,000 m and maintaining permanent snow cover. Many large rivers, including Karun, Dez, and Kharkeh originate here, draining into the Persian Gulf or the Caspian Sea. Scenic waterfalls, pools, and lakes add to the beauty of the mountainous landscape. The forest and steppe forest areas of the Zagros Mountain ranges have a semi-arid temperate climate, with annual precipitation ranging from 400 m to 800 mm, falling mostly in winter and spring. Winters are severe, with winter minima often below 25 degree Celsius, and extreme summer aridity prevails in the region.

The Kurdo-Zagrosian steppe-forest consists mainly of deciduous, broad-leaved trees or shrubs with a dense ground cover of steppe vegetation. The dominant species are oak (Quercus spp.), pistachio (Pistacia spp.) and a few others. In the northern reaches of the mountain range, lower altitudes (400 m to 500 m) host communities dominated by Astragalus spp., Salvia spp., or others while higher up (700 m to 800m) forests or forest remnants of Quercus brantii and/or Q. boissieri occur up to an altitude of about 1,700m. Above the timber line (1,900 m to 2,000 m) appears a relatively wide zone of sub-alpine vegetation. Further south along the range, the forest becomes more impoverished and a richer steppe flora develops among the trees. Forest remnants consist primarily of Quercus persica and, up to an elevation of 2,400m, xerophilous forest of Quercus spp., hawthorn (Crataegus), almond (Prunus amygdalus), nettle tree (Celtis) and pear (Pyrus spp) predominates. Below 1,400m, the vegetation is steppic, with shrubs predominating.

c) **Hyrcanian** which covers semi-humid and humid Arasbaran and Hyrcanian mountains and Caspian plain. This region extends throughout the south coast of Caspian Sea and northern part of the country which is bordered by the largest lake in the world. Mountains dominate the landscape of this ecoregion. Hyrcanian (Caspian) region could be divided into three subdivisions on the basis of geographical situations. These subdivisions has been defined as (1) Alborz Range forest steppe, (2) Caspian Hyrcanian mixed forest and (3) Caspian lowland desert.

d) **Khalijo- Ommanian** encompasses dry southern coastal plains with high humidity. The region with an area of 2,130,000 ha extends throughout southern parts of the country in Khuzestan, Boushehr, Hormozgan and Sistan- Baluchistan provinces. They are dominated by sub-equatorial climate. The main plant species of the regions are: Acacia- Prosopia- Ziziphus- Avicennia- Rhizophora- Populus, euphatica- Prosopis stephaniana. The plant species of the above four ecological zones are classified on the basis of average rainfall and altitude (Department of Environment, 2010).

Most of Iran is located in the Pala arctic realm and is considered the centre of origin of many genetic resources of the world, including many of the original strains of commercially valuable plant species such as wheat, or medicinal and aromatic species. The southwest has some Afro-tropical features, while the southeast has some species from the Indo-Malayan sub-tropical realm. There is no clear estimation on the rate at which genetic diversity is being lost in Iran. However, recent studies and population declines indicate that genetic erosion is rapidly increasing. Low genetic variation may also limit species adaptation to disease or climate change.

Around 8000 plant species of 167 families and 1200 genera have been recorded in Iran from which a large portion belongs to the highland regions. Nearly 20% of these species are considered endemic. Field surveys confirmed the presence of 521 species of birds, 194 mammals, 203 reptiles, 22 amphibians and 1,080 species of fish (Department of Environment, 2010).

In order to protect existing biodiversity of the country, representative natural land have been selected and are being conserved under different categories such as protected areas, national parks, wildlife refuges and national natural monuments. In 1997, the Department of Environment held supervision over 7,563,983 hectares of such areas.

Considering the wild relatives of field and horticultural crops, it is estimated from 12,000 identified plant species in Iran more than 75% are found in high elevation areas. However the expansion of agriculture following the construction of big dams and irrigation networks as well as excessive grazing of moving livestock (generally small ruminants) constitute a major threat in erosion of genetic resources. In high elevation areas due to climatic constraint (long duration of cold season) the erosion of genetic resources is less significant than in the lowlands, and these rich genetic resources are also monitored in protected zone in large areas. For example: in the northwest, a protected area of about 75 ha in high elevation areas has been established, and more than 1,072 plant species have been identified and protected. Similar protected areas in 7 other high elevation areas have been established.

In 1977 a small plant genetic resources unit was established in Seed & Plant Improvement Institute (SPII), in collaboration with FAO. This unit was elevated six years later in 1983 to the Department of Plant Genetics and Genetic Resources consisting of the National Plant Gene-Bank of Iran (NPGBI) and plant genetic research laboratories. Since 2010, Collection, characterization and *Ex-situ* conservation of more than 67000 accessions of crop plants and their wild relatives and *In-situ* conservation of 213 wild species as well as 6200 accessions of field collections of various fruit trees in 27 locations across the country are the major achievements of the unit. Table 4.3 showed the total accessions of the field crops which have been collected and conserved at the National Genebank of Iran till 2010.

Table 4.3 Ex-situ collection of various field crops at the Iran (National Plant Genebank , 2010)

Collection	No. Accession	Regenerated	Evaluated
Wheat	17876	10755	8884
Barley	7428	4813	4964
Rye and Oat	1100	342	322
WR of Wheat	5007	1814	1104
Rice	2852	1420	1200
Food legumes	11643	11823	10866
Vegetables	10106	4332	3862
Forages	7785	5122	8436
Industrial Crops	3042	4943	5305
Medicinal crops	629	-	-
Saffron	120	120	-
Total	**67000**	**38438**	**38707**

- **Highland biodiversity and genetic resources in Morocco**

Morocco has more than 31,000 species of which about 11 percent are endemic –the rate of endemism is about 20 percent among vascular flora. The terrestrial flora is relatively well documented with close to 6,500 different species distributed amongst phanerogams or vascular plants (about 4,500 species), then mushrooms (820 species), lichens (700 species), mosses (350 species) and ferns (60 species). The terrestrial fauna is very developed with close to 15,300 species essentially dominated by arthropods (14,495 species). Endemism is very important (about 2,280 taxa). Freshwater and wetlands fauna is comprised of almost 1,600 species with a rate of endemism of about 8.65% (USAID, 2008).

Moroccan highlands cover a variety of natural landscapes. They represent a large biological diversity because of their high bioclimatic variability and their vegetation levels. Moroccan highlands have the largest share of Moroccan biodiversity (flora and fauna). Indeed, 4,700 plant species have been listed there, among them 537 endemic, 106 mammal species, 326 bird species and 125 reptile and amphibian species. Highland Forest ecosystems cover 39 % of highland areas, and represent 30% of national forest. The forest vegetation is the typical Mediterranean flora of evergreen trees and bushes, maquis, and garigue. They are mainly made of Holm oak

(*Quercus rotundifolia*), cork oak (*Quercus suber*), zeen oak, tauzin oak (*Quercus pyrenaica*) kermès oak, cedar (*cedar atlantica*), argan (*Argania spinosa*), oleasters, Aleppo pine (*Pinus halepensis*), pine maritime (*Pinus pinaster*), black pines (*Pinus nigra*), and thuya (*Tetraclinis articulata*), red juniper (*Juniperus phoenicea*), thurifer juniper (*Juniperus thurifera*), Juniperus oxycedrus, fir (*Abies pinsapo maroccana*), Atlas cypress (*Cupressus atlantica*), Acacia gummifera (*Gommier du Maroc*), A. ehrenbergiana , A. radiana., thorny xerophyte formations, Stipa tenacissima, Artemisia spp. and carobs.

Forests are habitats for significant biodiversity. They house an important diversity of flora and fauna. The forest ecosystems are rich of shrubs and herbaceous species among them a great number of endemic species with a medicinal and aromatic values. The fauna is also rich and diversified with bird, reptile and mammal species (partridges, rabbits, hares, porcupines, boars, monkeys…). High mountains constitute a refuge for a great number of endemic and rare animal and plant species (Ministère Chargé des Eaux et Forêts , 2000).

The mountainous forest of oaks, cedars, argans, junipers, thuyas, pines, acacias, firs, cypresses, and alfa and xerophyte formations constitute the main mountainous ecosystem which house diverse and important flora and fauna as shown in table 4.4.

Table 4.4 Moroccan Highland biodiversity (Ministère Chargé des Eaux et Forêts, 2000)

Forest tree species	Altitude	Habitat for		Area in ha
		Flora	**Fauna**	
Cedar atlantica	> 1500 m	Quercus rotundifolia, Quercus faginea, Juniperus thurifera, Ilex aquifolium, Cytisus battandieri, Cistus laurifolius, Daphne laureola, Crataegus laciniata, Ribes uva-crispa, Berberis hispanica, Bupleurum spinosum….	260 and 30 Arthropod and bird species	133
Pines		Tetraclinis articulata, Juniperus phoenicea, Quercus rotundifolia, Pistacia lentiscus, Phillyrea spp., Rosmarinus officinalis, Rosmarinus tournefortii, Stipa tenacissima, Globularia alypum, Cistus spp….	150 and 30 Arthropod and bird species	73,5
Thuya		Juniperus phoenicea, Pinus halepensis, Ceratonia siliqua, Argania spinosa, Quercus rotundifolia, Pistacia lentiscus, Pistacia atlantica, Phillyrea latifolia, lavender, broom, rosemary, alfa, doum…	160 Arthropod species, bird species are the less varied	920,9
Junipers			100 Arthropod species and bird species: Alectoris barbara, Streptopelia turtur,	211

			Turdus merula, Sylvia melanocephala	
Fir	> 1600 m		30 bird species and some mammals: macaque, singularis porcus, otter…	3
Cypress				5
Holm oak	1000 to 1700 m		400 and 35 Arthropod and bird species	1317
Cork oak	< 2200 m	Cytisus linifolius, Thymelaea lythroides, Erica arborea, Erica scoparia, Cistus monspeliensis, Myrtus communis, Pteridium aquilinum....		208
Argan	< 1450 m	Periploca laevigata, Senecio anteuphorbium, Launaea arborescens, Warionia saharae, Acacia gummifera, Rhus tripartitum, Withania frutescens, Euphorbia officinarum subsp. beaumierana et subsp. echinus, Cytisus albidus, Ephedra altissima, Tetraclinis articulata	60 Arthropod species, 20 Amphibian and reptiles species and 17 bird species	686
Acacia			130 Arthropod species	1000
Thorny xerpphyte formations	2000 to 3500 m			
Stipa tenacissima			25 Amphibian and reptiles species, 37 bird species and 13 mammal species	458
Artemisia spp.			Perdrix gambra, Sirli de Dupont, Alouette de Clot-Bey (Rhamphocorys clotbey), Alouette bilophe (Eremophila bilopha), And some mammals such as gazelle stripped hyena , porcupine	

Morocco has an exceptionally rich diversity of locally adapted varieties and breeds of crops and domestic livestock. The main genera of wild relatives of crop plants include Avena, Medicago, Lupinus, Trifolium, Aegilops, Phalaris, Hordeum, Triticum, Lathyrus, Ononis, Vicia, Astragalus, Bituminaria, Lotus, Stipa, Eragrostis, and Beta. However, several species described in the past have now become rare or even extinct (example: some species of the *Medicago*, *Lupinus*, *and Cicer*. *genera*.); others are found only rarely in the mountainous zones on steep slopes that are difficult to access. Among the fruit trees cultivated in Morocco, one finds the highest level of genetic/varietal diversity amongst the following genera: *Olea* (olive), *Pistacia* (pistachio), *Ficus* (fig), *Prunus* (plums and related fruit trees) and *Amygdalus* (almond). Morocco has more than 8 ovine breeds two bovine breeds of special importance ("*the blond of Oulmes*" and the "*brunette of the Atlas*"), goat breeds Yahiaouia and Attaouias and some camel breeds with Aît Khebbach, Rguibis, Rahalis, Mamyas and Guerzinis (USAID, 2008).

All ecosystems are under pressure and most are moderately-to-severely degraded. The total number of threatened species for Morocco is estimated to be at least 2,280 species. Threatened species are strongly dominated by terrestrial taxa. Plant species, in particular, constitute, more than 80% of the Moroccan threatened species (USAID, 2008). For protecting and managing the biodiversity, Morocco has created 154 sites of biological and ecological interest (SBEI) (Herzenni, A. 2006).

- **Highland biodiversity and genetic resources in Turkey:**

Turkey encompasses major centers of crop diversity and centers of origin for globally significant crops, fodder plants and forages. Landraces of many of these crops are still used within traditional farming systems and pastures. Crop wild relatives and endemic species are found in their natural habitats in the rangelands and forest areas in different ecosystems. Flora of Turkey consists of high endemism of over 4000 out of the 12000 plant species. Turkey is also described as microcenters for many crops.

Turkey is one of the important countries due to its rich plant genetic resources and plant diversity. Two of the Vavilov's Centre of Origin (i.e., Near Eastern and Mediterranean Centers) extends into Turkey. Moreover, Turkey is one of the domestication center where ancient agriculture started. Turkey is endowed with a rich diversity of family, genera and species of plants (174 family, 1251 genera, and 9222 species). A study in 2000 showed that 8988 plant species are native and 2991 are endemic (Guner *et al*., 2000). Latest studies showed that there are still many species to be identified in Turkish flora. According to the latest figures, number of species including subspecies may increase to 12056 and number of endemics reaches to 4006. Turkish flora includes many wild relatives of important crops such as wheat, barley, chick pea, lentil, cherry, pear, apricot, chestnut, pistachio, etc). Additionally, the Turkish flora also includes many economically important timber species, and medicinal, aromatic, industrial and ornamental plants.

The importance of the protection of existing plant diversity is highly recognized and various conservation programs exist. The National Plant Genetic Resources and Plant Diversity Program (NPGRDP) operate under the coordination of General Directorate of Agricultural Research and Policy (TAGEM) of Ministry of Food, Agriculture and Livestock (MİFAL) involves *ex situ* since beginning of 1960s, as well as *in situ* conservation, including on farm conservation since 1990s.

Turkey actively promotes *in situ*/on-farm conservation of agro-biodiversity as well as various protection activities of nature. The availability of funding from Global Environment Facility (GEF), other donors and the ministries of MİFAL and Ministry of Environment and Urbanism

(MoE) and Ministry of Forestry and Water Resources (MoFWR) have support to enhance activities on biodiversity (*in situ*) conservation and on-farm conservation which were able to assess the status and threats to plant species and crops in selected eco-systems. The reserves in different status are designated to protect the biodiversity. The projects were rewarding in developing "*National Plan for in situ Conservation*" as well as "*National Biodiversity Strategies and Action Plans*" and the approaches for promoting *in situ*/on-farm conservation and ecosystem conservation and managements. The figures for the protected areas are given in Table 4.5

Turkey is one of the pioneering countries started to maintain the genetic resources and has considerable experiences on *ex situ* conservation since 1960s. Within the frame work of national program, the *ex situ* conservation is implemented both for generative and vegetative collections which are preserved in seed gene banks and field gene banks. The national collection in the gene banks with international standard, contain the landraces, wild and weedy relatives, other wild species which are especially economically important (medicinal, aromatic, ornamentals etc.) and endemic plant species. The total number of accessions of national collection both seed and vegetative collection in 2012 is over 70.000 with about 2700 species. The vegetative propagated materials of 16210 samples representing 51 plant species and fruit genetic resources including 2,132 grape samples are kept in field gene banks.

Table 4.5 Type and size of conservation areas in Turkey (Kaya and Raynal, 2001; General Directorate of Forestry, 2012 http://www.ogm.gov.tr/).

Conservation program types	**Number of Area**	**Area (ha)**	**% of Total Country Area**
Nature Conservation Areas	39	878801	1,12
Nature Parks	22	76180	0,10
Natural Monuments	105	5286	0,01
Nature Protection Areas	32	63008	0,08
Wildlife Conservation Areas	109	1800000	2,29
Seed Stands	322	32914	0,04
Gene Conservation Forests	344	46345	0,06
Specially Protected Areas	12	418800	0,53
Protection Forests	48	360130	0,46
Rest and Camp Areas	415	12770	0,02
Total	1.448	3,694,234	4,70

Wild relatives and wild ancestors of cereals include those of wheat (wild einkorn, *Triticumboeoticum;* wild emmer, *T.dicoccoides;* goat grass (*Aegilops* spp), barley (*Hordeum spontaneum,H.bulbosum, H.marinum* and *H.murinum)*, oats (*Avena* spp), and rye (*Secale* spp) (Fırat and Tan, 1998). Five wild species of lentil, *Lens orientalis, L.nigricans, L.ervoides, L.montbretii, L.odemensis;*the wild and weedy forms of *Pisum* (primary progenitor of pea, *P.humile; P.elatius*); wild progenitors of *Cicer (C.pinnatifidum, C.echinospermum, C.bijugum*. *C.reticulatum*) occur in Turkey. Extremely rich medicinal, aromatic and ornamental plant species are found in the flora of Turkey. Within the ornamental plants the great numbers of bulbous tuberous plants, woody and herbaceous perennials, biennials and annuals are found. Most of the ornamental species are grown in wild habitat among deciduous shrubs and under deciduous trees or scattered among bushes and/or rocks. The diversity of ornamental plant species are related to diverse topography and climate of Turkey. Medicinal and aromatic plants almost have same situation in Turkey. The rate of endemic is also high within those plant groups. The number of vegetable has their origin in Anatolia. The wild relative of *Brassica*'s *B.cretica* is found in South Anatolia (In South Aegean and Mediterranean Belt). Wild *Raphanus raphanistrum* has also distribution in the West and South coastal part. Wild celery, *Apium graveolens*; wild beet *B.maritima* and other *Beta* spp. (Tan *et al.*, 2000), wild carrots, *Daucus* spp.; wild rockets *Eruca* spp. wild lettuce, *Lactuca* spp.; wild mustard, *Sinapis* spp. are some of the wild vegetables commonly used as vegetable or salad plants (Tan and Taşkın, 2009). Many other wild plant species are used as salad and vegetable plants, but still are not utilized in development. The indigenous fruit trees are also found in Turkey. Those woody plants are valuable genetic resources as food crops. Because their resistance to insect, disease and their natural ability to an array of sites, such species as chestnut (*Castanea sativa*), olive (*Olea europea*) and walnut (*Juglans regia*) are some valuable fruit genetic resources. Wild relatives of apple (*Malus* spp.) pear (*Pyrus* spp.) and plum (*Prunus* spp.) are also found in Turkey (Gonulsen, 1986). The wild pistachios; *P.terebinthus, P.lentiscus*; wild hazel nuts *Corylus* spp.; wild plums *Prunus spinosa, P.divericata*; wild cornel cherry *Cornus sanguinea*, wild pears *Pyrus elaegrifolia* and other *Pyrus* species; wild almonds *Amygdalus* spp. are some of wild relatives of fruit trees found in Turkey. Sweet and sour cherries are also indigenous, various wild types are found especially in North Turkey. Most of those wild relatives of fruit trees are utilized as rootstock. There are also wild relatives of other fruits like wild strawberry, *Fragaria* spp.; wild blackberries *Rubus* spp. The wild relatives of forage grasses and legumes showing high genetic diversity commonly occur in Turkey (Tan, 2010).

4.1.4. Pasture and Rangelands

- **Rangelands and Pasture in Iran**

Rangeland as defined in Iran are the land consisting of mountains, hillsides and flat plains covered by native vegetation and providing food for animals at least on one grazing season. One of the reliable estimates of the area of rangelands is 90 million hectares (Rezaei ,S.A. 2007). In 1974, satellite images were used by an American company, leading to an estimate of Iran's rangelands of 90 million hectares. Aside from fallows, rangelands include lands located on mountains, hillsides or plains covered by natural vegetation during the grazing season and traditionally recognized as range. According to this definition, Iran's rangelands cover 90 million hectares (54.8% of the total land area of the country), which have been classified as being in poor, fair and good conditions. Annual production of these ranges is 20 m tons of dry forage. They play the most important role in soil protection. According to some recent references only 10.3% (9.3 million hectares) of rangelands could be classified as in good conditions, 41.4% (37.3 million ha) in fair conditions and 48.3% (43.4 million ha) in poor conditions. According to the recent survey conducted by the Technical Office of Engineering (TOE) of Forest, Range and Watershed Organization , FRWO (TOE, 2005), the area of rangelands is about 86,103,939 hectares and forests and desert lands 14,200,000 and 32,000,000 hectares respectively. This study took 3 years, using satellite images along with ground observation with GPS applied across the county.

On the basis of grazing season, rangelands could be put into two categories: Mountainous, uplands characterized by cool summers; and plains, lowlands characterized by warm winters (Rezaei ,S.A. 2007) . The area of summer grazing rangelands is estimated to be 23 million hectares producing 6.21 million tons equal to 3.415 million tons of usable total digestible nutrients (TDN). Grazing on these rangelands starts from early spring and continues until late summer. It is estimated that 54 million animal units could be grazed on these rangelands for a period of 100 days. Winter and fall grazing rangelands located on lowlands are 67 million hectares and are mostly used in winter. They produce 4.5 million tons of forage or 2.47 million tons of usable TDN.

Like other parts of the world, animal husbandry in Iran is the most productive use of the semi-arid zones bordering the desert. Approximately 31% of the meat production in Iran, 218,000 tons per year, is associated with the rangelands. In addition to forage production, mining, fuel wood, industrial use of rangeland products e.g. medicinal plants and recreation are other benefits of the Iranian rangelands (Rezaei S.A. 2007).

Harvesting medicinal plants dates back to past centuries. According to current information the amount harvested was some 39,000 tons (valued at 77.7 million US$) in 1989-1993. Considering the land area of the country, harvested products should be much more. There are many rangeland plant species with medicinal and industrial value. The extract of *Ferula gummosa*, a plant widespread over 700,000 hectares, called galbanum is widely used in different industries e.g. medicine. The income through the export of galbanum in 1998 alone was some 180,000 USD. The cultivation of such plants is encouraged nowadays in order to protect natural biodiversity from over exploitation. Several companies have been developed investing on medicinal crop production.

Range and livestock contribute an estimated 1.25 billion US$ to the non-oil GDP (or 6% of the total GDP) and the sector provides livelihood for some three million families of whom it is estimated that 180,000 are nomadic. As defined in the Section 3.1.3, the vegetation and rangelands of Iran have been categorized in to the 4 floristic regions.

- **Highland pasture and Rangeland in Morocco**

Rangelands in Morocco cover 53 million ha, not including forests which cover 7.5 million ha. It represents 4 billion forage units (FU) i.e. 36% of all available forage. However, this contribution is highly dependent of climate conditions which are very variable in time and space. Only 3.5 million out of 10 million hectares of collective rangelands have been legally registered. During the last thirty years about 2 million ha have been privatized illegally and cultivated to the detriment of rangelands and forests. Mountain rangeland covers 58591 km² which represents 47.7 % of total area of Moroccan highlands. In the mountains, rangeland and forests represent an important contribution to the feeding of small ruminants (ovine and caprine species). They contribute by 30 to 70 % of animal intake.

The main pastoral ecosystems in highlands of Morocco are described in Tables 4.6 to 4.9. (Yessef, M. 2006).

Table 4.6 Middle Atlas Pastoral Ecosystems

Main pastoral ecosystems	Species
Dense forests	Quercus rotundifolia
Wooded land and temperate valleys	Callitris articulata, Juniperus phoenicea, Pistacia lentiscus, Olea europea, Phillyrea angustifolia
Sub humid to humid forests	Cedrus atlantica, Acer monspessulanum, Quercus rotundifolia
Rangeland of asylvatic mountain	Thorny xérophytes épineuses such as Erinacea anthyllis, Cytisus purgans ssp. Balansae, Alyssum spinosum, mixed with herbaceous species
Mountain rangeland	Poa bulbosa, Dactylis glomerata, Stipa lagascae, Festuca rubra, Festuca ovina, Hieracium pseudopilosella, Scorzonera pygmea, Medicago suffruticosa
Humid zones with bushes and low vegetation	Adenocarpus boudyi, Genista pseudopilosa, Genista quadriflora, Festuca rubra, Hieracium pseudopilosella
Sub humid forest	Quercus suber, Arbutus unedo, Cistus spp., Halimium halimifolium, Dactylis glomerata
Sub humid forest with cold winter	Quercus mirbeckei, Q. rotundifolia, Crataegus lacinita, Rosa sp., Cynosurus elegans, Dactylis glomerata, Arrhenatherum elatius

Table 4.7. High Atlas Pastoral Ecosystem

Main pastoral ecosystems	**Species**
wooded land of the piedmont and temperate valleys	Many arborous and bush species (Callitris *articulata, Quercus rotundifolia, Juniperus phoenicea*, etc).
Mountain rangeland	Festuca maroccana, *F. rubra, Scorzonera pygmaea, Nardus stricta*, et *Trifolium humile*.
Land bushes of altitude	Vella *mairei*, *Bupleurum spinosum*, *Alyssum spinosum*, *Festuca maroccana*, *Dactylis glomerata*, and local *Juniperus thurifera*
Land bushes with low vegetation of low altitude	Ormenis scariosa, Adenocarpus anagyrifolius, Retama dasycarpa, Alyssum spinosum, Bupleurum spinosum, Dactylis glomerata, Stipa nitens.
High altitude steppe	Artemisia herba-alba, Ormenis scariosa et *Bupleurum spinosum*

Table 4. 8 Rif' Pastoral Ecosystem

Main pastoral ecosystems	**Species**
High shrub covered semi-arid zones with temperate winters	Pistacia lentiscus, Phillyrea angustifolia, Olea europea and localy *Juniperus phoenicea*, *Callitris articulata*, *Lavandula* spp., *Piptatherum miliaceum*.
High shrub covered zones along the Mediterranean sea and in the oriental part of the massif	Callitris articulata, Cistus villosus, Lavandula multifida, Teucrium fruticans, Hyparrhenia hirta, Piptatherum miliaceum
Forest and brushwood in semi-arid and sub humid with cold winter zones	Quercus rotundifolia, Thymus spp., *Cistus* spp., *Genista* sp., *Festuca rubra*, *Dactylis glomerata*
Herbaceous vegetation of the occidental sub humid zone	Urginea maritima, Asphodelus microcarpus, Cynodon dactylon, Chamaerops humilis, Plantago spp., *Rumex* sp.., and localy, perennial gramineae such as *Dactylis glomerata, Hyparrhenia hirta, Piptatherum miliaceum*.
Forest and wooded land in sub-humid zones with temperate to cool winters	Quercus suber, Erica arborea, Cistus spp. In temperate part, we find other species such as *Callitris articulata, Pistacia lentiscus, Arbutus unedo, Hyparrhenia hirta, Piptatherum miliaceum*
Shrub covered of humid zone with temperate to cool winters	Chamaerops humilis, Cistus spp, Erica arborea, Arbutus unedo. Localy, we can find *Ampelodesma mauritanica*
Humid forest with cool to cold winters	Cedrus atlantica, Acer monspessulanum, Quercus spp. And small forest of Abies maroccana.

Table 4.9 Anti Atlas Pastoral Ecosystem

Main pastoral ecosystems	**Species**
Coastal steppes with Saharan bio-climate and hot to temperate winters	Euphorbia echinus, Euphorbia regis-jubae, Helianthemum confertum, Retama monosperma; *Argania spinosa, Artemisia herba-alba, Euphorbia echinus*
Wooded steppes with arid bio-climate and cool to hot winters	Argania spinosa, Artemisia herba-alba, Ziziphus lotus, Stipa capensis et *Asphodelus fistulosus.*
Argania forest with semi-arid bio-climate and pemperate winters	Olea europea, Pistacia lentiscus, Genista sp., *Chamaerops humilis.*
Forests and afforestations	Callitris articulata, *Olea europea, Phillyrea angustifolia, Ceratonia siliqua, Pistacia lentiscus, Cistus villosus, Lavandula multifida, Thymus* sp*; Teucrium fruticans*
Oak forest with sub-humid bioclimate and cool winters	Quercus rotundifolia, Callitris articulata, Pistacia lentiscus, Arbutus unedo, Juniperus phoenicea.

Animal husbandry in the Moroccan mountains' rangeland is characterized by moving human and animals using large collective spaces. The management of these spaces is based on judiciary practices where traditional laws, Islamic land laws and modern state laws interfere. Nevertheless, we are witnessing a regression on the ability of traditional organization to manage the rangelands.

Rangelands are undergoing dramatic changes concerning the social organization, the economy, the innovative technologies and the ecosystem. These changes are due to the rise in population levels, increase in the occurrences of droughts, urbanization, industrialization and rapid increase in income. These changes have placed high pressure on natural resources which are of central interest for pastoral livestock systems. Urban income increase and policies that increases red meat prices lead to unprecedented increase in their demand, which in return has put more pressure on the rangelands and eventually leads to changes in animal husbandry practices.

Technological modernization in animal husbandry and marketing—including use of vaccines and medicines, artificial reproductive techniques, feed concentrates, mechanization of transportation and of feed production—have also changed the way livestock is raised and hence the way rangelands are exploited.

The changes have brought the development of new techniques of livestock management. Herders, in order to respond to the new conditions, associate animal husbandry with growing cereals, complement their animal feeding by bought animal feed, growing cash crops on small irrigated areas, and by draining income from emigration activities (Bourbouze, A., 2006). Motorization has become a new way of mobility which is compatible with family sedentary lifestyle, the encroachment on pastoral and collective lands in particular by new class of very important stockholders innovators but also predators (Bourbouze, A. 2006). The appropriation strategy is very simple. It starts with the construction in the mountain of individual sheepfold called azib and the practice of clearing dispersed parcels of the steppe. Then crops are grown even during drought years. These parcels mark the boundary of the territory in the process of being appropriated. The traditional institution (Jmaa) seems unable to control this process (Bourbouze, A. 2000).

The consequences of population growth in highland rangelands are usually an animal stock exceeding the pastoral potential by a factor of three to five, preventing regeneration of the interesting species for livestock and leading to the overgrazing. All these changes concerning rangelands are very crucial to understand for the rangeland conservation and for improving the livelihood of the local people.

- **Highland Pasture and Rangelands in Turkey**

In Turkey, grazing areas can be roughly classified as coastal and steppe rangelands. Coastal rangelands include grazing lands in the Black Sea, Marmara, Aegean, Mediterranean and Thrace regions. Coastal Rangelands constitute approximately 25 to 30% of the country’s all ranges. Annual rainfall in coastal rangelands varies between 600mm and 2800mm. Herbaceous vegetation in these rangelands turns to steppe formation as rainfall decreases. Due to the high precipitation and better soil conditions, more productive rangelands vegetation has been formed in the coastal rangelands.

In coastal rangelands, there are valuable Poaceae and Leguminous fodder crops, in different proportions depending on rainfall. Valuable rangelands plants are found in these rangelands, which are considerably saved from harmful overgrazing. In the rangelands highly destroyed by overgrazing, valuable meadow plants are replaced by Narduus, the shrubby wormwood (*Artemisia*), the Aleppo milk-vetch (*Astragalus*), the horned dock (*Rumex*), the knapweed (*Centaurea*), the goat-scented St. John’s wort (*Hypericum*), the sage (*Salvia*) and wild grass species that animals do not prefer feeding on much (Altın et al, 2005).

The grazing lands of arid and semi-arid areas with a total rainfall of 200 to 700mm are classified as steppe rangelands. Steppe rangelands are divided into two categories as mountain and plain rangelands in terms of altitude and topography. Since altitude and rainfall amount are relatively higher in mountain rangelands, more valuable poaceae and leguminous fodder crops are found. However, owing to continuous overgrazing, quality crops have largely been replaced by the thyme (*Thymus*) and the shrubby wormwood (*Artemisia*) species. Therefore, most of the mountain steppes have been turned into thyme steppes and are called with this name. These are large grazing areas, covering the Central, Eastern and South-eastern Anatolia Regions and the transition zones. The three-fourth of Turkey’s rangelands falls into this group. The Poaceae proportion of vegetation in the most arid parts of steppe ecosystems is around 20 to 30%. Most of leguminous are annual plants which yield a small amount of fodder in spring and dry up as temperature goes up. The rest of them are the thorny plants which animals don't feed on much during their development period (Anonymous, 2007).

In some parts of steppe rangelands which are flat, with deep soil and surface ground water, flat rangelands exist. These rangelands are fertile areas where green fodders are found even in hot and dry periods of summer and on which animals graze throughout the grazing season. Arid vegetation is found in the vicinity of Tuz Lake and Aslım marsh in Central Anatolia, and Sultan reed in Kayseri. Such poaceae crops as *Poa compressa*, the bermuda grass (*Cynodon dactylon*), the weeping alkali grass (*Puccinellia distans*), *P.ciliaris*, *Eremopyron orientale*, *Apera intermedia*, such leguminous plants as *Trigonella monantha*, *Astragalus lydius* and such halophilics as *Salsola plathyheca*, *Kochia prostrata*, *Atriplex tatarica* and the slender grass-wort (*Salicornia europea*) can be found in these regions where only halophytic crops can grow (Anonymous, 2007).

Rangelands in high plateaus and the alpine rangelands over timberline are very important for animal breeding, since those rangelands offer green grazing areas for animals in summer time when other rangelands are dry. Plauteu and alpine rangelands, which cover large areas in the Eastern Anatolia, Northern Black Sea, Taurus and anti-Taurus mountains, are found as small stains on the high mountains of other regions. In these rangelands, only some crops that can resist the cold weather persist as altitude become higher. With higher altitudes, leguminous plants and Poaceae are replaced by crops that animals do not feed on. So, places near the limit of permanent snow cover are not much valuable as grazing areas. In addition, in some parts of forest ecosystem where trees do not grow or are destroyed, the in-forest-rangelands have grown which are partly or completely covered by forest (Anonymous, 2007).

The exact area of rangelands is not known. According to the estimations, the rangelands area decreased from 44.2 million hectares in 1940 to 13.2 million hectares in 2001, and accordingly stocking rate declined from 4.3 in 1940 to 1.2 ha/Animal Unit (AU) in 2001 (Fırıncıoglu, 2004).

The greatest portion of range area is located in Eastern Anatolia highlands followed by Central Anatolian highlands, 75,9 % of the total range area is situated in the arid regions, which are Central, Eastern and Southeastern Anatolian Regions, according to the 2001 census and estimated values of 2010. After 1950s, the introduction of large-scale agricultural machinery enabled immense areas to be cultivated. The range areas were ploughed to grow crops, especially cereals, while rangelands were converted to cropping lands mainly for industrial crops.

Depending on the extent of agricultural land, the most unproductive rangelands of Turkey are located in the Central Anatolia, because of the prevailing unfavorable climatic conditions and the existence of overgrazing for extended periods over the decades. The annual precipitation varies between 289-500 mm from Karapınar County to the northern transient zone. Since there are prevalent periods of hot temperature and drought during summer, most of the range plant species completely dries out for 2.5 months of grazing season. Due to excessive grazing pressure, the range vegetation has been severely deteriorated to the extent that the plant cover cannot sufficiently protect the soil in some places. For this reason, in the Karapinar area, as a worst example, wind erosion caused formation of sand dunes. But, the deleterious effect of the water and wind erosion frequently occurs in most parts of the region. The Central Anatolian rangelands have a steppe character, but as the case in true steppes, the grass species are not dominant. Grass species such as *Festuca ovina*, *Bromus tomentellus* and *Poa bulbosa var vivipara* are accompanied by shrub species such as *Thymus squarrosus* and *Artemisia fragrans*. In some parts of region, as a result of further degradation, Artemisia rangelands have been replaced by Thymus pasturelands. Grasses constitute about 40 percent of the vegetation. Though the Central Anatolian region is a high plateau, unlike other regions there is no adjoining area of high mountain pastures on which livestock might be grazed during the hot summer season (Firincioglu, 2004). After cereal harvest, animals are driven to graze on the stubble, which becomes an important part of the daily ration. Because of this heavy grazing, the dried hay production of the rangelands has been reduced to an average of 300 kg/ha. Central Anatolia, among others, has the largest stocking rate at 2,467 ha/AU with 1.779075 animal units (SIS, 2001). In the western and north-west transition zones of Central Anatolia, the major plant species are *Festuca ovina, F. rubra, Agropyron desertorum, A. cristatum, Dactylis glomerata, Stipa sp., Astragalus sp., Thymus sp., Plantago sp*. in rangelands, whereas in rangelands *Agropyron intermedium, Festuca arundinacea, Lotus corniculatus, Phleum sp., Trifolium repens, T. pretense, Carex sp., Lolium sp. and Juncus sp*. are common species,. Shrub species such as *Crategus monogyna, Rubus caesius* and *Palirus spina* are prevalent in pasturelands. In this part of Central Anatolia, Juncus sp. is intensely encroached upon in the rangelands (Atalay et al., 2010). Livestock grazing in the hill pastures is a common practice during hot summers. For small ruminant production, a quasi-nomadic system is practiced.

The largest rangeland is found in the Eastern Anatolian Region. The grazing pressure is relatively low compared with other regions. Therefore, range condition is also in relatively better shape than the other regions, and excluding the Eastern Black Sea region, the climatic condition is more favorable for plant growth than any other areas. The botanical composition of this pasture lands is represented by grasses such as *Festuca ovina*, *Bromus tomentellus* and *Koeleria cristata*; the major leguminous family species are the spiny-*Astragalus ericephalus* and the various wild alfalfa species (*Medicago falcata*) are widespread (Gökkuş and Koc, 2001). Eastern Anatolia is more suited to animal husbandry and the cropping of cereal and industrial crops have some constraints owing to high elevation. More interestingly, most of the productive rangelands are situated in this region, which has a great capacity for animal husbandry and forage production and most of the villagers invest in livestock production for their livelihoods. A total of 2.056.029 AU of small and large ruminants with 2,268 ha/AU stocking rate exists in this region (SIS, 2001).

The rangelands of South-Eastern Anatolian region have more or less the same conditions as the Central Anatolian pasturelands, mainly due to dry conditions. Since summer and high temperature become prevalent earlier, the pasture forage dries out quickly, and the small ruminants are driven towards higher plateaus and pasturelands of Eastern Anatolia and highlands of south-eastern Taurus Mountains. The rangelands of this region are grazed heavily. South-eastern Anatolia has 787.356 AU equivalents of small and large ruminants with a 1.20 ha/AU stocking rate (SIS, 2001). Proper grazing times lie between 15 April and 30 June for spring, and from 15 September to 30 November for autumn, but these timeframes are not respected and uncontrolled grazing is widely practiced. In the Southeastern Anatolian Project (GAP) Area, the plant cover ratios of grass, legume and other species were determined to be the 11, 2.5 and 85.5 percent, respectively. *Dactylis sp*., *Avena sp*., *Phlaris sp*., Bromus sp. , *Hordeum sp*, *Festuca sp*. of the grass family, and *Astragalus sp*, *Vicia sp*., *Lathyrus sp. Pisum sp*., *Trifolium sp.*, *Trigonella sp.*, *Medicago sp.*, *Coronilla sp.* of the legume family are the major species in the GAP region (Polat et al.,1996). In general, an uncontrolled use of the communal land is widespread. Livestock feeding is largely dependent upon rangeland; all of the small ruminants and a major portion of cattle graze on pastureland for most of the year.

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 area and quality of pasture lands. The first step was to delineate the boundaries of rangelands. A big project on development of rangelands and forage production was initiated in 2006 with the collaboration of General Directorate of Agricultural Production and Development, General Directorate of Agricultural Research and universities. The research institutes and provincial directorates at the local level have put their effort together for the improvement of rangelands in Turkey. Under that Project, nearly 1000 projects have been implemented at the local level and nearly 1milion hectares of rangelands were rehabilitated by 2010.

4.2. Current socio-economic situation

4.2.1. Policy

In general, in the 3 countries studied the governments' development policy for highland agriculture revolves around development projects for specific areas. These projects generally deal with managing natural resources, increasing agricultural and livestock production, improving irrigation schemes and/or rural development. There is no general policy designed specifically for highlands.

In Iran, the policy for agricultural development of the government since the Islamic Revolution in 1979 has mainly been based on increasing self sufficiency of strategic agricultural commodities such as wheat, rice, maize, edible oil, sugar, potato, meat, dairy products and others. The government used to provide subsidies to farmers on chemical fertilizers, seeds, pesticides, electricity, fuel, gas, and others. The government has also made huge investment in building and developing basic infrastructures needed for agricultural development such as big dams, roads, electric power, irrigation and drainage systems, grain silos, etc. But, in 2011, the government initiated a national plan to reduce or remove subsidies on fuel, gas, water and many other inputs and services, although there are still substantial subsidies provided to agriculture sector on chemical fertilizers, animal medicine, fuel, and gas. The government has decided to pay the subsidies directly to the people and remove subsidies on consumption of electricity, fuel, gas, bread and other commodities. This sudden removal of subsidies on agricultural services has caused many difficulties to farmers and agricultural producers. They are in urgent need to improve productivity and efficiency of their production system and to rapidly adjust to the emerging reality. The long term impact of the government initiative to remove or significantly reduce subsidies on agriculture sector needs to be assessed in the coming years.

The government has also vastly invested to improve on- farm water management and efficiency of irrigation system by supporting research and technology development and providing financial support and cheap loans to farmers for improving their irritation system and use of modern technologies such as pressurized irrigation system. In 2011, the total area under pressurized irrigation system was around one million hectares and there is a plan to increase the area to around 2 million hectares by 2015. To promote the traditional irrigation systems, the government support farmers by providing 90% of the cost of the on farm projects for changing the traditional irrigation system to modern high efficient and pressurized irrigation systems.

The government of Iran has initiated several programs during the last decades to improve agricultural productivity, enhance agricultural production and protect natural resources. These included programs on 1) rural development and reconstruction, 2) restoration of rangelands and conversion of low productive dryland areas into permanent ranges, 3) enhancement of dryland orchards and olive trees in favorable regions, 4) expansion of pressurized irrigation systems and promoting on farm water management practices , 5) increasing wheat production and national self sufficiency on wheat , 6) expansion of conservation agriculture to around 3 million hectares by 2015 under irrigated and dryland farming systems.

Some of the above programs implemented earlier did not achieve their initial goals and were basically suffered from a lack of long term continuity of the program, sustained funding mechanism and socio economic assessment for effective implementation of the projects. Also, the high input of water, energy and fertilizers applied to increase crop yields was considered to be a major constraint in sustainability of the program and protecting the natural resources, particularly water and soil resources (Roozitalab M.H. and A. Keshavarz, 2011). There are no studies available on assessing the impact of the programs implemented in increasing the yields and protecting the natural resource base.

In 2005, Iran achieved self sufficiency in wheat production by producing around 15 million tons of wheat through implementation of a national plan to support the farmers and to transfer the production technologies to farmers for increasing their wheat production, particularly under irrigated condition. However, occurrence of severe drought in 2008 and climate variability in subsequent years seriously damaged the stability of the yield and therefore substantial reduction in the total wheat production.

The government has not yet formulated a separate comprehensive policy and plan to increase agricultural productivity in the highlands under the rainfed condition, although several suitable high yielding wheat, barley, forages and food legumes cultivars and other production technologies suitable for dryland agriculture are available to be adopted by the farmers.

In Maghreb countries, staple food crops such as wheat, barley, chickpea, lentil, sugar beet, and maize receive input subsidies (seeds, fertilizers, pesticides, fungicides, herbicides) which are not extended to vegetable crops. Also for some Maghreb countries, fruits and staple food crops have more stable prices guaranteed by the governments which are not applied to vegetables. To reduce natural resources degradation in highlands, the Moroccan, government interventions usually consist of reforestation, fallow-restoration, building terraces and putting in place protected areas such as national parks, natural reserves and sites with biological and ecological interest. Reforestation is done by new plantations and rehabilitation of existing ones. It attends to reduce erosion and protect watersheds in order to prolong dams' life. Combating erosion is done by planting trees and by building low walls or basins to keep water and soil in place and improve tree productivity. Sometimes, the population is asked to participate in defining and financing these efforts and to maintain these projects. The goal is to make the local population interested in preserving the environment. In many places in Morocco, the population is even hostile to these kinds of projects as they consider that these actions are a prelude to the seizure by the state of their land and the planted areas as a reduction, at least for a while, of their grazing capacities. Olive, almond and carob trees are examples of trees planted to protect hills from erosion. In general, this policy of reducing natural resource degradation fails because it does not address the root causes of the problem.

More recently, the projects tend to include organizing the population for participating in sustainable management of natural resources. However, the types of participation are still not very clear in particular the responsibilities of each party. The terms of the contract need to be clarified and the negotiation process to be improved for the policy to receive the population support.

As for livestock, the actions consist of the introduction of breeders, improving animal health and their feedings. In highlands, rangelands constitute an important part of animal feeding resources. Interventions in rangelands are usually an important component of projects in highlands. They aim to increase pasture and animal productivity. Generally, the actions are mainly planting perennial plants, fallow-restoration techniques and dropping improved grass seeds and fertilizers onto the rangeland. In drought years, in order to maintain animals, government subsidizes feed and builds wells to provide drinking water for the livestock.

The population in Morocco is generally reluctant to the fallow-restoration. This technique is very important in reducing rangeland degradation. The suggested hypothesis is that farmers have a short term view of the benefits they can get from the rangeland. This hypothesis has not been verified. Economists tend to explain the issue by the open access to the resources which makes the more powerful people from the community, the most beneficent from the investment. Hence, the principal reason for this degradation is the open-access to rangelands. Due to high meat prices, it is profitable to produce more meat in the country. With high feed prices, particularly for barley, the pressure on rangelands is high and encroachment has been encouraged. The substitution between bought feed and rangeland feed decreases with high feed prices. With a lower barley price, it will become less profitable to produce barley in marginal land; this will then reduce the attractiveness of encroachment (Sanders, J.H. and H. Serghini, 2003). To overcome the reluctance of the population the projects sometimes include compensation to herders for fallow restoration.

One of the main difficulties to reduce natural resources degradation in Morocco is the lack of well delimitation of different land status on the field. In general, forests belong to the state, rangelands are owned collectively by the local community, and cultivated lands have private status. However, conflicts rise about status limits and sometimes about the status of some parts of the land. Some communities in particular, do not accept the state ownership over the forests. Conflicts over the limits of rangelands rise among communities and between the later and the state. The government has programs to register and delimit forest domain. Yet, these programs are usually delayed due to difficulties and conflicts with communities. Rangelands are managed by the communities themselves. However, the management capacity is deteriorating as new relationships penetrate these communities. How to manage the natural resources in highlands is an important question without a satisfactory answer. The government now tries to include communities in this management. These experiences need to be evaluated.

The increase in agricultural product, the intensification of production system in irrigated and rain fed areas is done through irrigation improvement and promoting extension. Irrigation projects in highlands are generally aimed to promote efficient irrigation practices and to protect and rehabilitate irrigation schemes from flooding. Again, these efforts are not general. Rehabilitation of irrigation schemes increase the availability of water for crops and leads to an intensification of farming. This component of the projects is generally welcomed by farmers since it allows an important increase in income. Projects generally help water users to establish an association. Some of the results of the project zones are an increase in the areas reserved for trees, particularly olive and rosaceous trees, diversification of agricultural crops , improvement of production techniques and in particular the introduction of new varieties. As a result, the yields and incomes have increased. However the expansion of wells has caused a rapid decline in water tables in several highland zones. In order to stop or at least reduce this degradation, governments typically prohibit or reduce the possibilities of digging new wells. The success of such policy is quite limited.

In order to reduce highland isolation and to facilitate product trade and input procurement, some roads and trails have been built in some areas. There is rarely a general policy for breaking this isolation for the whole highland areas.

More and more gender issues are introduced in Morocco as a part of these projects. They consist mainly in introducing activities that generate revenues for women (in particular apiculture, rabbit breeding and handicrafts) and training activities targeting women (literacy campaign, information on sanitary issues).

The national economic policy makers seldom take into account the effects of their different policy options on the highlands. For example, the high tariff level on wood import would make pressure on exploiting the forest for its wood. The high tariff level on feed grains promotes more pressure on rangeland. A gas subsidy could reduce the damage to forests as people can substitute wood for gas for their cooking and heating.

The policy for highlands in Morocco can be summarized by the following statements (Ministère de l'Agriculture et de la Pêche Maritime, 2009).

- In policy terms, there is a lack of general strategies and long term visions and an insufficient taking into account of mountain specificities in agricultural and rural policies,

- In terms of institutions, the descendant approach is still dominant and an insufficient coordination among sectors with fragmented institutions
- In term of process, an absence of continuity and lack of monitoring and assessments

The question on what happens after the end of the project implementation in highlands of Morocco is generally not answered. Important lessons can be drawn from past experiences:

- Lack of integration of programs and activities targeting highland areas which reduces their effectiveness;
- Lack of institutional mechanism for consultation and coordination between different development actors;
- Centralized conception and management which is not helpful for addressing the needs of local communities;
- Lack of incentive framework for private investment in highlands.

Therefore, in order to confine the process of natural resource degradation in highlands of Morocco and other countries in Maghreb, and to improve the livelihoods of their population and thus reducing the poverty rates, a specific national policy for highlands should be conceived and implemented. This policy should be based on the development of agricultural production systems which increase farmer revenues without altering the ecological equilibrium (in particular by promoting local labels and biological products), diversifying economic activities and integrating the highlands in the national territory.

For the success of this policy, it is necessary to mobilize human and financial resources but also policies, incentives, laws and regulations that:

- Favor local communities, cooperatives, local businesses as the main beneficiaries of the commercial harvest of biodiversity products from state and collective-owned lands and waters.
- Provide for co-management of state-owned forest and/or rangelands;
- Create clear incentives for communities/businesses to invest in the regeneration/ restoration/ sustainable management of state-owned lands (USAID, 2008).

In Turkey, the main objectives of agricultural policies are set out in the Government's Five Year Development Plans. The main objectives of the policy are to ensure adequate levels of nutrition, to increase yield and output, to reduce the vulnerability of production to adverse weather conditions, to raise levels of self-sufficiency, to provide stable incomes for farmers, to increase exports and to develop rural areas. In the pursuit of these objectives, the government has implemented various measures (WTO, 2003).

Turkey has embarked on an ongoing structural adjustment and stabilization programs towards the end of 1999. Agriculture has been selected to undergo heavy adjustment due to the ineffective set of policies in the last decade. The reform program targets to diminish drastically heavy involvement of the state in the agricultural sector (Çakmak et al, 2004).

The guidelines of the Turkish agricultural policy are defined in accordance with the commitments put forth in the WTO Agreement on Agriculture as well as developments in the EU Common Agricultural Policy (CAP) and in international trade.

So, in recent years, the main policy objective in agriculture is the structuring of a highly competitive, sustainable and organized agriculture sector that considers the economic, social, environmental and international developments as a whole, to ensure the efficient utilization of resources.

The implementation of these policies indicates that two closely related objectives have been consistently persistent (Çakmak, 1998):

- Increasing yields and production levels. Expansion of cultivated land, promotion of the use of chemical inputs and credits at subsidized interest rates, combined with heavy public investment on irrigation increased both yields and volume of production.
- Increasing agricultural incomes and achieving income stability: the government used also output price support policies and trade measures to prevent at least the decrease in agricultural income and bring the agricultural per capita income to a level compatible with the rest of the economy.

Apart from these basic objectives of the agricultural policies, given a rather large resource base in agriculture, it has been tried to be achieved self-sufficiency both in individual products and in total nutrition volume. In accordance with the principle of food safety, balanced and adequate nutrition for the growing population is essential (MARA, 2010a).

It could be true to say that, through another way of looking at agricultural policies, there are two important types of agricultural policies in Turkey. First one is agricultural market and product specific policies which cover particular products like cereals, tobacco, sugar, cotton, oilseeds, pulses, vegetal oils, meat and milk. The other one is non-product specific agricultural policies through subsidization of inputs such as fertilizer, seed, pesticides, feed, irrigation, credit subsidies (Grethe, 2003).

In the light of the above explanations, it should be stated that, the future Turkish agricultural policy would be formed by following 5 different factors and their interactions among themselves (TUSIAD, 2005).

1. Turkey-EU relations and the future rural development and agricultural policy of EU,

2. New WTO-agriculture agreement and it's requirements,
3. Behavior of third countries and trade trend with them,
4. Turkish macroeconomic and resource distribution policy,
5. Changing circumstances for agriculture and rural areas of Turkey over the years.

Generally, the main goals of Turkish future agricultural policy would be to create sustainable and highly competitive international agricultural sector through some structural adjustments and improvements in input and output markets.

The new prospects of this type of agricultural policy, of course, will have some positive impacts on fruits and vegetables and olive-oil sectors in Turkey. Market liberalization and EU membership would increase competition in agriculture sector. Then, fruits and vegetables remain competitive and Turkey appears to be net exporter of fruits and vegetables (Oskam, et al, 2004). Food production depends heavily on the changes in agricultural production which is expected to be more commercial and to get more capital-based in the coming years in order to become more productive and competitive in the EU market. Increasing agricultural production and developing food industry would increase the accessibility of people to food and may create sufficient conditions to increase exports. In almost all-subsectors, investments by technology transfer, structural improvement or merger would help the enterprises to grow rapidly and become more competitive in the markets.

With the EU membership's perspective, Turkish agriculture would be more knowledge based and capital intensive in order to be more competitive and to become closer to the standards of developed countries. This would help much the agro-food industry to produce and trade more in the world markets as well as nourishing the nations (SPO, 2004). Then, there will be different items in the policy implementation for short and medium term policy agenda. In the short term, the items have been related to environmental protection schemes, crop insurance support and participatory rural development. Sustainable rural finance system, rural infrastructure targeted to irrigation, storage and marketing facilities, expansion of extension activities have been the medium term items. Though agricultural support program will continue in long term there will be changes in the implementation tools, since structural adjustment program in agriculture is expected to be continued. Agricultural subsidies are one of the very important instruments for increasing the efficiency and production used in a very effective way taking the international agreements and relation with Europe.

The agricultural policy is generally applied country wide. However, sometimes there are specific supports for different regions or selected provinces. These kinds of support have been implemented in a certain period of time and in a limited area for a specific purpose. For instance, recent support for the livestock in Eastern Highland is a good example for these kinds of subsidies. An investment in livestock sector based on approval of the projects by the MOFAL receives 40% of cost of the project as grant.

Rural development has become one of the key elements of Turkish agricultural policy in last decade. The main objectives of rural development policy are to increase the productivity of rural areas, to improve the income level and wealth of the rural population, to reduce disparities between rural and urban areas and to prevent excessive immigration to big cities. To this end, the necessary rural infrastructures for education, health, social security, organization, accommodation, and transport will have to be established and agriculture, agricultural industries, tourism, and local handicrafts will have to be developed. These activities will be carried out by governmental and non-governmental organizations (MARA, 2010b).

Rural development policy takes the form of rural development plans which have covered infrastructural elements. Indeed, Turkish policy is strongly oriented towards developing the basic conditions for agricultural production and improving basic infrastructure. So, rural development policy is more focused on large scale investments (Oskam, et al, 2004).Nearly 24 percent of the population of the country live in rural areas and earn the bulk of their income from agriculture. As a result, agriculture and rural development are top priorities for the government. The massive investments in the Southern Anatolian Project (GAP) are probably the best example of this policy.

4.2.2. Population

The total urban and rural population living in highlands of 3 countries of Iran, Morocco and Turkey are very significant in comparison with the total population of the countries.

In Iran, more than two third of the total population, which was around 75 millions in 2010, lived in the highland regions. Agriculture is still an important sector employing about 21% of the labor force and contributing about 13% to the national GDP in 2010. In several villages selected as a pilot site on the Upper Basin of the Karkheh River located in the highland region of Iran, the household heads under the age of 50 years represented about 51% of households. This indicates that young people makes up a large portion of the population in the highland areas of the Karkheh River Basin. The rural population in Iran has been decreasing during the last decades and has reached to about 21 million in 2010, i.e. 26% of the total population of the country. The average population density in Iran is around 44 and literacy rate for adult male is 89% and for adult female is 81%.The life expectancy at birth for female and male was around 74 and 70 years respectively in 2010. Total population in Iran is increasing by about 1.25 percent per year in 2011 (World Bank, 2012).

The highlands of Maghreb countries are well populated as they host 30%, 20% and 10% of the total population of Morocco, Algeria and Tunisia respectively with corresponding population densities of 46, 150 and 100 inhabitants/Km^2. These densities are higher than the national averages and are variable ranging from 10 inhabitants per Km^2 in the High Atlas of Morocco to more than 250 inhabitants per Km^2 in Krouminie in Tunisia and in the Rif in Morocco (ICARDA, 2003).

In Morocco, the proportion of the rural population relative to the total population in highlands and in the whole country was respectively 72.5% and 44.9% in 2004. The household sizes for the whole rural population are slightly higher in highlands than in the other areas of the country as shown in table 4.10.

Table 4.10 Rural population in Moroccan Highlands (Haut Commissariat au Plan , 2008)

	% Rural population	Household average size	Rural Household average size
Highlands	72.54	5.58	6.08
Morocco	44.92	5.28	6.03

In Turkey, according to the Address-Based Birth Recording System, the country's population was 73.7 million people in 2010 (TUİK, 2010) nearly 76.3% of the total population (56,222,356 person) lives in urban areas and 23.7% lives in rural areas (17,500,632 person). Highland population is estimated as 32.611.930 constituting the 44.2 % of total population. Total population is increasing by 1.58% each year. Turkey has an average population density of 96 people per km². People within the 15–64 age groups constitute 67.2 % of the total population; the 0–14 age group corresponds to 25.6 %; while senior citizens aged 65 years or older make up 7.2 %. Life expectancy stands at 71.1 years for men and 75.3 years for women, with an overall average of 73.2 years for the populace as a whole (TUİK, 2010). Education is compulsory and free from ages 6 to 15. The literacy rate is 97.73% for men and 90.13% for women, with an overall average of 93.96 %

4.2.3 Migration

Despite the exodus from the mountains to lowlands and outside the country, population density remains high relatively to the available natural resources. However, migration alleviates population pressure on the land and natural resource degradation by their remittance and by the reduction of the population density following the migration (Herzenni, A. 2006).

Statistics on immigration from highlands are not available. However, there are some studies done at the local level that might help comprehend this phenomenon. A study in Anougal valley in Moroccan High Atlas shows that emigration is very significant. Table 4.11 shows the magnitude of the population concerned by the emigration and how recent it is. In two out of three villages, the emigration concerns 20% of total population. The emigration seems to be more important during the last 5 years, 50% of the emigration occurred in Aderdour village during the last 5 years (Table 4.11).

Table 4.11 Emigration in Anougal Valley

Villages	% of migrant in the population	% of migrants during the last 5 years	% of migrants between 5 and 10 years	% of migrants for more than 10 years
Aderdour	20	18	22	60
Imzayan	9	26	32	42
Tizgui	19	50	12	38

Emigration is related mainly to the most dynamic segments of the population, young and newly married. As young and working age people migrate to urban areas to find employment, women, children and elderly tend to be left behind. This leads to the "*feminization of agriculture*" and "*hollowization of rural areas*" (FAO, 2008).

Emigration has deprived agriculture from young workers and probably its most educated people and so preventing it from adopting new technologies. Shepherds are becoming more difficult to find leading sometimes to the reduction of livestock activities and sometimes to the adoption of more intensive livestock activities such as the introduction of genetically improved cows.

No reliable information on the migration of population from the highlands of Iran and Turkey are available. However, the rapid growth rate of urban population in Turkey and Iran indicates increasing trend of migration from the rural communities to the big cities during 1980-2010.

4.2.4 Gender Issue

The role of women in highlands is becoming more and more important. Besides their daily housekeeping work and collection of wood and water, women do almost all of the livestock tasks such as feeding, milking, and cleaning of animal houses and they also participate in some of the crop production activities such as planting, weeding and harvesting. In addition, they produce some craft products such as carpets. One of the reasons of such an increase in the responsibilities of women in production systems in the highlands is the search by men for job opportunities outside the family farm in order to increase family earnings.

However, women are still dependants of men (husband, father or brother). Their decisional power is very limited. They tend to have a weaker voice in decisions related to their children's education. They are marginalized from development and policy processes which reinforce the inequity vis-à-vis women. This situation is worrisome especially as more and more women are becoming household heads. Studies in Iran on a highland region show that about 92% of households are male-headed though it shows the women head 8% of households; in some cases this ratio is 20% that indicates the importance of women's role in the community (Aw-Hassan A. and K. Noori, 2007).

In theory policies should take gender and equity issues into consideration, but they tend to get sidetracked partly due to narrow growth-oriented focus of their interventions. In particular, it has been highlighted that few policies were sensitive to gender issues despite the fact that women play a significant role in mountain and highland societies by maintaining families, lands and livelihoods. Specific attention needs to be paid to strengthening their ideas, talents and knowledge, to help them at improving their life conditions and social status and thus promote gender equity among mountain and highland people (FAO, 2008)

4.2.5 Poverty

The economy of highland areas is generally poor and fragile. In all the Maghreb Mountains, the rates of poverty are higher than the countries' averages. The highland areas have the highest population poverty rates of more than 40% in the region, despite the fact that they contribute significantly to the rural economies of the three countries (ICARDA and the NARS of Algeria, 2007). Per capita income represents, on average, half the per capita urban income, and poverty is high in most zones leading to high rates of emigration to other regions of the country and overseas (ICARDA, 2003). In Morocco, the rate of poverty rate reaches 36 to 40 % in the Middle and High Atlas.

In a pilot site study consisting of several villages in the highlands of Iran where about 50% of household income was adopted as an index for household grouping. Households with per capita income of less than the index are called poor group, and those with per capita income of more than the index are grouped as non-poor. About 33% of households are poor and 67% are non-poor households. Per capita income in 2006 for poor households was about US $ 0.7 per day and for non-poor group about US $3 per day (Aw-Hassan A. and K. Noori, 2007).

In 2009, 0.48 percent of Turkish population, approximately 339 thousand individuals living below the food poverty line and 18.08 percent of Turkish population, i.e. 12 million 751 thousand individuals were living below the complete poverty line that covers food and non-food expenditure. In 2004 and 2008, the ratio of individuals who living below the food poverty line was respectively 1.29 % and 0.54 % and the ratio of individuals who were living below the complete poverty line was 25.6 % and 17.11 % (Table 4.12).

In 2009, the monthly food poverty line is estimated 287 Turkish Lira (TRL) per capita, while monthly complete poverty line is 825 TRL for a family composing of 4-person.The ratio of individuals who live in rural areas and below the complete poverty line which was 34.62 % in 2008 increased to 38.69 % in 2009; the ratio of individuals who live in urban areas and below the complete poverty line which was 9.38 % in 2008 also decreased to 8.86 % in 2009 (Table 4.12)..

In 2009, while the ratio of individuals in the households which are comprised of 3 or 4 people and who live below the complete poverty line is 9.65 %, this rate among the individuals in the households comprised of 7 and more people is calculated as 40.05 %. While the poverty risk of households which are comprised of 7 and more people is 25.21 % in urban areas and 54.06 % in rural areas. According to household type, while the ratio of individuals who are in nuclear family with children and who live below the poverty line is 15.98 %, the poverty rate for individuals who are in nuclear family without children decreased to 9.86 %. The poverty rate for individuals who live in large families is estimated as 24.48 %. The poverty risk of individuals who are in nuclear family with children and who live below the poverty line is 8.47 % in urban areas where it is 39.71 % in rural areas.

Agriculture has the highest poverty rate among all sectors. While the poverty rate among the people employed in agricultural is 33.01 %, in industry 9.71% and in service sector 7.16 % in 2009. Poverty rates are 14.68% and 19.51% for economically inactive people and for unemployed persons, respectively in 2009 according to TUİK calculations.

Table 4.12 Poverty statistics in Turkey in 2004-2009 (TUIK)

	2004	2005	2006	2007	2008	2009
Rural						
Food Poverty	2.36	1.24	1.91	1.41	1.18	1.42
Complete poverty (food + nonfood)	39.97	32.95	31.98	34.8	34.62	38.69
Urban						
Food Poverty	0.62	0.64	0.04	0.07	0.25	0.06
Complete poverty (food + nonfood)	16.57	12.83	9.31	10.36	9.38	8.86
National						
Food Poverty	1.29	0.87	0.74	0.48	0.54	0.48
Complete poverty (food + nonfood)	25.6	20.5	17.81	17.79	17.11	18.08

In the highlands of Turkey, in total, 2.494.000 people are under complete poverty line, representing 7.65 % of highland population and 3.38 % of total population. The value for food poverty is negligible and it can be speculated that almost there is no people under food poverty line.

4.2.6. Employment

Agriculture and livestock activities remain the main source of employment for people living in highland areas of the 3 countries studied. However other activities such as fishing, bee breeding, hunting, crafting, trading and activities linked to forest wood play an important role.

But the percentage of people practicing activities outside farming and animal husbandry is lower and the income coming from these sources is equally low.

In Iran, field crops, horticulture and livestock production are still the main source of occupation and employment for the rural community living in the highland areas (Aw-Hassan A. and K. Noori, 2007).

In Morocco, in the last 20 years, mountain tourism activities have been developing and governments are placing more emphasis on these activities as a way for poverty alleviation in these areas. The lack of adequate employment is the main reason for the emigration out of the remote areas in the highlands.

In Turkey, the total number labor force in 2010 was 24.953.000 and the number of unemployed persons was 2.509.000 by mid 2011. The rate of rural unemployment was around 7.3% while the rate for the urban unemployment was 14.2%. The migration of the labor forces from the rural communities may have increased the rate of unemployment in the big cities Share of each sector in employment in 2010 was 26.9% in agriculture, 18.9 % in industry, 7.5% in construction and 46.7 % in services. The details of the employment statistics in 2006-2010 are given in Table 4.13.

Table 4.13 Employment statistics in Turkey in 2006 - 2010 (TUIK)

	2006	**2007**	**2008**	**2009**	**2010**
Total population	68.066	68.901	69.724	70.542	71.343
Employed	20.423	20.738	21.194	21.277	22.594
Unemployed	2.328	2.377	2.611	3.471	3.046
Unemployed rate (%)	10.2	10.3	11	14	11.9
Urban					
Total population	47.526	47.944	48.349	48.747	49.170
Employed	13.518	13.764	14.010	13.839	14.679
Unemployed	1.873	1.871	2.053	2.746	2.425
Unemployed rate (%)	12.2	12	12.8	16.6	14.2
Rural					
Total population	20.540	20.957	21.375	21.795	22.172
Employed	6.905	6.973	7.184	7.438	7.915

Unemployed	455	506	558	724	621
Unemployed rate (%)	6.2	6.8	7.2	8.9	7.3

4.2.7. Livelihood Sources/Income Generation

Agricultural and livestock activities are the main source of living for highland areas in Morocco, Iran and Turkey. Agricultural activities are mainly cereal production. To overcome their essential needs and cash, farmers tend to switch from crops for self consumption to crops, and livestock production directed to the market. Agriculture is becoming more diversified by the introduction of cash crops (vegetables and fruits) through the development of irrigation projects and the construction of dams and roads. The main fruits and vegetables are olives, apples, walnuts, cherries, prunes, peaches, potatoes, carrots, turnip, onion, green peas and beans, tomatoes, menthe, sesame seeds. The introduction of fruits and vegetables has not only increased cash income for farmers but it also helped diversify the diet of their family. The cultivation and marketing of medicinal and herbal plants are becoming much more important in many regions in the highlands.

Livestock is mainly made of small ruminants, particularly sheep. But raising cows is not anymore an exception and modern cattle industry for production of milk is increasingly expanding. The availability of irrigation water has made it possible to introduce forage crops (in particular, fodder barley, alfalfa and berseem) which help diversify animal feeding sources and the production of cow milk. The later in some cases constitutes a regular source of cash.

The insufficiency of income to cover the needs of the family of many farmers in highlands has pushed some of them to look for alternatives to agriculture and livestock as income sources. Some of them seek jobs in other farms, in services or in building houses and sometimes they are hired outside their region (emigration). In Morocco, 20% in the Rif and 47% in the Anti-Atlas of farmers have activities outside their farms (Conseil Général de l'Agriculture, 2008).

Income sources of highland inhabitants' income in 3 villages in oriental High Atlas in Morocco are illustrative of their importance in Moroccan Highlands. Farming activities including livestock constitute for all 3 villages the main source of income. But revenues from outside the farm and emigration are not negligible as shown in table 4.14.

Table 4.14 Income sources for 3 villages in Oriental High Atlas in Morocco[1]

Villages	Aderdour		Imzayn		Tizgui	
Income sources	**DH**	**%**	**DH**	**%**	**DH**	**%**

Vegetables	5055	18.7	4902	22.3	7965	36.2
Cereals	2157	8	1159	5.3	1377	6.3
Fruits	6644	24.5	4214	19.1	2106	9.6
Livestock	9135	33.7	7203	32.7	3444	15.7
Total Agricultural	22990	84.9	17478	79.3	14892	67.7
Outside farm activities	1688	6.2	3256	14.8	2620	11.9
Emigration	2408	8.9	1294	5.9	4490	20.4
Total	**27086**	**100**	**22028**	**100**	**22002**	**100**

[1] Centre Régional de la Recherche Agronomique de Marrakech : Amélioration des conditions d'existence des communautés rurales et gestion des ressources naturelles dans le Haut Atlas Occidental Cas de la vallée d'Anougal-

In Iran, income generating activities in highlands agricultural as indicated by a study carried out in the upper Karkheh River Basin might be categorized into three main groups (Aw-Hassan, A. and K. Noori, 2007). Agricultural activities on commodities including field crops, fruits and vegetables, wheat (rainfed and irrigated), rainfed chickpea, barely, lentil are dominant. Most of the incomes from agricultural activities are earned from field crops, while fruits and vegetables play little role in income-generation. Most of the income from livestock raising activities is related to keeping light animals (sheep and goats) and heavy animals (dairy cows and beef), while poultry and honey bees play little role in income-generation activities. Other activity groups consist of laborer (in agriculture or construction), office work services, driving and shop keeping. As a whole about 57% of income-generation activities are agricultural activities, 26% livestock activities, and about 17% are from other activities.

The main income sources of the rural communities in the highlands of Iran depend on the farming system according the study by Aw-Hassan and K, Noori (2007).

In rainfed dominated crop farming system, about 80 percent of incomes are generated from crops and 20 percent from livestock. About 40 percent of households are poor because of small lands, low production, and a few livestock. The average category is about 30% and the rich group is 30% of households, respectively. Rich households own about 6 hectares of rainfed lands and 40 sheep. The poor households own only 0.25 hectares, and most of them work in the other farms and towns.

In well irrigated crop production system, about 20% of households are poor, because they do not own any land for cropping and they only own a few animals. Each of the average and rich categories consist of about 40% of households. Rich households own five hectares of irrigated and four hectares rainfed lands, 10 dairy cattle and 50 sheep. The average households own three hectares irrigated and about one hectare rainfed, lands, 5-6 dairy cattle and 20 sheep. The poor households own only one hectare of irrigated and 0.5 hectares of rainfed, lands, 4-5 sheep and none to one dairy cattle.

In Sheep dominated mixed rainfed crops farming system, most farmers have sheep, about 10% of the households are poor, about 60% average and 30% are relatively rich. About 40% of households are without irrigated lands and only 10% of them rely on irrigated lands and sheep, however, about 24% of households in this system are without sheep.

In a small ruminant dominant open-grazing farming system, horticulture is the most dominant crop production and the most important source of income following sheep production. The main livelihood sources are sheep and fruit or wood. The 20% richest households own about 60-100 sheep and 3.5 hectares of land. The average household group owns about 30-60 sheep and one hectare of land and they represent 32% of the households in this system. In the poorest category which covers 48% of households, each family owns 30 sheep and no land.

In mixed irrigated and rainfed crop-livestock farming system, sources of livelihoods are about 80% agriculture (40 % rainfed and 60% irrigated) and 20% livestock (8% sheep and 12% dairy cattle). About 40% of households are poor, because of small lands and few livestock. Average and rich categories are comprised of about 40% and 20%, respectively. Rich households are those who own five irrigated hectares and 15 hectares rainfed lands, and four dairy cattle. The average category owns one irrigated hectare, two rainfed hectares and two dairy cattle. The poorest category has 0.5 irrigated hectares and one rainfed hectare and one dairy cow or none, and they work for other people or in towns.

In a mixed crop and livestock dominated farming system, most households own few milking cows and some own sheep. The main livelihood sources are 1) dairy cattle with each household having 2-3 cows, 2) crops (wheat, barley and other crops) 3) sheep. Some people work as laborers in fringes of towns and development plans, but generally this community has a high unemployment rate even for educated people. This area has usually also experienced large emigration of households to towns. Currently, about 50% of the owners of the agricultural lands are residents and about 50% are non-residents who live in towns and cities and come back during cropping season. About 20% of households are considered rich. They own about 5 hectares of irrigated lands, 60 sheep and four dairy cattle. A person with 12 hectares of lands (50% irrigated and 50% rainfed) and five dairy cattle is also considered rich. The average category has 1-2 hectares land, 40 sheep and two cows. About 40% of the households are classified as average income. Those who own no land and no livestock, usually rent land or work as farm laborers, or those with two cows and 10 sheep can also be classified as poor. About 40% of households are classified poor.

In a mixed crop-livestock with high water sources farming system, the livelihood sources are mainly from irrigated crops such as; wheat, alfalfa or clover, oil seed, sugar beet, legumes, corn and vegetables. Livestock, mainly dairy cows, is the second source of livelihood. In this area, about 40% of households are classified as rich. Each household owns about 10 hectares of land, three cows, a tractor and 20 sheep. About 35% of households are in the average income category and are dependents mostly on crops; they own about 4 hectares of land and one cow. The poorest households are estimated to account for 25% of the total households with small a parcel of land and few sheep, or without land. Most of these groups are laborers (Aw-Hassan, A. and K. Noori, 2007).

In Turkey, income generating activities in agriculture including highland agriculture can be categorized into three main groups:

Plant Production Activities: This group is composed of the production of field crops, fruits and vegetables. Among the field crops wheat including both bread and durum wheat, whether rainfed or irrigated. It is followed by barley, chickpea, fodder crops and lentil are known as dominant field crops followed by other field crops such as potato, sunflower and vegetables and fruits. Most of the incomes from agricultural activities are earned from field crops, while fruits and vegetables play less important role in income-generation in the highland. Almost 67% of the income generating activities falls in this group.

Livestock rising: Most of the income from livestock raising activities is related to small ruminants such as sheep and goats, and cattle animals such as dairy cows and beef. Raising honey bees plays much important role comparing to poultry in income-generation. Livestock raising activities have a share of 23% among the income generating activities.

Other Activities: This group includes labor force in agriculture such as fruit collection or irrigation work and animal keeping as shepherd, and running small businesses at the local level by selling and buying agricultural goods and inputs. This group constitutes nearly 10% of income generation activities.

Highlands and mountainous regions are increasingly witnessing rapid changes and revolution of social values and traditions. As a result, the cultural heritage of these areas is threatened. The traditional knowledge systems and practices have been well-adapted to mountain environments and can serve as an important basis for sustainable agricultural development and natural resources management. These knowledge and practices have potentials also to be used for sustainable economic development and valorization (FAO, 2008).

4.2.8. Access to Services

In general, the provisions of social services in highlands are usually much lower in the remote areas. For instance, highlands in Morocco have an important deficit in social services. However, for over a decade now, the government of Morocco has been making a considerable effort to overcome this deficit. It has a large program for building rural roads and providing drinking water and electricity to rural households. A particular effort has been done for the education of rural children.

The enrolment of kids in schools has increased sharply during the last 15 years. The rates of primary pupils' relative to the whole population are respectively of 13.2% and 11.8% in highlands and in the whole country. These figures are 14.6% and 14.1% for rural pupils relative to rural population in highlands (Table 15). These figures show that actually these rates are slightly higher than the national average in Morocco. However to be precise we need to report the number of pupils to the number of school age children. For junior and high school, the rates are lower for highlands..

Table 4.15 Schooling in Highlands of Morocco

	Highlands	**Whole Morocco**
Percent of primary pupils relative to the whole population	13.2	11.8
Percent of rural primary pupils relative to the rural population	14.6	14.1
Percent of junior high pupils relative to the whole population	3.7	4.6
Percent of rural junior high pupils relative to the rural population	2.7	2.5
Percent of high school pupils relative to the whole population	1.6	2.2
Percent of rural high school pupils relative to the whole population	0.7	0.5

According to available statistics, In Iran, most of the villages in highland areas receive a primary school education and about 60% of them have secondary school degree, but high schools are only present in larger villages or small towns which are usually located about 9 km distance to small villages. The available statistics of education for household heads shows about 48% of them are illiterate and about 35% have primary school education, most of them educated from classes held by Literacy Movement Organizations, 9.5% have a secondary school degree and some 6% have a high school education, and only about 1.5% of the household heads have a higher education, i.e., technicians with university degree as shown in Table 4.16 (Aw-Hassan A. and K. Noori, 2007).

Table 4.16   Features of households in Iran's highlands

Variable	**Average**
Families size (people)	5.3
Average age of household heads (year)	50
Household heads under 50 years old (%)	51
Head of household is male (%)	92

Illiterate	48
Primary school	35
Education status of head of household (%)	
Secondary school	9.5
High school	6
Higher levels	1.5

Since 1995, Morocco has launched a large program for bringing drinking water and electrification to Moroccan rural areas including highlands. By the end of 2007, about 93% of rural villages have benefited from the program, and thus allowed 11.6 million rural people to have access to electricity. This program has also permitted the electrification of 2500 rural schools and 337 rural clinics. This achievement has brought about the:

- Emergence of new economic activities and new small industries
- An increase of the rate of schooling in rural areas
- An improvement of the living conditions or rural households (household electrical appliances)
- A reduction in expenses house lightning due the substitution for traditional means

Nevertheless, electrical consumption by highland households is much lower than the national average (Table 4.17). It reached only 236 KWH per person while the national average is 544.9 KWH per person. The percent of subscribers relative to total population for drinking water is only 34.7% while the national average is 63.4% (Haut Commissariat au Plan, 2008).

Table 4.17 Electricity and drinking water in Highlands in Morocco

	Highlands	**Whole Morocco**
Electrical consumption in KWH/ person	236.0	544.9
Percent of subscribers for drinking water relative to the whole population	34.7	63.4

The provision of health services is much lower than the national average. The number of physicians for 1000 people is only 0.3 while it is 0.6 for the national average. However, the numbers for paramedical workers are similar for highland and for national average.

Table 4.18 Health personnel in Highlands of Morocco

	Highlands	Whole Morocco
NB of physicians /1000 inhabitants	0.3	0.6
NB of paramedical workers/1000 inhabitants	0.8	0.9

In Iran, all of the residents of several villages studied in the pilot villages on a cold highland region benefited from electricity, television, water, and health centers, but less than 40% benefit from telephone. Almost all the villages have access to road (Aw-Hassan A. and K. Noori, 2007).

In Turkey, the people who live in villages in highland areas have access to the school from primary to the high school as the other parts of the country, since the education is compulsory for the children between 6-15 years; state provides all necessary facilities and services to the people. All of the people living in highlands of Turkey enjoy facilities of accessing to electricity, telephone, internet, television, water, and health care, and all of the residential units including villages have access to road.

4.2.9. Marketing

Marketing differs in different highland regions of the 3 counties studied depending on geographical situation of villages and their access to main roads and cities. Almost all villages in Iran are not farther than 15 km from the main roads and the distances to nearest towns is less than 40 km, of course there are many villages that are located around or very close to towns and have far more easy access to markets.

In Moroccan highlands, agricultural production is characterized by its irregularity from one year to the next. Agricultural markets are generally competitive. 10 to 30% of hard wheat and 50 % of soft wheat are sold by highland farmers in local markets. Barley production is mainly used for feeding farmers livestock. The main cash crops are in fact fruits and vegetables. 60 to 70% of vegetables are sold on the market place while apple production is marketed mainly on the tree. Part of olive production is sold in the market or on the tree; the other part is transformed into oil. In general young animal are sold when herders need cash. With the exception of the sales for the Aid El Kebir, sales are not planned, so farmers are not following a management strategy to best valorize their animal production. The part of milk sold varies with the accessibility of the villages. For example, in Al Haouz highlands, farmers sell 95, 75 and 58% of their production respectively in low, middle and high mountains. In the Rif, it is estimated that 50% of milk production is sold while in Zerhoun massif which has no accessibility problem, 95% of milk production is sold. The part of wool sold in highlands is very low as wool is transformed locally at the exception of Zerhoun massif where it is totally sold. 80 to 90 of honey production are sold (Ministère Chargé des Eaux et Forêts, 2008).

In Morocco, Some small industries have been installed within the highland areas. There are more than 14000 traditional units of crushing olives called maâsras, 5700 traditional mills representing 72% of their total number at national level, 68 refrigerated warehouses and 16 very small dairies. Apart from these small industries, there are 115 modern olive mills, which represent 40% of the nation's total. Cereal storage capacities in highlands represent 20% of national capacities. However, access to roads is improving and these small industries may become uncompetitive. It is a serious threat to these small industries if actions are not taken.

Within the Rural Development Support Project between 2006 and 2011, establishment of 3.155 agro-industrial facility have been supported by MARA. Most of those facilities are in highland. The aim of the Project was to improve the conditions in the rural areas for processing the agricultural products locally produced. Those facilities have been contributing to the local economy through processing the local products. The products from those facilities mainly sold in local markets.

In Turkey, access to marketing facilities differs in different highland areas considering geographical situation of villages and their access to main roads and cities. Most of the villages can reach the main roads and to nearest towns easily, depending on the weather conditions. During the winter some roads may be closed for a while due to unfavorable weather conditions. On the other hand there are a lot of villages which are located very close to towns and cities and have far more easy access to markets.

4.3. Agriculture Production

4.3.1 Arable Land and Land Use

In Iran, total rainfed areas are around 10.0 m ha within which 4 m ha are annually kept under fallow. Therefore, total annual rainfed cultivated land account for about 6.0 million hectares. About 75% of the total rainfed areas (7.5 m ha) are located in highlands. Annually 4.6 m hectares of drylands are allocated for cultivation of wheat, barley, chickpea, lentil, (3.1, 0.720, 0.530 and 0.220 mha, respectively) and 130,000 ha are assigned to other rainfed crops. In the highlands, 3.4 m ha are also under fallow. Dryland farming is practiced on land even with slope of more than 12%. Dryland farming is also practiced by some farmers in areas which don't have sufficient rain for viable crop production Hence, in a "*National Pilot Project on Increasing Irrigated and Rainfed Wheat Production*" it was suggested that 340000 ha of low fertility and sloppy land located in low rainfall areas be excluded from rainfed farming system and changed in to pasture or rangelands.

According to a study carried out on various highland climatic- zones of Iran (De Pauw, E., A. Ghaffari and V. Ghasemi 2004) about 2.3 m ha of wheat growing areas are located in very cold highland areas and 0.8 m ha are located in cold highlands with varying annual precipitations. In very cold highlands, lentil is mainly grown in rotation with wheat. Chickpea is usually cultivated in rotation with wheat in cold to modernly cold regions. But, barley is grown in both very cold and cold highland areas.

In Maghreb countries highlands cover respectively 30%, 12.5% and 10% of the agricultural land in Morocco, Algeria and Tunisia. They constitute the main forestry resources. They also host most of the region's biodiversity and water resources: 65% of the forest area in Morocco, 31% in Algeria and 60% in Tunisia are located in mountain zones (ICARDA, 2007).

Arable land is generally scarce in highland. In Maghreb Mountains arable land consists mainly of micro to small holdings. In these zones the average size of farms is generally small and cropped land is fragmented. Farms with less than five hectares of land represent 80% of mountain farms, and make up about 25% of total small farms nationwide. As a consequence, wherever water resources are available, farmers tend to shift from traditional crops to more rewarding new crops such as potatoes and fruit trees (apple trees in particular) which contribute significantly to highland household income. The prevailing production systems consist mainly of cereals, fruit trees and livestock, and contribute significantly to domestic agricultural production in the respective countries. The importance of cereals, fruits and livestock in Maghreb highlands is shown in Table 4.19

Table 4.19 Crop and livestock in Maghreb mountain areas

Country	**% National area in mountains**		**% National head of animals in mountains**		
	Fruit trees	Cereals	Sheep	Goats	Cattle
Algeria	3	70	21	31	61
Morocco	42	30	28	35	25
Tunisia	10	14	15	20	10

In Morocco, arable land in highlands covers 3.2 million hectares which represents 35% of all arable land in the country. The percentage of arable land relative to the total area of highlands varies from only 2% in Oriental High Atlas to 45% in South Rif. Cereal crops are dominant as in the rest of the country. They cover 62% of arable land, fallow covers 15%. Plantations represent 14% of SAU and 54% of Moroccan orchards. Other crops cover limited areas (leguminous 3.3%, vegetables 2%, forage 2%).

The farming system in the highlands has adjusted to harsh natural conditions and to the socio economic evolution of their inhabitants. Depending on climatic patterns, altitudes levels as well as soil and irrigation water endowment, different farming systems have been developed. In Moroccan highlands, only 15% of the land is arable. This percent varies from 3% in Oriental High Atlas to 43% in the south of the Rif. When this percent is low, agricultural activity is mainly based on livestock which can be categorized as pastoralist farming system. When it is high, livestock become less important and crop based production system become more significant. In between, the importance of livestock increases with the percent of arable land.

In most Moroccan highlands, irrigation is present but varies in different areas. The percentage of irrigated area out of arable land varies between 2.5% in South Rif to 32.3% in Occidental Middle Atlas. When irrigation is important the crop based production system, the importance of vegetables and orchards increases, this is particularly the case of apple trees.

Most farms in highlands are very small. Indeed, 64.5% of farms in highlands have less than 3 hectares and yet they form 22.8% of arable land. Farms with more than 50 ha represent only 0.2% and exploit 6.2% of arable land (Table 4.20).

Table 4.20 Moroccan Highland Farm structure [1]

	Number of farms		Areas of Arable lands	
	1000	**%**	**1000 ha**	**%**
Less than 3 ha	284	64.9	379.4	22.8
From 3 to 20 ha	147.1	33.6	1015	61.0
From 20 to 50 ha	5.6	1.3	167	10.0
More than 50 ha	0.9	0.2	103	6.2
Total	**437.6**	**100.0**	**1664**	**100.0**

1.Conseil Général de l'Agriculture, Atlas de L'Agriculture., Pour une territorialisation de l'agriculture, 2008

Livestock in Moroccan highlands is very important source of income for local highland population. It represents also an important part of national livestock. Highlands hold respectively 23.6%, 23.2% and 46.9% of the total number of cattle, sheep and goats in the country (Table 4.21).

Table 4.21 Number of animals in Moroccan Highlands (1000 heads)

	Cattles	Sheep	Goats
Anti-Atlas	53.5	231.1	220.3
Haut Atlas	168.5	1649	1430.6
Moyen Atlas	67.3	1366.3	472.4
Rif	273.6	631.5	549.4
Highlands	562.8	3877.9	2672.8
National	2383.1	16726.7	5703.5
Highlands/National in %	23.6	23.2	46.9

The relative importance of each species is variable from one massif to the other depending on the importance of rangeland, the arable land and of the climate. In the Rif's areas, cattle species represent 54.2% of total UGB this is explained by the high level of humidity in comparison with the other highlands. Moreover, the Rif's rangeland is relatively less abundant. In High Atlas and Middle Atlas, small ruminant species are dominant because of the abundance of rangeland and forest relatively to arable land. In Middle Atlas, small ruminant are mainly sheep species. In the anti-Atlas, the composition of the livestock is the same for all 3 species (Table 4.22).

Table 4.22 Equivalent cattle units (UGB) in % [1]

	Cattles	Sheep	Goats
Anti-Atlas	37.7	32.2	30.1
High Atlas	21.8	42.3	35.9
Middle Atlas	15.7	63.0	21.3
Rif	54.2	24.7	21.1
Total	**30.5**	**41.5**	**28.0**

1. Conseil Général de l'Agriculture, Atlas de L'Agriculture., Pour une territorialisation de l'agriculture, 2008.

The livestock production system can be categorized mainly as pastoralist, extensive and based on transhumance of herders. However this transhumance is diminishing. This system can be subdivided into:

- A sedentary livestock production system with different combinations of cattle, sheep and goats. This system is common in areas with cereal and non irrigated orchards (mainly olive and almond trees) and it is found in low mountains and plateaus. Cereals have replaced rangelands in many places.

- A sedentary extensive livestock production system with mainly small ruminants and a rare presence of cattle. It is found in low mountains. The meager rangeland forage resources are used as well as the available resources of the forests in the area. However, as new sites are transformed from rangeland to cultivated areas, livestock relies more and more on farm produced forage resources and on bought feed. The tendency is also to use rangeland in high mountains during the summer.

- An intensive livestock production system is associated generally with irrigation in low altitudes, in the piedmonts and in the high altitude valleys. Livestock is part of the farm activities which include cereals, fruit, vegetables and forage crops (in particular alfalfa). The size of the herd including cattle is generally small (Ministère Chargé des Eaux et Forêts, 2008).

- Beekeeping activities are very common in highlands. The honey produced is very appreciated by consumers who are willing to pay very high prices. The rich and diversified flora of the honey is probably the reason behind this appreciation.

Due to the nature of the terrain in highland and to the lack of accessibility, modern technology is not as widespread as in lowland with the exception of fertilizer use. Mechanized plowing is used only by 25.2% of farmers in highland while this percent reaches 45.1% at national level (Table 4.23). The same differences exist for mechanized harvest, phytosanitary, improved seeds uses and the importance of improved bovine races.

Table 4.23 Modern technology use in Moroccan Highlands [1]

	% of farmers using					% of improved cattle races
	Mechanized plowing	**Mechanized harvest**	**Fertilizers**	**Phytosanitary products**	**Improved seeds**	
Middle Atlas	25.2	18.8	54.3	48.1	19.0	23.6
High Atlas	14.2	4.1	45.2	12.0	5.2	10.0
Anti-Atlas	12.1	0.9	3.9	1.3	1.4	0.8
Rif	8.2	3.8	79.5	14.1	8.9	13.9
Highlands	13.0	5.8	56.2	17.0	8.4	12.6
National	45.1	29.8	49.0	31.6	15.4	39.2

1. Conseil Général de l'Agriculture, Atlas de L'Agriculture., Pour une territorialisation de l'agriculture, 2008

In Turkey, cultivated lands cover about 27 million hectares and forest and pasture about 21.2 million and 14.6 million hectares respectively. The agriculture sector has been Turkey's largest employer and a major contributor to the country's GDP, exports and industrial growth. However, as the country has developed, agriculture has declined in importance relative to the rapidly growing industry and services sectors. Turkey is expected to stay self-sufficient in food for the prudent future, provided that food production grows at 3-4%.

In Turkey, the total land areas are about 77 million hectares of which roughly 39 million hectares in 2011 were being used for some form of agriculture. There were almost 24.2 million hectares in field crops, of which 4.2 million hectares lay fallow. Another 3.7 million hectares were in use as vineyards, orchards, and olive groves, 14.6 million hectares rangeland and pastures. And nearly 21.2 million hectares were covered by forests and other woodlands.

Cultivation increased primarily at the expense of rangelands and grasslands, which diminished from about 46 million hectares in the mid-1920s to about 14 million hectares in 2010. Although cultivation of the larger area made greater agricultural production possible over the short run, it created long-term problems for livestock production. It also resulted in the destruction of tree cover and the plowing of marginal fields that were too steep and that received barely sufficient rainfall even in normal years. By the early 1960s, government agents were encouraging farmers to practice contour plowing and to take other measures to minimize erosion, but to little effect. By the late 1970s, more than half the country's land was judged to have serious erosion problems, and some plains regions were experiencing dust-bowl conditions. All of Turkey was affected, with the mountainous eastern provinces hit hardest. Some areas lost all topsoil and could support few plants.

In the 1970s, the government conducted land-use studies and found that more than one-fifth of the land should have been used differently to achieve optimum long-term production. Misuse was greatest in rain-fed cropped fields, but some grazing land and wastelands were found better suited to other uses such as cropping and forestry. Turkey's unusually high proportion of fallow land also limited production. In 1981, the government began encouraging double cropping and the planting of feed crops on fallow fields. A broad land-use policy has been considered since mid 1970s. There have been several attempt and different projects for the consolidation of agricultural land. Nowadays, Ministry of Food Agriculture and Livestock accelerate the preparation of agricultural land consolidation projects and private companies have been involved in the implementation of those projects at the field level. By the end of 2009, consolidation works have been completed in 795.000 ha throughout the country and another 675.988 ha area were planned for 2010. In consolidated land it is expected that efficiency of agriculture is higher, and in fact it has been the case especially in Southeastern Anatolian Region within GAP Project area.

Total agricultural and forest land is over 60 million ha by 2010. Land used in agricultural production, including pasture and rangelands, is little over 39 million ha by 2010. Almost 2,4 million ha of agricultural land, 8,94% of total comparing to 1995 value, has been removed from agricultural use in last 15 years Unlike the change in land use, area used for fruits, olive trees and fodder crops have been increased. As shown in Table 4.24, increase in fodder crops was quite high (3.78 times) during the last 15 years between 1995 and 2010.

Table 4.24 Changes in agricultural land use during 1995-2010 (TSI)

Turkey	(1000 ha)							
	Total lands	Sown Area	Fallow	Vegetables	Fruits	Vine Yards	Olive Tree	Fodder Crops
1995	26,835	18,252	5,124	938	1,399	565	556	305
2010	24,436	16,333	4,249	801	1,749	478	826	1,461
Change (ha)	-2,399	-1,920	-875	-137	350	-87.213	270	1,156
Change (%)	-8.94	-10.52	-17.08	-14.56	25.01	-15.44	48.54	3.78 times

Note: Fodder Crops area included in sown area.

Despite the overall market size and developments, agricultural land is highly fragmented due to inheritance and 65% of all farms are smaller than 5 hectares. These small farms own only 21% of the total arable land. On the other hand, only 0.74% of all farms are bigger than 50 hectares and they own only 11.26% of all arable land.

General structure of land ownership of agricultural holdings can be applied to the highland. The land in highland is also fragmented and almost 60% of the farms have less than 10 ha area.

Almost 64 % of Turkish agricultural land situated in highland. All of the agricultural lands in Central and Eastern Anatolia are in highland. Biggest portion of the Black Sea region and more than 40% of Agean, 32.3% of Southeastern region are in highland. Very small part of Marmara region, 3.1% is in highland.

Total land irrigated in highland is approximately 959.167 ha with 17.4 % in total irrigated land. Central south highland benefits from irrigation most having the share of 8.7 % in total irrigated land and 50% in highland irrigated land. Even though biggest irrigation project in Turkey implemented in the Southeast, highlands of Southeast (SE) get the lowest share from the irrigation facilities.

When this figures implemented to the plant production, roughly more than 50% of cereal production, more than 80% of chickpea production, 40% of lentil production, %65 of fodder crop production are in the highland. Fruit, grapes and vegetables are also produced in the highland depending on the season.

4.3.2. Farming System

The Iranian agriculture has been considerably influenced by the composition of the different farming systems: Moreover, the changing society's food preferences (both urban and rural) due to more income and better nutrition have highly influenced the expansion of different fruit tree orchards and vegetable crops areas as well as development of industrial dairy and livestock production system in the country and in the highland regions. Although in highlands, farming systems have also been mainly influenced by climatic conditions and the amount and distribution of precipitations.

The following seven production systems were identified in two villages of Honam and Merek selected as the benchmark sites for the CGIAR Challenge Program on Water for Food on Karkheh River Basin in the highlands of Iran (Aw-Hassan, A. and K. Noori, 2007).

1- Rainfed dominated crop production system

In this farming system the households' income is mainly depended on the rainfed crop production. The main agricultural activities in these areas are rainfed crop production. In fact, more than 90% of croplands are rainfed and less than 10% are irrigated land. The major crops are wheat, barley, chickpea and lentil. Only little vegetable and forage crops or fruit trees based on water availability are grown. Generally, About 45% of the land is covered by rainfed wheat, 10% by dry barely and 30% by dry chickpea or lentil. Also there may be few small ruminants in these areas using the feed or crop residues produced by this farming system. About 40% of the households are poor because of small land and few livestock resources. The middle income category is about 30 percent.

2- Well- irrigated crop production system

In this system, around 50% of the lands are irrigated and 50% are rainfed. The main crops are wheat, sugar beet, chickpea, corn, alfalfa, barley and vegetable crops. Livestock play a non-significant role in total household income. The sources of livelihoods are 90% from crop production (30% irrigated wheat, 15% rainfed wheat, 15% rainfed chickpea and the rest from sugar beet, corn and other crops), and only 10% livestock (50% dairy cattle and 50% sheep). About 20% of the households are poor. The middle and rich category constitute each for about 40 percent.

3- Sheep- dominated mixed rainfed crop-livestock system

The areas near the pasture is dominated by the system of sheep or small ruminant and mixed dry land cropping system. Most of the lands are in the rainfed and less than 10% are under irrigation. Rainfed crops include wheat, barley, chick pea and lentil. The livelihoods strategies are balanced between crops (50%) and livestock with sheep being the dominant livestock (90%) and cows contribute to only 10% of the overall village income. About 10 percent of the households are considered as poor and 60% as the middle category.

4- Small ruminant- dominant free grazing system

This system is generally located in marginal areas which only support raising of small ruminants under free grazing condition. The households are heavily depended on sheep production which is partly dependant on the utilization of high elevated rangelands. However, households own relatively smaller land and cropping is not a major source of livelihoods. Moreover, the climate in the winter is extremely cold for crop growth when the water is abundant. In spring and summer, when the climate is more favorable for crop production the farmers face water shortages. This farming system has the lowest irrigated areas. Most of the irrigated crops are horticulture.

The sheep production system highly integrates open grazing of rangelands and mountains regions during April to July utilizing crop residues for three months and hand feeding for the rest of the year. In the past, the whole family would go with livestock during the mountain grazing period, but currently the households are settled and only men take sheep out to the mountain rangelands. In the village, 21% of the households are better off and 32% of the households are in the middle group. The rest of the households (47%) are considered as the poor.

5- Mixed irrigated and rainfed crop-livestock system.

This system represents mixed irrigated - rainfed crops and livestock system. In this farming system, agriculture is more important than livestock. About 67 % of crop lands are rainfed and the rest are irrigated. There are no rangelands. Irrigated crops are wheat, sugar beet, corn and alfalfa. Rainfed crops include wheat, barley and chickpea or lentil. The main source of livelihoods is about 80% from agriculture (40% rainfed and 20% irrigated) and 20% from livestock production (8% dairy cattle and 12%) system. About 40% of the households are poor and the middle and rich households each constitute about 40% and 20% respectively.

6- Mixed crop and livestock cattle dominating system

It represents mixed irrigated and rain-fed crop and livestock production system with dairy cattle as the main source of income. As for the crops, wheat is the main crop and there are also few horticultural and vegetable crops. These areas represent important urban-rural interactions. About 70% of lands are rainfed, and 30% irrigated. However, shortage of water in spring and summer is a major constraint.

Most households have few cows and some people have sheep. Only those who live in the village have livestock. For about 5 months, livestock graze out on the rangelands close to the village and use crop residues for 2-3 months. They are fed in the yard during the autumn and winter. The non-residents do not have livestock. About 20% of the households are considered better off and about 40% are classified in middle income group.

7- Mixed crop-livestock with high water endowment

It is a common production system in the down -steam part of the catchment. Crops are more important than livestock, due mainly to greater water availability. Adequate water resources have also allowed development of fish farming. A wide variety of food and forage crops are cultivated under irrigation, and dairy cows are more important than sheep. The areas offer good services as well as strong off-farm employment in the form of permanent jobs. This probably represents an ideal situation for any rural community in highland agriculture for future development. The lands are mostly flat with adequate water. About 40% of the households are considered as economically better off and the poor households are perceived to account for about 25 percent.

In Morocco, Farming systems are moving from pastoral systems to agro-silvo-pastoral systems which associate, agricultural lands, rangelands and forests. More and more herders are feeding their animals not only from forests and rangelands but also from their feeding resources produced within the farms such as stubble, straw, barley, and grass growing on fallowing lands. However, the balance sheet for animal feed remains dominated by feed resources from rangelands and forests. Small ruminants constitute in most cases the dominant species in highlands herds. Livestock activities remain in general extensive. Even if a majority of herders become sedentary, their herds are still mobile. They tend to construct or buy houses and warehouses for storage and have their family settled in the village. The herd mobility is facilitated by the construction of paved roads or rural trails (Bourbouze, A. 2000).

Agriculture remains dominated by cereals which are expanding at the detriment of fallow, rangelands and forests. Nonetheless more and more other crops are expanding in particular fruits and vegetables which generate more cash for the farmers.

The average Farm size in the Moroccan highlands is only 3.8 hectares (Table 4.25). This is much smaller than the national average (6.1 ha). Moreover very small farms (less than 3 ha) represent 65% of the number of the farms in the highlands. This national percentage is only 53%. Small farms (between 3 and 20 ha) hold 61% of the arable land in the highlands (Table 4.25).

Table 4.25 Farm sizes in Highland of Morocco[1]

Farms	Areas in %		Number of farms in %		Average area by farm	
	Highlands	Whole country	Highlands	Whole country	Highlands	Whole country
< 3 ha	22.8	12.3	64.9	53.2	1.3	1.4
Between 3 and 20 ha	61.0	54.9	33.6	42.7	6.9	7.8
Between 20 and 50 ha	10.0	17.5	1.3	3.3	29.8	31.9

> 50 ha	6.2	15.4	0.2	0.8	114.4	121.9
Total	**100.0**	**100.0**	**100.0**	**100.0**	**3.8**	**6.1**

1. Conseil Général de l'Agriculture, Atlas de L'Agriculture., Pour une territorialisation de l'agriculture, 2008

The farming system is responding mainly to farmer's strategy to combat economic and climatic risk. The association of cereal and livestock in the same farm allows farmers to feed their animals during the summer by using stubble of cereal fields and storing straw and grains produced at the farm level for use at other seasons. The bought feed from the market (mainly barley) allows for completing the feeding of farm animals. The revenues of the emigration make it possible for farmers to buy feeds and to meet the needs of their families. When it is possible, irrigation is a powerful tool for reducing climatic risk (Bourbouze, A. 2000).

Production systems in Moroccan Highlands are mainly dominated by livestock activities. The importance of crops and livestock species depends on the importance of arable land relative to the rangelands and to irrigated areas. We can distinguish 3 production systems:

Small ruminants associated with cereals

This system is characterized by the importance of rangeland and forest as the main source of feed for livestock. Farm barley is used for complementing the feeding of the animal but also to feed farmer families. Grazing, fallow, stubble and barley grains are gaining higher percentages in animal ration. Even if bought feed is playing an increasing role in animal ration, their percentage remains small. In this system, cattle may also be present but their importance is low. This system is dominant in High and Middle Atlas (Table 4.26).

Crop based production system with possibility of irrigation

In this system crops are diversified especially when irrigation is available. Subsequently, fruits (in particular apples) and vegetables constitute an important source of farmer income. Cattle and sheep are usually presents in the farm but their numbers are small. Farmers are still using the rangeland as a source for feeding their animals but with a lesser importance. This system is mainly present in the Middle Atlas and in the Middle and High Atlas but with a lesser importance.

Crop based production system with no significant irrigation possibility

Cereals are the dominants crops. However non irrigated trees also play an important role in the farm: the main trees are olive trees and almond trees. The presence of cattle is significant. Although sheep and goats are also present but their importance is minor in comparison with other systems. This system is dominant in the Rif Mountains.

Table 4.26 Importance of animal species in Moroccan Highlands [1]

	% total animals				Arable land/rangeland
	Cattle	Sheep	Goats	Total	
Anti-Atlas	10.6	45.8	43.6	100	0.1
High Atlas	5.2	50.8	44	100	0.15
Middle Atlas	3.5	71.7	24.8	100	0.35
Rif	18.8	43.4	37.8	100	0.81
Total Highlands	7.9	54.5	37.6	100	0.28
National	9.6	67.4	23	100	0.13

2. Conseil Général de l'Agriculture, Atlas de L'Agriculture., Pour une territorialisation de l'agriculture, 2008

In Turkey, the most common agricultural/ faming system is cropping system (table 3.25) which constitutes 25.7 % of the whole agricultural system. Within the cropping system, field crops cover 84.2 % of all arable land, while fruit trees cover 7.2 %, vine yards 2 %, olives 3.4 % and vegetables 3.3%. According to the results of the survey (TUİK, 2006), wheat and barley are the most common crops with 48.9% and 19.9% respectively. Other important crops are sunflower with 4.3%, maize with 4.2%, cotton with 4% and sugar beet with 2.2%. These crops constitute 83.5% of the total areas of the field crops. In the rainfed areas of highlands, the cereal-fallow is a common rotation used by farmers. In the first year, wheat, barley or oats are grown and harvested for grain. In the following year, the field is left under fallow. Table 4.27 shows the share of different agricultural systems and holding income distribution in Turkey

Table 4.27 Agricultural systems and holding income distribution in Turkey

Agricultural System	% of Agricultural System	Holding Income Distribution (%)		
		Agriculture	Livestock	Other
Field crops only	25.7	88	0	12
Horticulture (vegetable and flower only)	1.0	85	0	15
Permanent (perennial) crops	19.8	92		8
Grazing livestock	16.7	0	85	15
Poultry	0.1	0	90	10

Mixed cropping	9.1	90	0	10
Mixed livestock	6.1	0	90	10
Mixed crops and livestock	21.7	35	55	10

4.3.3. Production

Highland areas in Iran play a significant role in agricultural and livestock production in the country. About 75% of the Iranian agricultural production is produced in highland areas. Agricultural production in lowlands is generally produced using water supplied from the highlands. More than 75% of wheat, 85% of barley, 90% of sugar/fodder beet, 72% of horticultural crops, more than 90% of livestock (milk and meat), and more than 95% of poultry (chicken and eggs) are produced in highland areas.

On an annual average basis; 2.8 million tons of wheat, 0.76 million tons of barley, 0.43 million tons of chickpea, and 0.23 million tons of lentil are produced in the highlands areas These respectively constitute 68%, 75%, 94% and 100% of the total rainfed production and around 22%, 25%, 85% and 100% of the country's overall production of the aforementioned commodities. Therefore, highlands play a very significant role in the country's food security. In more favorable years, there is an excess production of chickpeas which is exported.

In addition, horticultural crops such as grapes and almonds are also grown in some highland areas in Iran. Rainfed grapes and almonds are grown on more than 80000 ha and 75000 ha, respectively. Of course, some specific horticultural crops, mainly known as medicinal plants, such as Barberry, Sumac and Damascus rose (*Rosa damascena*) (used for rose-water and perfume) are also adapted to rainfed condition in highlands.

Crop yields in highland areas of Iran have been increasing over last 20 years (1992-2008). They have benefited from technical/financial supportive schemes and research achievements. For example: irrigated wheat grain yield has enjoyed a continuous growth of 2% (Fig. 2), and corn grain yield has increased from 3.7 tons/ha to 7 tons/ha over this period. Rainfed wheat grain yield, however, has followed a sinusoidal variation significantly influenced by variations in climatic conditions over this period. Research achievements and technical/financial supports have not yet had due impact on rainfed wheat grain yield (Fig. 4.1).

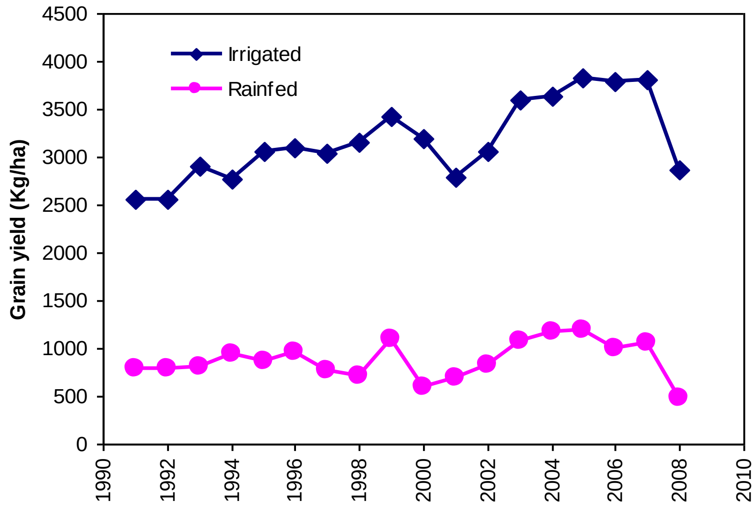

Figure 4.1 Wheat grain yields in Iran in the period 1992- 2008 (Jalal Kamali 2012)

Variation in grain yield of four major rainfed field crops in Iran over the period of 1985-2005 are also shown in Fig. 4.2.

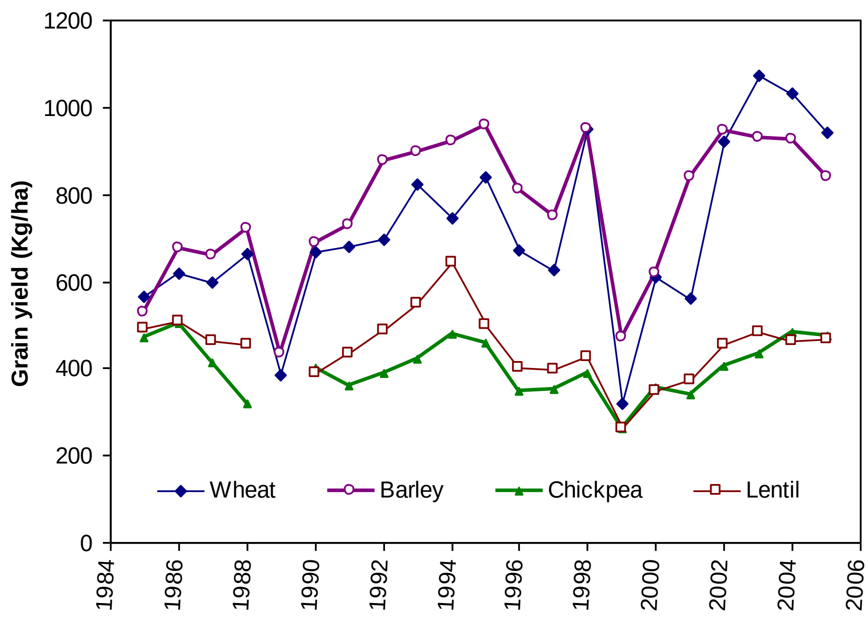

Figure 4.2 Variation in grain yield of four major rainfed field crops in Iran over the period of 1985-2005 (Grain yields for 2001-2005 have been calculated based on harvested areas)

For example: average grain yield of rainfed wheat over the period of 1985-2005 was 715 kg/ha, with five seasons with grain yields less than 600 kg/ha, and eight seasons with grain yield of 600-700 Kg/ha. This also applies to the other rainfed crops. Average grain yield of rainfed chickpea over the period of 1985-2005 was 403 Kg/ha with seven seasons with grain yields less than 350 Kg/ha and eight seasons with grain yields of 350-450 Kg/ha. The trend of variation is very different and variable; it is the same for rainfed lentil.

In Morocco, large parts of crop areas are in the Highlands. 19% of Moroccan arable land is located in Highlands. Moreover, 30.3% of fruit trees and 25.2% of fallow are in highlands (Table 4.28). As for the national level, cereals are the main crops cultivated in highlands (58.5%) followed by fruit trees as the next most important use of arable land (13.6%).

Table 4.28. Importance of crops in Moroccan Highlands[1]

	% of Highland arable land	% of National arable land
Cereals	58.5	17
Legumes	3.4	24
Vegetables	1.7	12.5
Fodder	1.9	16.6
Fruit trees	13.6	30.3
Other crops	4.6	48.3
Fallow	16.3	25.2
Total	100	19.1

1. Conseil Général de l'Agriculture, Atlas de L'Agriculture., Pour une territorialisation de l'agriculture, 2008

Red meat production in Highlands reaches 400,000 tons. Sheep, cattle and goat meat represent 47%, 35% and 18% respectively. Milk production is important for many areas in the highlands. However, there is no estimate for it and some small dairies have been established in some highland areas. As for the wool production, it is estimated at 3800 tons mainly in the Middle Atlas (44%), the High Atlas (34%) and the Rif (13%). Apicultural production is dominated by traditional techniques with low productivity. Indeed a traditional beehive produces 3.5 Kg/year while a modern one can produce 25 Kg/year (Ministère Chargé des Eaux et Forêts 2008).

In Turkey, agricultural development has been among key policies and strategies for development of the country in four economic, social and cultural ninth plans conducted since 1960. Agricultural productions considerably increased over the period of these planned periods. For example: wheat production increase from 11 million ton to over 21 million ton while field crops total productions increased from 23 million tons in 1960 and over 70 million tons in 2011, and horticultural crops productions increased from 20 million tons to 43 million tons, over this period. Wheat production increased from 8 million tons to 15 million tons over the period of 1993-2007. During this period, the government significantly contributed to agricultural development through financing facilities, and infrastructure activities investment development of research, and implementation of technical and supportive programs. Unfortunately, in highland rainfed areas, due mainly to inadequacy of research achievements and inefficiency of those inadequate findings, crop production has been mainly influenced and determined by climatic conditions. For example: annual average of highland rainfed wheat production of 2.8 million tons decreased, in some seasons, to 1.5 million tons.

Although 23.7% of the Turkish population live in the rural areas, today agriculture still remain one of the largest sectors in Turkey, employing more than 24% of the country's workforce and contributing 8.4% to the Gross National Product in 2010. Although on an upswing over the past few years, the agriculture sector in Turkey increased by just 2.4 % in 2010 and 6.95 % in 2011 (Table 4.29). The share of plant products in the total agricultural production is 72.4% that of livestock products is 21.6%, for fisheries it is 3.9% and 2.46% for forestry. Turkey is a producer of grain, cotton, tobacco, grapes, olive oil, sugar beets, pulses, hazelnuts, and tea, small and big ruminants and poultry. The share of wheat in grains is 67% (MARA, 2000).

Table 4.29 Growth and GDP statistics in 2007-2010

	2007	2008	2009	2010
Grwoth in Agriculture	-6.9	3.5	3.6	2.4
Grwoth in GDP	4.6	0.9	-4.8	9.0
% Agriculture in GDP	7.5	7.6	8.3	8.4
GDP (million USD)	658.786	742.094	616.703	734.929
% Agriculture in GDP (million USD)	49.409	56.399	51.186	61.734
GDP Per Capita (USD)	9.333	10.436	8.590	10.067

Turkey is also the largest producer and exporter of agricultural products in the Near East and North Africa. Total market value of agriculture is estimated to be more than 74 billion USD (TUIK, 2010). Despite the overall trade deficit of Turkey, the agriculture trade balance is significantly positive, providing some relief to external accounts. Rising production, new marketing opportunities and demand in the region including EU resulted in agricultural product exports rising to a value of nearly $ 11.2 billion in 2009). Turkey is a significant agricultural exporter. Turkey's main trade partners are the EU-27 countries. Turkey has a significant trade surplus with the EU-27 (1322 million euro in 2010) mainly due to exports of edible fruits & nuts, vegetables, preparations of fruit and vegetables. Turkey has also important trade relations and a trade surplus with countries in the Mediterranean basin and the Gulf region.

Turkey has a vast range of agricultural products including crops such as, cereals, legumes, fruits, vegetables and animals such as sheep, cattle, goat etc. The share of plant products in the total agricultural production is 72.4%, livestock 21.6%, fisheries 3.9% and forestry 2.46%. The value of agricultural production has a steady increase in the years and had a market value of approximately 74.7 billion USD in 2010.

The value of crop production in 2010 is 80.0 billion TL which is approximately 47 billion USD (Figure 4.3). In 2010, value of cereals has increased by %9.9 with respect to previous year and reached to 28.5 billion TL (16.8 billion USD) approximately, the value of vegetables has increased by 36.1% and reached to 26.6 billion TL (15.6 billion USD) and the value of fresh fruits has increased by 9.3% and became 25.0 billion TL (14.7 Billion USD)).

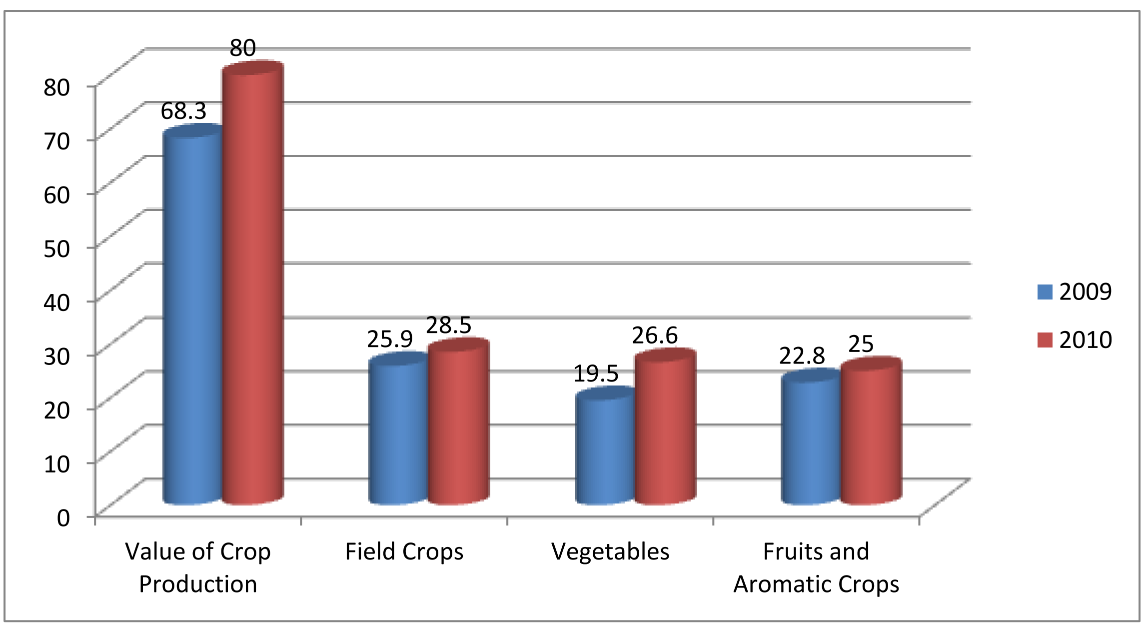

Figure 4.3 Value of crop production in Turkey, 2009-2010

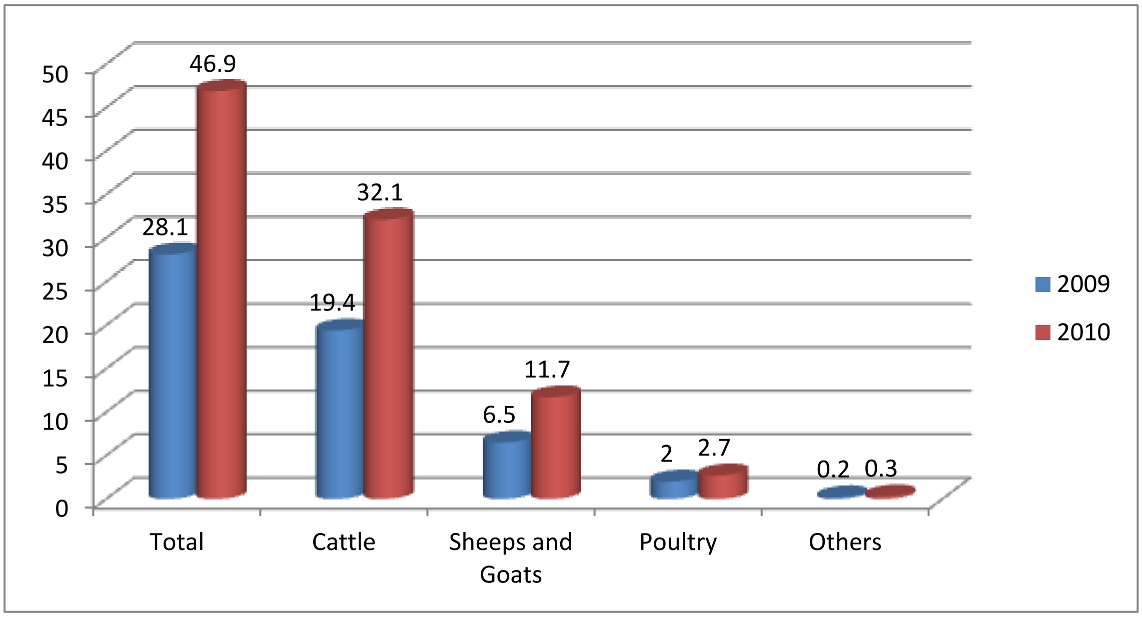

Figure 4.4 Value of animal production in Turkey 2009-2010

In 2010 total values of animal products reached to 46.9 billion TL which is approximately 27.6 billion USD (Figure 4.4). The value of cattle products was 32.1billion TL (18.8 billion USD), sheep and goats 11.7 billion TL (6.9 billion USD), poultry 2.7 billion TL (1.6 billion USD) and other animal products such as honey etc. 0.3 billion TL (0.2 billion USD). As previously indicated share of the highlands in total crops, vegetables, horticulture and livestock production in Turkey is more than 70% of the total production.

Chapter 5

Constraints and Opportunities

5. Constraints and Opportunities

5.1. Environmental Conditions

Highlands face a severe environmental stresses and fragile natural resources which are perceived to be the main constraints for increasing agricultural productivity and livelihood resiliency of the rural community.

In Iran, the frequency of drought and improper distribution of annual precipitation are quite high. In the highlands, severe drought years vary from 2 to 3 out of 10 years in different parts of autumn sown seeds of wheat and barley. This is mainly due to a delay in the initial rainfall or low rainfall in fall as well as long duration from sowing to emergence due to sudden cold. Sometimes, seeds germinate but emergence is caught under snow cover and long duration of cold and freezing days, which are 100-122 days in cold to very cold regions, disrupt plant growth. Sever cold, sometimes less than 25°C, causes damage to autumn sown cereals, particularly, in areas without snow cover. Variation in day and night temperatures and late frost in spring, particularly in very cold areas lead to short plant stature, spikes sterility, and reduced crop growth. These are the major environmental constrains of the dryland farming systems in the highlands of Iran.

In Turkey, similar to Iranian highlands, variation in day and night temperatures and late frost in spring may lead to short plant stature, spikes sterility, and reduced crop growth. However, plant growth period in the central and western part of Turkey is longer with higher average annual precipitation and better yearly distribution. Water scarcity and drought confounding with the impact of climate change are also becoming increasing challenges to enhance agricultural productivity in the highlands of Iran and Turkey.

In Summary, The major abiotic stresses in highlands of Turkey and Iran are mainly inadequate precipitation, cold, terminal drought and heat. Inadequacy and timely rainfall at the seeding time is the main reason for poor emergence, poor establishment and poor tailoring, hence, crops are not well acclimated prior to approaching cold winter. Severe cold in winter especially in very cold year without snow cover is another constraint, Deficit rainfall in spring particularly at flowering stage is also the main problem for grain filling for cereals. Sudden rise in temperature and lack of rainfall, particularly in cold areas after winter period will intensify drought and causes shriveled and small grains. This phenomenon will reduce grain yield and quality of wheat and barley in the highland areas. Late frost occurrence in spring, as previously indicated, may damage cereal crops in some years in the highlands of Iran and Turkey. Deficit rainfall and early raising temperatures are also major abiotic stresses for food legumes in these areas.

In Moroccan highlands, the aridity is increasing from north to south and from west to east. Drought is becoming the main environmental constraints for improving agricultural production in the highland areas, for instance 50% of the years during 1995 to 2005 were drought years. Large parts of the highlands have an acidic climatic condition and farmers apply irrigation at different rate. The percentage of irrigated area in arable land varies between 2.5% in South Rif to 32.3% in Occidental Middle Atlas.

In recent years sudden cold and decreasing temperature in the fall and spring are becoming another major constraint for field and horticultural crops in the highland of Morocco and have severely damaged agricultural production in these areas.

Moroccan highlands have a large ecological diversity between the various mountains and also in different regions of each mountain. Diversity is present from one valley to another and there are differentiations depending on the altitude and the orientation of the versants. However natural resources are deteriorating under the pressure of overexploitation. Every year, deforestation is estimated at about 31 000 hectares. Rangelands are losing their productivity because of overgrazing and the extension of cultivated land to the detriment of rangelands (1.3 million ha extension of agricultural landduring1982 and 1995). The erosion is also accelerating, i.e. 500 tons of sediments per km^2/year (Herzenni, A.). In Iran and Turkey, land degradation and deterioration of natural resources are also other major challenges in dryland agriculture in the highlands and mountainous areas.

The major biotic stresses in the highlands of Turkey and Iran for the major crops are as followings:

1. Wheat yellow rust followed by common bunt and soil borne diseases are major diseases. Although common bunt can be managed by seed treatments with appropriate fungicides, but due to additional cost and non-availability of cash to bear the cost in time, it has not been effective measure in controlling the disease. Yellow rust incidence occurs in cropping seasons with high rainfall and mild temperature, however, it is not an all time disease in these areas and epidemics may come time to time. Soil borne diseases are also common and there is no chemical treatment for these diseases. Some varieties are found to be resistant or moderately resistant to the soil born diseases.

2. *Sunn* Pest is the major pest for wheat followed by **C**ereal Cyst Nematode and *Zabrus tenebroides* in the dryland farming systems in highlands of Iran and Turkey. Scald and Powdery mildew are two major barley diseases. *Sunn* Pest may also damages barley in these areas. The major diseases for chickpeas in Iran and Turkey are *Fusarium* and *Aschocyta blight*. *Agrotis* larvae are the major damaging pest for chickpeas. *Fusarium* is the major disease for lentil.

5.2. Socio-economics

Highlands face many socioeconomic and development challenges but nevertheless includes many opportunities. All need to be identified and developed.

Impediments

The main constraints to the development of highlands can be summarized as follows:

1. Lack of a holistic policy approach or a separate comprehensive plan by the governments with regard to sustainable agricultural development of the highlands, particularly for enhancing agricultural productivity in dryland agriculture taking into account fragile environmental(degradation of land resources, deterioration of rangelands, erosion of biodiversity , increasing water shortage and frequent drought) and socioeconomic conditions in many highland regions
2. Higher level of poverty, illiteracy rates and small farm sizes compared to other regions
3. Low agricultural productivity, fragile environment and marginal agricultural resource base which need special attention and more investment.
4. Isolation and remoteness from urban centers in some highlands such as in Morocco, Afghanistan, Kirgizia and Tajikistan.

For example, Moroccan Highlands suffer from different socio-economic constraints. Although, Morocco has undergone a major development in agriculture sector since late 1990, the highlands as mentioned earlier, still face a major deficit in infrastructure and social services. The persistence of ambiguity over land ownership in particular for rangeland, is an important explanatory factor for the lack of investment and the overexploitation of natural resources. In addition, public services in the highlands have a modest budget and thin human resources. The community organizations are declining under the effect of degradation of economic and social conditions leading to weaknesses of community power over their natural resources management (Herzenni, A 2006).

Degradation of natural resources is the result of the expansion and mechanization of annual crops in marginal rangelands. This has led to a high rate of erosion and a loss of biodiversity in the Maghreb countries where rangelands have been decreased by 10 to 13 percent since the mid-1970s. Only 20 percent of the remaining rangelands are considered satisfactory (Pratt, D.J., et al, 1997). Overgrazing is the consequence of the growth in the size of small ruminant herds, scare feed resources and increasing in rural population in the highland regions. This situation has led to the increase in wood demand for heating and cooking as well as for over pumping of ground water for irrigation purposes.

In Turkey, the agricultural policy is applied country wide in general. Some times there are specific supports for different regions or selected provinces in different regions. Supports of these kinds have been implemented in a certain period of time and in a limited area for a specific purpose. Now a day, support for the livestock investments in Eastern Highland is good example for these kinds of subsidies. An investment in livestock sector based on approved projects by MİFAL gets 40 % of cost as grant.

Rural development has become one of the key elements of Turkish agricultural policy in last decade. The main objectives of rural development policy are to increase the productivity of rural areas, to improve the income level and wealth of the rural population, to reduce disparities between rural and urban areas and to prevent excessive immigration to big cities. To this end, the necessary rural infrastructures for education, health, social security organization, accommodation, and transport will have to be established and agriculture, agricultural industries, tourism, and local handicrafts will have to be developed. These activities will be carried out by governmental and non-governmental organizations (MARA, 2010b).

Though there are considerable developments, still in Turkey and Iran, important challenges in dryland agriculture in highlands are inadequate economic incentives for farmers to adopt new technologies for improving the management of natural resources and for enhancing agricultural productivity. Proper use and timely access to inputs are also a problem for many areas in the very cold to cold highlands.

Potentialities:

Highlands have remarkable assets for agricultural development. The communities have usually strong solidarity amongst them and have wide experiences and traditional knowledge in coping with the harsh climatic conditions and managing the natural resources. Highlands have a particular diversity, typical quality products and a great variety of landscapes. By managing natural resource, communities are producing environmental services (positive externalities). Also they have know how to use biodiversity for their living including for food and nutrition. Furthermore, farmers in highlands can harvest crops at the different time than the other agricultural areas which allows them to sell their products at a higher price. Highlands are also suitable for the production of seeds such as for sugar beet and potatoes. In addition, medicinal and aromatic plants constitute an important asset in the highlands. Their development and valorization can become an engine for highland development and income generation for their inhabitants. Likewise, there are large possibilities of rehabilitating and developing natural resources such as rangelands and reforestation.

Positive externalities are an important asset for highlands. Externalities can be paid for by taxes, subsidies and payment for services. They can become a source of additional income and a driving force for their development. They can be internalized through certification of trading quality of products at higher prices (e.g. bio-certification, mountain labeling product and quality labeling of origin). Honey, goat meat, goat cheese, olive oil, herbal and medicinal plants are some examples of such products in highlands, which are already renowned for these attributes (Herzenni, A 2006).

5.3. Institutional Aspects

5.3. 1. Informal and Traditional Institutions

Land ownership is probably the main institutional challenge in the development of highlands in the countries studied. Property rights over natural resources (e.g. water, rangelands and forests) vary from country to country. They can be private, state owned or owned by local communities. In general, rangelands belong to an ethnical group or the community and forests to the state. In Iran, all rangelands belong to the state, but a community or villagers have the right to use the nearby rangelands. Even though rangelands in Turkey belong to the state, villagers, within their villages' territories or private people through renting can have the righ to use the rangelands. However, most of the cultivated lands in the 3 countries studied are owned privately. In Morocco, cultivated land can be owned by the community yet cultivated privately. But, these cultivated land with time become quasi private.

When natural resources belong to the community, the later through their traditional institutions, establish rules to benefit from these resources and strictly define access to these resources, particularly for rangelands. Rules have to be implemented in order to preserve these common resources and avoid their depletion and mining uses. Not respecting these rules leads to open access and free-for-all competition.

Because of uncertainty over property right, lack of accepted / appropriate legislation or unclear delimitation of different land status, in some regions conflict on the boundaries of the fields about the access to natural resources emerges from time to time between communities or within the same community. It is difficult to identify people who have the right to use these common resources and not to overuse them. In Morocco, agreements among communities to transfer irrigation water to the whole valley or management of rangelands and forests are usually customary.

In the past, traditional institutions were strong and have been managed to keep the use of natural resources under control. For instance in Morocco, the ability of communities to control their members or to negotiate with other communities on collective lands has declined substantially over time (Sanders, J.H. and H. Serghini, 2003). The strength of traditional institutions comes from the common interest and trust among the whole group. As long as the group members are quite homogeneous and the group is relatively small, the group control over its members is quite effective and natural resources are socially well under control. The social evolution in highland areas has changed this situation so that institutions that manage common resources have been weakened and disorganized.

The population and the size of the traditional communities have been increasing in the 3 countries studied. The highland economy is also diversifying. Electrification and improvement of transportation and telecommunication have allowed the development of marketing and new economic activities such as tourism, diversification of agricultural production systems toward more cash driven activities. More and more government agencies and new actors (traders, touristic agents, elected body, NGOs…) are present in the highlands. All actions taken by these actors are influencing the highlands traditional institutions. These are thus confronted with modern ones such as government agencies, NGOs, modern democratic representatives and development projects where they don't necessarily have a say. Hence, traditional institutions are undermined and weakened.

The weakening of the traditional institutions has permitted the open access to natural resources which has led to their degradation. For instance, in Morocco with the loss of the social power of these traditional institutions we are witnessing an appropriation of some of these resources by powerful people as well as overgrazing and forest degradation. Can these traditional institutions be replaced by modern ones? Some projects have succeeded in Morocco in introducing cooperatives for managing natural resources, but how effective are they, after the end of the project? A post evaluation of these projects might answer this question. Under the pressure of political, economic and social changes in the highlands of Morocco, the common land status will certainly evolve in the future. Will it evolve towards a status which can preserve them from the continuous degradations? Privatization is one option. Is privatization politically and socially feasible? Is it efficient in safeguarding the environment? A long term process of privatization is already underway in many highlands of Morocco (forests and rangelands). Influential people from the community or from outside the community appropriate illegally portions of common land simply by cultivating it. Also, the state legally leases for long term periods the common land to some private entrepreneurs. The importance of these encroachments in common land is usually not evaluated. If this process is not put under strict control, deterioration of natural resources may be accelerated.

Some innovations in natural resource management are tested in Morocco. Contracting with local communities for managing and organizing natural resource uses is certainly one of the possibilities. The terms of the contract need to be very clear and its implementation should be scrutinized. For this innovation to be successful it is necessary that the contract be beneficial not only to the community as a whole but also to all stakeholders. However, it is very more and more difficult to reconcile all stakeholders' divergent interests.

Two solutions are proposed in the Maghreb countries for the common-access problem (Sanders, J.H. and H. Serghini, 2003):

1. Reinstitute or strengthen community control by helping form cooperatives, supporting them with public-sector help in training, and providing sanctions. There is no clear pattern of the success of cooperatives in the region so it is necessary to understand the factors associated with successful cooperative development;

2. Facilitate the movement to privatization, as it is the case in central Tunisia. Privatization secures investments made by farmers and encourages them to make more investments. The risk-management effects formerly achieved by moving herds can be approached by farmer diversification and public support. However, a serious income-distribution problem is associated with this strategy.

Policy governance is another institutional challenge when it comes to highland development. There is an agreement among development community that decentralization and civil society participation for policy implementation are important ingredients for the success of this policy. But what are the capacities of the local administration and local civil society to handle effectively this participation? In some project training programs are proposed for these actors.

5.3.2. Research Institutions

In Iran, there was not any specific research institution mandated to carry out research activities in highlands although agricultural research activities for the whole country including highlands on several areas such as plant breeding and agronomy, animal health, soil and water resources date back to more than 60 years ago.

In 1975 an independent research organization (Agricultural and Natural Resource Research Organization, ANRO) with a board of trustee and a research council was established as an umbrella organization for all national agricultural research institutes and provincial agricultural research centers for overall coordination and integration of agricultural research activities in the country. This organization was restructured several times during the last 30 years and finally Agricultural Research, Education and Extension Organization, AREEO was established in 1995. Since then, the number of affiliated agricultural research institutes, centers and stations has increased.

Presently, AREEO are made-up of 23 national agricultural research institutes /centers, 33 provincial agricultural research centers and more than 330 research stations around the country. They are involved to a carry out all various agriculture and natural resources research activities on crops, horticulture, livestock, fisheries, rangelands, forest, soil, water and others under AREEO’s umbrella. Considering the importance of dryland and irrigated agriculture in highlands, several agricultural research institutes and provincial research centers are presently involved in conducting research activities on highland agriculture in Iran. Agricultural research on dryland farming systems in highlands was initiated about 40 years ago, but it was scattered in different research institutes. Few research stations located in the highlands areas, such as Sararood (in Kermanshah Province), Gachsaran (in Kohguiloieh and Boeirahmad Province) and Margheh (in East Azarbayjan Province) were only established for rainfed research activities.

In 1974, CGIAR decided to strengthen dryland agricultural research in arid and semi arid areas. Therefore, establishment of an international highland agricultural research station in Iran near

Tabriz and a low land station in Lebanon was considered, however, due to emerging political situation in the region this initiative did not take place. However, rainfed agricultural research activities in Iran was continued and a rainfed cereal research department was established in Seed and Plant Improvement Institutes, SPII, the oldest and largest agronomy and plant breeding research institute in the country . However, rainfed agricultural production was not improving as planned. Thus an agreement with the International Center for Agricultural Research in the Dry Areas (ICARDA) was signed in 1989 to enhance multidisciplinary and multi-institutional research activities on dryland agricultural. The agreement's aim was to increase agricultural production, and to generate appropriate recommendation packages to improve agricultural production in dryland areas in Iran. Later on, establishment of the Dryland Agricultural Research Institute (DARI) with the technical support of ICARDA in Marghaeh which has a similar climatic condition with the site selected in 1976 by the CGIAR was become a priority. Consequently, DARI was established in 1992 and gradually its research stations were expanded in various agro- ecological zones ranging from warm to very cold zones in highlands., After 20 years of activity as an independent research institute, DARI now enjoys from the contribution of about 40 well educated scientists working in 6 main research stations (4 in the highlands and 2 in the lowland area) and 9 research fields to develop new improved varieties of cereals , food legumes, foragers, safflower as well as generating new technologies on conservation agriculture and managing natural resource base.

In Turkey, agricultural research was started in 1925 with the establishment of the so called "*Wheat Research Stations*" in Ankara, Eskişehir and Istanbul. In early ages of the research works, basic subject was to improve the agronomic practices through tillage and crop management under harsh conditions and to develop pure lines selected from landraces. Gradually agricultural research institutes in Turkey expanded in various ecological zones and provinces.

In 2011 research system includes 47 research institutes scattered throughout Turkey under General Directorate of Agriculture and Policy Research in the Ministry of Food, Agriculture and Livestock. There are now 11 central research institutes, 10 regional research institutes, 24 institutes on genetic resources and 26 subject research stations located in various agro-climatic zones in Turkey. These Institutes are working on a broad range of areas of research, including plant breeding, agronomy, pathology, quality, biodiversity and genetic resources on field crops, vegetables, oil crops, fodder crops, industrial crops, fruit trees, ornamental crops, aromatic and medicinal crops, and natural resources protection and management.

In the highlands of Central Anatolian, 3 research institutes (Ankara, Eskişehir and Konya) are working on cereals, legumes, forage crops and aromatic and medicinal crops while one research institute specifically works on potato. In Eastern Anatolian, in Erzurum one regional research institute which works on various crops in highland and one institute just working on potato have been established.

In Morocco, no research institution is specialized in highland agricultural research. However, one institute is mandated to forestry research. Since most of the Moroccan forests are located in highlands, part of the research needed for highland development is carried out by this institute. However, most of the agricultural research activities on plant breeding, agronomy, horticultural crops, vegetables, animal sciences, soil and water and other disciplines are carried out by The National Institute of Agronomic Research (INRA) and Agronomic and Veterinary Hassan II Institute (IAV Hassan II). INRA has established several research stations in lowland for conducting research on dryland and irrigated crops, vegetables, fruit trees such as olive and citrus in the country. INRA has strong collaboration with ICARDA on improving agricultural productivity through developing wheat, barley and food legumes varieties suitable for Moroccan climatic conditions as well as natural resource management and increasing water productivity. It has also collaboration with several European universities and research centers, mostly on lowland agriculture.

5.4. Agricultural Development

Highland sustainable development requires a holistic and long term approach as well as a balance between economic, social, institutional and environmental components. In general, even though all governments have a development plan for their countries, they do not have specific policy targeting sustainable development for the highlands. Therefore, participation of highland inhabitants in the development of a national policy for the highlands for most parts is limited. Policies do not in general address the vulnerability of these communities and the diversity of highland areas.

The goals of a sound development policies for highlands should be targeting in improve income of economically vulnerable people in order to alleviate poverty, preserving ecosystems and the biodiversity and reducing the risk of drought, cold, flood and forest fires. They can be achieved through:

1. Increasing marketable goods and services (organic or exporting goods, seed production, medicinal and herbal plants, vegetables, fruits, rural tourism, etc) by improving access to market in lowland and urban areas;
2. Support to the public good production and protecting biodiversity and ecosystem services by defining clear property rights over forests and rangelands as well as empowering highland communities.

Highland development is not only important for the highland communities but for the whole nation; that is why national solidarity is required for developing these areas. Managing natural resources is very complex and has important consequences not only for highlands but also for the downstream lowlands. To insure effectiveness and successful outcome, formulation and implementation of highland policies should be the responsibility of all government branches at all levels.

The members of the Adelboden Group, on the occasion of their Third Meeting in Rome which was held on 1-3 October 2007, expressed their serious concern and fully endorse the following recommendations on policy options and strengthening institutions and processes in mountain and highland regions of the world (FAO, 2008).

Policies:

A long-term vision and holistic approaches should be adopted by governments and their development partners, in order to remedy the present common lack of strategies and integrated approach to policies for sustainable agriculture and rural development , SARD in highlands and mountain regions;

1. Higher priority should be given to mountain issues in national, regional and global policymaking, either through incorporating mountain-specific requirements into general policies or through specific mountain policies;
2. Awareness of mountain specificities and of possible impacts of current policies on mountains needs to be improved among policy-makers and civil society partners;
3. Economic diversification as well as value-added production and services need to be fostered, with the objective of improving employment and incomes;
4. Better integration of mountain economic activities through improved access to markets and the promotion of public-private partnerships must be encouraged;
5. Securing long-term land tenure for mountain agriculturalists, including for women-headed households, is a fundamental prerequisite for SARD-M;
6. Higher priority should be given to indigenous traditional knowledge in order to protect mountain environments and promote SARD-M.

Institutions and processes

The institutional capacity for SARD-M policy formulation and implementation as well as for policy coordination should be improved at the national level to achieve better complementarities and coherence between policies;

Transnational approaches to SARD-M should be fostered at the regional level, for instance in the context of regional mountain conventions, such as the Alpine Convention and the Carpathian Convention;

Knowledge generation and management, information sharing and networking need to be rapidly developed at all levels;

Participation of civil society in policy formulation should be ensured at all levels;

The capacities of all stakeholders should be strengthened to ensure that they can participate effectively in all policy formulation and implementation processes;

The evaluation and monitoring of mountain-relevant policies as well as their implementation should be systematic"

Livelihoods in highlands depend mainly on crop and livestock production as well as forest resources. Agricultural productivity is very low and product access to markets is weak. Agriculture production should be oriented to high quality products as resources are scared. Already the quality of highland products is recognized for some goods in the informal markets. The creation of a label for mountainous products would improve highland people income. Law on geographic indication needs to be adopted or implemented in the highlands. Local actors in general lack the resources and the training for taking advantage of this proposal.

One of the main impediments to highland development is the lack of financing possibilities for most of t farmers and herders. For instance, credit supply is not usually well developed in these areas because of their isolation and high transaction cost due to the lack of property ownership by many farmers and herders. For poor people micro-credit is generally presented as a solution for financing their activities to take them out of poverty. However, micro-credit with high interest rates is only suitable for activities which have a rapid turnover.

As mentioned earlier, adoption of modern technology is very low in many places of highlands because of low level and ineffective extension services as well as unavailability of appropriate production technologies for resource poor farmers. Hence, agricultural development should also focus on generating technologies and strengthening extension services and technology transfer units.

Agricultural projects in highlands ought to develop and modernize irrigation schemes wherever irrigation water can be mobilized. Existing schemes should also be protected from floods. The technical efficiency of irrigation water should be prioritized, and agricultural production is intensified in order to increase its added value (processing and marketing). These are also a need to put more emphasis on developing processing of producing essential oils and marketing aromatic and medicinal plants. Demand for these products is increasing in the international markets.

Livestock production is considered to be the main income-generating activity for almost all farms in highlands. Its development can help reduce poverty in these areas. However, livestock activities, including apiculture and aviculture are very traditional and characterized by low input-low output. Livestock development should focus on reducing the number of animals that are grazing on rangelands and intensifying their production by improving animals' health conditions, ameliorating their feeding by supplementation and by introducing high-producing crossbred animals.

Beekeeping can also be practiced by small landowners or even by landless villagers as beehives occupy minimal space and can be placed anywhere, even on marginal land. It does not compete with other sectors of agriculture for resources, as the bees collect nectar and pollen from wild and cultivated plants. Moreover, beekeeping does not involve high investment costs or complicated technology (Onur Erkan O., et al, 2001).

5.5. Sustainable use of biodiversity

In many highland areas, rangelands and forests along with soil resources are overexploited and severely under degradation. Firewood and many non-timber products are also very seriously and illegally over-exploited. In addition, rangelands and forests are converted to agricultural land. Agro-biodiversity is also under increasing pressure and is overexploited due to overgrazing and land degradation as well as urban and industrial encroachment.

In Morocco and other countries, rangelands are community owned and forests are state owned while livestock is privately owned. This ownership system provides little incentives for people living in these areas to conserve biodiversity. They are systematically excluded as resource users from benefiting of marketing forest products. Commercial products from organized timber sales are almost always harvested by relatively wealthy elite farmers. Access to most grazing lands is de facto open access. To overcome these problems and to better conserve highland ecosystems, policies and projects are needed for the development of the economic potential of these natural resources and the value chains of biodiversity products to benefit the local population and to ensure an equitable sharing of the benefits. This will create incentives for the local population for sustainable use of highland resources. In fact no participatory forest and/or range management systems have been developed in Morocco and other countries. The policies should include co-management of biodiversity resources on both forests and rangelands (USAID, 2008).

Chapter 6

Research Achievements and Impacts

6. 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.

6.1. 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.

6.2. 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 6.2).

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 6.1 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 6.2 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 6.3 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 6.4 and 6.5 show bread and durum wheat varieties released during 1984-2010.

Table 6.4 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 6.5 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 6.6

Table 6.6 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 6.7 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 6.8 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 6.9 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,	800-1100	Central Anatolia Plateau , spring

			high yielding,		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
Menemen 92	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 6.11). Almost, %80 of the lentil areas covered by the varieties has been developed by Agricultural Research Institute of MİFAL.

Table 6.10 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

6.3 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. Also, since 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.

As for 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.

6.4 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 6.12.

Table 6.11 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.

6.5 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.

6.6 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. These supports provide good bases 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.

6.7 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.

6.8 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.

6.9 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.

6.10 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.

6.11 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:

9. Development of suitable crop varieties of wheat, barley and chickpea tolerant against cold and drought for cold to very cold highland regions.
10. Development of technologies for conservation agriculture suitable for the cold highlands
11. Soil conservation and improving soil organic content
12. Suitable crop rotation and diversification of agriculture in cold to very cold highlands and overcoming the constraint facing the issue.
13. Diversification of production systems such as inclusion of horticulture, vegetables medicinal and herbal plants, etc
14. Integrated natural resource management and the effects of climate change on highland agriculture.
15. Enhancing water productivity and managing increasing drought and water scarcity
16. Study on socio-economic constraints facing the adoption and application of research findings in dryland farming system
17. 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.

Chapter 7

Elements of Highland Research Strategy

7. Elements of Highland Research Strategy

7.1. 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.

7.2. 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).

In order 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.

7.3. 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).

7.4. 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.

Chapter 8

Research Priority Areas

8. 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:

8.1. 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)

8.2. 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

8.3. 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:

1. **<u>Cereal based farming system</u>**
   1.1. 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
   1.2. 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)
   1.3. Developing IPM of major pests for rainfed and irrigated production system
   1.4. 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. **<u>Horticultural based System</u>**
   2.1. Identification of adapted varieties of fruit trees and Improvement of cultivars/rootstocks of trees suitable for the highlands.
   2.2. Improving orchard establishment methods (access to healthy plantlets, planting system; planting distance, irrigation system) and postharvest processing and marketing.
   2.3. Developing of orchard management practices (pruning, pollination, mulch, irrigation, fertilizer application, weeds control, and disease and pest management).
   2.4. Introduction of suitable techniques for rainfall water harvesting and increasing water productivity.
   2.5. Identification and introduction of high value crops (strawberry, cut-flowers, medicinal /ornamental plants,) for generating more income for farmers.
3. **<u>Rangeland and livestock System</u>**
   3.1. Introduction of suitable forage and range species and development of alternative feed sources and supplementary feeding (nutrients, vitamins, minerals...)
   3.2. characterization of native livestock breeds suitable for highlands and development of proper livestock breeding strategies
   3.3. Developing guidelines and databases for utilization of crop residues and agricultural by-products in feeding calendars
   3.4. Integrated management of crop/rangeland/livestock in highlands and promotion of honey bee production.

3.5. Determination of prevalent diseases and promoting suitable prevention measures

3.6. Survey of livestock management in the nomadic and transhumant systems and increasing their productivity through participatory research approach.

3.7. Grazing management and analysis of trade-offs of crop-residues for better crop/livestock integration

4. Cross Cutting Issues

4.1. Capacity building of NARS including long and short term (degree and non-degree) education and training courses

4.2. Strengthening Involvement of private sector in ARD, networking and regional collaboration (exchange of visits, regional and international conferences and meetings)

4.3. 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.

Chapter 9

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

9. 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:

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.

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,

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.

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.

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;
- ~~Indigenous~~ Traditional knowledge is inventoried, documented and associated with modern tools and technologies;
- A consolidated database on community and household constraints and opportunities is developed.

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.

Chapter 10

Conclusion and Recommendations

10. Conclusion and Recommendation

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.

References

References

1. Acherkouk, M., 2007. Projet de Vision pour le Développement du Centre Régional de la Recherche Agronomique de Tanger. Institut National de la Recherche Agronomique.
2. Altın, M., A. Gökkuş, A. Koç. 2005. Meadowand Rangeland Rehabilitation. The Ministry of Agriculture and Rural Affairs. The department of The Meadow-Rangeland and Forage Crops, Publication ISBN 975-407-188-8.
3. Anonymous, 2007. The National Biological Diversity Strategy and Action Plan. Ministry of Environment and Forestry of Turkey, General Directorate of Nature Conservation and National Parks, Ankara. ISBN: 978-605-393-030-3
4. Associate for International Resources and Development (AIRD), an Economic Appraisal of the Impact of Government Policies on Rangeland Livestock Systems of North Africa and the Middle East.
5. Atalay, A., K., Erdogdu, Sever, L. Kara, İ., Aygun, C. 2010. Determination of Genotypes on Homogenous Area, Numbered As 13 in Grassland of Eskişehir ProvinceI.Ulusal Toprak Ve Su Kaynaklari Kongresi. Eskisehir-Turkey. Pp.1010-1018
6. Aw-Hassan A. and K. Noori, 2007. Characterization of Production and Livelihood Systems of Rural Communities in Upper KRB, Proc. of Inter. Workshop on Improving Water Productivity and Livelihood Resilience in KRB, Sep. 10 -11 2007 Karaj – Iran, ICARDA – AREEO, Report 2
7. Bakır, Ö. 1971. Range Management in Turkey. In: The proceedings of the development of feed resources and improvement of animal feeding methods in the CENTO region countries. P: 69-78
8. Banaei M.H. , 1998. 1:2,500,000 Maps of Soil Moisture and Temperature Regimes of Iran. Soil and Water Research institute, Tehran, Iran
9. Bourbouze, A.,2000. Pastoralisme Au Maghreb: La Révolution Silencieuse, CIHEAM/IAM de Montpellier.
10. Bourbouze, A., 2006. Livestock systems and animal production in North African steppes: A new reading of the pastoral society in the Maghreb, Science et changements planétaires / Sécheresse. Volume 17, Number 1, 31-9.
11. Cakmak, İ., et al. 1996. Zinc deficiency as a critical problem in wheat production in Central Anatolia. Plant Soil. 180, 165-172.
12. Cakmak, İ., 1998. Agricultural Policy Reforms and Rural Development in Turkey, Mediterranean Development Forum. September 3-6, Morocco.
13. Cakmak, İ., et all, 1999. Zinc deficiency as a practical problem in plant and human nutrition in Turkey: A NATO-science for stability Project. ELSEIVER, Field Crops Research 60; pp: 175-188
14. Cakmak, İ., et all, 2004, Characterization of Agricultural and Agro-Industrial Sector in Turkey, EU-MED Agpol, Delivarable D3

15. Cakmak, İ., 2008. Zinc Deficiency in Wheat in Turkey. In “Micronutrient Deficiencies in Global Crop Production”. Edt. Alloway, Brian J.. Chapter 7, pp:181-200. Springer, Netherlands, Isbn: 978-1-4020-6860-7.
16. Campbell, B. M., Hagmann, J., Stroud, A., Thomas, R., Wollenberg, E., Navigating amidst complexity: Guide to implementing effective research and development to improve livelihoods and the environment, Center for International Forestry Research, Bogor, Indonesia, 2006.
17. Celis, D., E. De Pauw and R. Geerken. 2007. Assessment of land cover/ land use in the CW ANA region using A VHRR imagery and agroc1imatic data. Part 1. Land Cover/Land Use - base year 1993. International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, vi+ 54 pp. ISBN 92-9127 -192-4.
18. Christensen, J.H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, I., Jones, R., Kolli, R.K., Kwon, W.-T.,Laprise, R., Magaña Rueda, V., Mearns, L., Menéndez, C.G., Räisänen, J., Rinke, A., Sarr, A. and Whetton, P.(2007) In: Solomon, S. , Qin, D., Manning, M., Chen,Z., Marquis, M., Averyt, K.B. , M. Tignor, M., and Miller, H.L. (eds.) Regional Climate Projections. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
19. Conseil Général de l’Agriculture, 2008. Atlas de L’Agriculture., Pour une territorialisation de l’agriculture.
20. De Pauw, E., W. Goebel and H. Adam. 2000. Agrometeorological aspects of agriculture and forestry in the arid zones. Agricultural and Forest Meteorology 2793 (2000) 1-16
21. De Pauw, E., A. Ghaffari and V. Ghasemi. 2004. Agro-climatic zones map of Iran, explanatory note. DARI
22. De Pauw, E. 2008. Climatic and Soil Datasets for the ICARDA Wheat Genetic Resource Collections of the Eurasia Region. Explanatory Notes. ICARDA GIS Unit Technical Note (URL:http://geonet.icarda.cgiar.org/geonetwork/data/regional/GRU_NetBlotch/Doc/Report_NetBlotch.pdf)
23. De Pauw, E. 2010. Agroecological zoning of the CWANA region. In A. El-Beltagy and M.C. Saxena (Eds.). Sustainable Development in Drylands – Meeting the Challenge of Global Climate Change. Proceedings of the Ninth International Conference on Development of Drylands, 7-10 November 2008, pp. 335-348, International Drylands Development Commission, ICARDA.
24. De Pauw, E. 2011. Agro-ecological characterization is a prerequisite for the sustainable management of the highlands of North Africa, West Asia and Central Asia. Abstract of Regional Expert Meeting on Highland Agriculture, 19-21 November 2011, Karaj, Iran
25. Department of Environment. 2010. Iran’s fourth National Report to CBD – Final. Department of Environment, GEF and UNDP

26. Dixon, J., A. Gulliver and D. Gibbon. 2001. Farming Systems and Poverty. FAO and World Bank, Rome and Washington D.C., 412 pp. ISBN 92-5-104627-1.
27. Dryland Agriculture Research Institute, DARI. Unpublished data, Maragheh, Iran
28. DSİ, 2011. Annual Report of DSİ (General Directorate of State Hydraulic Works) for 2010 (Published in Turkish). Ankara-Turkey
29. Eyupoglu, F. , 1999. Productivity Status of Soil of Turkey. General Directorate of Rural Affairs-Publications of Soil and Fertilizer Research Institute. General Publication No: 220 (Published in Turkish) Ankara-Turkey.
30. Eyupoglu, F., Kurucu, N., Sanisa, U., 1994. Status of plant available micronutrients in Turkish soils, in Turkish. In: Annual Report. Report No. R-118. Soil and Fertilizer Research Institute, Ankara, pp. 25-32.
31. FAO. 1995. Digital soil map of the world and derived soil properties. CD-ROM, version 3.5, Food and Agriculture Organization of the United Nations, Rome, Italy.
32. FAO, 2008. Project for Sustainable Agriculture and Rural Development in Mountain Regions (SARD-M) Interregional analysis of the strengths and weaknesses of policies, institutions and processes for SARD in mountain regions
33. FAO, 2008. Project for Sustainable Agriculture and Rural Development in Mountain Regions (SARD-M), Framework for a Rapid Assessment of Policies, Institutions and Processes for SARD in Mountain Regions, Practical Guide.
34. Firincioglu, 2004. An assessment of the pasture and forage production of Turkey. Journal of Central Research Institute for Field Crops, Ankara.
35. Gökkuş, A., A. Koç. 2001. Range and Meadow Management. Atatürk University, Agriculture Faculty, Text Book Publication Number: 228, Atatürk University Agriculture Faculty, Erzurum.
36. Grethe, H., 2003, Effects of Including Agricultural Products in the Customs Union Between Turkey and the EU, Center for Globalization and Europeanization of the Economy, Göttingen .Group on Beta. First Meeting, 9-10 September 1999. Broom’s Barn, Bury St.
37. Guner, A. et. All, 2000. Flora of Turkey and Aegean Islands. Vol.11 (Suplement2). University Pres. Edinbur
38. Herzenni, A. 2006. Evaluation Rapide Des Politiques ADRD-M, Cas du Projet d’Aménagement du Bassin Versant de l’Oued Lakhdar au Maroc, FAO et CIHEAM, Bari.
39. Haut Commissariat au Plan, 2008. : Annuaire Statistique du Maroc, 2008.
40. ICARDA-AREEO. 2012. Iran-ICARDA Collaboration for Efficient, Effective and Relevant Agricultural Development, a Review Report-Draft.
41. ICARDA- GISU, 2008. GIS map of the WANA Region
42. ICARDA and the NARS of Algeria, 2007. Improving the Livelihoods of Rural Communities and Natural Resource Management in the Mountains of the Maghreb Countries of Algeria, Morocco and Tunisia,

43. ICARDA, 2003 Sep..'Improving the Livelihood of Rural Communities and Natural Resource management in the Mountains of the Maghreb Countries of Algeria, Morocco and Tunisia', SDC-Maghreb Mountain Project.
44. ICARDA and the NARS of Algeria, 2007 Dec. Improving the Livelihoods of Rural Communities and Natural Resource Management in the Mountains of the Maghreb Countries of Algeria, Morocco and Tunisia,.
45. Jalal Kamali, M. R. 2012. Personal communication, CIMMYT- Office, Karaj, Iran
46. Kaya, Z. and Raynal, D.J. 2001. Biodiversity and Conservation of Turkish Forests. Biological Conservation 97/2:131-141.
47. Mazid, A., Amegbeto, K. N., Keser, M., Morgunov, A., Peker, K., Bagci, A., Akin, M., Kucukcongar, M., Kan, M., Karabak, S., Semerci, A., Altikat, A., Yaktubay, S. (2009). Adoption and Impacts of Improved Winter and Spring Wheat Varieties in Turkey. Published by ICARDA.
48. Ministère Chargé des Eaux et Forêts, 2000. 'Définition d'une Politique de Montagne au Maroc'.
49. Ministère de l'Agriculture et de la Pêche Maritime, 2009. Conseil Général de Développement Agricole, Pilier II du Plan Maroc Vert, Montagnes et Oasis,
50. Ministère Chargé des Eaux et Forêts, Politique de Montagne au Maroc, 2008
51. MARA, 2010a. Strategic Plan 2010-2014. Ministry of Agriculture and Rural Affairs. (Published in Turkish)-Ankara
52. MARA, 2010b. Rural Development Plan 2010-2013. Ministry of Agriculture and Rural Affairs. (Published in Turkish)-Ankara
53. Mesut, Keser. 2012. Personal communication , ICARDA-Office , Istanbul , Turkey
54. National Agricultural Research Institute: INRA, 2004. Nearly one century of Serving and Modernizing Moroccan Agriculture.
55. National Agricultural Research Institute: INRA, 2008. Unpublished data
56. National Plant Gene Bank, Iran, 2010. Personal Communication
57. Nsarrellah, N. 2012. Personal communication , Rabat, Morocco
58. Ozden,M.O., et al . 2001. Soil Geographical Database of Turkey at a Scale 1:1.000.000 - 4th Approximation, Research Report, Agriculture Services Ministry National Information Center for Soil and Water Resources and Cukurova University, Soil Department Collaboration, Ankara-Adana, Turkey
59. Oskam , A., et all, 2004, Turkey in the European Union, Consequences for Agriculture, Food, rural Areas and Structural Policy, Final Report,(Report Commissioned by the Dutch Ministry of Agriculture, Nature and Food Quality), Wageningen University, Holland.
60. Polat, T., et al. 1996. An investigation on the effects of the different restoration techniques on the yield potentials of the Tektek Mountains in the Şanlıurfa province. IN: The Proceedings of Turkey third National Pasture and Forage Crops Congress. 17-19 June 1996, p. Erzurum.

61. Pratt, D.J., Le Gall, F., and de Haan, C., 1997. Investing in pastoralism: Sustainable natural resource use in arid Africa and the Middle East. World Bank, Technical Paper No 365. Washington, D.C.: World Bank.
62. Pratt D.J. and L. Preston. 1997. The economics of mountain resource flows, FAO.
63. Rezaei, S.A. 2007. Rangelands of Iran an Overview, Forest, Range and Watershed Management Org. I.R. Iran
64. Roozitalab, M. H. and A. Keshavarz, 2011, Highland of Iran, Challenges and Opportunities for enhancing agricultural productivity and sustainable natural resources management, Regional Expert Meeting on Highland Agriculture 19 -21 Nov. 2011, Karaj - Iran
65. Seed and Plant Improvement Institute, SPII. 2011. Personal communication , Karaj, Iran
66. Sanders, J.H. and H. Serghini, 2003. 'Impacts of IFPRI/ICARDA Policy and Property Rights Research on the Mashreq and Maghreb Project', Impact Assessment Discussion paper N° 19, IFPRI, P.25
67. SIS, 2001. General Agriculture Census. State Statistic Institute, Ankara , Turkey
68. SPO, 2004. Sector Profiles of Turkish Industry, State Planning Organization.(Published in Turkish)-Ankara.
69. Tan, A. Aykas, L. and Inal A. 2000. Status report of Beta genetic resources in Turkey.
70. Tan, A. ve T. Taskin. 2009. Ege Bölgesinde Sebze Olarak Kullanilan Yabani Bitki Turleri ve Kullanim Amacları (Edible Wild Species used as Vegetable). Ege Tarimsal Arastirma Enstitusu Mudurlugu, Yayın no: 136. 174 s. ISBN: 978-975-407-278-5.
71. Tan, A., 2010. State of Plant Genetic Resources for Food and Agriculture in Turkey. Second National Report.
72. TCV, 1995. Environmental Problems of Turkey'95 (Published in Turkish). Published by Environment Foundation of Turkey, Ankara-Turkey.
73. Technical Office of Engineering, TOE, 2005. Vegetation map of Iran. Forest, Range, and Watershed management Organization of Iran, Tehran.
74. TurkStat, 2010. Turkey's Statistical Yearbook, 2010
75. TUSIAD, 2005. Turkish Industrialist' and Businessmen's Association, Turkish Agriculture in 21th Century (in Turkish), Istanbul.
76. UNESCO, 1979. Map of the world distribution of arid regions. Map at scale 1:25,000,000 with Explanatory Note. United Nations Educational, Scientific and Cultural Organization, Paris, 54 pp.
77. USAID, 2008.'Morocco Biodiversity and Tropical Forestry Assessment'.
78. World Bank, 2012. Countries Statistics.
79. WTO, 2003, Trade Policy Review, Turkey, Report by the Secretariat
80. Yessef, M. 2006. Structure, fonctionnement et dynamique des écosystèmes steppiques au Maroc: Bilan et perspectives de recherche. Institut Agronomique et Vétérinaire Hassan II, Maroc.

Appendix

Appendix I

Outcomes of the three Parallel Working Groups on identification of priorities for highland agriculture in the CWANA Region

1st Regional Expert Meeting on Highland Agriculture

19-21 November 2011, Karaj, Iran

Three concurrent working groups were organized on 20-21 November 2011 during the 1st Regional Expert Meeting on Highland Agriculture to discuss and elaborate on the priority areas of agricultural research proposed by the Review Team on the highlands of Iran, Morocco and Turkey and to identify new priority areas of agricultural research based on the following terms of reference:

- Elaborate on research priorities, proposed by the Review Panel on highlands and make suggestions to endorse or refine the priorities
- Identify priorities of the researchable issues to improve the productivity of the highland production systems, improve livelihoods of the rural community and to enhance the sustainable use of the natural resources
- Elaborate on specific targeted activities for each identified research priority for 2012-2016
- Make suggestion or advice on the relevant benchmark sites/agro-ecological zones for implementation of collaborative research projects on highlands
- Identify potential donors interested in supporting the research projects on highlands

Group 1: Natural resources management and climate change

The group followed the outline of the synthesis document and identified gaps in priorities in terms of definition of highlands, scale, scope and sequence of studies to be undertaken.

1. **Definition of highlands**

The group agreed on the need for clear definition of highlands by making a separation between the 'definition', 'subdivision' and 'characterization' of highlands.

2. **Scale, scope and sequence of studies to be undertaken**

➢ Regional assessment of highland areas in North Africa, West Asia and Central Asia (NAWACA): Need to compile in a spatial database on current knowledge of land and water resource base (climate + Climate change, land, water, biodiversity), production systems, potential and constraints, data gaps, formulation of research questions at regional scale and identification of project areas. This is broadly covered under the research priority 'Agro-ecological Characterization'

- To follow the general spatial framework of the CRP1.1: Need to use target areas – benchmark areas (and not ‘Benchmark Sites’!) to be differentiated from Action Sites
- Importance of systematic approach: Research priorities should come after problem identification taking into consideration existing knowledge and using possibly the two-track approach with concurrent work being conducted at different scales.

3. Gaps in the synthesis document

There is a need for including and stressing the following aspects in the introduction:

- The importance of/threats to biodiversity in highlands
- The implications of population dynamics (e.g. outbound migration of the young) on the sustainable management and social stability
- The implications of climate change
- The landscape value of mountains

4. Cross-cutting research priorities

- Improve knowledge on highland agricultural environments of NAWACA
- ‘Agro-ecological characterization’ common denominator for activities related to:
  - Differentiation and characterization of agricultural environments in terms of ecologies and farming/production systems, land suitability
  - Identification of data gaps
  - Interpretation in terms of potential and constraints of the identified agro-ecosystems
- Review of research gaps and identify network of institutions that can do the research and the research problems;
- Review of indigenous knowledge on soil, water and biodiversity management and Climate change perceptions;
- Land use planning;
- Negotiating/reconciling human needs for different land uses with needs for ecological services (e.g. protected areas)

5. Thematic research priorities

I) Land and soil management

- Assess sustainability of the agricultural resources base through studies of sustainable land management, including land use planning and traditional land management
- Hillside management:
  - Reducing land degradation while
  - Improving land use productivity
  - Evaluating impact of natural disasters and hazards on mountain agriculture
- Plains: intensification/improving productivity of irrigated areas
- Optimizing land use/cropping patterns through land use planning

II) Water management

- Improving water productivity
  - Identify best irrigation management systems for the highlands
  - Valuate water productivity of crops under different water applications
  - Review institutional capabilities and policies related to natural resource conservation
  - Role of supplemental irrigation and water harvesting
- Evaluating upstream-downstream interactions, including competition between water users, impact of water harvesting and supplemental irrigation using integrated water resources management

III) Biodiversity

- Assessing the status and threat to agro-biodiversity in the predominant farming systems;
- Review-based research on threatened ecosystems in the highlands of the region

IV) Linking climate change to highland agricultural resources management

- Downscaled climate change projections for highlands
- Linking current/past precipitation patterns of variability and trends to climate change projections
- Analysis of changes in extreme events (min and max. temp, precipitation and drought)
- Implications of climate change on
  - Water resources availability in space (upstream and downstream dependencies) and time (seasonal distribution) for cropping systems
  - Erosion, landslides, flood hazards
  - Migration of vegetation communities
- Risk of pests and diseases
- Documenting recent changes in cropping patterns and assess feasibility of crop insurance schemes

6. Miscellaneous issues

- Anticipatory research:
  - Need to develop indicators of environmental change for use in benchmark areas (e.g. changes in irrigated areas, population, changes in snow cover, flowering dates of plants)
- Anticipating benchmark areas:
  - Potential pilot areas in Iran: Karkheh River Basin, Ouroumieh Basin
- Anticipating activities:
  - Water management/Climate Change: monitoring drought and snow cover using remote sensing

Group 2: Socio-economic and policy

The Group discussed the various topics related to the socio-economic and policy and identified the following priority areas on the highland agriculture.

Research areas

1. **Database**
    - Database at the highland level on the following areas to be compiled from different institutions:
        - Natural resources
        - Climate
        - Population, education, emigration
        - Farming systems
        - Crops
        - Livestock
        - Infrastructure and services
        - Non-farm activities
        - Ecological services
        - Research results
        - Studies
        - Institutions and organizations
        - Maps and GIS information
    - At the research site and household level

2. **Household economics and returns to technology options**
    - Income sources:
        - Farm activities
        - Employment
        - Other activities
        - Nutrition
    - Returns to technology options
    - Return s to resources in particular natural resources
    - Risk assessment
    - Access to services

3. **Policy impacts**

Modeling/simulation

- Domestic or export and import subsidies
- Price support
- Direct payment
- Technology introduction
- Natural resource policies
- Financing
- Marketing
- Border policy

4. **Value-chain analysis**
   - Demand for organic products
   - Certification of organic products
   - Economic return assessment of new varieties, new technologies
   - Institutions such cooperative
   - Local and export markets
   - Effect of policy
   - Logistics and infrastructure
   - Local processing and marketing
   - Marketing chain (warehouses)

5. **Institutional issues**
   - Land tenure: ownership, legislation, structure, fragmentation
   - Social organizations: community organization for:
     - The access and management of the common resources (rangelands, forests, water...)
     - Marketing
     - Access to information/capacity building
     - Access to technology, in particular seeds
   - Evaluation of alternative rangeland and (water) management options: public, private, cooperatives, community

6. **Evaluation of ecological environmental and cultural services**
   - Economic assessment of adaptation measures to climate change

7. **Monitoring and out-scaling technology adoption**
   - Baseline technology adoption
   - Out scaling (dissemination)
   - Monitoring and evaluation (economic, social and technical)
   - Reasons for low or high adoption rates

<u>Prioritization and number of sites</u>

Areas	Priority	Number of sites
Database	1	All selected benchmark sites
Social organization and land tenure	2	3-4 sites to be identified
Monitoring and out-scaling technology adoption	2	3 sites
Household economics and returns to technology options	3	2 sites
Policy impacts	4	2 sites
Value-chain analysis	5	2 sites and few high-value

		products
Evaluation of ecological, environmental and cultural services	6	2 sites

Links with other areas of research (groups)

- **Ex-ante activities: diagnostic/characterization/baseline (done jointly)**
- **Joint activities**
- **Ex-post activities**
- **Integrated action plan for all aspects (3 groups)**
- **Beyond 2016?**

Potential donors

- **GEF (Environment, biodiversity and climate change)**
- **Italian Government (water, watershed management, nutrients…),**
- **SDC: Mountains**
- **EC: research and development, FP7**
- **FAO**
- **IFAD: Policies, natural resources, institutions**
- **JICA**
- **Partners: NARS, ICARDA, CIMMYT, FAO, ICMOD, CIHEAM, GTZ.**

Group 3: Integrated and intensification of production systems

The Group recommended focusing the research on cold and cool highlands zones since they cover more than 75% of the highlands. The Group also identified five major farming systems with the focus on the first three; a) Cereal-based farming system (legumes, forages, oil crops, etc); b) Horticultural-based system; c) Rangelands and livestock system; d) Aquaculture and fisheries system; and e) Agro-forestry system. The group recommended refining the characterization and definition of the highlands and the prevailing production systems.

Main research areas for the Cereal-based farming system

- **High yielding and adapted germplasm with quality, resistance to diseases and pest (wheat, barley, maize, chickpea, lentil, oil crops, feed legumes (alfalfa, vetch, etc.)**
  - Cold and drought tolerance
  - Yellow rust, common bunt, root diseases, Ascochyta blight, fusarium wilt, parasitic weed, storage pests (weevils))
  - Water-use efficiency
  - Application of Marker-assisted selection
  - Haplotyping of cereal based germplasm for highlands
  - Germplasm exchange

- **Germplasm conservation and utilisation**
  - Collection, characterisation (molecular + agronomic), evaluation, utilization
  - Pre-breeding

- **End-use quality**
  - Biofortification and end-use quality (bread, pasta etc.)
  - Nutritional quality,
  - Quality grading
  - Chemical residues
  - Malting,

- **IPM of major pests**
  - Wheat: Sunn pest, Russian wheat aphid, sawfly, thrips
  - Chickpea, lentil: parasitic weeds
  - Alfalfa: weevil

- **Suitable crop management packages (Agronomy section)**
  - Conservation agriculture (rotation, minimum tillage, residual management, weed control, machinery)
  - Nutrition management, planting dates etc.
  - Precision farming
  - Water productivity
  - Developing forecasting systems for major pest and rainfall
  - Supplemental irrigation for rainfed area
  - Management activity (planting, nutrition, weed control etc.
  -
  - Seed systems (production, processing and distribution)
  - Seed quality control, certification
  - Source seed, breeders seed production,
  - CBSE, private sector,

- **Demonstration of packages (Extension efforts)**
  - On-farm trials
  - Promotional activities (information dissemination)
  - PVS
- **Introduction of alternative crops including off-season crops (Agronomy)**
  - Triticale, Flax, Safflower
  - Summer crops: quinoa, amaranth, sorghum, millets

Benchmark areas:

Maragheh, Erzurum (dryland -cold);Ardebil, (cold - irrigated), Karaj (irrigated cool); Ankara, Kerminshah, (dryland cool); Balushistan and Gilgit (Pakistan); Atlas Mountains (Tiaret in Algeria and Annoceur in Morocco)

Main research areas for the horticultural-based system

- **Mechanisms for information exchange and networking**
  - Establish a Community of Practice on horticulture in highlands (network, website,..)

- **Characterization of environments suitable for various horticultural crops**
  - Characterization of growing season in highlands.
  - Documentation and use of local/indigenous knowledge ;

- **Characterization, conservation and use of genetic diversity**
  - Use of molecular markers for characterization of genetic diversity;
  - Identify and promote adapted under-utilized crops;
  - Domestication and cultivation of medicinal species

- **Identification of adapted crops and varieties for different highlands**
  - Introduction and evaluation of existing varieties;

- **Improvement and selection of suitable cultivars/rootstocks for highlands.**
  - Selection on the basis of productivity, quality and adaptation;
  - Explore use of Markers Assisted Selection.

- **Improving orchard establishment methods in highlands (access to healthy plantlets, planting system; planting distance, irrigation system).**

- **Orchard management practices (pruning, pollination, mulch, irrigation, fertilizer application, weed control, disease and pest management).**
  - Develop guidelines/manuals for good agricultural practices for management and post-harvest processing for major crops (grapes, almond, pistachio, cherries, apple, …); FAO is already planning this activity

- **Determination of suitable techniques for rainfall water harvesting and productivity.**

- **Identification and introduction of high value crops (strawberry, cut-flowers, medicinal/ornamental plants, …)**

- **Post-harvest processing and marketing**
  - Conduct value-chains studies for selected species (pistachio, saffron, walnuts, …);

Targeted species for focus Fruit trees: Grapes, apple, cherries, apricot, almond, pistachio, plum, prunes, walnuts, olive, fig, strawberry, Medicinal plants: Saffron, Rosa, Vegetables: Consult with AVRDC and private sector

Benchmark sites Iran: Karaj and Shahr Kord; Turkey: Isparta ; Morocco: Meknes; WA: Aarsal or Ajloun or Sweida; Pakistan: ; CAC:?

Main research areas for the rangelands and livestock-based system

- **Determination of suitable forage and range species**
  - Identify and promote adapted forage species

- **Characterization of native livestock breeds suitable for highlands**
  - Use of molecular markers for genetic diversity analysis;

- **Development of alternative feed sources and supplementary feeding (nutrients, vitamins, Minerals..)**
  - Develop guidelines and databases for utilization of crop residues and agricultural by-products in feeding calendars

- **Integration and promotion of honey bee production**
  - Develop and disseminate technological packages for income diversification of small holders

- **Study the performance and management of livestock**

- **Development and adoption of proper livestock breeding strategies**
  - Promote and up-scale of community-based breeding of small ruminants

- **Determination of prevalent diseases and promoting suitable prevention measures**
  - Availability of vaccines on proper time

- **Socio-economic studies of livestock management with particular emphasis on nomadic societies**
  - Survey of livestock management in the nomadic and transhumant systems

- **Local processing of livestock products**
  - Value-chain analysis of target livestock (meat, dairy, fibre, etc,)

- **Provision of market studies of animal products**

- **Testing the adaptation of introduced breeds**

- **Management of livestock in highlands**

- **Integrated management of crop/rangeland/livestock in highlands**
  - Study the different institutional and policy options for rangeland management and rehabilitation across the highlands
  - Grazing management and analysis of trade-offs of crop-residues for better crop/livestock integration

▪

Targeted species Sheep, goat, cattle, bees

Benchmark sites, Iran: Shahr Kord and Golpaygan; Turkey: Ankara and Erzurum; Morocco: Boulmane; Pakistan: Loralai; Afghanistan and, CAC

- **Cross cutting themes and activities**
  - Analysis of value-chain and marketing;
  - Climate forecasting and drought preparedness;
  - Access to credit, inputs
  - Characterization of biotic and abiotic stresses
  - Conservation of genetic resources
  - Capacity building including Degree (MSc, PhD) and non-degree (Post-doc, Sabbatical etc.) training,
  - Involvement of private sector
  - Strengthening networking and regional collaboration (exchange of visits, Conferences, regional and international meetings)