Land cover change and prediction in Bamyan, Afghanistan

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List of abbreviation

CIS	Commonwealth of Independent States
GLADA	Global Assessment of Land Degradation and Improvement
UNDP	United Nations Development Program
GLASOD	Global Assessment of Human-induced Soil Degradation
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nation Environment Programme
NDVI	Normalized Difference Vegetation Index
MRRD	Ministry of Rural and Rehabilitation and Development
USAID	United States Agency for International Development
BWk	A cold desert climate
MAIL	Ministry of Agriculture, livestock and Irrigation
NEPA	National Environmental Protection Agency of Afghanistan
CPR	Common Property Resources
CDC	Community Development Councils
GIS	Geographic Information System
GPS	Global Positioning System
NGO	Non-governmental Organization
VISIT	Vegetation Integrated Simulator for Trace Gases
DEM	Digital Elevation Model
ANDMA	Afghanistan National Disaster Management Authority
AKDN	Agha Khan Development Network
MLC	Maximum Likelihood Classification Method
MODIS	Moderate-Resolution Imaging Spectroradiometer
RGB	Red Green and Blue
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
ENVI	Environment for Visualizing Images

DAIL	Department of Agriculture, Irrigation, and Livestock
UA	user accuracy
PA	producer accuracy
OA	overall accuracy
Kappa	Kappa coefficient
FAO	Food and Agriculture Organization
NEP	Net Ecosystem Production
GPP	Gross Primary Productivity
CLCN	Global Land Cover Network
GLS	Global Land Survey
SRTM	Shuttle Rader Topography Mission
HWSD	Harmonized World Soil Database
ECMWF	European Centre for Medium-Range Weather Forecasts
NCEP US	National Center for Environmental Prediction
T_0:	temperature of representative point
T:	temperature
H_0	elevation of representative point
H	elevation
d	dew point
r	atmospheric density at representative point
h	specific humidity
r_{Ed}	daily accumulated solar radiation calculated from ECMWF 12 hours data.
r_{Nd}	daily accumulated solar radiation calculated from NCEP hourly data.
r_{Nh}	hourly accumulated solar radiation of NCEP
r_h	hourly accumulated solar radiation in representative point
d_f	ratio of diffuse solar radiation
S_{top}	Solar radiation at top of atmosphere
ϕ	latitude

δ	declination
k	Julian day
S_{ECMWF}	solar radiation at surface (ECMWF/NCEP data
S_{direct}	direct solar radiation at surface
$S_{diffuse}$	diffuse solar radiation at surface
S	solar radiation at each grid cell
v	normal vector of surface at each grid cell
u	vector of solar radiation
e_3	unit vector for z direction

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学 位 論 文 要 旨

Land cover change and prediction in Bamyan, Afghanistan

(バーミヤンにおける土地被覆変化と予測)

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Afghanistan is inland mountainous country, basically semi-arid to the desert. Long years of anthropogenic activities and lack of land management have resulted in environmental problems such as overgrazing, de-shrubification, deforestation, soil salinization, water pollution, climate change, biodiversity loss, flood and soil erosion. Land degradation is critical problem of which 16% of the territory is severely affected by human activities. Over three decades of conflict and the destruction of the traditional and institutional system resulted in heavy pressure on its environment. Information on land degradation and land cover change are sparse in Afghanistan, and no research has yet been focused specifically on Bamyan. To improve the situation, it is required to disseminate science-based information among farmers, officers, and planners. It will contribute to providing significant understanding, especially when adopting regional and national policies of land use in marginalized communities in Afghanistan, to maintain the ecosystem services which have been strongly damaged. Considering the needs, objectives of the study were to assess the spatial and temporal land cover changes, prediction of future land cover changes and land degradation. This study is conducted in Bamyan province of Afghanistan.

Firstly, the study assessed the spatio-temporal changes in land cover in Bamyan from 1990 to 2015 and lack of land management. To achieve this goal, an inclusive fieldwork survey was conducted in the study area. 97 questionnaires were completed of which 88 persons specified that in recent 30 years land cover had changed due to population rise, overuse of natural resources, overgrazing, shrub collection, frequent drought and lack of management. A semi-structured interview with the governmental and non-governmental organizations (NGOs) was also done and verifying the verity of the critical problems such as land covers changes and land degradation. Also, land cover maps were prepared by applying Maximum Likelihood Classification (MLC) method from Landsat images of 1990, 1999, 2008 and 2015. Grid cell process with unique cell IDs was defined which enabled quantification of spatio-temporal changes in land cover categories. A significant land cover change has occurred showing the rangeland area declined from 60.2% to 37.9%, similarly the bare soil rapidly increased from 31% to 52.2% and the built-up area has increased from 0.9% to 1.5%. The statistical assessment of land cover in 0.81 km^2 Grid square cells specified a reduction in rangeland having a negative strong correlation with that of bare soil increase. Furthermore, the growth of built-up areas showed strong positive correlation with plantation areas and negative correlation with bare soil around Bamyan city. Based on the results, from 1999 to 2015 the socio-economic changes have caused the land cover change around Bamyan city and from 1990 to 2015 the land cover in Bamyan has changed due to over-use of natural resources and lack of management.

Secondly, prediction of future land cover changes and land degradation were performed by the ecological model of Vegetation Integrated Simulator for Trace gases (VISIT). The VISIT model simulates Leaf Area Index (LAI) as well the land degradation prediction from the production of fodder and bushes. The LAI change and land degradation hypothetical scenarios were simulated for the years until 2050. The scenarios called S0, S1, S2, and S3 while S0 simulates constant fodder and bush collection, S1 simulates fodder and bush use increase as population increase ratio, S2 and S3 shows 2% and 3% reduction per year for S1. The maps were prepared from applied scenarios for LAI, S0, S1(2030, 2040, 2050), S2(2030, 2040) and S3(2030, 2040) and the maps of land degradation produced based on applied scenarios for S1(2030, 2040), S2(2030, 2040) and S3(2030, 2040).

Thirdly, extensive fieldwork surveys with 56 local people, governmental organization, NGOs were conducted. The results of land cover maps, the predicted LAI, and land degradation maps were presented them to facilitate understanding of science-based information and it affected their understanding of land cover change and degradation areas. Moreover, 32 questionnaires were completed without sharing the maps and result of each questionnaire was compared and shows

slight differences in people perception. The people who saw the result has more concerned about land cover changes and land degradation, and people who did not see maps show less concern. Consequently, it is suggested to limit the bush collection and maintain the rangeland by supporting local people through awareness, establishing alternatives, having effective programs and management policies, applying the integrated and participatory method of natural resource management to limit land cover change and land degradation.

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Chapter 1

Background

1. Introduction

Afghanistan is a landlocked country of plain and mountains, over three-quarters of the land is mountainous. More than one-quarter of the national territory lies above 2,500 m. It is strategically located at the crossroads of three main regions: the Indian sub-continent to the east, Central Asia to the north and the Middle East to the west. Afghanistan's neighbors are the landlocked Commonwealth of Independent States (CIS) countries (Turkmenistan, Uzbekistan, and Tajikistan) to the north, Pakistan to the east and south, the Islamic Republic of Iran to the west and China to the northeast Figure 1.1 (Favre and Kamal 2004).

Geographically Afghanistan lies between 29° and 38° N and 61° and 75° E, and essentially semi-arid to the desert (Thieme and Suttie 2006). Based on Palka (2001) Afghanistan is dominated by rugged, mountainous terrain. The massive Hindu Kush Mountains form a barrier between the Northern provinces and the rest of the country. This mountain range divides Afghanistan into three distinct geographic regions: The Central Highlands, the Northern Plains, and the Southwestern Plateau.

The climate of Afghanistan is one of the extremes and with a considerable variety of microclimates. Climate is influenced by high altitudes together with the continental with big differences in temperature from day to night, from one season or region to the next and ranging from 20-40°C in summer in the lowlands to minus -20- -40°C in the winter in high-lands. The higher mountains of the east are permanently snow-covered and the considerable areas above the 2,500meter contour suffer from long winters of six months (McLachlan 2007 and UNEP 2008).

The temperature in Afghanistan differs broadly due to topography. Altitude has a high effect on temperature, air temperature decreases as elevation increase as a function of the environmental lapse rate, which averages about 6.5°C per 1,000 meters of elevation. Hindu Kush mountains dominated much of Afghanistan and the altitude must be considered wisely. With peaks exceeding 5,000 meters, this mountains temperature may differ by 10°C to 20°C over comparatively small horizontal distances. The quantity of incoming solar energy or insolation that Afghanistan receives is mainly a function of its latitude. Between 29° and 38° north latitude, Afghanistan lies just north of the subtropics. The high amount of energy is receiving in summer when the northern hemisphere is tilted towards the sun and periods of daylight are longer. Therefore, it results in warm temperature with daily maximum temperature all over the country frequently above 38°C. Moreover, this high level of insolation generates high possible evapotranspiration rates affecting the availability of soil moisture. Furthermore, winter insolation is significantly less as the sun is lower on the horizon and subsequently the day lengths are shorter, in cooler temperatures (Palka 2001). Climate greatly influences a mass of environmental events such as vegetative growth, soil construction, watershed hydrology, geomorphic denudation, as well influences human activities such as agricultural practices.

Afghanistan highly under pressure, nearly half of the population are very poor or susceptible to extreme poverty. Around 80% of Afghanistan people live in rural area and their livelihoods reliant on natural resources. Years of conflicts and droughts negatively impacted the farmlands, rangelands, forests and water resources. The people traditional coping methods have been damaged by soil degradation, deforestation, unsustainable land use practices, military action and long-lasting insecurity of livelihoods (USAID 2010).

From a total land area of 65 million hectares, only 12% is arable, forests mate up 1.3% of the country total land area, and deforestation taking place in a rate of 3% per year and rangeland occupy about 30 million hectares, roughly 45% of Afghanistan territory. But agriculture resources have been under considerable pressure with the increasing population and refuges return (MAIL 2006, USAID 2010 and UNEP 2008).

Rangeland degradation in arid and semi-arid landscapes in the reasons that lead to degradation have been of concern and debate between range scientist for several periods. According to estimation world's rangelands, 10%-20% are already degraded, and the major causes of degradation are overgrazing, fuelwood collection, dryland agriculture and lack of government policies and regulations. The countries facing conflict or post-conflict uncertainty are in more complex conditions because traditional and historic, community-based natural resource management practices may not and even exist, or may disrupt by new multiple challenges (Jacobs et al., 2015 and Shroder 2012). Afghanistan rangelands are an especially valuable resource as that supporting animal husbandry, provide vital food, fuel, medicinal plants, and habitat for wildlife, which collectively from the natural resource base that supports the big number of country population. Unlikely, overgrazing, conversion of rangeland to rain-fed agriculture, fuelwood collection and overuse of resources has resulted in the decrease of rangeland productivities and heavy land degradation, as well resulted in extensive desertification (NEPA and UNEP 2015).

Land degradation remains a global environment and development problem. For policy support and action plan for economic development, environmental integrity, food, and water security and resources conservation up-to-date information are required. To meet this need, the Global Assessment of Land Degradation and Improvement (GLADA) used remote sensing to recognize degraded areas and areas where degradation took place or reversed. Economic development, growing cities, and growing rural populations are driving record of land-use change. On the other hand, unsustainable land use and long loss of ecosystem function is the cause of land degradation. Its symptoms include soil erosion, nutrient depletion, salinity, water scarcity, pollution, disruption of biological cycles, and loss of biodiversity (Bai et al., 2008).

Figure 1.1. Overview of Afghanistan (UNEP 2015)

1.1 land degradation

Land degradation, due to its contrary impact on agronomic productivity, the environment and its effect on food security and the quality of life will remain an important global issue for the 21st century. Land degradation is a concept which by one or more combination of human-made procedures acting upon the land and it impacted the value of the biophysical environment. As well it closely states the loss of natural quality of soil component of any ecosystem (Eswaran et al., 2001 and Eni 2012). Land degradation includes the decrease of the physical, chemical and biological condition of land which may lead to restriction of land productive abilities and it included soil degradation and vegetation losses such as reduction of plant density, structure, species and decrease on plant cover productivity. Land degradation similarly is a treat to ecosystem services such as provisioning services of the landscape (e.g. timber, food etc.), cultural services (e.g. recreation) and regulation services such carbon cycling and by supporting services for example nutrient cycling (Grainger 2015).

Land degradation takes several types, counting depletion of soil nutrients, salinization, agrochemical pollution, soil erosion, vegetative degradation because of overgrazing, and clearing forest area to farmland. The kinds of degradation cause deterioration in the productive capacity of the land, reducing potential yields. To maintain the lands yields farmers, need to prepare more input supply such as fertilizers or manures or may stop the cultivation of some plots temporarily or permanently. On the other hand, degradation may bring pressure to convert land to lower-value uses such as converting cropland to grazing land (Scherr and Yadav 2001).

According to Shrestha (2011), only 11 percent of the worldwide land surface can be recognized as major land to feed growing world population the problem of land degradation is a key concern for food security and the quality of the environment. Land degradation refers to land that lost their economic function and the original natural ecological function due to natural processes or human activities such as deforestation, unsustainable agriculture practices, overgrazing. Land degradation happening in numerous courses and forms, like soil erosion due to water and wind, physical decline (compaction, sealing), chemical deterioration (soil productivity loss, salinization, acidification), and vegetation degradation. Land degradation, through a variety of direct and indirect process, has a various and complex impact on ecosystem role and environment services which eventually influence peoples' livelihood through reduced ecosystem function like reduction on productivity, flooding, sedimentation, or through pollution of the ecosystem such as contamination of soil and water.

Land degradation exposes itself in various ways. Scarce of vegetation that provides fodder and fuel, water courses dry up, soils become cracked and stony and rich pasture loss its palatable plants. These indicators have possible sever influence for land users and for those who depend on for their living on the goods from a healthy landscape. People may have a different perception of land degradation. For instance, a woman involved in fuelwood collection and fetching water will have worries about the shortage of these natural resources and the burden to travel a long distance to access them. A herder of livestock in the same village will have worries about the pasture. Therefore, there are diverse perspectives on a local society which need to be reflected in any filed level assessment of land degradation (Micheal and Murnaghan 2000).

The estimations of the global extent of land degradation illustrate that Europe is the lest impacted and Asia has very affected and followed by Africa. United Nations Development Program (UNDP) estimates $42 billion in revenue and 6 million hectares of fertile land are lost every year. It is projected that 2.6 billion people are impacted by land degradation and desertification in more than a hundred countries, influencing over 33% of the earth's land surface (Barman et al., 2013).

Global Assessment of Human-induced Soil Degradation(GLASOD) based on the experts' impressions, estimates that nearly 2 billion hectares globally (22 % cropland, pasture, forest, and woodland) have been degraded since mid-century. From 2 billion some 3.5 percent approximated to be severely degraded, which reversible only by the high cost of engineering measures. 10 percent has been moderately degraded this degradation can be recovered by major on-farm investments. Of the approximately 1.5 billion hectares of cropland universally, about 38 percent is degraded to some degree. Asia has the maximum percentage of degraded forestland; Africa and Latin America show the greatest proportion of degraded agricultural land. Several sources comment that 5 to 10 million hectors of land are under severe degradation annually. If this trend remains the same, 1.4 to 2.8 percent of entire cropland, pasture, and forestland will be lost through 2020 (Scherr and Yadav 2001).

Land degradation defined by UNCCD as "Reduction or loss of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (1) soil erosion caused by wind and/or water; (2) deterioration of the physical, chemical and biological or economic properties of soil; and (3) long-term loss of natural vegetation" (UNCCD 2012).

According to UNCCD (2012), The major source of land degradation and desertification is the unsustainable misuse of land production by pastoral, farming, and agro-pastoral land uses. This condition worsened by unwise or absence of policies. Overpopulation and livestock are frequently understood as the drivers of land degradation and desertification. Nevertheless, they are eventually the significance of poor decisions and mishandling. For example, livestock is commonly stated the main cause of overgrazing leading to desertification, but with suitable management methods, livestock itself can become an important part of the solution.

The causes of the degradation can be either natural or human. The natural causes comprise earthquakes, tsunamis, droughts, avalanche, landslides and mudflows, volcanic eruption, flood, tornado, etc. the research showed that the direct impact of the earthquake on the land degradation and affected the agriculture in historical time has led to an extreme change in agriculture for a few years. Drought is another reason, but quantifying drought impact is very difficult in comparison to another natural disaster such as tsunami or hurricanes. The impact of the drought is different from region to region even though, they are the same in intensity, duration, because of change in social characteristics. On the other hand, soil loss its structures aggregation due to drying of topsoil and this drying of topsoil can easily be blown away because of wind and rain.

Numerous human actions cause land degradation directly or indirectly, include deforestation, overgrazing by livestock, irrigation practices, urban growth and commercial development, contamination from industries, extracting, and mining activities. The indirect activities include pressure on agriculture intensification and population growth (Barman et al., 2013). Faster land degradation is usually caused by of human influence in the environment. The properties of this interference are determined by the natural landscape. Besides the aforementioned wide classes, varied diversity of distinct causes is combined. These causes can be the conversion of inappropriate low potential land to agriculture, the failure to undertake soil conserving measures in areas at risk of degradation and the removal of all crop residues resulting in soil loses its nutrients at a rate greater than resupply. They are enclosed by social and economic conditions that encourage land users to overgraze, over-cultivate and deforest (Michael and Murnaghan 2000).

A basic estimation of the annual cost of soil erosion in the world cost around US$26 billion, and as stated by UNEP, about half of this cost was borne by developing countries. A decade later, proposed US$28 billion per year as the cost of dryland degradation. The Global Assessment of Human-Induced Soil Degradation (GLASOD), was the first worldwide relative analysis to attention specifically on soil degradation is based on an official survey of regional experts. While GLASOD was intended to deliver continental estimates of the degree and severity of degradation from World War II to 1990, and finally, the study result concluded that from 1.9 billion hectares 23% of the worldwide used land had been degraded (Scherr 1999).

According to Oldeman (1992), two classes of human-induced soil degradation processes were documented. The first class draw attention to soil degradation by movement of soil material and the two main types of soil degradation of this class are water erosion and wind erosion. The dislocation of soil material will lead to off-site effects such as reservoir, harbor or lake sedimentation, flooding, river bed filling and river bank erosion, the disproportionate situation of the basin land, coral shellfish beds and seaweed destruction are all the cases of water erosion off-site effects. the wind erosion off-site effects are an invasion of sand sheets on roads, buildings and plants cover. The second class of soil degradation deals with major soil physical and chemical deterioration. In this class, only on-site effects of soil degradation recognized that has been unrestricted or is forced into less intensive usages. It does not mention to cyclic fluctuations of soil chemical and physical circumstances of comparatively stable agricultural systems, in which the soil is actively managed to continue its productivity, nor to gradual changes in the chemical composition because of soil forming processes. The (Table 1.1) shows different soil degradation types belong to these two classes.

Table 1.1. 12 types of soil degradation and each degradation type is characterized by a symbol

W: Water erosion	**E**: Wind erosion	**C**: Chemical Deterioration	**P**: Physical deterioration
Wt; loss of topsoil through is a common type of soil degradation and it is known as the surface was or sheet erosion.	**Et**: loss of topsoil This degradation type is defined as the uniform displacement of topsoil by wind action. It caused by loss of vegetation cover, either due to overgrazing or removal of vegetation for domestic use or for agricultural purposes.	**Cn**: Loss of nutrients and/or organic matter: When agriculture is partied on poor or moderately fertile soil soils, with no sufficient application of manure or fertilizer. It origins a general depletion of the soils and leads to decreased production	Pc: Compaction, sealing and crusting
Wd: terrain deformation/mass movement: the greatest phenomena of this degradation category are rill and gully creation.	**Ed:** Terrain deformation: It is challenged as the rough displacement of soil material by wind action and leads to depression hollows and dunes	**Cs**: Salinization: Human-induced salinization can be the result of three causes. Firstly, the result of poor management of irrigation systems. A high salt content of the irrigation water or too little attention given to the drainage of irrigated fields can lead to salinization of the soils. Secondly, salinization will occur by using saline ground-water. A third type of salinization occurs where human activities lead to an increase in evapotranspiration in soils on salt-containing parent material or with saline ground-water	**Pw**: Waterlogging It includes flooding by river water and submergence by rainwater caused by human intervention in natural drainage systems
	Eo: Overblowing: defined as the coverage of the land surface transported by wind as particles	**Ca**: Acidification **CP**: Pollution such as industrial, waste accumulation, chemical uses, oil spills etc.	**Ps**: Subsidence of organic soils as caused by drainage and/or oxidation, is only recognized if the agricultural potential of the land is negatively affected

In GLASOD the status of soil degradation is an appearance of the severity of process and it is characterized by the degree, which soil is degraded in relation to change in agriculture suitability, productivity declined, and some cased in relative to its biotic functions. The four level of soil degradation are shown in Table 1. 2.

Table 1.2. level of soil degradation

Light	Moderate	Strong	Extreme
The terrain had slightly lost it agricultural suitability, nevertheless is suitable for use in local forming systems. By adjustment of the management system, restoration for full productivity is possible. As well the original biotic functions are mainly unbroken.	The land significantly lost it is agriculture productivity ability, but still suitable for use in local farming systems. Key achievements are obligatory to restore the productivities.	the original biotic functions are greatly destroyed and the terrain is non-recoverable at the farm level. A high engineering works are required.	The land is irreclaimable and beyond restoration. Original biotic functions are entirely demolished.

Source: Oldeman (1992)

The term 'soil degradation' indicates a social problem. Only environmental processes like leaching and erosion occur with or without human intrusion, but for this process to be defined as degradation suggest social criteria which relate land to its actual or possible uses. Therefore, the correlators were asked to specify what kind of physical human interference has caused the soil to be degraded. Then the bellow causative factors are given:

f: Deforestation and removal of the natural vegetation for a different purpose.

g: Overgrazing and other effects livestock such as trampling and as well it will increase the water and wind erosion hazard.

a: Agricultural activities this causative factor demarcates the improper management of agricultural land.

e: Overexploitation of vegetation for domestic use such as vegetation for fuelwood, etc. which the land cover is removed and the remaining vegetation does not anymore provide enough protection to soil erosion.

i: (Bio) industrial activities, this usually leads to degradation type `Cp: pollution` in the GLASOD wastelands are recognized which, historically or recent natural processes have turned these lands into a wasteland without considerable vegetative cover or agricultural potential. The following types are recognized:

D: active dunes

Z: salt flats

R: rock outcrops A deserts

I: ice caps

M: arid mountain regions

Afghanistan, due to its socioeconomic and geographical conditions has been strongly affected by land degradation for decades. This in succession is a contributing factor to increased ecological migration and additional pressure on the ecosystem. Extensive indicators elaborate that the cost of desertification to Afghanistan is huge and continuously increasing. The soil fertility is being highly decreased due to poor agricultural practices. The grazing patterns have changed because of conflicts and drought, and have impacted traditional grazing patterns, silting and flooding. Afghanistan same as other developing countries, there are various direct and underlying causes of land degradation. As well it complicated by insufficient national policy, infrastructure, resources, and governance, in addition to the sense of social unrest that demonstrates periods of war and conflicts (UNEP 2008).

United Nation Environment Program study showed that forests of Afghanistan have been reduced by an average of 50 percent since 1978. With the loss of forest and vegetation, overgrazing, rain-fed agriculture in dry-land and high steps, soils are being uncovered to serious erosion from wind and rain. Similarly, the productivity of land base is decreasing, driving people to move from rural to urban for seeking employment and food (UNEP 2003).

As stated by (Bai et al., 2008) Land degradation may be defined as a long-term loss of ecosystem function and productivity caused by disturbances from which the land cannot recover unaided and is measured in terms of net primary productivity using the normalized difference vegetation index (NDVI) as a proxy. Based on this analysis, 7,658 km² of Afghanistan's land was degraded between 1981 – 2003 resulting in a loss to 62,859 tons of carbon suggesting very generally that Afghanistan's ecosystems are losing the capability of delivering goods and services.

According to (Shroder 2014) the natural ecosystems of Afghanistan have been heavily degraded except for a few inaccessible or uninhabitable areas in general, any area within reach by shepherds and hooved animals is commonly overgrazed, as well as exploited for fodder plants and uprooted shrubs for fuel that are transported offsite and caused land degradation. This also applies to remote deserts, as well as the high mountain valleys and alpine meadows that are used seasonally as rangeland.

Most of Afghanistan appears to be subject to some degree of land degradation. Based on a global assessment of soil degradation (GLASOD) around 16 percent of Afghanistan's land area is unkindly impacted duet to anthropogenic activities, and Figure 1.2, shows the causative factor of land degradation of Afghanistan. while this country vulnerable to desertification is one of the highest in the world (3/4 of Afghanistan is vulnerable to desertification). Afghanistan geological, topographic and climate feature naturally increase the country vulnerability to the processes of soil erosion. Although, human activities occasionally have worsened them by farming of steep slopes, deforestation, de-shrubification of land and unsustainable use of bush and grasslands. Some degradation is so severe that recovery is impossible without human intervention (UNEP 2008).

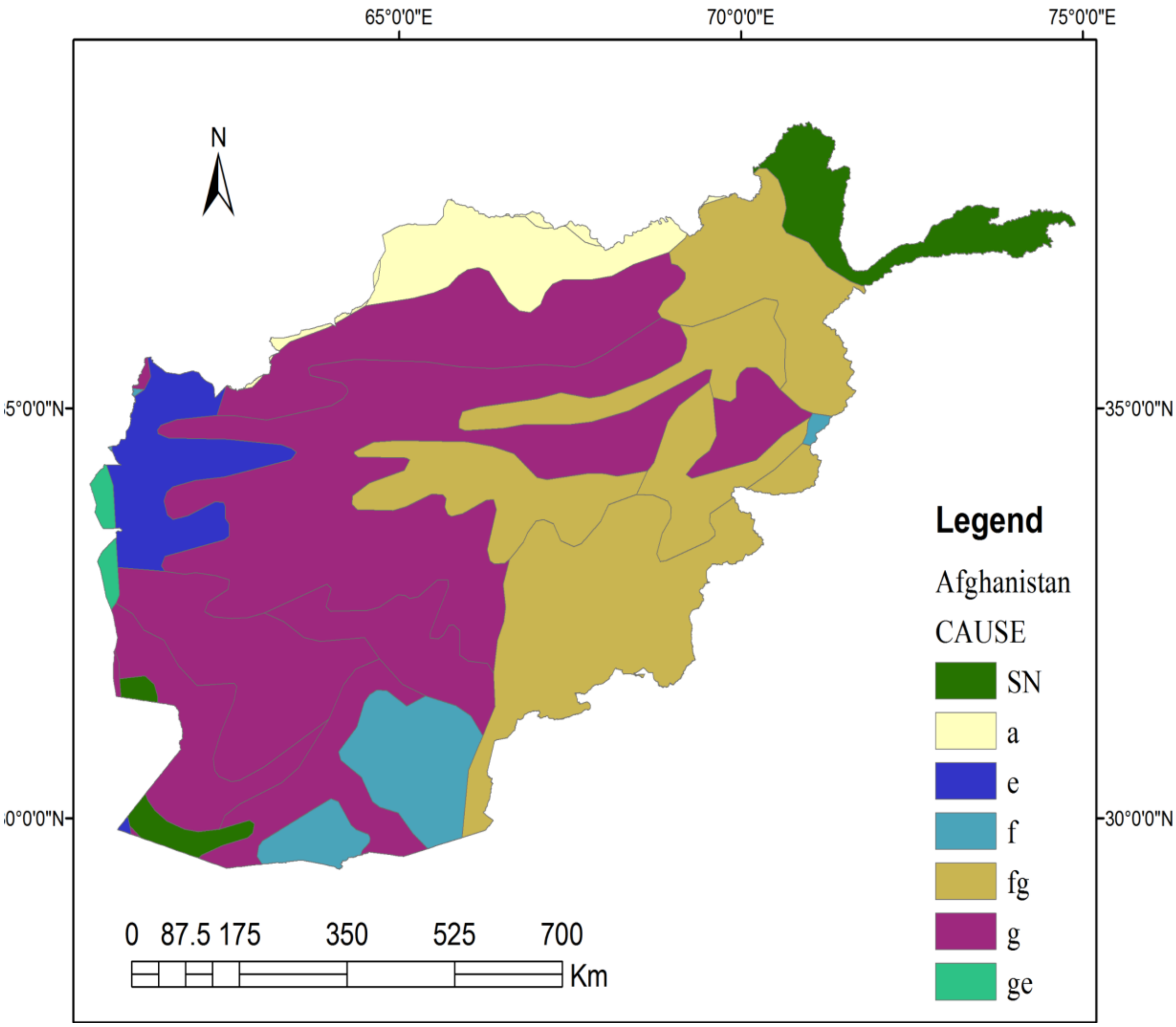


Figure 1. 2. Causative factor of land degradation of Afghanistan based on GLASOD

1.2 Bamyan Province

Bamyan province lies in the central highland of Afghanistan between 33.91-35.48 degrees of latitude and 66.28-68.28 degree of longitude (Figure 1. 3) with the Hindu Kush mountain range that crosses Afghanistan from the northeast to southwest with an extension of 1920 km in the Koh-i-Baba mountains range, with an altitude ranging from 2,000 to 5,000 m. The Province is surrounded by eight other provinces, namely: Baghlan in the northeast, Parwan, and Wardak in the east, Ghazni in the southeast, Daykundi in the southwest, Ghor in the west, Sari Pul in the northwest and Samangan in the north. The Province is administratively divided into 8 districts, from northeast to southwest: Kahmard, Sayghan, Shibar, Bamyan Center, Yakawlang number 1 and Yakawlang number 2, Panjab, and Waras. This 8 administration districts of the province cover 18,292.25 km^2 of which 968.0828 km^2 are used for agricultural purposes. According to general topographic information of Bamyan province, 93.6% of the area is mountainous (77.5 percent is mountainous area and 16.1 % semi-mountainous area (MRRD 2013, Wily 2004 and USAID 2008). Bamyan province is highly mountainous and lowest agricultural productive areas in Afghanistan. Much of Bamyan land is barren and inaccessible, with sever water deficiencies, small landholdings, widespread food insecurity, the soil quality is poor in most of the region. On the other hand, the mineral assets are not well surveyed in Bamyan. The coals mines in the Kahmard and Yakawlanong districts exist, but the possibility to provide help for economic growth is limited, through the illegal excavation and transportation of coal from these mines. There are very remarkable deposits of Iron Rocks in Haj-e Kak area, of Bamyan. Generally, there is the potential of minerals and stone that may offer the main contribution to the economic development of Bamyan in the future (MRRD 2013).

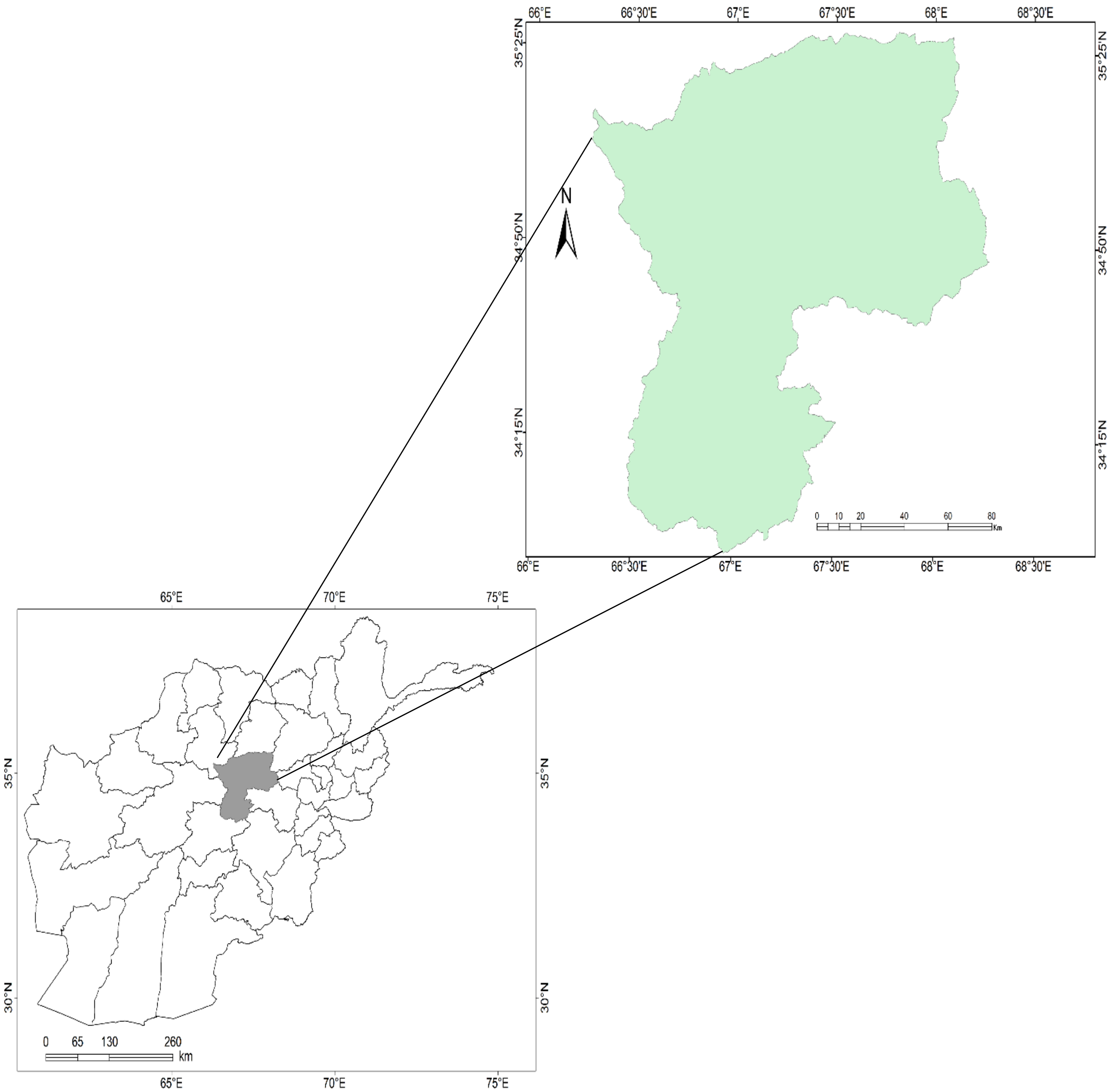


Figure 1. 3. Map of Bamyan, Afghanistan (UNEP 2015 Afghanistan International Borders)

1.2.1. Bamyan Climate

Afghanistan by a great annual range belongs to the continental climate zone. As stated that Afghanistan is the dry zones with a desert climate (BWK) in Koppen classification climate. The central part of the country is in the semi-arid zone with a steppe climate (BSK) with surrounding areas. The Bamyan province is fit into the desert climate (BWK) (MRRD 2013 and Gan and Ping 2017).

As stated by Cook (2012) the Bamyan province is categorized as dry, mountainous climate by high partiality for microclimates and the Baba (Koh-i-Baba) and Hindu Kush mountain ranges made up by numerous steep valleys. The highest place in the Bamyan province is Foladi peak (Shah Fuladi) which has a maximum height of 5,029 m, but most of the province is above 2,000m elevation with significant areas positioned above 4,000m. Across all area of the province exist high spatial inconsistency in climate. There is lack of detailed climate data, the few records existed and that highlights two outstanding features of the annual climatic conditions. Firstly, strong cold periods in winter which air temperatures usually do not exceed -5°C during the day, on the other hand, minimum air temperatures below −20°C are common. Secondly, in summer months' large diurnal temperature differences are recorded and daily temperature ranges may exceed 20°C. While Bamyan province is not as hot as the low land of Afghanistan and the mean annual daily temperature is 7°C. In the Bamyan, summer days are warm and infrequently reaching hot in temperature. The existing data show the highest recorded air temperature in Bamyan was 38.3°C. Nevertheless, the temperatures in Bamyan not often exceed 30°C on summer days. The most challenging time is winter where air temperature can go down as low as -20°C and the lowest temperature was recorded in January 1978 in Bamyan was -31°C. As stated by historical records, the temperature in Bamyan may vary greatly within a single day and highly variable between day and night (MRRD 2013 and Cook 2012).

Based on MRRD (2013) record of AGROMET from 2003 to 2012 the whole province of Bamyan in average rainfall was 213.2 mm. The annual volume of rainfall by district and the amount of rainfall was classified into small (less than 150mm), medium (less than 250 mm) and large (more than 250mm). based on this the districts of Panjab and Waras located in the south of the province the amount is large, the district of Yakawalong and Kahmard situated in the north to the center-west the volume is medium and the districts of Shiber, Sayghan and Bamyan center positioned in center-east of the province the amount is small. The highest amount of the precipitation in Bamyan is falling as snow. The snow melts from surrounding mountains in spring and early summer increase the river discharge in the valley bottom and increase air moisture. This plays a part in increased atmospheric uncertainty and storminess in forthcoming summer months' result in warmer air masses. The precipitations as rainfall occur at the annual minimum in summer with isolated thunderstorms. The thunderstorm movement is recorded higher in the months of April and May, by an average of two to three days per month. In June, the thunderstorm movement drop to an average of one-day storms per month and the remaining of the year is characteristically no storms.

The light snow falling starts in late September with an average of one-day snow per month it gradually increases from October onwards, enriching precipitation in the area. The number of snowfall day occurrence is greater amongst January and March with 10-11 days to each month. In this time of the year, the snow depth in around Bamyan town probably is as much as 1m, while in general, the average depths are more than 0.8 m (Cook 2012). As stated by MRRD (2013) average snowfall in the whole province of Bamyan is around 107 cm and the highest volume of rainfall and snowfall occur in Panjab district in around 250 cm and following that Shibar district in about 150 cm annually but the snowfall is less in the districts of Kahmard, Syghan, Yakawlang, and Bamyan center where the volume is less than 100 cm annually. There is not exist record for the district of Wars but situated in the elevation of lower than Panjab and it estimated between those of the Yakawlang and Shiber districts.

There are six river basins in Bamyan province specifically: Kunduz basin, Balk Ab basin, Helmand basin, Ghorband wa Panjsher basin, Khulm basin and Upper Hari Rod basin. The main basin in this province are classified as the Kunduz basin in the north, Balkh Ab basin in the center and the upper Helmand basin the south. The Kunduz basin is shaped through three rivers, and they are the Surkhdar river that flows down from the west of Bamyan center district to Shibar distract and it is headwater covering an area of 8,862km^2 account for the 50 percent of the entire area of Bamyan province. The Balkhab river basin tributaries covering 4,123 km^2 and formed by Band-e Amir river of Yakawlang district. This basin accounts for 23% of the entire province. The Upper Helmand basin area is 4,719 km^2 and it accounts for 26% of entire province area. This basin formed by the Qarghajor River in the west and the Sorkhjoi Gelmind River that flows down and both rivers flows towards the east or west, crossing Waras district and join after flowing this district. Between them, the three basins such as Ghorband wa Panjsher, Khulm, and Upper Hari Rod stay very minor, they cover and area of 5 km^2 and account for (0.03%), 18 km^2 (0.10%) and 151 km^2 (0.80) of province total area (MRRD 2013).

1.2.2 Land use in Bamyan

Human has used the land resources of central highland and had an important effect on the area for thousands of years. A major part of silk route passed through Bamyan and it is recognized as that the Bamyan town was settled more than 2,000 years ago. Undoubtedly, people were living in Bamyan and surrounding areas much longer. The Buddha statues of Bamyan which destroyed by the Taliban in 2001 are believed to have been built in the fifth century AD. Alexander the Great was in Afghanistan 2,300 years ago, and there is no question that people used the land for thousands of years (Bedunah et al., 2010).

People have been using the land of Bamyan for thousands of years as an essential humanized landscape which existing and historic anthropogenic activity is an essential part of the management of the environment. The land use practices comprise of settlements, irrigated and non-irrigated (rain-fed) cultivation, livestock grazing, fodder collection, shrub collection for fuel, hunting and collection of plants for food and medicine. The villages and rural community situated along drainages and river originating and stream sites and houses are commonly built on valley slopes, whereas the valley bottom which is more productive kept for agricultural practices and tree plantations (MAIL and NEPA 2014).

As stated by USAID (2008) from the total land area of Bamyan 4.5 % (82,963 hectares of land) mostly along the Bamyan rivers basins where the soils are more fertile, and the cultivated area is concentrated in those ranges. There is lack of statistical data that concerning the use of remaining 95.5% of the land, nevertheless, it is supposed they consist of natural meadows, built up area (urban) and steep mountain area without vegetation. As stated by MRRD (2013) the Bamyan province physical terrain limits the possible extent of landholding capacity. On the other hand, the population growth pressures in recent years have the consequences of the additional downgrading of farmland. About 70% of the land in Bamyan Province is owned privately, although 10% is common property resources (CPRs), and government-owned 20 percent. The surrounding villages use the common property resources as grazing land and managed by traditional rules which established by local. Currently, there are attempts to transfer the right for using the common property resources to Community Development Councils (CDCs), but in most of the areas are not working appropriately.

According to Central Statistics Organization (2012) in Bamyan Province 76.3% of household owned agricultural land. In comparatively from all district of Bamyan the household in the provincial center (61%) and Panjab district (68.5%) they owned fewer agricultural land. But the other districts the percentage of household they owned agricultural land, ranged from 77.3% in Yakawlang district to 91.5% in Saighan district. In overall the size of land that farmer-owned is small in compression to other provinces of Afghanistan. The half of all household they owned land, their land is less than five Jerib or 10,000 m^2 (1Jerib = 2,000 m^2).

As a result of the elevation, mountainous landscape, and long winters, the Bamyan region has inadequate agricultural land in comparison to rest of Afghanistan. Based on Agro-Ecological Conditions, Bamyan Province is classified as a mountainous area by an arid climate. Therefore, the shrubs and grasses are the dominant vegetation type and different ecological variations are found in the same districts. The agro-ecological features of the districts, taking into consideration indicated in Table 1.3 and can be characterized into three types: firstly, the Kahmard and Sayghan districts have arid vegetation areas and that remain dominated by Afghan Mountains Semi-Desert. Secondly, districts of Shibar, Bamyan Center and Yakawlang, although have several grassland and vegetation areas as well trees with some orchard found throughout the grassland. Third, the districts of Waras and Panjab are grassland area and influenced by Ghorat-Hazarajat Alpine Meadow environments (MRRD 2013 and UNEP 2008)

Table 1.3. Eco-region by districts in Bamyan Province

District	Eco-region	Altitude (m)
Bamyan center	Ghorat-Hazarajat Alpine Meadow (mountain grassland and shrublands Biome Afghan Mountains Semi-Desert (Deserts and Xeric Shrub Lands Biome)	2500-4000
Yakawlang	Ghorat-Hazarajat Alpine Meadow (mountain grassland and shrublands Biome) Paropamisus Xeric Woodlands (Deserts and Xeric Shrub Lands Biome)	2500-3500
Panjab and Waras	Ghorat-Hazarajat Alpine Meadow (mountain grassland and shrublands Biome) Central Afghanistan mountains Xeric Woodland (Deserts and Xeric Shrub Lands Biome)	2500-3500
Shibar	Ghorat-Hazarajat Alpine Meadow (mountain grassland and Shrubland Boime) Afghan Mountains Semi-Desert (Desert and Xeric Shrub Lands Biome) Central Afghan Mountains Xeric Woodlands (Desert and Xeric Shrub Lands Biome)	3000-4000
Kahmard	Afghan Mountains Semi-Desert (Deserts and Xeric Shrub Lands Biome) Paropamisus Xeric Woodlands (Deserts and Xeric Shrub Lands Biome)	2000-3500

Sources: MRRD 2013 and UNEP 2008

The amount of precipitation is much less than the minimum plant necessity for their growth (300mm). The aspect of controlling the growth of vegetation and crops production is the sum of water accessibility from surface water sources, for instance, rivers, springs, and from groundwater foundations. In respect to the situation the Kahmard district has a high diversity of vegetation and addition to natural grasses and shrubs there are planted fruits trees. In addition, the Kahmard district is in a temperate, arid area, and its topographic situation qualifies collection of water from surrounding areas and consequently resulting in a wide variety of vegetation. The district of Sayghan has limited snowfall in the catchment area and has fewer surface water resources. The district positioned in an arid area but due to climatic condition the vegetation coverage is decreasing and diversity of crops that can be cultivated is limited. Bamyan Center and Shibar districts due to water availability the vegetation diversity is relatively high and the condition for agricultural production is good and irrigation system drawing water from rivers to the fields. Yakawlang district is rich in water resources such rivers and lakes with constant water flow both the natural and plantation diversity is high and meadow and some forest are seen in the area. Panjab and Waras districts are in the mountain zone, even though, these districts have many arid lands and the pasture can be seen in rainy season. The reduction of grassland and shrubland areas, as well as erosion and soil fertility loss, is increased. But the verity of plant and vegetation is high in the area due to topography. In order to preserve the vegetation and farmland, actions for soil conservation and flood protections are strongly recommended (UNEP 2008 and MRRD 2013).

The growing season in Bamyan province is comparatively short in relative to other provinces. Wheat, barley, potato, vetch, and Lucerne are the core sources of fodder and industrial crops. Alfalfa and clover are very valuable and important as fodder for livestock. Bamyan farmers in all districts grow alfalfa, clover, and vetch to feed their livestock. As well, farmers collecting high amount of hay from mountains (rangeland) and hills for winter feeding of animals (USAID 2008, 2006 and MAIL 2006).

1.2.3 Rangeland of Bamyan province

Much of Afghanistan land surface is extensive grazing land, desert, semi-desert or high and steep mountain. There are no statistics on the grazable land area available and it said to be only 40% is suitable for winter grazing. Desert can provide opportunistic grazing when there is precipitation. Afghanistan is the conjunction of numerous vegetation types, the Mediterranean, the Tibetan, the Himalayan and to the Pakistan border is influenced by the monsoon. The main grazing vegetation type is *Artemisia* steppe and its great elevation adds to the diversity of vegetations. Trees are frequently counted as sound indicators of ecological zoning; Afghanistan's forests land been sparse but in the recent year they negatively impacted and it destructed either by local population firewood or through illegal logging for export by warlords (Thieme 2006).

In elevation between 3,600m and 4,000m in the drier central and northern Hindu Kush, there is a cushion bushland with diversity of species of Acantholimon, Artemisia, Astragalus, Cousinia, Ephedra, and Onobrychi. Similar thorny cushion scrublands from mountain ridge to mountain ridge with a high diversity of species composition change are found in many of the central highland mountains of Afghanistan such as Koh-e Bab range.

The Central Highlands area, with a high range of endemic, occur such as subalpine thorny cushions, semi-deserts, alpine semi-deserts and deserts and meadow vegetation with a mixture of several plant formations. On mountain elevations above the tree line at about 3,300 m alpine shrubland, subalpine, alpine heaths, and meadows occur which take often higher percentage cover, and consequently offer a good choice of fodder for domestic animals (Breckle 2007). On the other hand, in the area exist a various mosaic of plant communities, which resemble to various geography and land use of the area. The best distinguished of these plant communities are the alpine rangeland wherever the summer herds are grazed and at that moment the subalpine zone starting down and changing to semi-desert foothills. The cushion thorny tragacanth plant is found in both lower zones and they formulate one of the highest distinctive features of the Central Highlands. Each zone has its own specific plant communities such as those which inhabiting scree slopes, gullies, marshland, and floodplain meadows. Through distribution upward into several levels and integrating with other plant communities through a variety of habitats within their specialized plants, like plateaus which have typical vegetation in the spring, caused by humid soils and comparatively high air humidity to higher temperatures. In these highlands ground cover, could be between 40 percent to 90 percent; in the summer, due to high temperature and water deficiency most of the plants do not survive and plant communities sense of a long history of grazing and human use have developed adaptive strategies to survive through grazing like the *Acantholimon, Acanthophyullum, Cousinia, Eremurus* and *Eremostachys*, communities which dominated the landscape. However, these resilient classes are susceptible to uprooting through collecting for fuel which negatively impacts the plant potential to regrowth and the soil will remain barren without root system which causes soil erosion and loss of topsoil. Rangelands account for 1.3 million ha or 92.4 percent of the whole of Bamyan province and are used extensively for livestock grazing and harvesting of critical plant resources for fuel (NEPA and MAIL 2014).

As stated by Bedunah et al. (2010) rangeland types of Bamyan divided into broad types such as: (1) Artemisia-Acantholimon Steppe, it has been assumed that most of the *Artemisia* steppe of the central highlands was not the natural vegetation and it was originally a grass steppe and by heavy grazing it is converted to an *Artemisia* steppe. Undoubtedly, heavy grazing pressure caused the reduction of grass cover and increased unpalatable species. The productive the Artemisia-Acantholimon steppe, provide a significant grazing resource for livestock and wild animals; the Artemisia steppe community has the abilities to produce the noteworthy amount of forage.

(2) Semidesert Shrub, a semi-desert shrub rangeland: this type is found, at lower elevations (1,925 m to 2,800 m) and on drier features. The combinations of these types are comparatively large unfertile areas with little vegetation.

(3) Juniper Steppe: this community growth forms varying from distribution low shrubs to moderately tall shrubs to large trees. This type was defined as remnant woodland devastated through overexploitation. This kind is significant for aesthetic values and wildlife habitat, in overall produce low to moderate forage for livestock.

(4) Canyon-Bottom Complex: this community often formulates a unique environment for diverse plant community. This type is composite many plant communities through species from mesic woodlands to semi-desert, in its grouped based on location with canyons.

(5) Riparian Shrublands: Along the streams, several shrub-dominated community types are found and these plant communities have the high productivity. This community limited by agriculture crop, intensive livestock grazing, and additional human uses.

(6) Wetlands and Sedge Meadows: grouped into two types and both are generally dominated by sedges (Carex spp.) and arise in sub-irrigated environments. While a small area of these plant communities has higher productivities and it is important as a grazing resource. The wet meadows are frequently together or combined with riparian shrub communities with a high diversity of some species.

Clark (2015) stated that the Bamyan rangeland is vulnerable to over-grazing and over-foraging. Particularly the problem of pulling out of the plant by its root for fuel and plant root is also pulled out and nothing left on the ground for regrowth. It causes degradation of rangeland and it would be a disaster for the local community for long time survival, in addition making extra vulnerable to flooding.

1.3 Research brief (problem statement)

The rate, scale and spatial influence of human changes of land surface are remarkable. Changes in land cover or biophysical attributes of the earth surface and land use or human activities in this surface are very significant. Land use and land cover changes are being extensive universally and they are impacting the key aspect of earth system functioning as well influence the biotic diversity globally and contribute to local and regional and climate change, as consequently as to universal climate change and they are the primary sources of soil degradation (Lambin et al., 2001).

Many landscapes have undergone a dramatic transformation during the past two centuries due to changes in management practices driven by social, political, and economic forces controlling land use (Turner 2005). Globally, transformation processes leading to land degradation will likely become a major policy issue in the 21st century as they have major effects on farmers' livelihood strategies, food security, and environmental quality (Eswaran et al., 2001).

Afghanistan has remained strictly spoiled over the last decades due to the ongoing conflict created by religious radicalism, life-threatening poverty, traditional armed resistance to invasions by foreigners, cultural hostilities, and the absence of regulation, policies and action plans. Eras of human damage to the land and severe impact from three decades of war and extensive corruption with a certain degree of the climatically-stressed desert, steppe, and alpine terrain, have led to the inclusive environmental problem in Afghanistan.

Generally, most of Afghanistan is exposed to some degree of land degradation as stated by the global assessment of soil degradation. In approximation, the 16% of Afghanistan's land area is severely impacted by anthropogenic activities, while the country's vulnerability to desertification is one of the highest in the world. The majority of Afghanistan surface is used as rangeland for grazing livestock and overgrazing is affecting the land in a negative way. On the other hand, soil erosion is also a serious problem due to loss of vegetation cover.

Furthermore, overstocking adversely affect livestock, wildlife and leading to an initial stress on the sensitive mountain grassland ecosystem. These interconnected problems make the land more vulnerable to the effects of recurrent droughts, different natural and manmade event and that impacts the livelihoods of more than 80% of Afghanistan's population. In consideration of the background, the study focuses on following objectives.

1.4 Objectives

In likened to the background the proposed study objectives are as follows:

To assess the spatial and temporal land cover changes, prediction of future land cover changes and land degradation and disseminate science-based information among farmers, officers, and planners. This will contribute and provide significant understanding, especially when adopting regional and national policies of land use in marginalized communities in Afghanistan, in order to maintain the ecosystem services which have been significantly damaged.

1.5 Methods and Material:

Bamyan regions proposed for the study are situated in the Hindukush along the north slopes of the Koh-e Baba Mountains. In the area, natural resources (soil, water, plant, and animal) are most important for the Bamyan people. On the other hand, Shah Folladi mountains feed five of Afghanistan main water catchment and its sustainable management is thus of national importance.

To achieve the objectives the methods are briefly explained:

1- Satellite images are used to make land cover maps; the GIS and remote sensing techniques are used to analysis the changes during conflict and post-conflict from1990 to 2015.

2- For a full determination of the ground truth situation, field-work conducted across the study area from mid-July to mid-August of 2015. Throughout the field survey, photos were taken for ground reference data with GPS facilities, and land cover types were recorded. In addition, farmers, local councils, and related governmental and non-governmental organizations were visited to validate present and past land-cover patterns and discuss the causes of land-cover changes and used field investigation for further analysis. Moreover, ancillary GIS datasets and other ancillary satellite data were collected from NGOs to assist with the study. Land cover changes and processes of land degradation are influenced by many drivers such as political conditions, natural hazards, land use techniques and farming strategies, and changes in population density and distribution. Therefore, a socioeconomic household survey and local council interview have been conducted in 2015. Also, semi-structured interviews with experts from the different relevant organization (governmental and non- governmental), they are dealing with biodiversity conservation, rangeland management, and land management token place.

3- Applying an ecological model of Vegetation Integrated Simulator for Trace gases (VISIT), this model show adaptation for the current situation and estimates future situation. The model shows the biomass changes over time and estimates the spatial distribution of Net Primary Productivity

(NPP) and Leaf Area Index (LAI). The input data for model have been collected from different sources such as Harmonized World Soil Database (HWSD), Shuttle Rader Topography Mission (SRTM), land cover data, population data, Biomass data, rangeland data, livestock data and climate data from European Centre for Medium-Range Weather Forecasts (ECMWF) and NCEP and the climate data were corrected using elevation data with 30 resolutions.

4- Field Work Survey: in addition to facilitate the understanding of science-based information and land use limitations, using the outcomes of my aforementioned studies, it is important to consider the perception and behavior of the local communities that they are using natural resources for their livelihoods. Therefore, field visits were conducted from (mid-September to mid-October 2017) to collect data and information by proposing different management scenarios by using the result of Ecological Model within semi-structured questionnaires in the villages under coverage of the study area. The target respondents were the local communities. The first respondents were sampled in four categories such as remote villages with government and NGOs interventions, remote villages with no government and NGOs interventions, villages close to centre district with government and NGOs interventions and villages close to centre district with no government and NGOs interventions which the result of VISIT model and land cover maps were shared with them. Furthermore, for the second respondents, the results of VISIT model and land cover maps were not shared to get their perceptions. Additionally, government officials of relevant organizations such as Directorate of Agriculture, Irrigation and Livestock (DAIL, Bamyan), National Environmental Protection Agency of Afghanistan (NEPA-Bamyan), Afghanistan National Disaster Management Authority (ANDMA, Bamyan), United Nation Environment Programme and Agha Khan Development Network (AKDN) were interviewed.

Chapter 2

Land Cover Change in Bamyan, Afghanistan from 1990 to 2015: land degradation induced by lack of land management

2.1 Introduction

Afghanistan due to years of conflict, severe poverty, invasion by foreigners, civil war, and cultural dispute has been in the headline news for past decades (Winterbotham 2012). Years of human influences and demolition to the land, along with the history of conquering by well-known invasions in a geography with desert climate alpine terrain and steep slope has created extensive environmental problems. This issue intensified by Overgrazing, shrubs collection (uprooted) for cooking and heating, soil erosion, soil salinization, water deterioration, climate change, biodiversity loss and floods (Shroder 2012). Amour et al. (2016) stated that majority of Afghanistan land is under land degradation conditions. As well UNEP (2008) specified that this country vulnerability to desertification is among the highest in the world and about 16% of its land area is intensively impacted by anthropogenic activities. The biggest portion of Afghanistan surface is utilizes as grazing land, most of the area has been overgrazed, and land lost its productive and protective cover and consequently, soil erosion and land degradation is widespread concern and problem (UNEP 2003, Norgrove et al., 2008).

Afghanistan during three decades of war and lack of management has intensely lost its green cover as a study by United Nations Environment Programme (2003) intricate that Afghanistan has lost its forest cover by an average of 50% since 1978. The problems of soil erosion and land degradation are created by deforestation, overgrazing, rain-fed agriculture in the steep area and uprooting shrubs for cooking and heating as well as these activities uncovered the soil and made it susceptible to wind and rain erosion. On the other hand, land lost productivities to provide enough food for rural communities and subsequently they migrate to urban to seek new job and food. Obtained reliable satellite remote-sensing data over a span of years can be processed and used to recognize and explain changes of a large area of land that affected by natural and anthropogenic activities (Bagan et al., 2007, Arsnjani et al., 2013 and Gomez et al., 2016). United Nations Environment Programme(UNEP) used satellite image from 1977 and 2002 to investigate land use change over two northern provinces of Badghis and Takhar of Afghanistan. Their analysis exposed that the forested area and woodland have reduced by more than 50 percent between years of 1987 and 2002 (UNEP 2003). Shroder (2012) argued that the reason of this change associated with deforestation, overgrazing, changing to agricultural land, drought, flooding, water shortage, climate change, habitat destruction and many other environmental problems.

Afghanistan was occupied by Russia in 1979 and then resistant and battle start against them and finally withdraw them and upcoming of that civil war began in Afghanistan and these issues limited the research and studies on land cover analysis (UNEP 2008). A study by Pervez et el. (2014) show that irrigated area in Afghanistan has increased from 2000 to 2013, they used Normalized Difference Vegetative Index (NDVI) data from the Moderate-Resolution Imaging Spectroradiometer (MODIS) satellite instrument for their analysis. Furthermore, time-series MODIS INDVI data was utilized by (Simms et al. 2014) to assess crop information throughout Afghanistan, their attention was on the main opium producer provinces among the years of 2005 and 2009. But this study still faces shortage of wide-ranging of land cover change and land degradation information.

Additionally, during years of conflict academic institutional and legal organization suffered. Therefore, Environmental strategies, policies, laws, and regulations are a new development in Afghanistan with the first Environmental law approved by National Assembly in 2007. Subsequently then further laws and strategies, like the Rangeland Law and Natural Resources Management Strategy are in the channel, however, deficiency of technical capacity and financial mechanism have been issued for operation at the field level. It is clear that there is still the gap of studies and research using high-spatial-resolution remote-sensing images to demonstrate detailed land cover changes in Bamyan, Afghanistan.

The Current study objective was to analyze the spatio-temporal changes in land cover due to anthropogenic activities in Bamyan province from 1990 to 2015 by integrating remote sensing images, GIS, and comprehensive fieldwork. To obtain the objective the Maximum Likelihood Classification (MLC) supervised classification method was applied to accurately classify land cover maps from Landsat images obtained in 1990, 1999, 2008 and 2015. The accessed land cover maps were combined with (900m * 900m) grid cells to observe spatio-temporal land cover changes and explore their statistical properties. This method enables, that we can understand the changes of land cover and observes the influences of human activities on the environment over 25 years.

2.2 Materials and methods

2.2.1 Study area

Bamyan province is categorized by a dry, mountainous climate, through vast variable microclimates including the numerous steep valleys that make up the Koh-i Baba) or Baba mountain in the Hindu Kush Mountain ranges and Bamyan province positioned in the central high land of Afghanistan (Figure 2.1). Bamyan province is located in high elevation which most of the province is above 2,000m elevation with a remarkable area situated above 4,000m and the highest elevation is Foladi Peak (Shah Foladi) which the maximum height of this peak is 5,029m. Based on limited records that are accessible from Bamyan province, it underlines three outstanding structures such as severe cold time period occurs in winter in that time air temperature usually do not greater than −5 °C during the day, even though, lowest air temperatures under −20 °C are common. Second, in the summer months' large diurnal temperature differences are recorded, while the daily temperature can pass from 20 °C. Third, in Bamyan, the mean annual precipitation is smaller than 165 mm, and most of this falling as snow (Cook 2012).

In addition, In Bamyan crops need a continuous water supply to produce satisfactory yields. Therefore, at that time precipitation is less than evapotranspiration, the crops need to be irrigated, either from surface water such rivers and streams fed by glaciers or from groundwater (Schidt and Roner 2014). As specified by Shroder (2014) the causes of land degradation in the headwaters of overall main Afghanistan drainage basins are by overgrazing, deforestation, uprooting shrubby plant for cooking and heating as fuel. Furthermore, population growth is another factor that causes overuse of natural resources in Afghanistan, especially in Bamyan. Based on the Afghanistan Central Statistics Organization (2016) Bamyan province population are approximately doubled from 1990 to 2015. As stated by Karim (2013) the rapid population growth leading to a high number of population; and this huge number needed shelters, water, food which bring an unexpected burden on natural resources and land. As theorized by Timah et al. (2007) population increase have an impact on indigenes of an area due to supplying feed beyond of sustainable limits, consequently causing the extinction of fauna and flora, beforehand of its potential usages for the well-being of current and future generations.

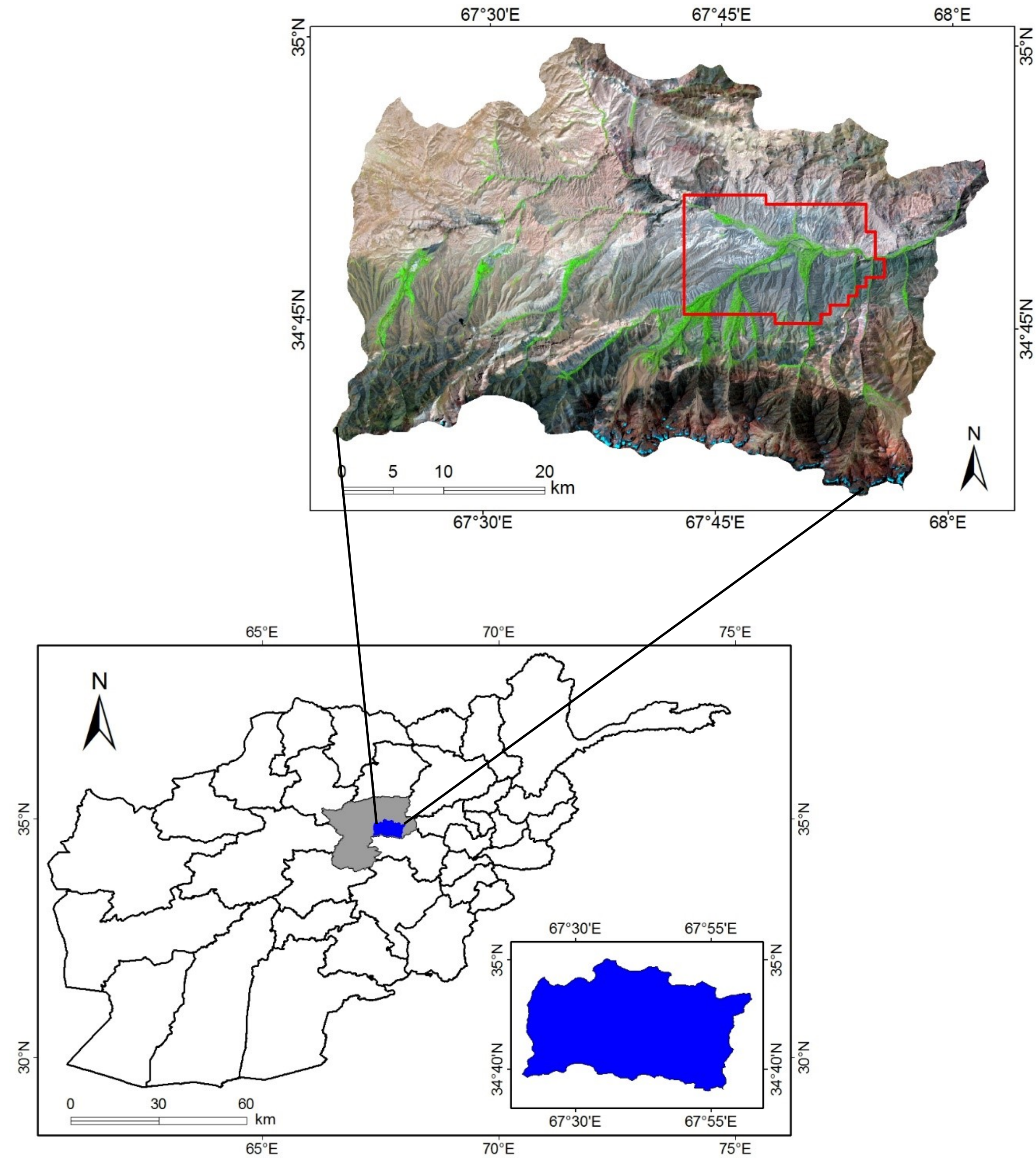


Figure 2.1. Study area boundary. The grey area shows Bamyan province, and the blue area shows the study area in the central Bamyan district. The right-hand image shows the August 1999 Bamyan district Landsat TM image (RGB= bands 3, 4, 5). The red outline indicates the area around Bamyan city.

2.2.2 Field work survey

Laterally through ground reference data collection, interviews were conducted with farmers, local councils, and governmental & non-governmental organizations to investigate land degradation problems and causes. The questionnaires were completed randomly with people where their occupation is not farming but some of them were indirectly involved in farming and with farmers which their occupation is farming and agricultural activity. The questionnaires were filled out from locations such as villages in a higher part of the valleys, the villages in mid part of the valleys and villages in lower parts or flat area. Fifty-nine questionnaires were completed within local people with sex ratio of 49 males and 10 females with age composition between (20-29) 36 people, among (30-39) 9 people, between (40-49) 2 people, between (50-59) 8 people and between (60-70) 3 people of local people and 38 questionnaires by farmers which all of them were male with ages between (20-29) 9 people, between (30-39) 7 people, between (40-49) 5 people, between (50-59) 9 people, and between (60-70) 8 people. The questions were similar for both groups.

Q1. Have you been collecting bushes and shrubs from rangeland for your livelihood?

Q2. Do you think the land cover has changed over the last 30 years?

Q3. What is the reason for this land cover change?

2.2.3 Datasets

Landsat TM and Landsat 8 scenes (Level-1T, provided by USGS) were acquired from four different dates (1990, 1999, 2008, and 2015) to examine land-use/land cover changes for the study area over a 25-year period of time (Table 2.1).

Table 2.1. Path, row, and acquisition date for the Landsat time-series scenes.

Year	Date	Source	Path	Row	Spatial resolution (m)
1990	1990-08-26	Landsat-5 TM	154	36	30
1999	1999-08-19	Landsat-5 TM	154	36	30
2008	2008-07-10	Landsat-5 TM	154	36	30
2015	2015-07-14	Landsat 8 OLI	154	36	30

The years of 1990, 1999, 2008, and 2015 has been selected based on the following descriptions: quick after the Russian invasion, the struggle against the communists starts to withdraw them. Consequently, the battle began in Bamyan city between 1979 and 1989 with the migration of people out of Bamyan province to another provinces and countries; this displacement process became intense during the Taliban era until 1999, while the agricultural area drooped down and the provincial and local government broke down and mishandling had happened (Wily 2004).

On the other hand, in the post-conflict phase migrants started to get back to Bamyan between approximately 2001 and 2008, and consequently more land had been used for agriculture, raising livestock and shelter which triggered a scarcity of natural resources (Willy 2004 and Winterbotham et al., 2011).

Landsat scenes provided by the USGS had already being corrected using a digital elevation model and ground control points. All Landsat images were geometrically corrected to a common map position system: Universal Transverse Mercator (UTM) projection, UTM Zone 42 North, WGS-84 geodetic datum. The images with low cloud cover from green vegetation season from June to August were used to maximize the existence of the vegetation information for the separate monitoring date. Entire analyses carried based on the optical and thermal infrared bands of the Landsat data. Furthermore, ancillary GIS datasets and other ancillary satellite data such as Worldview-2 and GeoEye-1 were used as reference data to assist with our field investigation in the determination of typical land-cover classes and in selecting ground reference sites for each Landsat recording date. The Land use patterns are very small in populated areas such as Bamyan city and it's very problematic to distinguish between Landsat images. therefore, high resolution 39 images of Worldview-2 and GeoEye-1 where used as reference data to support the field investigation in the determination of distinctive land-cover categories and choosing ground reference sites for each Landsat recorded date.

2.2.4 Ground reference data collection

From mid-July to mid-August of 2015 a field work was conducted throughout the study area for best determination of the ground truth situation. For ground reference data photos were taken with GPS facilities during the field survey, as well as land cover categories had been recorded in land use land cover recording sheet. Figure 2.2, shows some characteristics of the landscape of the study area. Furthermore, for validation of current and past land cover patterns and causes of land cover changes the related governmental organization and non-governmental organizations, local councils and farmers were visited. By using field examination result, land use maps, visual interpretation of the remote sensing data and by deliberation of Landsat scene achievement dates, eight land cover categories were designated (Table 2.2) As Bamyan province is located in the semi-arid zone there is no forested area. But in the area which there is water accessibility along the stream and below irrigation canals are some species of trees such as poplars, willow, and orchard are planted.

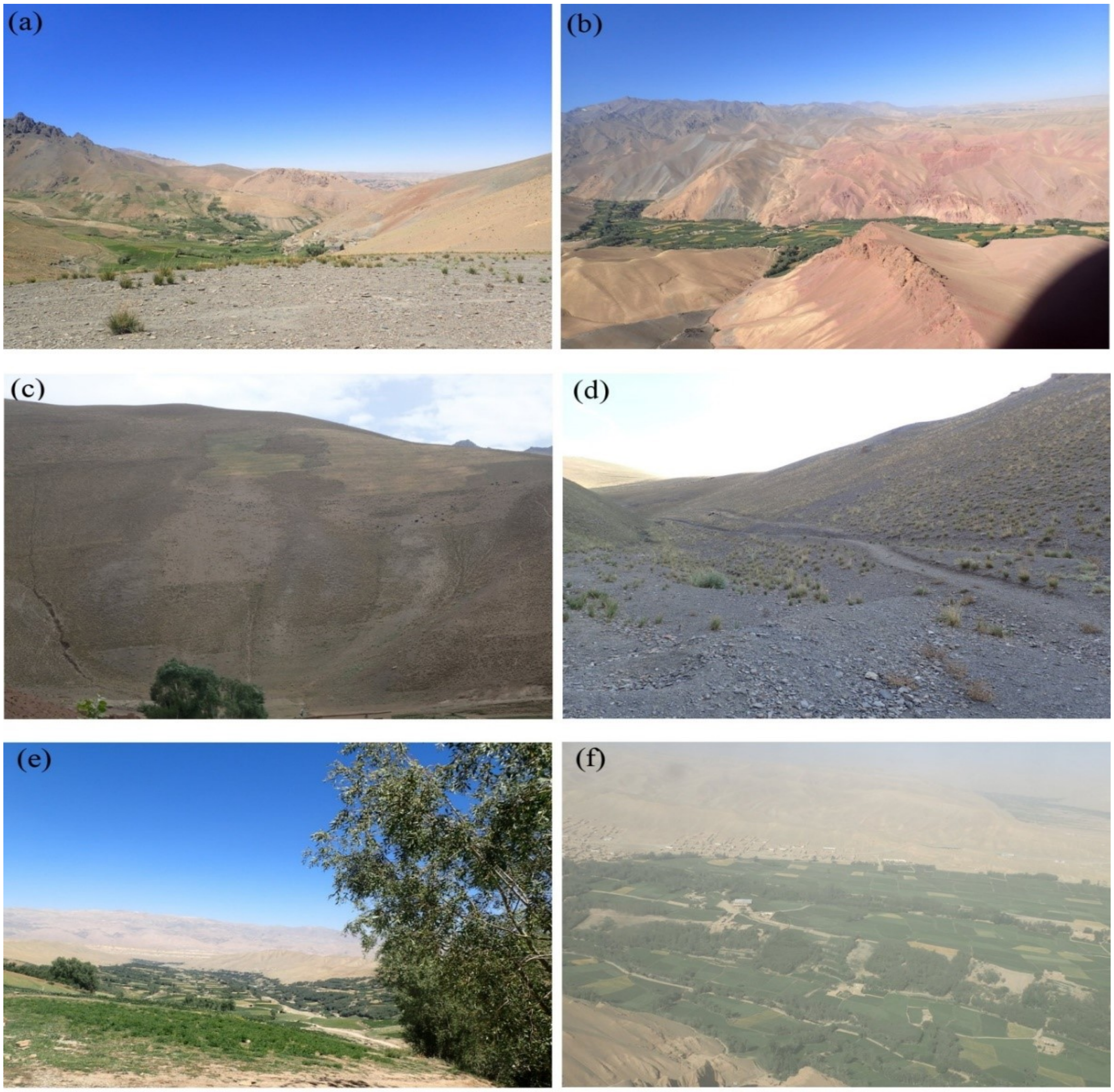


Figure 2.2. Various landscapes in the study area: (a) plantation in high steppes, (b) bare soil around plantations and built-up areas, (c) rain-fed agriculture in high steppes, (d) rangeland, (e) seriously degraded land near Bamyan city, and (f) built-up expanses.

Table 2.2. Description of the land cover classification system and the number of training and test pixels for images acquired in 1990, 1999, 2008, and 2015.

Class	Class description	1990		1999		2008		2015	
		Training	Test	Training	Test	Training	Test	Training	Test
Rangeland	Vegetation with canopy coverage between 5% and 50%.	9592	3383	732	213	8794	3253	1830	1009
Water	Lakes, reservoirs, and rivers.	926	310	128	55	176	83	955	317
Snow	Permanent snow and glaciers	1389	436	176	48	234	126	727	220
Plantations	Cropland for cultivation; cropland that has water supply and irrigation facilities and planting crops; cropland planting and dense grass vegetables. Trees between fields and woody vegetation are also included in this class.	8909	1400	247	76	882	300	3031	738
Built-up	Buildings and other man-made structures.	13	9	32	12	65	27	70	28
Shadow	Mainly referring to the mountain shadow generated by relief and sunshine exposure as well as could shadow	4994	1206	235	106	216	105	2429	1017
Bare-soil	Areas of gravel and soil covered land with exposed and less than 5% vegetation cover during any time of the year.	13709	4941	5502	1073	18841	7263	20856	7301
Cloud	Aerosol comprising a visible mass of liquid droplets or frozen crystals made of water or various chemicals. The droplets or particles are suspended in the atmosphere above the surface of a planetary body.	—	—	419	167	—	—	—	—
Total		39532	11685	7471	1750	29208	11157	29898	10630

For each mapping category ground position data sites, had been selected as well as separate Landsat recording date to precisely represent the spectral complexity and variability within each particular category. All original digitized ground reference sites had been associated with the corresponding Landsat imagery achieved in 1990, 1999, 2008, and 2015 to anticipate the accurate interpretation for the time of the image date. Furthermore, as explained above, for supporting image interpretation and to supply considerable information as possible to facilitate locating the ground references, other ancillary images and ancillary GIS datasets were used. If a sample site contained several classes or was inadequately defined, a new homogeneous sample polygon or line was defined within the original site. Importantly elaborate that separate site contained no less than nine pixels (Congalton et al., 2008).

A subsection of the image-interpreted sites has been field visited and extra sites were collected, excluding snow, Shadow, and cloud. For instance, in rangeland areas display greater spectral variation because of the high variability of the canopy in the study area. Although 1m × 1m quadrat technique for determination of the 5% and 50% thresholds of canopy cover for rangeland were used and the over-all plant canopy cover of the plot was estimated visually. After that based on knowledge gained by dimensions in quadrats, diverse rangeland, sample sites were designated, representing the spectral variation of rangeland.

Consequently, specified reference sites were recorded using Exelis Visual Information Solutions (Exelis VIS) ENVI 5.2, Esri ArcGIS 10.3 software package. For ensuring spatial disjointing and to decrease the potential for correlation among the training and the test data the reference site was randomly divided into training and testing sets (Table 2.3).

Table 2.3. Number of training and test pixels for images acquired in 1990, 1999, 2008, and 2015

Class	1990		1999		2008		2015	
	Training	Test	Training	Test	Training	Test	Training	Test
Rangeland	9592	3383	732	213	8794	3253	1830	1009
Water	926	310	128	55	176	83	955	317
Snow	1389	436	176	48	234	126	727	220
Plantations	8909	1400	247	76	882	300	3031	738
Built-up	13	9	32	12	65	27	70	28
Shadow	4994	1206	235	106	216	105	2429	1017
Bare soil	13709	4941	5502	1073	18841	7263	20856	7301
Cloud	—	—	419	167	—	—	—	—
Total	39532	11685	7471	1750	29208	11157	29898	10630

2.2.5 MLC Classification methods

The MLC supervised classification method, it is a very popular classification system in the remote sensing community was utilized to each of four datasets (Table2.1) to generate land cover maps from the Landsat images.

According to Minggua (2009) Maximum Likelihood Classification (MLC) has been considered to be the most advanced classification strategy for a long time and one of the great characteristics of the MLC algorithm is that it can make use of the previous likelihoods resulting from ancillary information concerning the area to be classified, hence that remotely sensed data can be integrated with data collected predictably. Prior probabilities can be a strong aid to improve classification accuracy among classes that are poorly dividable and resolve confusion among classes.

MLC is built based on the assumption of a normal or near normal spectral distribution for each category of interest. An identical prior probability between the classes is similarly assumed. This classifier is based on the probability that a pixel belongs to a specific category class.

$$p(x \mid \omega_i) = \frac{1}{(2\pi)^{\frac{N}{2}} \left|\Sigma_i\right|^{\frac{1}{2}}} \exp\left[-\frac{1}{2}(x-m_i)^T \Sigma_i^{-1}(x-m_i)\right] \quad (1)$$

where x is a pixel digital number (DN) vector, m_i is the mean DN vector for class ω_i $(i = 1, \cdots, C)$, and Σ_i is its covariance matrix of size $N \times N$. C is the number of classes and N is the total number of spectral bands, this leads to the discriminant function.

$$g_i(x) = P(\omega_i)p(x \mid \omega_i) \tag{2}$$

where $P(\omega_i)$ denotes that x has equal prior probability among the classes. Taking the natural log of both sides, we have

$$g_i(x) = -\frac{1}{2}(x - m_i)^T \Sigma_i^{-1}(x - m_i) - \frac{1}{2}\ln|\Sigma_i| - \frac{N}{2}\ln 2\pi + \ln P(\omega_i) \tag{3}$$

note that $P(\omega_i)$ is equivalent for each class, hence the discriminant function can be written as

$$g_i(x) = -(x - m_i)^T \Sigma_i^{-1}(x - m_i) - \ln|\Sigma_i| \tag{4}$$

Then, pixel x is classified using the following decision rule

$$x \in \omega_i \text{ if } g_i(x) > g_j(x) \text{ for } j \neq i \ (i, j = 1, \cdots \tag{5}$$

Therefore, MLC needs illustrative training samples for each category to precisely estimate the mean vector and covariance matrix required by the classification algorithm (Lillesand et al. 2008).

2.2.6 Post-classification change analysis

To distinguish and calculate the changes in land cover patterns for three intervals, 1990, 1999, 2008 and 2015 then a post-classification change analysis method was performed, constructing a matrix wherever the diverse combination of changes are recognized.

Furthermore, this enables to measure the change by understanding how much of a specified land-cover category had changed to other type and to recognize trends in land cover change that had occurred in the study site between 1990 and 2015.

2.2.7 Grid cell process

A Landsat pixel-derived grid cell method was developed by Bagan and Yamagata (2012) and it facilitates an association amongst change of land cover categories. In this method, we directly use the 2008 Landsat TM5 image to generate the grid cells. The benefit of the grid square cells method is that it has the ability to avoid the possible problem of fluctuating administrative unit boundaries throughout the time period of interest, and it allowed us to aggregate the classes for each map and to achieve quantitative analysis (Bagan and Yamagata 2014, Qian et al., 2014). On the other hand, in Bamyan is very difficult to recognize each class and the accuracy in each class is not very high, therefore, this method is suitable to reduce the error. The focal steps of the proposed method are as follows. First, we converted the 30 × 30 Landsat pixels to generate a blank grid square cell (polygon) and allocated a unique ID to every grid cell. Hence, the spatial resolution of grid square cells is (900m*900m). To calculate the percentage of every land cover category with each cell, the land covers classification maps (30 m spatial resolution) on the 900m x 900m grid cells were overlaid and stored the result to a new attribute table. While computing the percentage of a land-cover category within a cell, the sum of land covers classes area divided by the area of the cell. This methodology calculated the percentage of land-cover categories within every grid cell, allowing for spatially obvious evaluations of the relationships between changes in land-cover forms.

2.3 Results and Discussions

2.3.1 Result of field work Survey

Forty-three answers from local people present that they collected shrubs and bushes for cooking and heating from rangeland; whereas 16 people replied that they are not collecting bushes and shrubs. On the other hand, fifty local people specified that land cover had changed over the last 30 years, although nine people thought land cover hand not changed. The respondents specified multiple reasons of which given by both groups for land cover changes were: population increase and overuse of natural resources (24), drought (13), weather changes (8), no management of the land (8), overgrazing (5), and war (1). Equally, all 38 farmers responded that they collected and used bushes for cooking and heating from rangeland; they specified that land cover had changed within last 30 years. They provide multiple reasons for land-cover change as follows: population increase and overuse of natural resources (19), drought (8), overgrazing (7), war (2), weather changes (1), and no management (1). Semi-structured Interview with key informants including Department of Agriculture, Irrigation and Livestock (DAIL), National Environmental Protection Agency (NEPA) and the United Nation Environment Programme (UNEP) was conducted to understand land management challenges.

The DAIL described that due to overuse of natural resources, collecting of vegetation cover for heating and cooking and overgrazing land is under degradation and it is a serious problem for Bamyan. Similarly, the NEPA explained that people in Bamyan mostly depend on scarce natural resource especially shrubs for cooking and heating as well as overgrazing is taking place and these factors lead to a serious problem of land degradation. In addition, the UNEP specified that people in Bamyan highly rely on their natural resources and land for their livelihoods. This comprises grazing livestock and gathering shrubs and native plants for the purpose of fuel, fodder, and other household consumptions, which contributes to land degradation. Climate change, drought, land use, and population growth, each has a direct and substantial potential to lead to overall land degradation. Furthermore, the indirect factors consist of poverty, population increase due to returning the migrants and inadequate fuelwood for heating and cooking. Moreover, the Afghanistan Agricultural Support Programme (ASP) stated that land in Bamyan is seriously degraded. The rain-fed agriculture practices in steep terrain not in an appropriate system which is used in Bamyan and not an appropriate system for Afghanistan's dry climate. On the other hand, Bamyan residents don't have access to alternative energy sources, therefore, the cutting and collecting of bushes for heating and cooking is central cause leads to land degradation.

2.3.2 Spatio-temporal changes of land-cover classes

The classification results of the study area have shown in Figure 2.3. The MLC classification system applied with none probability threshold and accordingly, all pixels were classified. To evaluate the quality of the image classification, confusion matrices (Conglalton et al., 2009), matching test pixels Table 2.4, to the classification results were produced, and overall accuracy, producer and user accuracies, and kappa statistics of the agreement were produced. The whole accuracy for the land cover maps alternated from 84.76% and Kappa coefficient ranged from 0.7329 to 0.8823. The most difficult class was built-up among all categories and it was often confused with bare soil category because the building in Bamyan is mostly made of mud, so the rooftops return the light in the similar way as bare soil do. Hence, the built-up area was the highest challenging to classify; this describes the minor producer accuracy (11.11% in 1990 and 44.44% in 2008) of the built-up category.

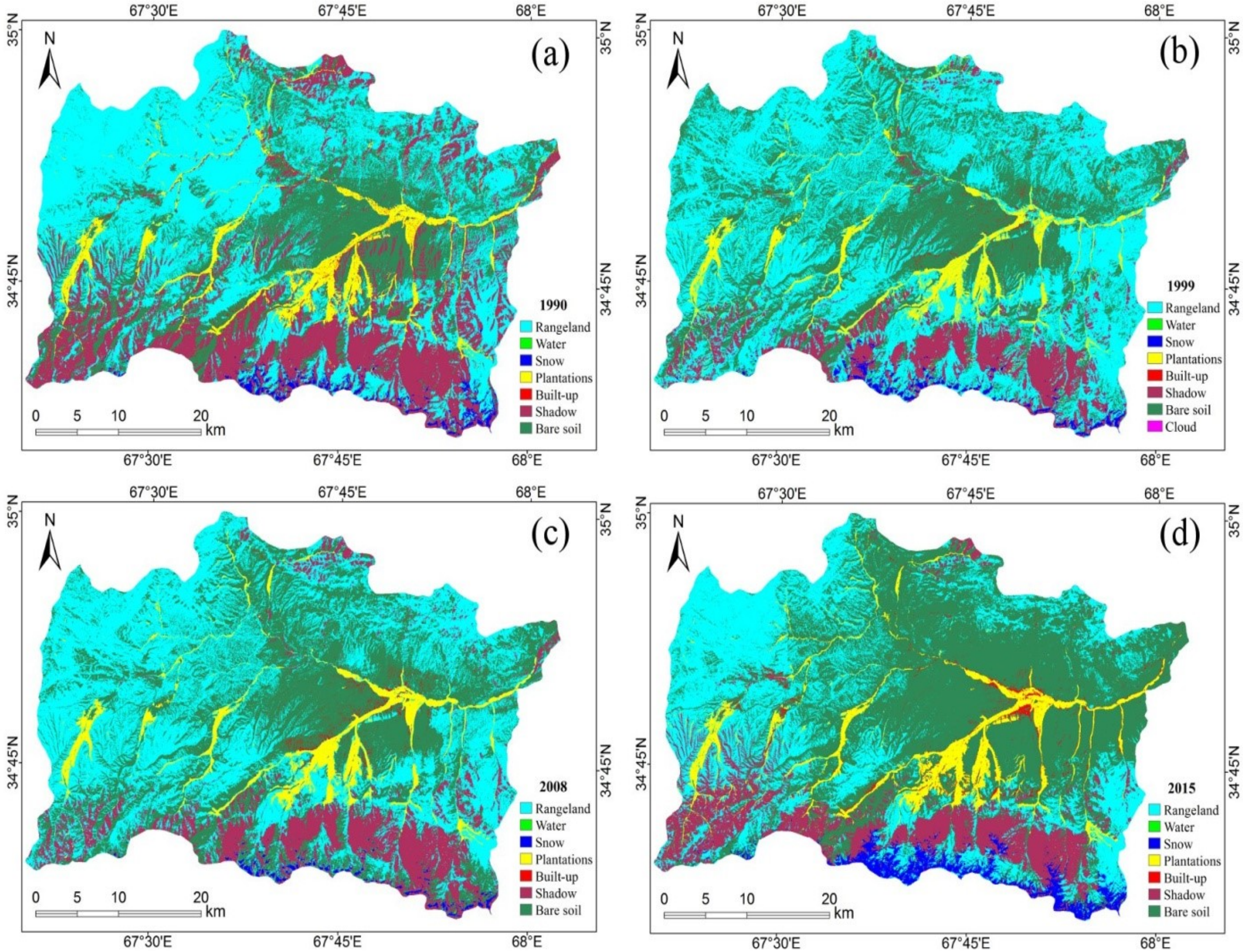


Figure 2.3. Land-cover maps for the study area: (a) 1990, (b) 1999, (c) 2008, and (d) 2015.

Table 2.4. Confusion matrices of obtained land-cover maps.

1990	Rangeland	Water	Snow	Plantations	Built-up	Shadow	Bare soil	Total	UA (%)
Rangeland	**3135**	2	2	134	0	0	385	3658	85.7
Water	0	**304**	0	0	0	6	0	310	98.06
Snow	0	0	**427**	0	0	0	0	427	100
Plantations	5	4	0	**1210**	0	0	1	1220	99.18
Built-up	1	0	0	41	**1**	0	49	92	1.09
Shadow	72	0	0	12	0	**1184**	65	1333	88.82
Bare soil	170	0	7	3	8	16	**4441**	4645	95.61
Total	3383	310	436	1400	9	1206	4941	**11685**	
PA (%)	92.67	98.06	97.94	86.43	11.11	98.18	89.88		
OA (%)	91.58								
Kappa	0.8823								

1999	Rangeland	Water	Snow	Plantations	Built-up	Shadow	Bare soil	Cloud	Total	UA (%)
Rangeland	**175**	1	0	23	1	9	100	1	310	56.45
Water	0	**49**	0	0	0	0	0	0	49	100
Snow	0	0	**47**	0	0	0	0	0	47	100
Plantations	3	0	0	**53**	0	0	0	0	56	94.64
Built-up	1	0	0	0	**8**	0	57	0	66	12.12
Shadow	0	0	0	0	0	**97**	0	0	97	100
Bare soil	34	5	1	0	3	0	**916**	12	971	94.34
Cloud	0	0	0	0	0	0	0	**154**	154	100
Total	213	55	48	76	12	106	1073	167	**1750**	
PA (%)	82.16	89.09	97.92	69.74	66.67	91.22	85.37	92.22		
OA (%)	85.66									
Kappa	0.7699									

2008	Rangeland	Water	Snow	Plantations	Built-up	Shadow	Bare soil	Total	UA (%)
Rangeland	**2814**	0	0	53	0	5	224	3096	90.89
Water	0	**82**	0	0	0	0	0	82	100
Snow	0	0	**125**	0	0	0	0	125	100
Plantations	0	0	0	**245**	0	3	0	248	98.79
Built-up	2	0	0	2	**12**	0	58	74	16.22
Shadow	0	0	0	0	0	**94**	0	94	100
Bare soil	437	1	1	0	15	3	**6981**	7438	93.86
Total	3253	83	126	300	27	105	7263	**11157**	
PA (%)	86.5	98.8	99.21	81.67	44.44	89.52	96.12		
OA (%)	92.7938								
Kappa	0.8512								

2015	Rangeland	Water	Snow	Plantations	Built-up	Shadow	Bare soil	Total	UA (%)
Rangeland	**834**	0	0	111	0	0	368	1313	63.52
Water	0	**307**	0	3	0	1	0	311	98.71
Snow	0	1	**206**	0	0	0	0	207	99.52
Plantations	0	0	0	**601**	0	0	2	603	99.67
Built-up	35	1	0	16	**18**	0	564	634	2.84
Shadow	13	1	0	1	0	**1016**	339	1370	74.16
Bare soil	127	7	14	6	10	0	**6028**	6192	97.35
Total	1009	317	220	738	28	1017	7301	**10630**	
PA (%)	82.66	98.85	93.64	81.44	64.29	99.9	82.56		
OA (%)	84.7601								
Kappa	0.7329								

UA = user accuracy; PA = producer accuracy; OA = overall accuracy; Kappa = kappa coefficient

User Accuracy (UA) is the ratio between the number of correctly classified and the row total. It concerned about what percentage of the classes has been correctly classified. Producer Accuracy (PA) is the ratio between the number of correctly classified and the column total. It indicates the quality of the classification. Overall accuracy (OA) is the probability that a value in each class was classified correctly and it indicates the quality of the map classification. Kappa Coefficient(Kappa) measures the agreement between classification and truth values and it reflects the difference between actual agreement and the agreement expected by chance. A kappa value of 1 signifies perfect agreement, although a value of 0 represents no agreement.

Relatively small producer accuracies were shown for the plantation class in 1999 (66.67%) reveal the difficulty of differentiating plantation pixels from rangeland pixels, due to four years of drought from 1998 to 2002, water tables fell significantly such that orchards and furthermost of agricultural land could not be irrigated (Faver 2004). Shroder (2012) similarly stated that droughts, floods, and increasing temperatures represented the highest hazard to ecosystems and livelihoods in Afghanistan. As displayed in Figure. 2.3, bare soil and built-up areas enlarged over 25 years with a quick intensification from 1999 to 2015, alongside with a decrease in rangeland. For more accurate change detection the shadow and snow classes from the four images were removed and making them statistically comparable.

Figure 2.4a illustrates the grid-cell-based spatial variation of rangeland from 1990 to 2015 in Bamyan province. The value of each grid square cell was calculated by subtracting the rangeland area of 1990 from that of 2015 in each grid cell and at that point dividing the changed area by the cell area. Figure 2.4(b-d) shows the grid-cell-based spatial change of built-up, plantation, and bare soil classes from 1990 to 2015, respectively, which were calculated in the similar method as for Figure 2.4a. Usually, rangeland area quickly decreased around the populated central Bamyan area although the built-up area increased, as did plantation and bare soil. The bare soil increase seems to be the outcome of over-use of natural resources such as over-grazing, cutting bushes for fuel and absence of management in the area. The result of fieldwork survey analysis shows that most of the people use bushes and shrubs for heating and cooking in the area. From all surveyed local people 43 people and all 38 farmers are collecting bushes and shrubs from rangeland areas. They stated that de-shrubification, lack of management and overgrazing are another source of rangeland lose and bare soil expansion.

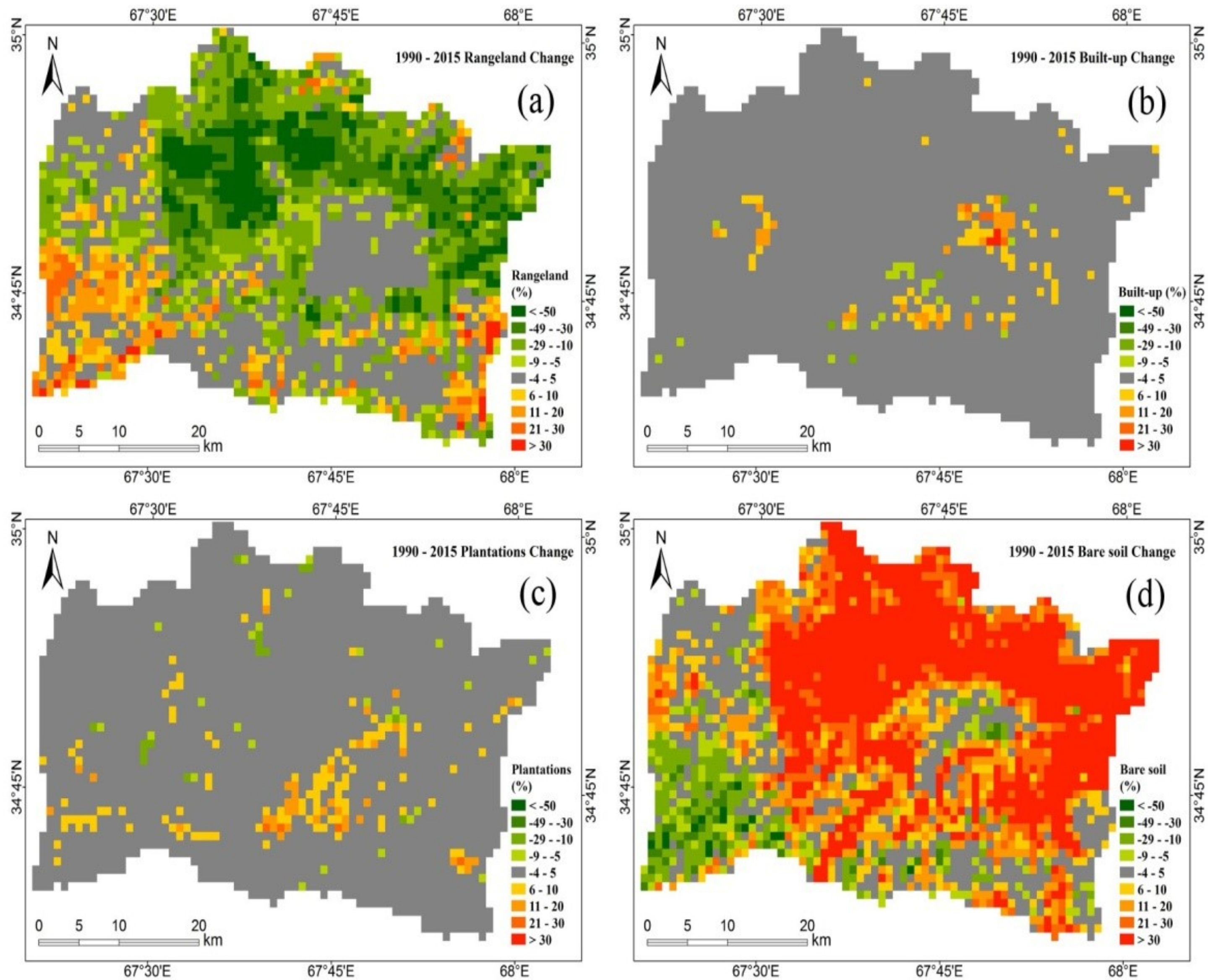


Figure 2.4. Special temporal analysis from 1990-2015: (a) rangeland, (b) built-up, (c) plantation and (d) bare soil classes.

2.3.3 Land-cover change detection and analysis

To identify and quantify the changes in land cover patterns from 1990 to 2015, a post-classification change-analysis approach using the land cover maps were followed and producing a matrix where diverse combinations of variation from 2008 to 2015 are identified Table 2.5 as a sample.

Table 2.5. Change detection statistics from 2008 to 2015

		2008						
		Rangeland	Water	Plantations	Built-up	Bare soil	Row Total	Class Total
2015	Rangeland	**502448**	0	1932	39	79434	583853	583853
	Water	295	**126**	85	1	316	823	823
	Plantations	23932	0	**100390**	230	928	125480	125480
	Built-up	6181	4	1037	**2734**	12619	22575	22575
	Bare soil	256477	47	383	11787	**538973**	807667	807667
	Class total	789333	177	103827	14791	632270	0	0
	Class changes	286885	51	3437	12057	93297	0	0
	Image difference	-205480	646	21653	7784	175397	0	0

To correctly recognize the changes in each map the classified images were also compared pixel by pixel. Table 2.6, illustrates the land cover change movements of rangeland, built-up, bare soil, and plantation categories.

Table 2.6. Land cover class proportions (%) for the land cover maps

Class	1990	1999	2008	2015
Rangeland	60.21%	53.06%	51.24%	37.90%
Water	0.13%	0.01%	0.01%	0.05%
Plantations	7.80%	6.35%	6.74%	8.15%
Built-up	0.88%	0.55%	0.96%	1.47%
Bare soil	30.99%	40.02%	41.05%	52.43%

As Founded from field result, all 38 surveyed farmers and 50 local people out of 59 local people in the survey debated that within 30 years land cover has been changed, due to overuse of natural resources, population increase, drought, deficiency of land management, overgrazing, and conflict. The finding and results of this study are consistent with historical descriptions in this region. Afghanistan's recent history determines the importance of war and civil clashes as drivers of land-cover and land-use change (Berus and Henebry 2008). Conflict and hostility in Bamyan broke down management and infrastructure, although a huge mass of people left the area and migrated out of the country or to other cities. Thousands of households left Bamyan Province throughout 1979 and 1989, moved to Pakistan and Iran or to another place or city in Afghanistan. The process of migration became stronger during the Taliban era in 1999, in which 17% of houses were destroyed; approximately 90% of the inhabitants' run-away and agricultural production plummeted (Wily 2004). Qureshi (2002) pointed out that the main reason for farmer migration to other country was war inconsequently the agriculture dropped down. Therefore, from 1999 to 2015, the bare soil, built-up, and plantation categories all increased, whereas rangeland decreased.

The socio-economic changes and conflict that has impacted Afghanistan over the last 20 years have been extra than adequate to considerably disturb the land surface. Wily (2004) stated that, after Taliban taking away, people starting to return to the area in December 2001, and the population of central Bamyan increased since the majority moved to Bamyan city. As quantified by the Afghanistan Central Statistics Organization (2016) the population of Bamyan city closely doubled over 25 years. Furthermore, rural communities in Afghanistan collect and store huge amounts of bushes and fuelwood to supply their winter energy needs, making a significant influence on the structure and composition of rangeland vegetation and exposing land and soil to wind and water erosion (Norgrove et al., 2008).

2.3.4 Correlation among the land cover changes

To find the relationships amongst lands cover changes, the correlation coefficients (r) of the land-cover classes (rangeland, water, snow, plantations, built-up, and bare soil) based on 900 m × 900m grid square cells were calculated. To assess the spatio-temporal changes of land-cover classes and associate them, the classified images were intersected with empty (900 m * 900 m) grid square cells and the percentages of the six land-cover categories within each cell were computed. Thus, the grid cells allow us to combine the categories for each map and to calculate their proportions. Furthermore, they enable us to evaluate the spatio-temporal changes in land-cover categories to allow a much easier statistical comparison of the land-cover changes. We calculated the correlation coefficients (r) of the land-cover classes (rangeland, water, snow, plantations, built-up, and bare soil) based on (900m * 900m) grid square cells. Table 2.7 demonstrates a summary of the linear correlation coefficient matrix among the variations in land cover groups, from 1990 to 2015 based on 12, 590 grid cells. Figure 2.5 shows a scatter plot of the rangeland change against the bare soil change from 1990 to 2015. The value of separate point was calculated by deducting the rangeland area of 1990 from that of 2015 in each grid cell and then dividing the changed area by the cell area. Also, the bare soil area changes from 1990 to 2015 was calculated in the similar method by subtracting the bare soil area of 1990 from that of 2015 in each grid cell and then dividing the changed area by the cell area.

As Table 2.7, and Figure 2.5 show, the strong negative relationship ($R^2 = 0.6$) amongst rangeland and bare soil changes specify that the increasing settlements triggered a loss of rangeland.

Table 2.7. Correlation between land-cover classes during 1990-2015.

	Rangeland	Water	Snow	Plantations	Built -up	Bare soil
Rangeland	1					
Water	0.02	1				
Snow	0.05	-0.06	1			
Plantations	0.07	-0.02	-0.04	1		
Built-up	-0.03	-0.08	-0.02	0.03	1	
Bare soil	-0.77	-0.16	-0.15	-0.2	-0.08	1

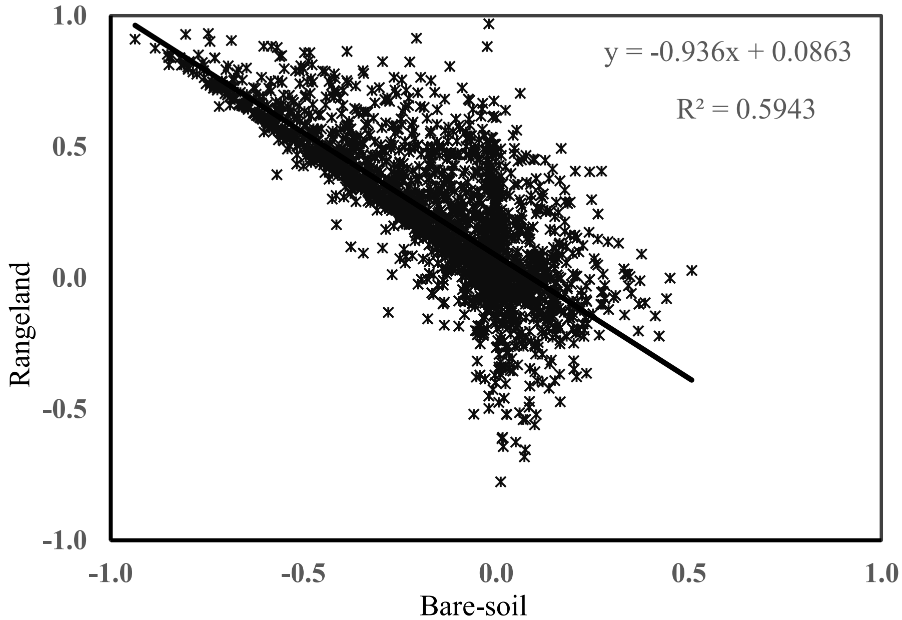


Figure 2.5. Scatter plot of the rangeland change versus the bare soil change for 1990-2015

2.3.5 Land cover changes in and around Bamyan City

Built-up areas are rising quickly worldwide as a result of population growth, rural-to-urban migration, and wealth increases in many parts of the world (Vliet et al., 2017). To explore the influence of human activities on land cover change, the focus has been concentrated on Bamyan city (red outlined area in the right of Figure 2.1 because the population is growing rapidly due to the coming back of migrants and overall urban expansion.

Figure.2.6 illustrates comprehensive land-cover maps for the area around Bamyan city, and Figure 2.7 displays the grid-cell-based percentage change of land cover categories from 1990 to 2015 around Bamyan city.

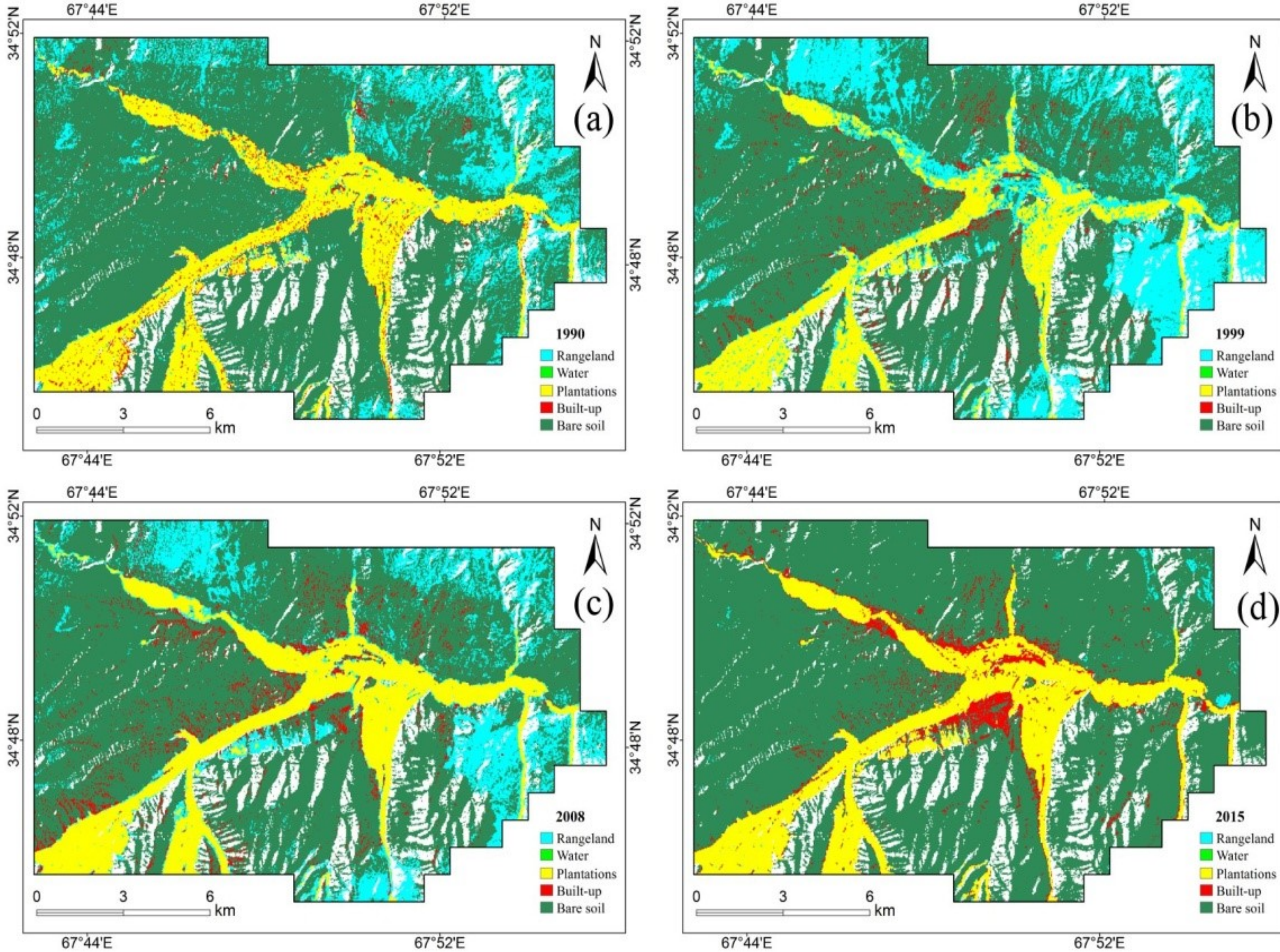


Figure 2.6. Classified image of the area, around Bamyan city (a)1990, (b) 1999, (c) 2008, and (d) 2015.

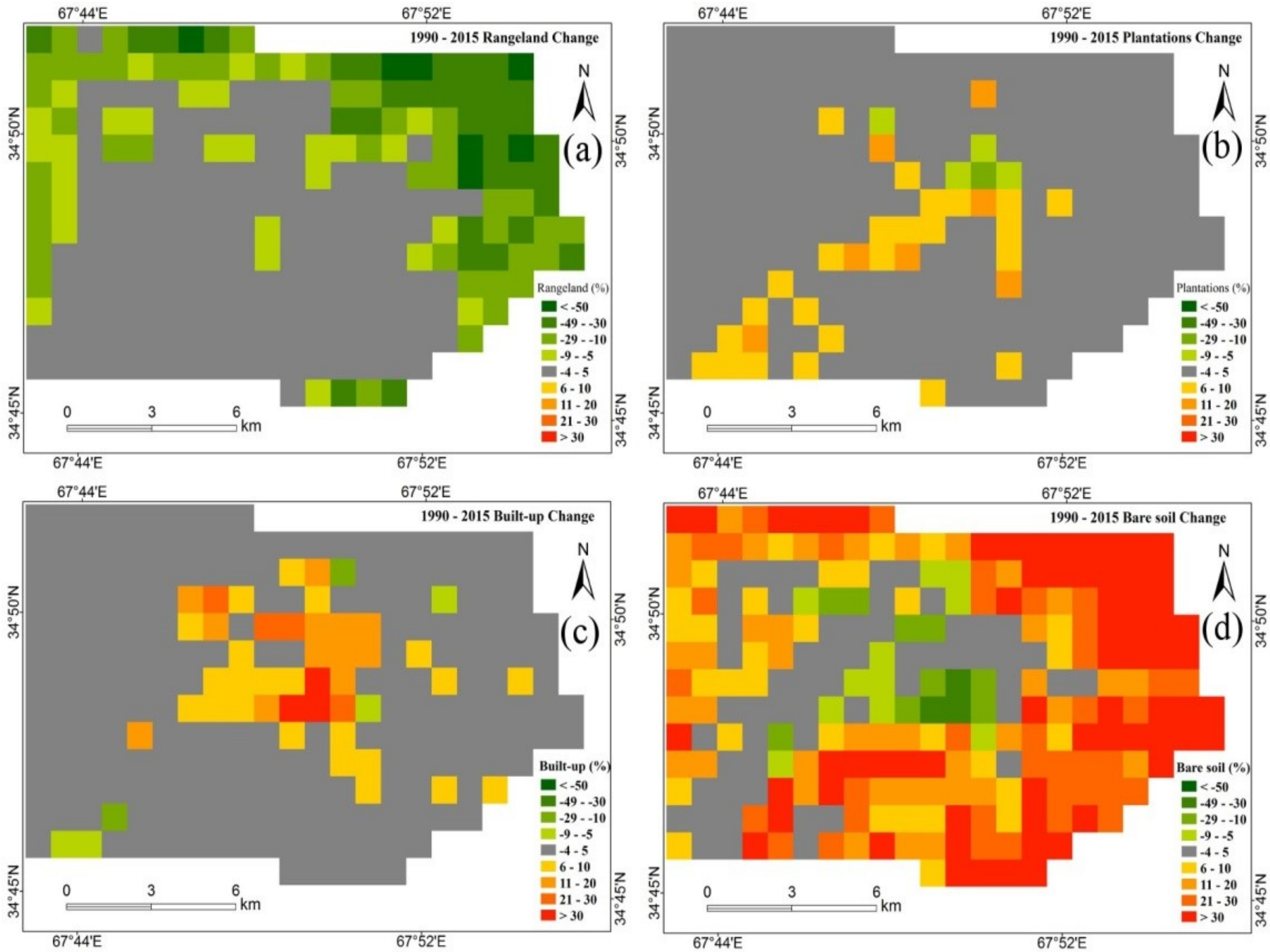


Figure 2.7. Spatio-temporal analysis of land-cover changes around the city of Bamyan: (a) rangeland, (b) plantation, (c) built-up, and (d) bare soil classes.

Due to a rapid population increase of Bamyan city, built up area expanded due to gradual construction. The field survey analysis describes that fast-growing population influence surrounding the area and causes bare soil expansion and decline of rangeland area. As indicated by 24 persons from local people and 19 farmers that population growth and misuses of natural resources are also origins of land cover changes in Bamyan. To examine the association among the land-cover changes produced by human activities, the correlation coefficients (*r*) among the changes in land cover classes based on the (900m * 900m) grid square cell in Bamyan city from 1999 to 2015 were calculated, as Table 2.8 displays, there is a strong negative linear relationship amongst the bare soil and rangeland categories (r = -0.89), a moderate negative correlation between bare soil and plantation classes (r = -0.32), and a positive correlation between built-up and plantation classes (r = 0.51). Consequently, population increases and additional human actions have had a direct impact on land-cover change.

Table 2.8. Correlation between land-cover classes around Bamyan city 1999-2015.

	Rangeland	Plantation	Built-up	Bare soil
Rangeland	1			
Plantation	-0.08	1		
Built-up	-0.06	0.51	1	
Bare soil	-0.89	-0.32	-0.31	1

Based on the result of field survey specifically by responded from the village near the city center and they explained that plantation area increases and rangeland changed to plantations, Table 2.9, as an example. Similarly, to point out the bare soil and built-up expansion majority of respondents from local people and farmers from the village near to the center described that population has increased, therefore natural resource overused and change the rangeland to the bare soil as well as built-up increased. These findings agree with the findings of recent studies. Wily (2004) described that, after Taliban withdrawal, the population of central Bamyan enlarged since the majority of the returned population relocated to Bamyan city.

Table 2.9. Rangeland changes based on respondents' answers

Questions		1--In your view, over the last 20 years and more, has pasture productivity been increased, decreased, no change?			2- If you observed any changes, what are they?	
Villages categories	Number of respondents	decrease	No change	Increase	Lack of plant and shrubs	Changed to agricultural land
Far from center	22	18	2	2	8	0
Medium distance	17	14	2	1	5	1
Near to center	20	15	3	2	5	5
Total	59	47	7	5	18	6

2.5 Conclusions

This study identified and quantified trends in land cover change along with the land degradation induced by anthropogenic activities and lack of land management policy and action plan through classifying satellite imagery and comprehensive field work survey from Bamyan province in central part of Afghanistan, which has suffered from more than three decades of conflict, and traditional systems breakdown and socio-economic changes.

This is the first study makes an effort to assess and recognize land-cover changes in the area from 1990 to 2015. Land cover maps with 30 m spatial resolution were produced with an overall accuracy amongst 84.76% and 92.79%, acceptable for all classes except built-up areas.

In this study grid cells process were employed with unique cell IDs to distinguish correlations between land-cover categories. In the overall study area, there was a strong negative correlation among the bare soil and rangeland classes. There was a strong negative linear relationship between bare soil and rangeland and among bare soil and plantation classes in around Bamyan city. This indicates that population rises, lack of management policy and anthropogenic activities have a direct influence on land degradation. Because of population raises, human actions and conflict the land cover has change and leading to an increase in bare soil and reduction of rangeland and other vegetated areas, consequently reflecting and an overall decrease of natural resources over the 25 years among 1990 and 2015. Based on these results the policymakers understand that land degradation becomes serious, but then they don't know the seriousness by numerical number. One of the significant results of this study is to guide the policymakers recognize the seriousness by numerical number. Secondly, potentialize, simulation of land policy effect by ecosystem model, since the simulation model needs past land cover change data.

Chapter 3

Land cover change prediction in Bamyan, Afghanistan using ecological model of VISIT

3.1 Introduction

Afghanistan is arid country, most of it is mountainous or desert with a total land area of 652,090 km^2 and only 12% is usable as farmland (Groninger 2006 and Wiley 2003). Afghanistan natural resources damaged by long conflict and years of life-threatening drought that have damaged the people's traditional managing and mitigation strategies. Fuelwood demand and unsustainable land use practice such overgrazing and cultivation of high steep and marginal land have degraded forests and rangeland and triggered deforestation, flooding, water scarcity, and soil degradation (Denmark 2007). Afghanistan is a country under pressure with 14 million of its population nearly half of Afghans are very poor or susceptible to risky poverty. According to estimation 80% of Afghans live in rural areas and are reliant on natural resources for their livelihoods (USAID 2010). As stated by Ali and Shaoliang (2013) it is obvious that rangeland inhabit is the biggest proportion of Afghanistan's land. About 45 % of this country's over-all area is categorized as rangeland. On the other hand, a big area of land classified as barren or unused land, which this land also using as opportunistic grazing, especially in the winter or in the year with good rainfall or precipitation. The total area under extensive grazing is projected to be amongst 70% to 85% of the entire land area of Afghanistan. The main and direct use of these rangelands is for livestock grazing. Raising livestock in the rangeland and widespread use of the rangeland properties are the key factor of the local farming system and livelihood strategies for more than 80% of households in Afghanistan. Afghanistan's rangeland besides fodder supplying for livestock is as well a significant provider of some very important ecosystem good and services such fuelwood, habitat for wildlife, medicinal plants, preserve soil and water and assistance to regulate the climate.

Rangeland is not providing only green browsing in spring and summer also dry fodder in winter, but is important sources of cooking and heating fuel, as well supply critical ground cover in water catchment systems for valley settlements and farming. In the recent decades, the rangeland resources have been deteriorating and losing vegetation cover through overgrazing and overexploitation of bushy plants for fodder and fuel. This process has directed to increased soil erosion, reduced infiltration, and additional speedy run-off. Several previously suitable rangelands have converted nearly barren wastelands. The rangeland degradation has accompanied by the change of some area which was used as grazing land into rain-fed agriculture. Which this procedure, in drought years and places with low rainfall destroys the ability of the land to restore a stabilizing vegetation cover. Thus, the deforestation sequence combined with overgrazing and drought has directed to improve soil erosion, landslide, watershed dilapidation; damage of biodiversity, harming of livelihood sources, desertification, land degradation and decreases ecosystem services (Denmark 2007 and MAIL 2006).

3.2 Objective

The objective of this chapter is the prediction of future land cover changes and land degradation in Bamyan. Most people in Bamyan don't know how much biomass they can use sustainably. It is difficult to build a consensus of land-use without knowledge of future land degradation and land cover change. To achieve the objective, the information of land degradation offered with some scenario we can build consensus for land use limitation and develop an operational method for land cover change and land degradation. The scenario has built based on fodder and bushes use and LAI data which are simulated by VISIT.

3.3 Method and materials

3.3.1 Livestock and bush collection in Bamyan center

Rangeland resources due to the arid to semi-arid nature of Afghanistan have very low and highly variable fodder productivity ranging between 0.4 and 0.8 tonnes/hectare in years with good rainfall (Bedunah 2006). Table 3.1 shows the fodder productivity of rangeland and number of livestock in Bamyan center.

Insufficient investigations have been accomplished to evaluate the dry matter production of the rangeland of Afghanistan and the amount of pasture productivity highly fluctuates between areas, amongst season and from year to year (USAID 2006). Ali and Shaoliang (2013) stated that the grazing is predominately "free-grazing" without rotation and suggests the stocking levels may have exceeded carrying capacity and a decline in pasture conditions. Bedunah (2007) specified that in view of the number of livestock inside the grazing area, there is a mean of 3.98 ha/head/year of livestock. This will be a high grazing degree if it continues and will cause rangeland degradation. According to (Mohibbi and Cochard 2014) calculations specified that a typical 'bundle' (donkey load) contained 750 shrubs (mostly *Artemisia spp*. and *Acantholimon spp.)* of 50 kg weight at harvest. For such harvest, a relatively productive shrub land area of up to $100m^2$ was cleared (biomass mostly included partly dug-out below-ground parts of plants). This calculation took place in Band-e Amir national park close to current study area with a similar situation. The amount of bush per household used is based on a survey in 2015 Table 3.2.

The communities usually graze animals near the village pastures in spring, but from mid-spring until early autumn they graze animals to high altitude far from villages and agricultural areas. From mid-autumn to late autumn again they bring the animals near the villages for grazing. From late autumn, the indoors feeding is starting and they keep the animals in the stables. In Bamyan center an average 4 months indoors feeding is common due to the cold season(winter). Beside animals grazing communities collect bushes from range land for cooking and heating. The bush collection is taking place from early spring to late autumn. The highest collection season is spring and early autumn. In Bamyan 69.1% (Figure 3.1) of household collect bushes for their livelihood and for bushes collection they must walk 5 to 10 km.

Table 3.1. number of livestock, rangeland area and fodder productivity

Range-land area ha/ (FAO 2010)	Livestock/ NO	Ha/head	Fodder productivity/year/ tonnes/hectare
123509	43496	2.83	0.4 – 0.8

Table 3.2. Average bush collecting per household and total bush use in Bamyan center district per year.

Average Donkey load bush/household	32
Average weight donkey load/kg	50
Area of a donkey load/sqm	100
Average household consumption ton/house/year	1.6
Household/NO in Bamyan district center 2011	12000
Population/2011	85200
Percentage of household use bush	69.1
Number of household use bush	8292
Total bush/year/ton	13267.2

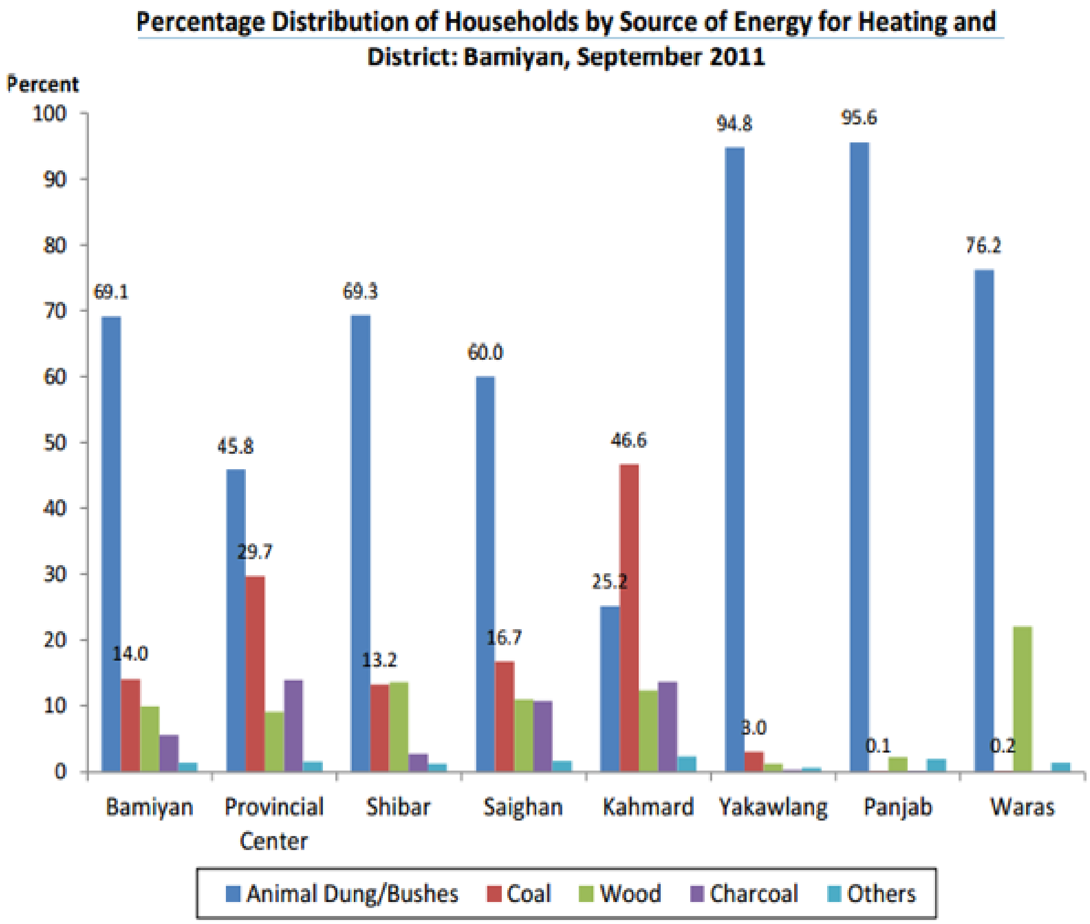


Figure 3.1. The source of energy for heating and cooking in Bamyan.

Source: Central Statistics Organization (2012), Socio-demographic and economic survey Bamayn

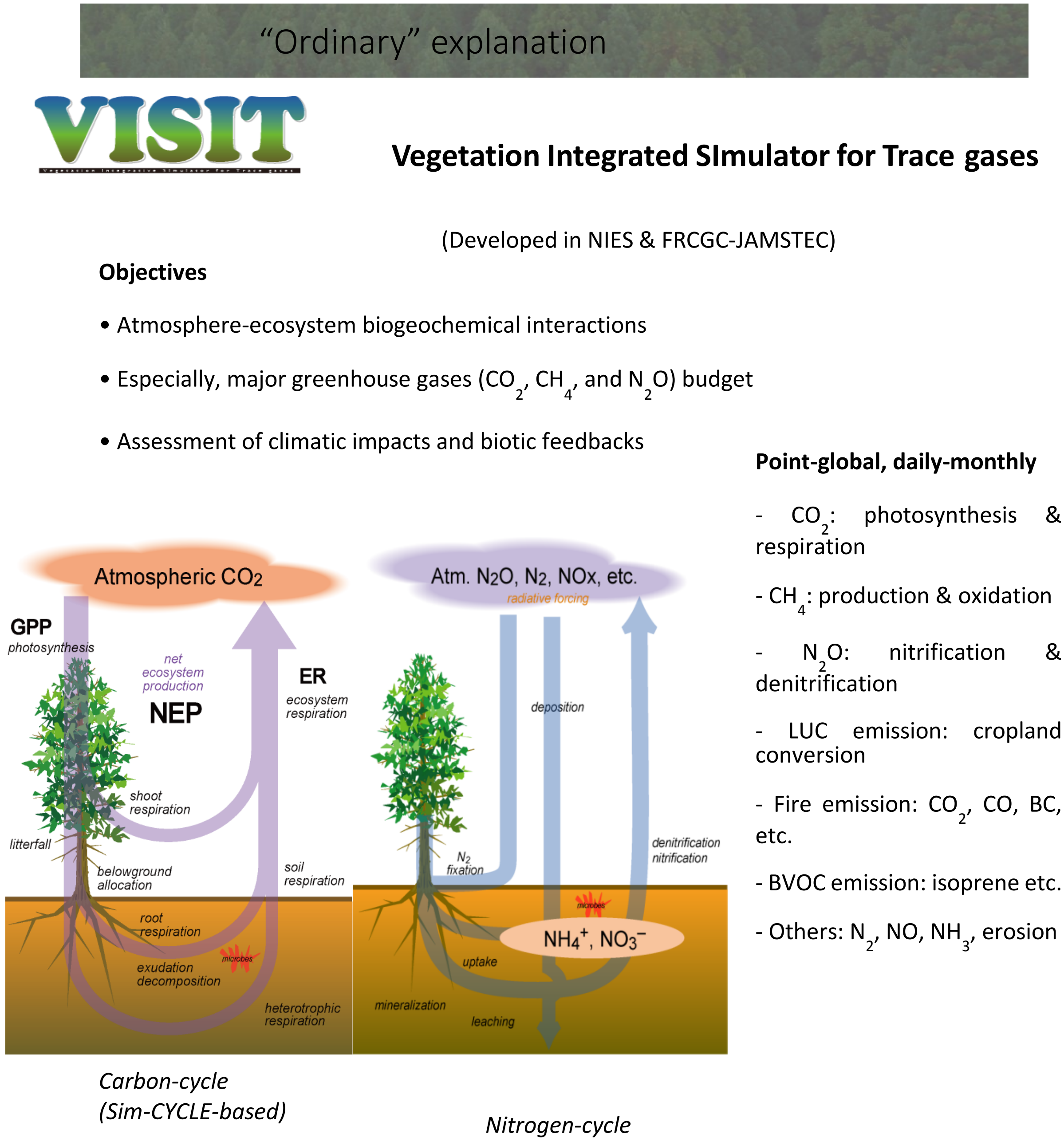
3.3.2 Vegetation Integrated SImulator for Trace gases (VISIT)

VISIT is a process-based model of the terrestrial biosphere and originated from Ito and Oikawa (2002) and notable development achieved. Consequently, VISIT is skillful of simulating changes in the form and function of the ecosystem (SAITO et al., 2011). According to (Hirata et al., 2014) VISIT model can deliver daily components of the carbon balance, containing NEP, GPP, RE, NPP, biomass, and soil organic matter, by simulating biogeochemical and hydrologic processes.

As specified by Ito (2010) the VISIT model simulates intra-ecosystem carbon flows accompanying with, for instance, litterfall, provision of photosynthate, growth, and leaf phenology at daily time phases, as well using data on soil temperature, air humidity, solar radiation, air temperature, cloudiness, precipitation and wind velocity. The model was improved to be suitable for wide-ranging and it is appropriate for regional carbon budget studies, although it similarly successfully captures ecosystem carbon cycle and growth processes at the site level (for example 1 ha). The spatial simulation of VISIT extend from point to global scale in the temporal simulation range is from daily to a monthly simulation.

As stated by Ito and Inatomi (2012) VISIT has been advanced on the foundation of Sim-CYCLE by including a nitrogen cycle structure and extra trace-gas exchange schemes (for example CH4 production and oxidation, biomass burning, emission of biogenic volatile organic compounds). This model verified through assessments with a diversity of experimental data at diverse scales. For instance, evaluation of the carbon dynamics at 17 locations around the world displayed that the model has successfully captured the productiveness, biomass, and soil carbon stocks of ecosystems extending from tropical rainforest to arctic tundra.

VISIT is applicable in global, regional and local scale. VISIT can simulate future land degradation as well suitable for long-term prediction such as land cover changes and carbon budget. VISIT is applicable in semi-arid and low forested area and cool semi-desert shrubs. Figure 3.2 show ordinary explanation of VISIT model.



Source: Ito 2010

Figure 3.2. Ordinary explanation of VISIT model

3.3.2.1 Input data for the VISIT model

Land cover data: The land cover data of 2010 of Bamyan district center was used which was made by FOA for Afghanistan. And the land cover database presents information on land cover distribution. It has been generated using the FOA/ Global Land Cover Network (CLCN) methodology and tools.

Satellites imagery from SPOT-4 (2009-2011) and Global Land Survey (GLS-2011) Landsat satellites, high-resolution satellite imagery and high-resolution aerial photographs, ancillary data were used as the main data sources (FAO 2012) Figure 3.3.

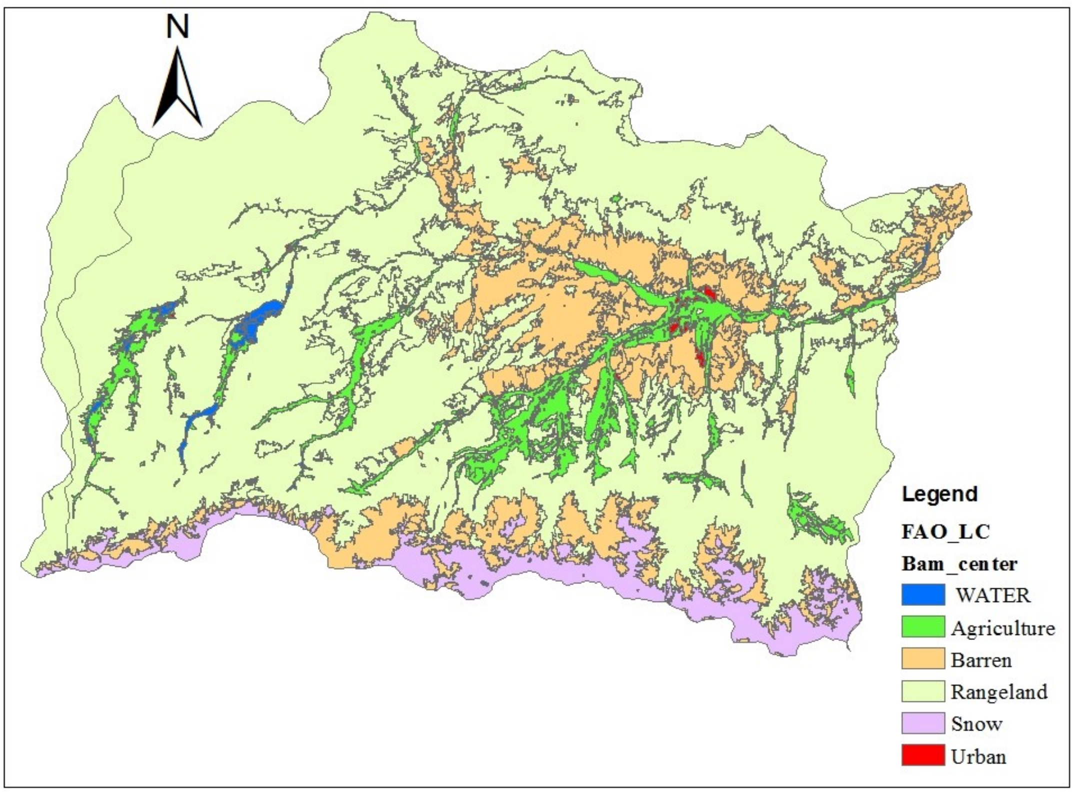


Figure 3.3. Land cover map (2010) of Bamyan district center

Shuttle Rader Topography Mission (SRTM): with 30 m resolution from USGS were used figure 3.4

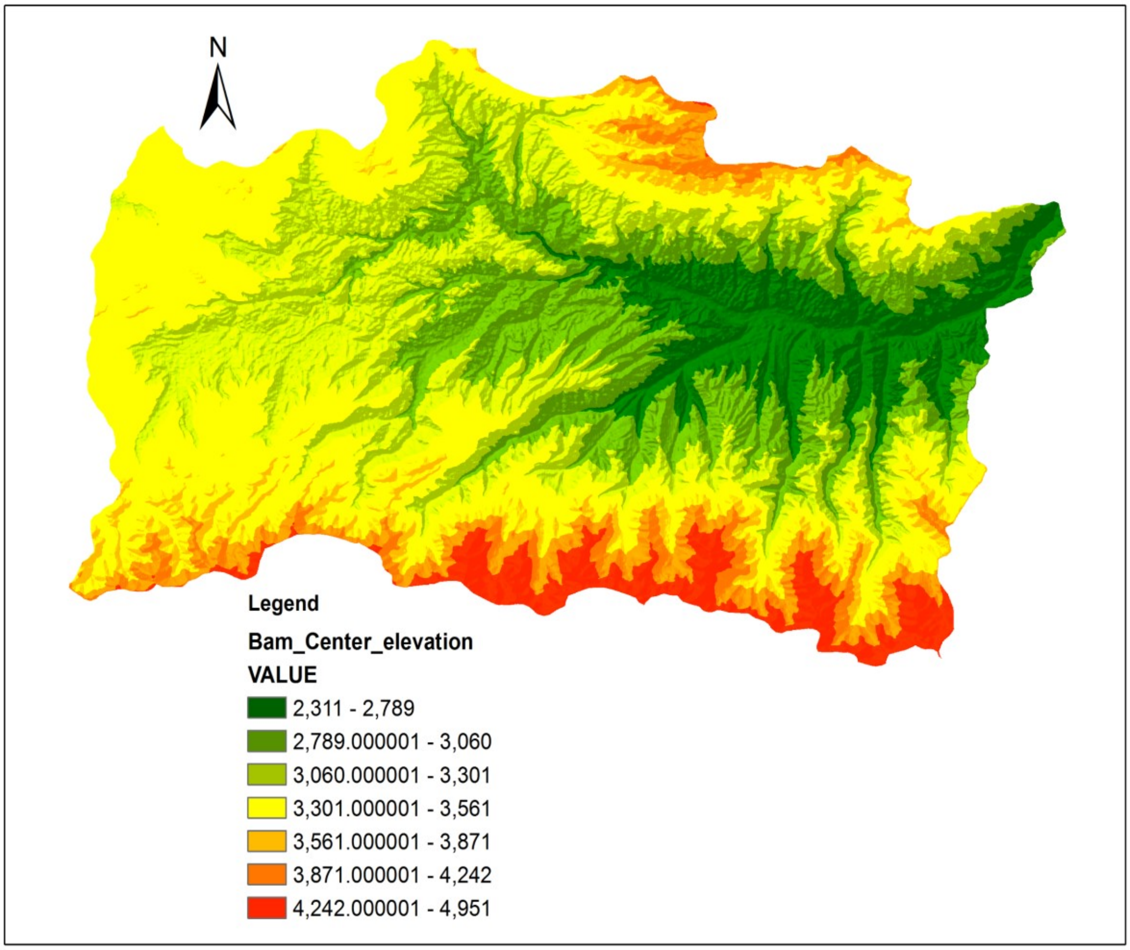


Figure 3.4. Elevation map of Bamyan district center

Soil data of Bamyan: were extracted from Harmonized World Soil Database (HWSD).
The HWSD comprises of a 30 arc-second (or ~1 km) raster image and a characteristic database in Microsoft Access 2003 arrangement. The raster image file has been stored in double format (ESRI Band Interleaved by Line - BIL) which can be read directly or imported by many GIS and Remote Sensing software (Nachtergaele et al., 2012). The GIS was used to extract Bamyan soil Figure 3.5

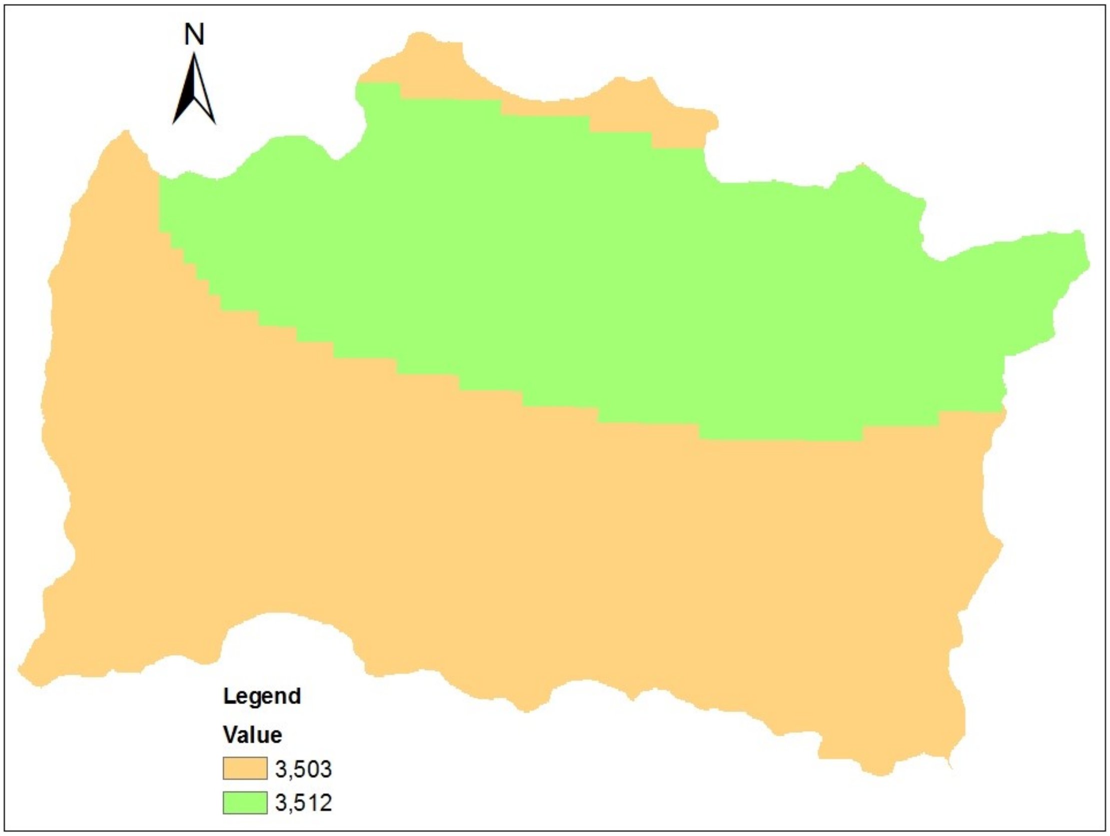


Figure 3.5. Soil map of Bamyan district center from HWSD.

The climate data: are produced from 1978- 2016 the sources of data are European Centre for Medium-Range Weather Forecasts (ECMWF) and the US National Center for Environmental Prediction.

As stated by Huld and Pascua (2015) Various methodological applications required data on outdoor air temperature at the near-ground level, frequently called 2-meter temperature from the standard height of meteorological measurements. Though, the accessibility of 2 m-temperature measurements differs strongly: whereas some areas have a relatively high system of measurement stations, but some areas in the world have a limited network of measurement stations. High variation in the 2 m-temperature in short distances is happened particularly if there are big differences in elevation, even measurement stations have short distances away might not be representative of local conditions.

For the VISIT model, daily temperature data from ECMWF at 2m-temperature was produced. The ECMWF resolution is coarse, the Bamyan topography is very diverse such as big differences in elevation with high slopes (Figure 3.6), Therefore, this data corrected by Shuttle Radar Topography Mission (SRTM) 30m resolution as follows:

Correction: by elevation $T = T_0 + 0.0065(H_0 - H)$

T_0: temperature of representative point

T: temperature

H_0: elevation of representative point

H: elevation

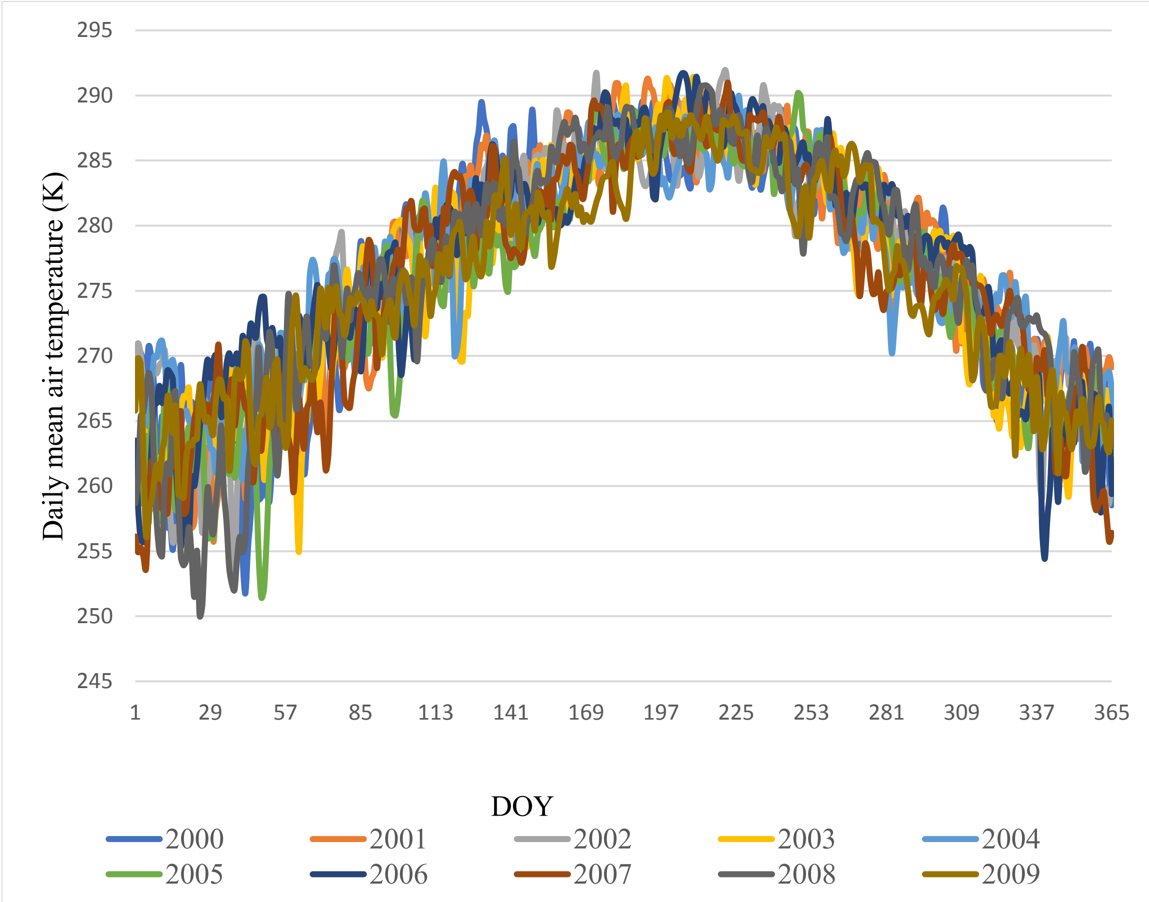


Figure 3. 6. Daily mean air temperature from 2000 to 2009

Specific Humidity is the mass of water vapor per unit mass of air.

The dew point was produced in every 6-hour period from ECMWF then the daily average humidity was estimated by averaging four data (4*6) Figure 3.7. The specific humidity was calculated on daily based on dew point by the following equation.

d: dew point

r: atmospheric density at representative point

h: specific humidity

$e_0 = 6.11 * 10^{\left(\frac{7.5*d}{(23,7.3+d)}\right)}$ water vapor pressure at representative point

$a_0 = \frac{217*e_0}{d+273.15}$ water vapor content at representative point

$h = a_0/(1000r)$

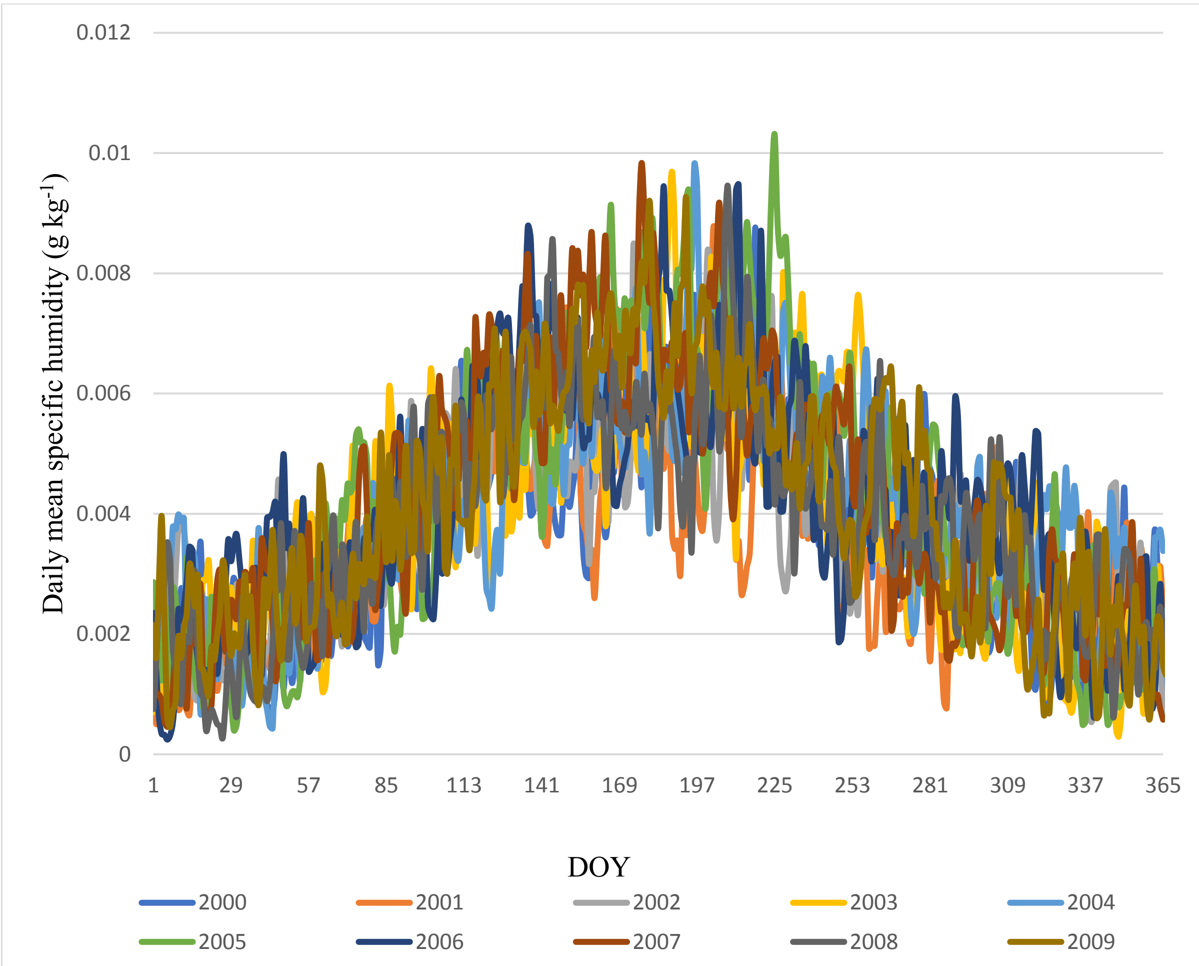


Figure 3.7. Daily mean specific humidity from 2000 to 2009

The daily precipitation data were sued from ECMWF within 6 hours period. The daily precipitation was calculated by summing up of four data (4*6). Figure 3.8.

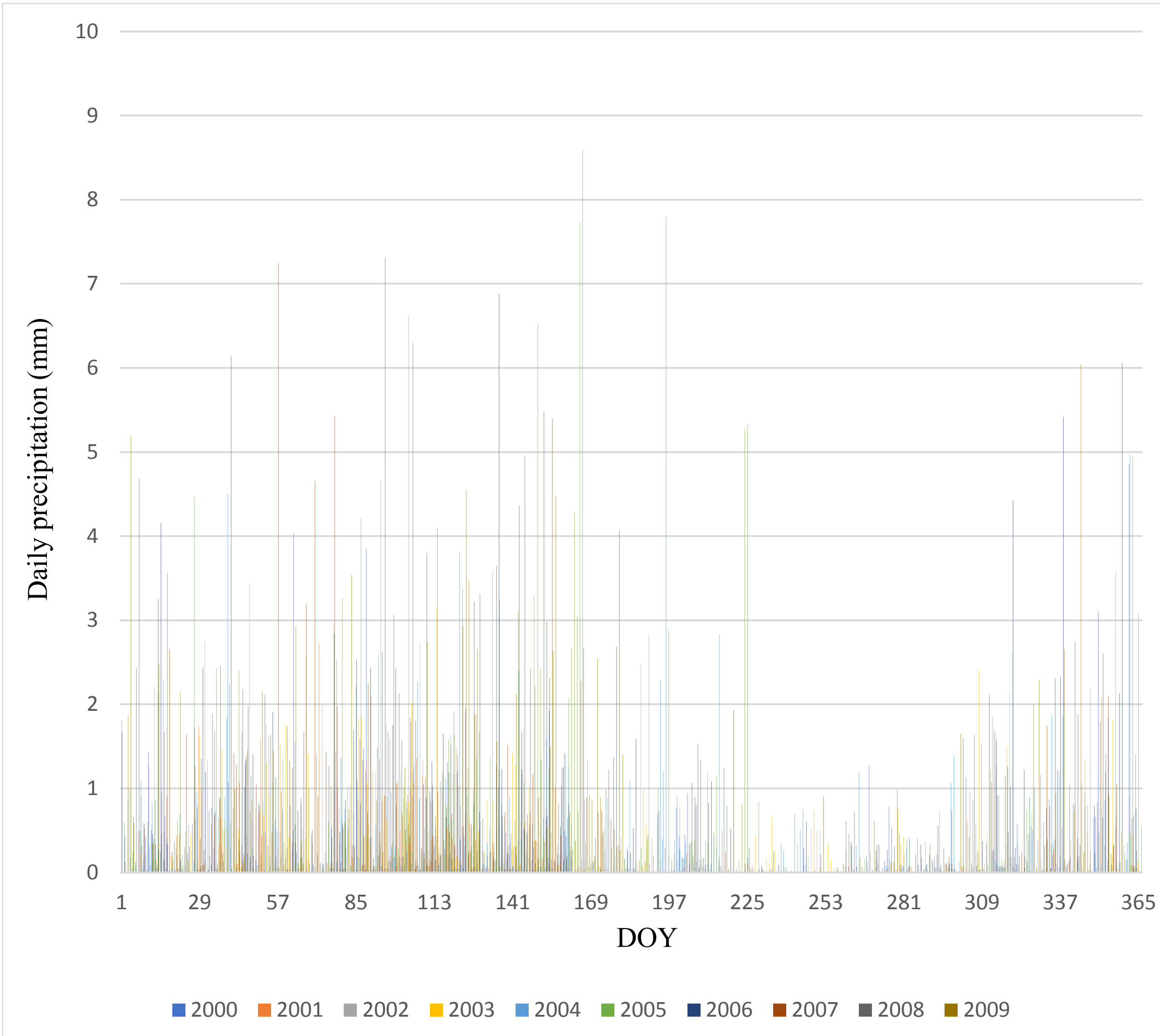


Figure 3.8. Daily precipitation from 2000 to 2009

The daily wind speed was produced from ECMWF within 6 hours period. The daily wind speed was calculated by averaging four data (4*6) Figure 3.9.

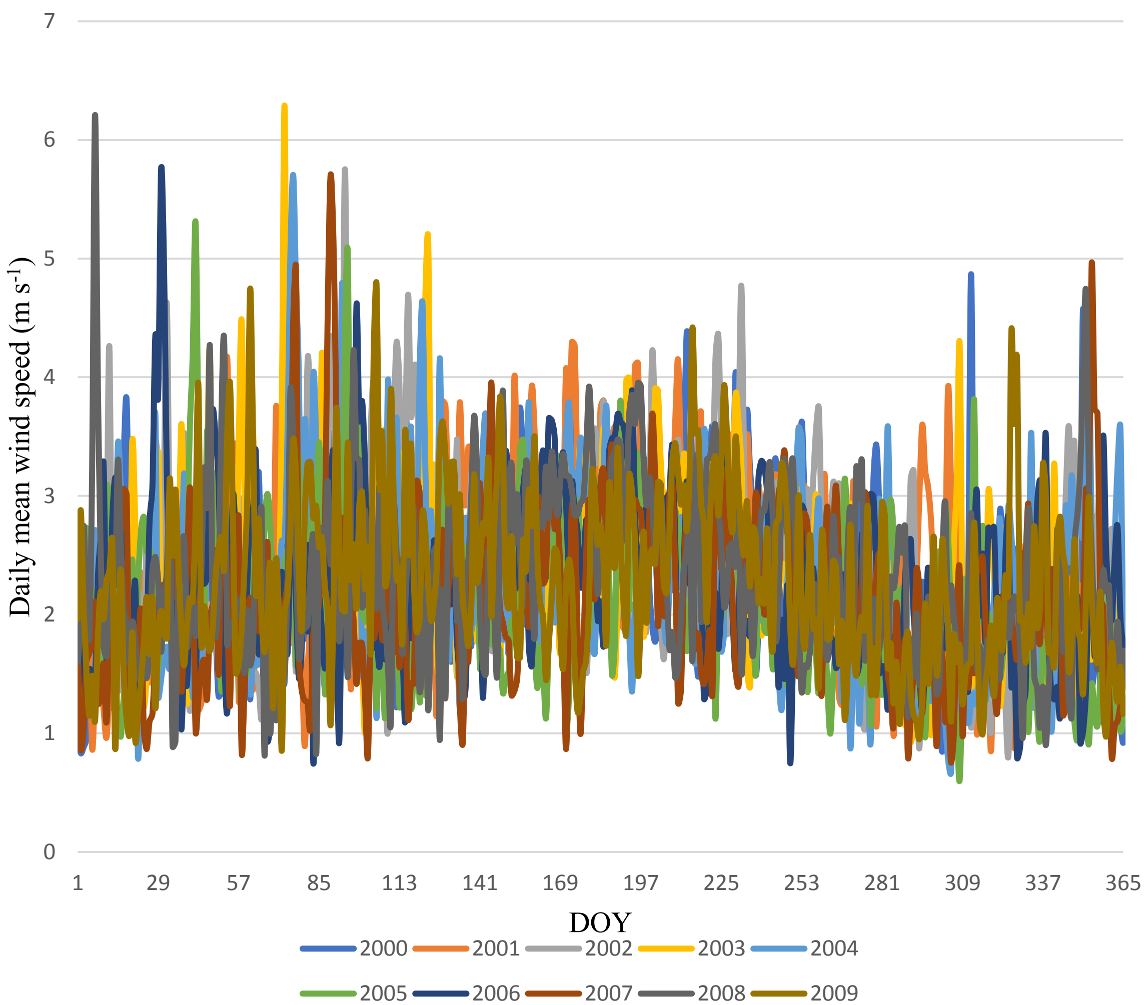


Figure 3.9. Daily mean wind speed from 2000 to 2009

- The hourly solar radiation was used which gathered from ECMWF and NCEP Figure 3.10. 12 hourly data were collected from ECMWF and 1-hour data was collected from NCEP. The resolution of (ECMWF and NCEP) are coarse in the slope differences in Bamyan is diverse, therefore these data are corrected as follows:

Correction: interpolation of time.

r_{Ed}: daily accumulated solar radiation calculated from ECMWF 12 hours data.

r_{Nd}: daily accumulated solar radiation calculated from NCEP hourly data.

r_{Nh}: hourly accumulated solar radiation of NCEP

r_h: hourly accumulated solar radiation in representative point

$$r_h = r_{Ed} * r_{Nh}/r_{Nd}$$

Solar radiation

$$S_{top} = I_{00}\left(\frac{d_0}{d}\right)^2 (\sin\phi \sin\delta + \cos\phi \cos\delta \cos h)$$

$$h = 15.0 \times (localtime - 12) \times \frac{\pi}{180}$$

$$I_{00} = 1366$$

d_f: ratio of diffuse solar radiation

$$\left(\frac{d_0}{d}\right)^2 = 1.00011 + 0.034221 \cos\eta + 0.00128 \sin\eta + 0.000719 \cos 2\eta$$

S_{top}: Solar radiation at top of atmosphere

ϕ: latitude

δ: declination

$$\eta = (2\pi/365.24)k$$

k: Julian day

I_{00}: solar constant

$$d_f = 0.958 - 9.882 * S_{surf}/S_{top}$$

S_{ECMWF}: solar radiation at surface (ECMWF/NCEP data)

$$S_{direct} = S_{ECMWF} * (1 - d_f)$$

$$S_{diffuse} = S_{ECMWF} * d_f$$

S_{direct}: direct solar radiation at surface

$S_{diffuse}$: diffuse solar radiation at surface

$$S_0 = S_{direct}/(\boldsymbol{u} \cdot \boldsymbol{e}_3)$$

$$S = S_0 \cdot (\boldsymbol{u} \cdot \boldsymbol{v}) + S_{diffuse}$$

S: solar radiation at each grid cell

$\boldsymbol{v}$: normal vector of surface at each grid cell

$\boldsymbol{u}$: vector of solar radiation

$\boldsymbol{e}_3$: unit vector for z direction

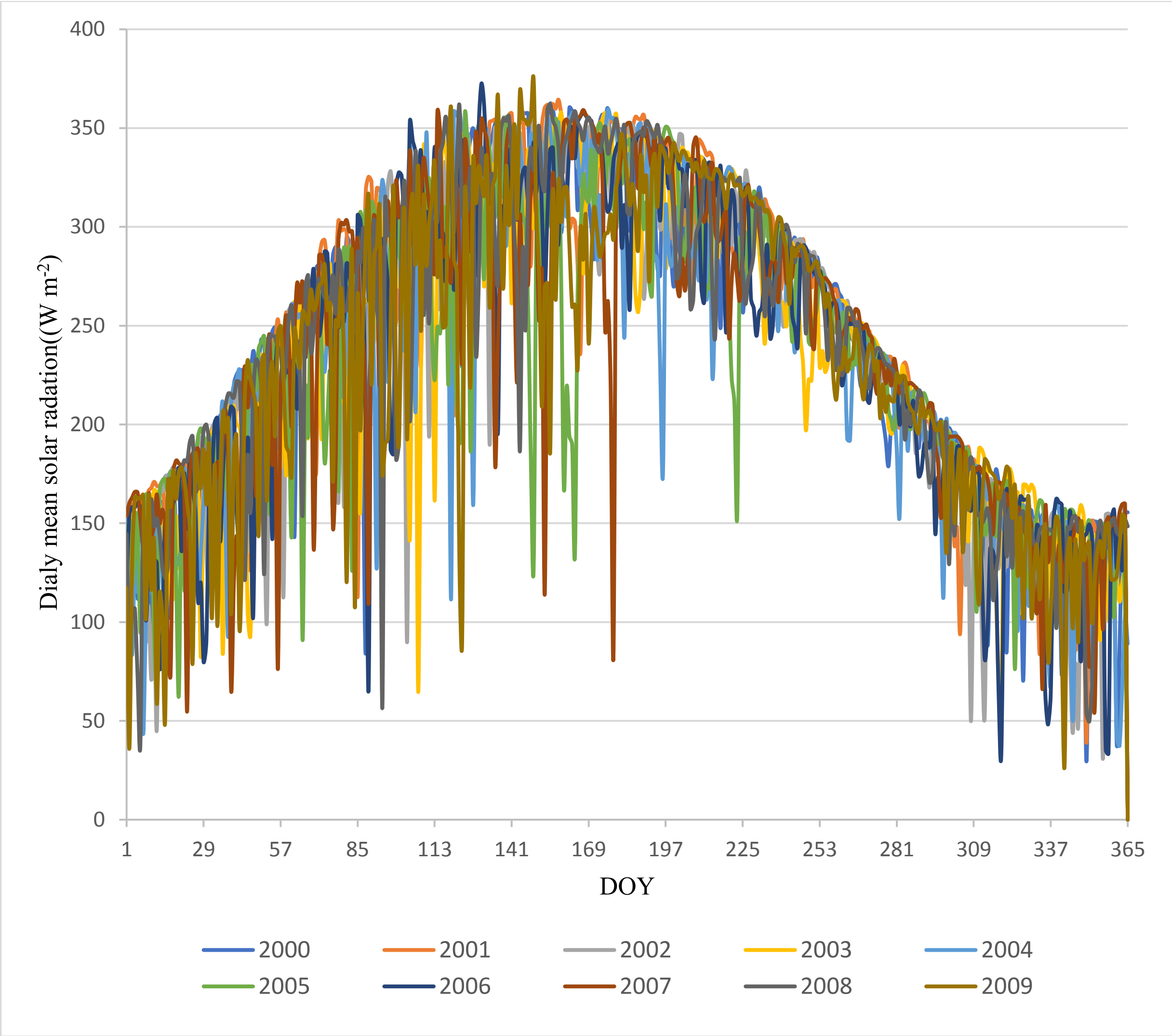


Figure 3.10. Daily mean solar radiation from 2000 to 2009

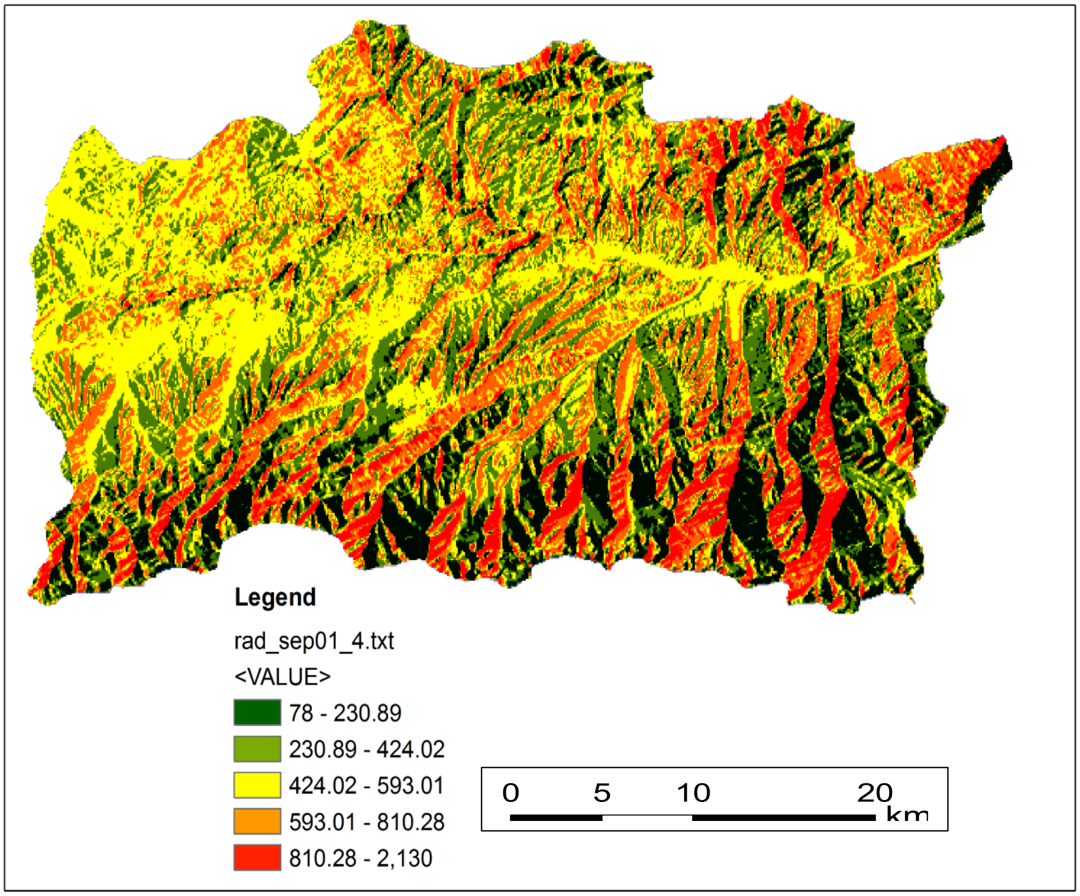


Figure. 3.11. Solar radiation ((W m^{-2}) first September 2005 of Bamyan district center.

3.3.2.2 Method of land degradation prediction

land degradation area is estimated based on NPP data which the NPP data is same as consumption of fodder and bush collection for fuel. Degradation is severe in the area where NPP is high. The collection of fodder and bushes are higher in the areas where the NPP is high. The VISIT model can't specify which areas the changes have occurred. Therefore, the Landsat classified images 2015 were used in compared the spatial distribution of NPP to detect the change area.

The NPP of 2000 Figure 3.13 of Bamyan central district is extracted by polygons of rangeland area and barren land area of 2015 Landsat classified images Figure 3.14. The two-sample t-test is used. The NPP which has been extracted by rangeland polygon have the lowest NPP an average of 0.41 and with standard deviation of 0.19 and the area which has been extracted by barren land polygon have the higher NPP with average of 0.90 with standard deviation of 0.43, and the P-value <0.001, Table 3.3, and Figure 3.12. There is a significant difference in NPP between the area of a barren land polygon and rangeland polygon. We can argue that the higher amount of NPP are collected from the barren land area which people used biomass as fodder and fuel for cooking and heating, and it leads fast loss of land cover and consequently caused land degradation especially in a populated area.

Table 3.3. The NPP (2000) average and standard deviation and number of observation

	Bare soil area 2015	Rangeland area 2015
Average	0.9	0.41
St.D	0.43	0.19
Observations	682	694

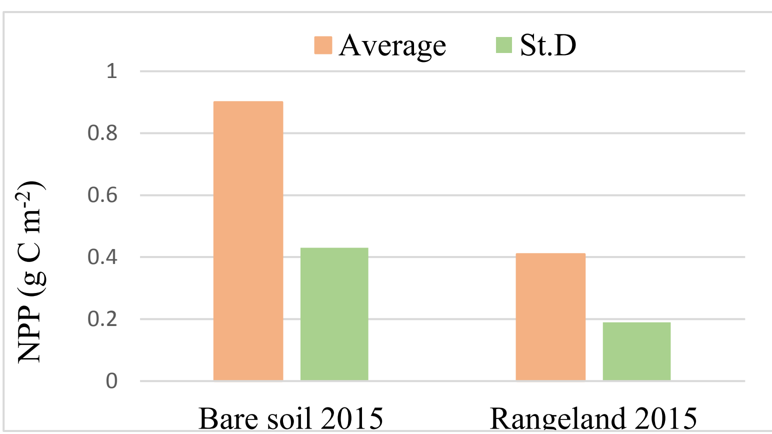


Figure 3.12. The distribution of average NPP (2000) which extract by barren land and rangeland polygons of 2015 of Bamyan district center

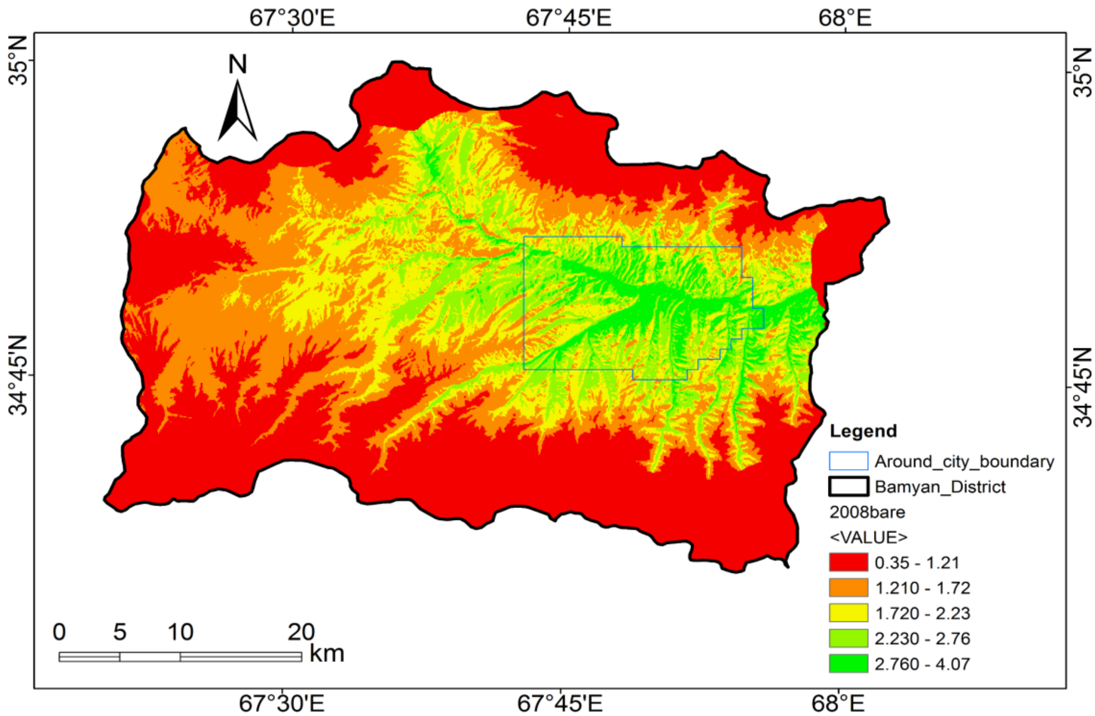


Figure 3.13. NPP map of 2000 of Bamyan district center and the blue boundary is indicating around Bamyan city.

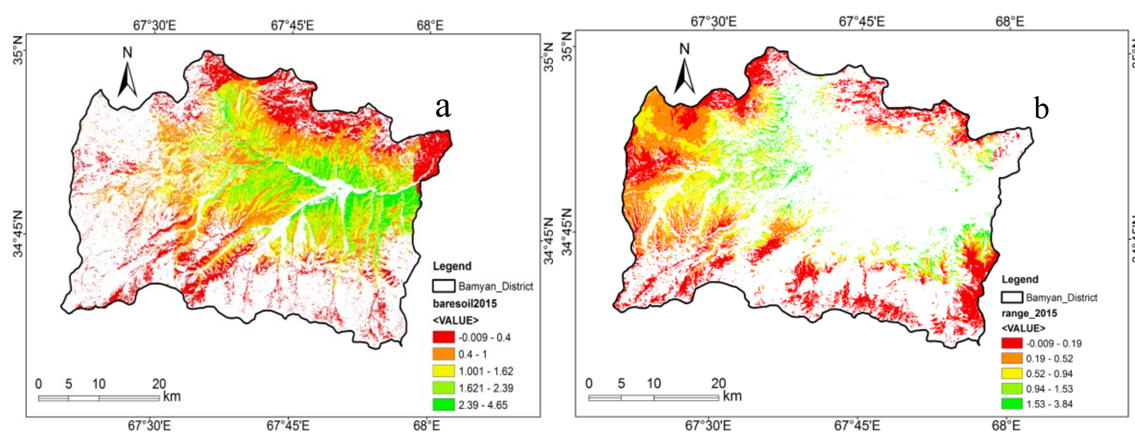


Figure 3.14. The NPP map extracted by barren land (a) polygon and rangeland polygon(b)

The high NPP area is the bush collection area which people collected fodder and bush for cooking and heating in this area is under a high level of degradation due to the removal of plant covers.

3.3.3 Result of VISIT Model

The land degradation area and Leaf Area Index (LAI) of Bamyan district center was simulated by VISIT model. The degradation area is estimated by the production of fodder and bushes and degradation area is severe in the area where Net Primary Productivity (NPP) is high.

Different scenarios were projected which Scenario, S0 is the constant fodder and bushes use (Figure 3.15). Scenario S1 is the fodder and bushes use increase as the incremental ratio of population in Bamyan.

Scenario S2 shows 2% reduction per year for S1 and S3 shows 3% reduction to S1 per year.

The LAI maps were produced for S0, S1 for the years of (2030, 2040 and 2050) as well for the scenario S2 simulate for the years of 2030 and 2040 and LAI maps of years of 2030 and 2040 where simulated within 3% reduction to S1. Although the land degradation maps where simulated based on applied scenarios were made for S1 (2030, 2040) and S2 (2030, 2040) scenarios. Then the maps were compared based on years to define the changes.

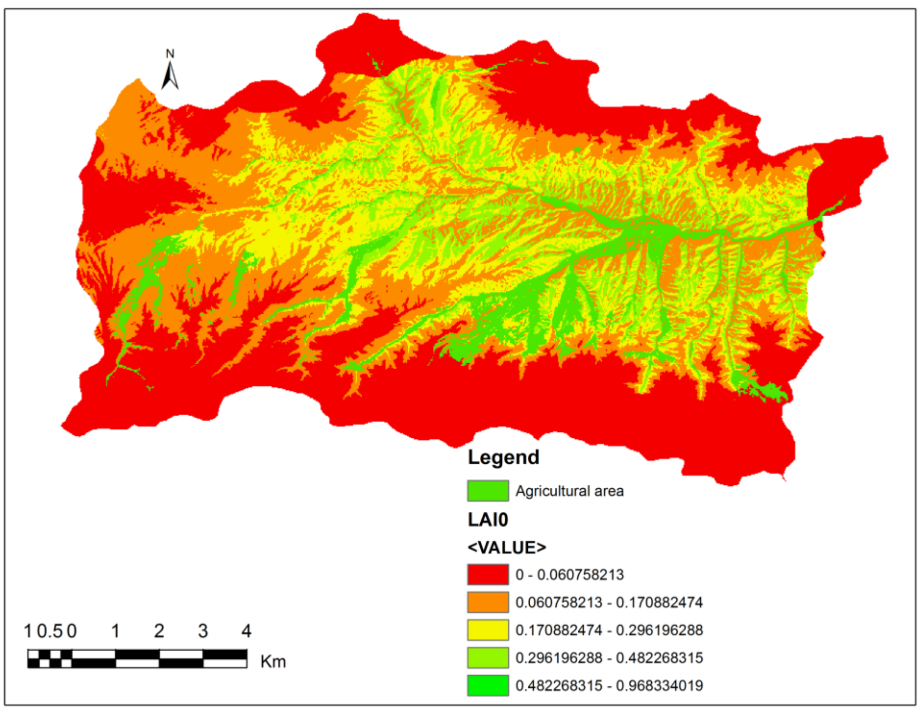


Figure 3.15. Leaf Area Index of Bamyan center of S0 (constant fodder and bushes collection).

LAI scenario S1(fodder and bushes use increase as the incremental ratio of population in Bmayan) is compared with S2 (2% reduction) in the year (2030) and shows the LAI area has increased Figure 3.16.

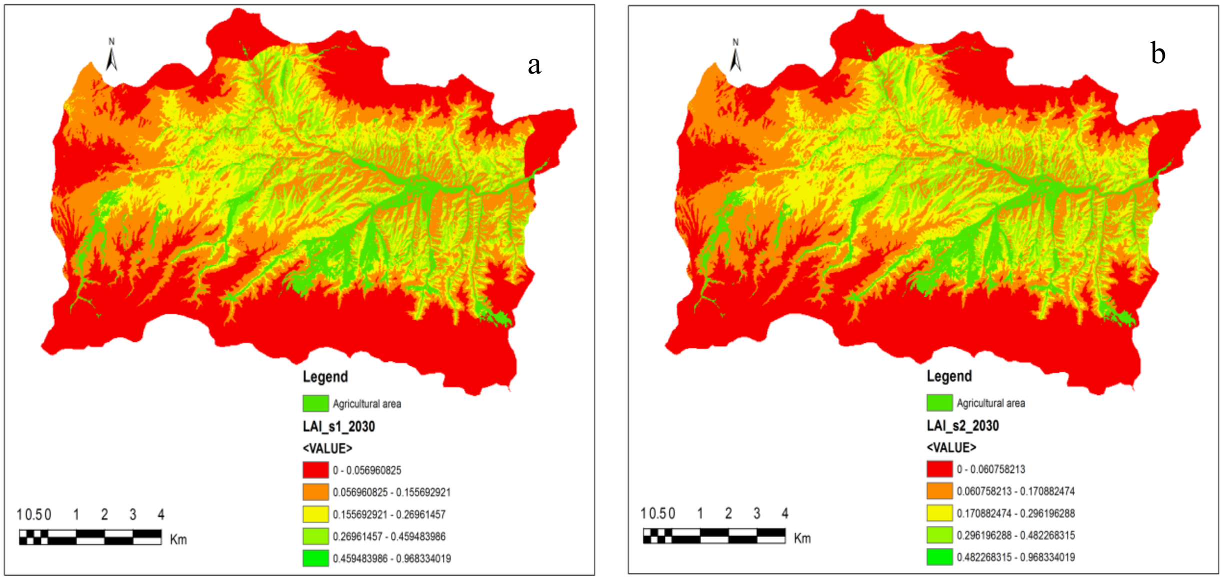


Figure 3.16. (a) bush and fodder use increase as the incremental ratio of population in Bamyan and (b) is the 2% reduction each year of fodder and bushes use.

LAI scenario S1(fodder and bushes use increase as the incremental ratio of population in Bmayan) is compared with S2 (2% reduction) in year (2040) and shows the LAI area has increased.

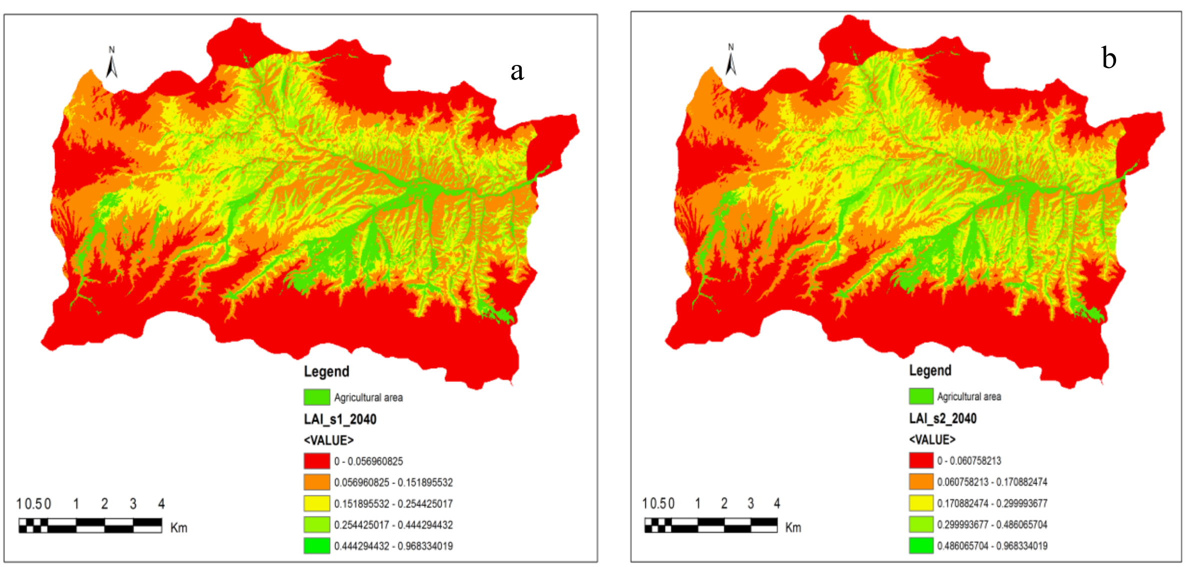


Figure 3.17 (a) bush and fodder use increase as the incremental ratio of population in Bamyan and (b) is the 2% reduction each year of fodder and bushes use.

AI scenario S1(fodder and bushes increase as the incremental ratio of population in Bmayan) is compared with S3 (3% reduction) in year (2030) and shows the LAI area has increased.

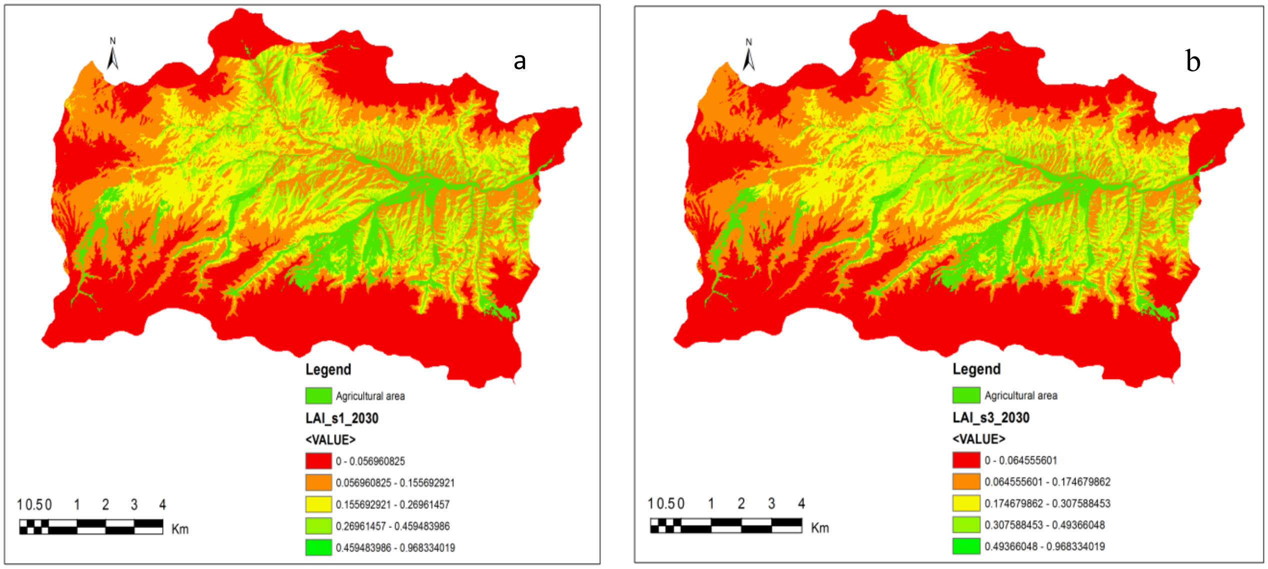


Figure 3.18. (a) bush and fodder use increase as the incremental ratio of population in Bamyan and (b) is the 3% reduction each year of fodder and bushes use.

LAI scenario S1(fodder and bushes increase as the incremental ratio of population in Bamyan) is compared with S3 (3% reduction) in the year (2040) and shows the LAI area has highly increased.

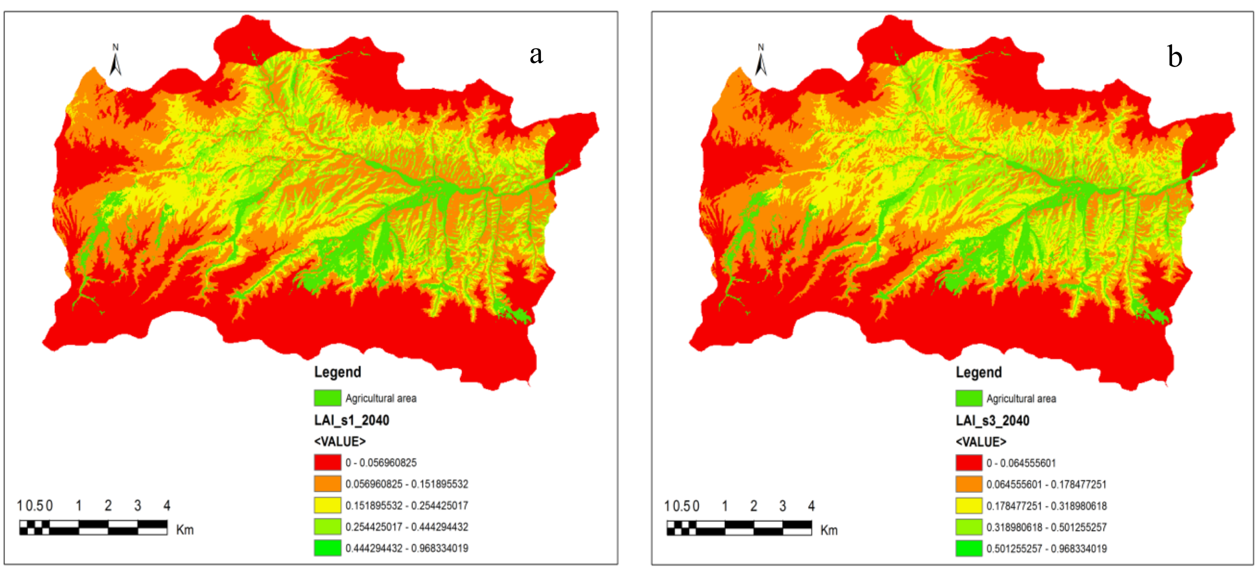


Figure 3.19 (a) bush and fodder use increase as the incremental ratio of population in Bamyan and (b) is the 3% reduction each year of fodder and bushes use.

Constant fodder and bushes(S0), S1(Fodder and bushes use increases as the incremental ratio of population in Bamyan) and reduction scenario (S2 and S3).

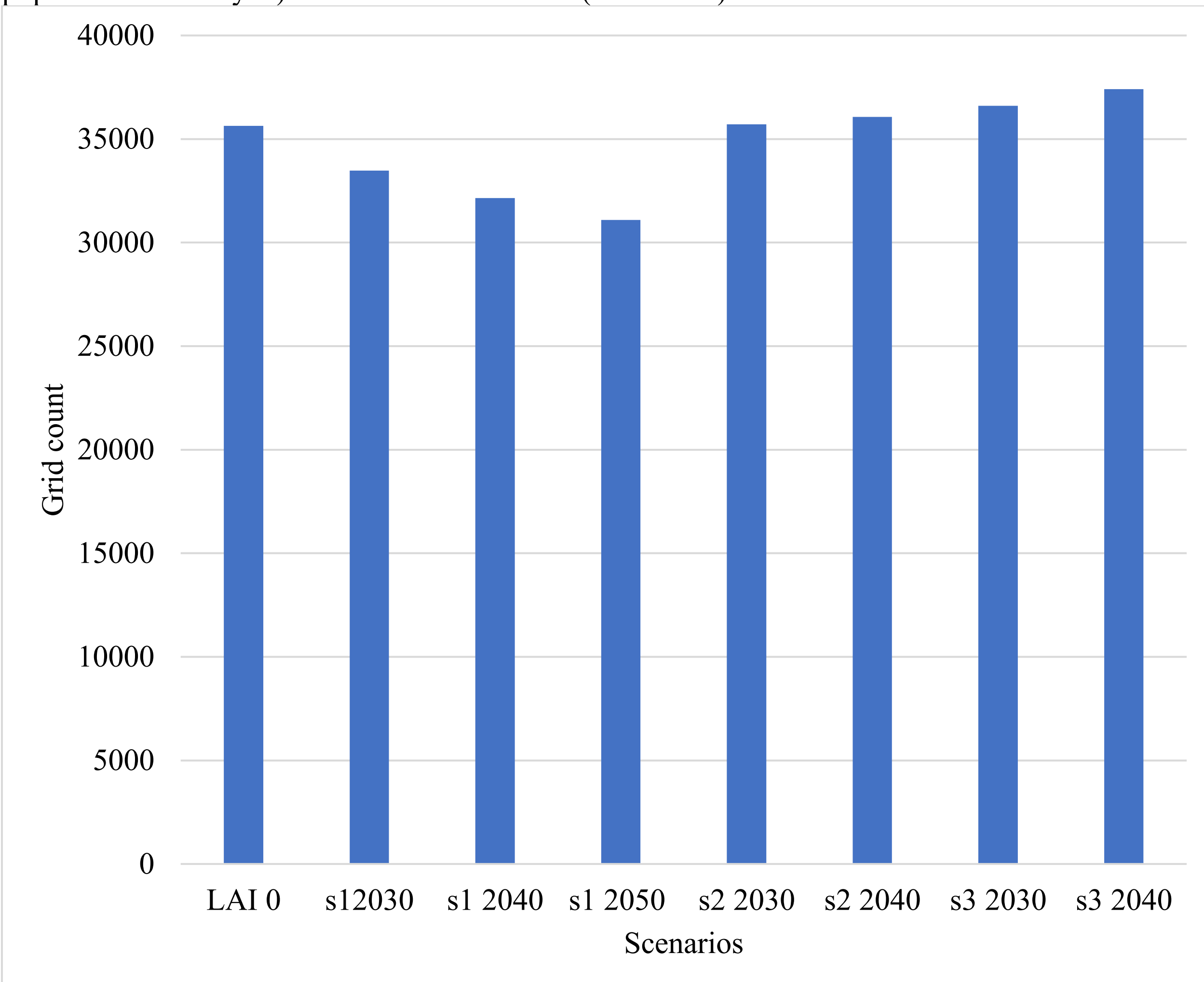


Figure: 3.20. Fodder and bushes use increases as the incremental ratio of population in Bamyan and reduction scenarios.

3.3.4 Discussion and conclusion

Land use and land cover change are accounted significant human-driven environmental changes on all spatial and temporal levels. These changes incorporate the extreme environmental concerns of human populations today containing climate change, biodiversity loss, contamination of water, soils, and air. Monitoring and preventing the adverse consequences of land cover change, while sustaining the production of critical resources has become a key priority of policymakers and research around the globe. The land use and land cover pattern of an area is a consequence of natural and socio-economic influences and their exploitation by the human in time and space. The information regarding land cover and land use change is significant for various policy and planning and management activities (Kumar et al. 2015).

Land use and land cover (LULC) models are very important for analyzing land cover change and predicting land use necessities and are treasured for guiding realistic land use planning and management. Though each model has its own advantages and limitations, we used VISIT model which is a processed based model and it has the skill of simulating changes on the form and function of the ecosystem. This model is applicable from global to point level. By this model, NPP and LAI of Bamyan district center are calculated using various data such as climate data, soil data, land cover data, biomass data, elevation model etc.

In Bamyan, people are collecting fodder and bushes as fuel in the source of this biomass is rangeland. The rangeland is highly under pressure of degradation. As stated by Shroder (2014) Afghanistan, in general, any area with access to shepherd and their animals is commonly overgrazed mostly by angulated animals such as sheep and goat; exploited for fodder plants and the shrubs are uprooted for fuel. The overgrazing weakens the protective ground cover. The supplementary fertile upper layers of the soil become more exposed to wind and slope-washed water erosion.

The land degradation areas are calculated based NPP data. The NPP data is equal to the consumption of fodder and bush collection for fuel. The biomass collection takes place in the areas where the population concentration is high and leads to significant land degradation. This finding agrees with (MAIL 2006) which states that rangeland in Afghanistan is under particular risk of degradation by heavy grazing which reduced protective cover and exposed soil to erosion. It is observed that vegetation cover is being removed for fuelwood and rangeland area has changed for dryland cultivation. This process led to increased soil erosion, landslide, watershed degradation, loss of livelihood sources, land degradation and reduced ecosystem services. According to (UNEP 2009) the environment in Afghanistan is categorized by a precarious equilibrium among low levels of precipitation and primary production. Currently, we can observe a condition of biodiversity loss, land degradation due to natural and anthropogenic reasons, the denudation of bio-physical protection which hastens wind and water erosion, and an actual lack of productivity in the arid zones. Poor soils are reducing carrying capacity, subsequent to overstocking, farming of inappropriate land for agriculture purpose, and exposure of soils to wind and water erosion.

As Bamyan population is growing rapidly and they are using the bush for cooking heating and winter fodder for animals. On the other hand, fodder productivity of rangeland is low and the rangelands are under threat of losing its plant cover and this will be a bigger issue for the future of Bamyan environment. Based on the simulation, if the trend of bush cutting and fodder collection continues as the ratio of population increase, Bamyan center district will lose much more of it is plant cover until 2050. This loss will be more intensive around the settlement areas and will lead to land degradation.

Therefore, to reduce the overuse of biomass we propose some percentage reduction on bush and fodder collection for some period to limit the land cover loss and reduce the land degradation. The scenarios such as scenario S2 which elaborate 2 % reduction in bush and fodder collection per year was run until 2050 which showed a significant reduction in land degradation. Scenario S3 (3%) reduction of bush cutting and fodder collection in each year, predicts faster reduction of land degradation. Consequently, to limit land degradation and land cover loss we should apply some applicable management ways to reduce overuse of rangeland and limit the bush collection. As well the prediction of LAI change shows that if the trend of fodder and bushes consumption continues as current rate the land degradation area will expand as the ratio of population increase (2.5%). The finding of this study is shared with the governmental and non-governmental organizations and local people in Bamyan to show them the future predicted land degradation and they wish adopting some and management policy.

Chapter 4

Dissemination of science-based information and people perception

4.1 Field work survey

A field work survey from mid-September to mid-October has been conducted with related key governmental organization such as National Environmental Protection Agency of Afghanistan (NEPA) Bamyan, Department of Agriculture, Irrigation and Livestock (DAIL), Afghanistan National Disaster Management Authority, Bamyan (ANDMA) and NGOs that are working toward natural resources management and environmental issues like United Nation Environment Programme and Agha Khan Development Network (AKDN). Similarly, a semi-structured interview has been conducted with local villagers, who are working in resource management and supplying livelihoods such as livestock management, bush collecting, and farming. 56 questionnaires were filled out from four categories the remote villages with NGO or government interventions, remote villages with no NGO or government interventions, villages close to district center with NGO or government interventions, and villages close to district center with no NGO or government interventions Table 4.1. The result of VISIT model and land cover maps (from 1990 to 2015) were presented to governmental and non-governmental organizations as well as to local communities and they can see the changes of land cover and land degradation area and that affect their perception regarding natural resources management and land use practices such as grazing and bush collection.

Table 4.1. The survey sample with villagers in Bamyan center district.

Community A	Remote area With NGO or government interventions	7 respondents age 18-35 7 respondents age 35-70
Community B	Remote area No NGO or government interventions	7 respondents age 18-35 7 respondents age 35-70
Community C	Close to district center With NGO or government interventions	7 respondents age 18-35 7 respondents age 35-70
Community D	Close to district center No NGO or government interventions	7 respondents age 18-35 7 respondents age 35-70

Furthermore, a fieldwork survey was conducted with 32 people from the younger generation (18-35 years old) and elderly (35-70 years old). While the result of VISIT model and land cover maps were not shared with them and then the results of both surveys were compared.

4.2 Result of field work survey

4.2.1 Survey with governmental and non-governmental organizations

A survey with National Environmental Protection Agency of Afghanistan (NEPA) Bamyan:

NEPA think that Land degradation is a problem in Bamyan province especially in Bamyan center due to population growth and overuse of natural resources such as cutting bushes and overgrazing, changing the rangeland to rain feed agriculture (which is productive for one year) and changing the rangeland to the built-up area especially near to the Bamyan city.

NEPA think that most of Bamyan's people livelihood depends on agriculture and livestock and bush collection for heating and cooking. Currently, NEPA doesn't have a specific policy and action plan and practices for land degradation. But NEPA with their partner NGOs is working on awareness raising and policymaking. Nevertheless, NEPA thinks tree plantation can reduce pressure from rangeland in the future because the communities can use the branches of trees as fuel for cooking and heating. On the other hand, NEPA have a plan of rangeland reseeding in partnership with NGOs to rehabilitate the rangeland in Bamyan center as well, because this intervention had good results in another district of Bamyan province. Regarding the question of limiting the number of livestock in Bamyan, they mention that currently, NEPA doesn't have any plan to reduce the number livestock because the Bamyan people are poor and their livelihoods depend on agriculture and livestock.

A survey with Department of Agriculture, Irrigation, and livestock (DAIL):

DAIL thinks land degradation is an important problem in Bamyan province due to change of rangeland to the plantation (rain-fed agriculture) and built-up area and overuse of bush (bush collection). Because land lost their productivities and barren land is increasing rapidly. Rapid population increase in Bamyan province especially in district center brings extra pressure on land because they are overusing the bushes for cooking and heating.

DAIL doesn't have a specific policy for control of land degradation. But DAIL has a strategy for mitigation and improvement of natural resources which support land and limit the degradations. This strategy has three sections:

1. Rangeland management: Grazing management such as rotation grazing, banding some specific area for two to five years (quarantine) and not allowing grazing to quarantine area to produce seeds and regrowth the plants. Furthermore, DAIL establishing pasture management committee (this committee get training from DAIL for awareness raising

and then they share there learned knowledge with other community's members).

2. Forest management and improvement: this section involved in producing sapling, propagation, and distribution in the communities to manage water sheets. In addition, tree plantation will support to reduce bush collection from the mountain as the tree branches will be an alternative to the bush for cooking and heating.
3. Protected area section which focuses on landscape protection and biodiversity management.

DAIL is trying to reduce the bush collection from rangeland by establishing village bakery (making bread it is baking in a tandoor), passive solar house establishment and introducing gas tandoors. Due to the poor livelihood of Bamyan people, DAIL does not have any plan to reduce the numbers of livestock in the Bamyan province because their livelihood is depending on agriculture and livestock.

Survey with UNEP (United Nation Environment Program)

UNEP did not conduct any specific research about land degradation in Bamyan. But UNEP Bamyan thinks land degradation is an issue for now and for the future of Bamyan province if the trend is continuing same as now. The land degradation is more severe in the area which highly populated and agricultural area expanded in the remoter villages.

Currently, UNEP doesn't have specific plan and policy for the control of land degradation. UNEP current work in Bamyan focuses on climate change issue and protected area management. UNEP is working with few villages making village management plans. In the village management plan, UNEP considering the land degradation as in issue and UNEP support the community to establish community nursery then plant trees. The tree plantation will support the communities' fuelwood and decrease the pressure from rangeland area and they will collect less amount of bushes. UNEP is making check dams and protection walls in the villages which have projects to protected agricultural lands and built-up, from flood risks. UNEP stated that most of Bamyan people livelihood depends on agriculture and livestock, UNEP also supports rangeland restoration by reseeding and rotational grazing and awareness rising. As well UNEP introduced low fuel consumption cookstoves (fuel-efficient stoves) in the Bamyan center in partnership with NEPA and DAIL. Regarding the question about reducing the number of livestock; UNEP mentioned this can be a policy which mostly depends on governmental organizations such as DAIL and NEPA, but Bamyan people is poor for now it is difficult to apply such policy.

Survey with Afghanistan National Disaster Management Authority (Bamyan) (ANDMA)

ANDMA thinks land degradation is very severe in the Bamyan center and land degradation will create a big problem for the future of Bamyan. Because the land lost its plant cover and reduces its productivities and protective abilities. Consequently, when the land loses it is cover the flash flood will happen very frequently. According to ANDMA Bamyan experiences, the flash flood frequency is increased within 15 years because land lost it is the protective cover. ANDMA Bamyan, have disaster committees in each valley. Through these committees ANDMA gives awareness and support rangeland restoration by tree plantation in a disaster-prone area, building check dams and protecting walls. As well ANDMA encourages the communities to reduce overuse of natural resources such as bush collecting from mountains especially close to living (villages) areas. ANDMA think the methods for controlling of land degradation are plantation of trees to reduce the pressure from rangeland as alternative for bush collection and limiting the number of animals and introducing village bakery and also passive solar house (making plastic house in front of houses to cover the window to make warmer the house during the winter). ANDMA think reducing the number of livestock is very difficult now because the people livelihoods rely on agriculture and livestock, but limiting the bush collection and reducing the number of livestock will support to control the land degradation.

Survey with Agha Khan Development Network (AKDN)

AKDN natural resources branch think land degradation is severe in Bamyan area due to overuses of natural resources by rapid population increase and absence of clear land management policies and action plans specifically for land degradation. AKDN have an approach for natural resources management this approach called Mountain to Market. This approach has focused on pasture management, water sheet management, Farm, and Market.

In pasture level, AKDN in the project area has pasture management committee and give them consultation about pasture management as well distributing the seeds for reseeding the rangeland and planting native trees in the area which there is the possibility of growing trees and try to plant those trees which have more resistance to drought and dryness. In the water sheet level, AKDN has water sheet management committee give them technical consultation for water sheet management. AKDN conducted the projects such as making check dams, built terraces and planted trees for water sheet management and protection. In the farm level, AKDN supports agricultural system and orchards. AKDN think the good method is reseeding the rangeland by considering the ecological condition of the area, as well increasing fodder production in the areas which there is the possibility of irrigation to reduce fodder collection from rangeland. Planting trees, limiting the bush collections and reduce the number of animals according to rangeland carrying capacity. But, based on current livelihood dependency of many people on livestock is difficult to reduce the numbers.

4.2.2 Semi-structured questionnaire with local people

The main research questions for local communities were as follows:

a) Why are livestock and bush collection important for local people in terms of cultural, religious, economics values?
   - Are there differences in livestock and bush collection values, beliefs and practices between communities they have been involved in government and NGOs rangeland activities versus communities who have not been involved?
   - Are there any differences between the younger generation and older generation interests and values for livestock and bush collection?

b) How are community values and management preferences around livestock and bush collection similar or different to interventions proposed by NGOs and government?

c) What would be cultural, political, and economical appropriate solutions for reducing land degradation in Bamyan?

4.2.3 The semi-structured questionnaire result of local communities

The semi-structured questionnaires were asked from four categories such as villages remote from center which there were some interventions by government and non-governmental organizations (NGOs), remote villages there were not any interventions by government and NGOs regarding livestock and bush collection, villages that are close to district center and there were some interventions, and villages close to center district without interventions. The respondent was divided into two age categories such as age group between 18-35 and age group among 35-70.

There were no big differences in the longevity of raising livestock between communities which were far from the central district within management interventions and without management interventions. The younger generations (18-35) from the remote area which there were interventions mentioned that first thing that they got interested on raising livestock is the overall livestock products (6 people out of 7) and secondly dungs for fuel (3 out of 7) and thirdly they learned from their parents (inheritance). The older generation (35-70) first interest of them for raising livestock is producing dungs for fuel (4 out of 7), second overall production (3 out of 7) and third is inheritance. But in the remote communities which there were not interventions for the younger generation first thing which gets their interest to raise livestock was economic support (3 out of 7 people) and second thing was they inherited (2 out of 7) from their parent, but from the same communities, older generation get interested was livelihood support (3 out 7) and economic benefit come second. In the villages close to district center with governmental or NGO interventions, the things which younger generation got interested to raise livestock, was livelihood support (2 out of 7), economic support (2 out of 7) and inheritance (2 out of 7). But for the older generation in these communities to get interested in raising livestock, the priority was the overall animal products (4 out of 7) and second the economic support (3 out of 7). For the younger generation in the communities' closer to the district center without interventions the first interest for raising livestock was the overall products of livestock (6 out of 7), second thing that younger generation get interested to raise livestock was that they learned from their parent, but for older generation in same villages the first thing got their interest to raise livestock was the economic support (3 out 7) and second was the livelihood needs. For more information see Table 4.2.

Table 4.2. The longevity of livestock raises and reason of interest to raise livestock.

Age group and area	1) How long(years) have you been raising livestock?				2)What first made you interested in raising livestock?						
	10	**20**	**40**	**60**	**Products**	**Manure**	**Dungs for fuel**	**Inheritance**	**Livelihood**	**Religious events**	**Economic**
18-35											
Close to district center with NGO or government interventions	2	5	0	0	1	1	0	2	2	0	2
Close to district center with no NGO or government interventions	2	5	0	0	6	2	0	4	0	0	1
Remote area with NGO or government interventions	3	4	0	0	6	1	3	2	0	1	0
Remote area with No NGO or government interventions	2	4	0	0	0	0	1	2	1	0	3
18-35 Total	**9**	**18**	**0**	**0**	**13**	**4**	**4**	**10**	**3**	**1**	**6**
35-70											
Close to district center With NGO or government interventions	0	1	6	0	4	1	0	2	0	0	3
Close to district center with no NGO or government interventions	0	0	3	4	1	0	1	1	2	0	3
Remote area with NGO or government interventions	0	3	4	0	3	1	4	2	0	0	1
Remote area with No NGO or government interventions	0	2	4	0	1	0	0	0	3	0	2
35-70 Total	**0**	**6**	**17**	**4**	**9**	**2**	**5**	**5**	**5**	**0**	**9**
Grand Total	**9**	**24**	**17**	**4**	**22**	**6**	**9**	**15**	**8**	**1**	**15**

The main reasons that people raise livestock are livelihood dependency and economic support. Mostly the younger generation (18-35) from a remote area with government and NGO interventions priorities the livelihood support of livestock (6 people out 7 people). Similarly, for the older generation, they give equal priority for livelihood (2 out of 7) economic (2 out 7) and dungs for fuel (2 out of 7). In the remote villages without interventions the main reason did not change and both younger and older generation equally priorities the livelihood supports of livestock as the main reason and economic support come to the second reason. In the villages, close to district center with governmental and NGOs and villages close to district center without interventions the main reason was livelihood support and second was the economic support and there was no difference based on age group. For more information see Table 4.3.

Table 4.3. The main reason for livestock raise and reason that people want to rise livestock

Age group and area	3)What are the main reasons that you raise livestock now?				4)What do you like about raising livestock?				
	Livelihood	Economic	Dung for fuels	All products	Product	Dairy	Manure	Easy to raise	Dung for fuel
18-35									
Close to district center with NGO or government interventions	7	2	0	0	5	3	1	0	1
Close to district center with no NGO or government interventions	7	1	0	1	4	1	2	0	0
Remote area with NGO or government interventions	6	0	1	2	4	1	2	0	1
Remote area with No NGO or government interventions	4	2	1	0	5	2	0	0	0
18-35 Total	**24**	**5**	**2**	**3**	**18**	**7**	**5**	**0**	**2**
35-70									
Close to district center with NGO or government interventions	5	3	1	0	5	1	0	0	0
Close to district center with no NGO or government interventions	7	4	0	0	4	1	2	0	0
Remote area with NGO or government interventions	2	2	2	1	4	1	1	1	0
Remote area with No NGO or government interventions	4	2	0	0	4	0	1	0	2
35-70 Total	**18**	**11**	**3**	**1**	**17**	**3**	**4**	**1**	**2**
Grand Total	**42**	**16**	**5**	**4**	**35**	**10**	**9**	**1**	**4**

All respondents from all four categories of communities mentioned that they raise their livestock in rangeland during spring, summer and late fall then during the winter they raise them in the stable (winter shelter) and provide them fodder. All communities' graze their livestock into near the village during early spring and late fall and during the mid-spring, to late fall they send their livestock to the far area (high mountain rangeland). The villagers sell their livestock in the village and as well as in market (in Bamyan). But the younger generation from the remote villages which there was intervention like to, sell their livestock to the market (6 out of 7) but the older generation prefers to sell in the villages (5 out 7). On the other hand, in the remote villages which there was no intervention by the government and NGOs both generations had the interest to sell their livestock in the villages. Although in the villages, those are close to the district center both generations answered they sell their livestock to the Bamyan market. Majority of respondents mentioned that they sell their livestock in the fall. But there was a difference the communities which that was close to center without interventions, (4 people out of 7) from old generation mentioned that they sell their animal during the religious events and (3 people out of 7) from young generation answered the same as older people. For more information see Table 4.4.

Table 4.4. The livestock grazing area and livestock market and selling time

Age group and Area	5)Where do you graze your livestock	6)Where do you sell your livestock		7)When do you sell your livestock to the Market				
	Near villages and far	**Village**	**Market**	**Fall**	**In summer**	**Any time based on need**	**Religious events**	**In spring**
18-35								
Close to district center with NGO or government interventions	7	1	7	4	3	2	2	0
Close to district center with no NGO or government interventions	7	0	6	5	0	2	3	0
Remote area with NGO or government interventions	7	3	6	6	3	1	2	0
Remote area with no NGO or government interventions	6	6	2	5	2	2	0	1
18-35 Total	**27**	**10**	**21**	**20**	**8**	**7**	**7**	**1**
35-70								
Close to district center with NGO or government interventions	7	1	7	6	2	1	1	0
Close to district center with no NGO or government interventions	7	0	7	4	0	1	4	2
Remote area with NGO or government interventions	6	5	5	4	2	1	2	0
Remote area with no NGO or government interventions	6	5	4	5	3	0	1	1
35-70 Total	**26**	**11**	**23**	**19**	**7**	**3**	**8**	**3**
Grand Total	**53**	**21**	**44**	**39**	**15**	**10**	**15**	**4**

The respondents' answers regarding best management practices for raising livestock was different between age groups as well between communities which there was government and NGOs interventions and communities were not interventions in both areas close to district center and remote areas. The younger people (18-35) from a remote area with government and NGO interventions thinks that providing good fodder, good rangeland, sending the livestock for grazing in the rangeland area far from the village and less number of animal per rangeland area with the application of vaccine will be a good practice. From the same areas (remote area) the older people (35-70), thinks that providing fodder and add nutrition with fodder will be a good option. The difference in best management practice between this two-generation is that the older generation don't consider the number of animal per rangeland area but the younger generation do. On the other hand, the communities in a remote area which there is not government and NGOs intervention the younger generation thinks that good rangeland and good fodder will be best option to raise good livestock and they did not think about the number of animal per area. But the older people in the same communities' think that providing good fodder and rising into the high mountain (far rangeland) is best practice to raise livestock. Furthermore, in the communities' close to center with interventions the young people think less number of animal per rangeland area (3 people out of 7) and providing good fodder (4 out of 7) and applying vaccine will be good practices for rising livestock. From the same communities,' the older generation give equal priority for providing good fodder, less number of animal per rangeland as good practice for raising livestock. But in the communities' close to the center without government and NGOs intervention both generation (young and old) thinks providing good fodder (4 out7), applying vaccine and less number of animal per area is good management practice.

The younger generation from remote communities with government and NGOs intervention thinks the challenges for raising livestock in their area are lack of grazing land (5 out 7), lack of palatable plants, lack of fodder and less access to vaccines. But from the same communities,' the older generation thinks diseases and lack of fodder (3 out of 7) is the main challenge. On the other hand, from remote communities, there are no interventions; both young (7 out of 7) people and old generation (4 out 7) think the disease of livestock is the main challenges to raise them. Furthermore, the younger generation from communities' close to district center with intervention thinks that the disease (5out 7 people), lack of grazing land (3 out of 7 people), and lack of fodder is the main challenge for raising livestock. But from the same communities, the older generation thinks lack of grazing land (5 out of 7 people) is the main challenge but the disease and lack of fodder are the second challenges to raise livestock. In addition, from communities' that are close to district center without intervention the younger generation thinks that lack of fodder (5 out of 7 people) is the main challenge but lack of grazing land and disease are the limitation to raise livestock. Similarly, the older generation from the same areas thinks that lack of grazing land (4 out of 7) is the biggest challenge to raise livestock. For more information see Table 4.5.

Table 4.5. The management practices and challenges for livestock raising

Age group and area	8) What do you think are the best management practices for raising livestock?							9) What are the challenges of raising livestock?					
	Good fodder	Good rangeland	Less animal per rangeland	Vaccine	Proper place in the winter	High mountain	Good nutrition	Lack of palatable plant	Lack of grazing land	Less access to vaccines	Lack of fodder	Diseases	Cold weather
18-35													
Close to district center with NGO or government interventions	4	1	3	3	1	0	0	1	4	0	3	5	0
Close to district center with no NGO or government interventions	4	2	2	2	2	1	0	0	4	0	5	4	0
Remote area with NGO or government interventions	4	4	2	2	2	3	1	2	5	2	2	0	0
Remote area with No NGO or government interventions	2	4	0	1	1	0	0	0	0	0	2	7	4
18-35 Total	**14**	**11**	**7**	**8**	**6**	**4**	**1**	**3**	**13**	**2**	**12**	**16**	**4**
35-70													
Close to district center with NGO or government interventions	2	1	2	1	1	0	2	0	5	0	3	4	0
Close to district center with no NGO or government interventions	4	0	2	2	1	0	0	1	4	0	2	2	0
Remote area with NGO or government interventions	3	1	1	1	1	1	1	1	2	0	3	4	0
Remote area with No NGO or government interventions	5	0	0	1	1	3	0	1	0	1	0	4	0
35-70 Total	**14**	**2**	**5**	**5**	**4**	**4**	**3**	**3**	**11**	**1**	**8**	**14**	**0**
Grand Total	**28**	**13**	**12**	**13**	**10**	**8**	**4**	**6**	**24**	**3**	**20**	**30**	**4**

The remote and close to district center villages which there was governmental and NGOs interventions and communities without interventions have the same traditional system of livestock grazing and they send their livestock to high mountains in late spring as share sheep keeping (collectively).

The remote villages and close to district center villages which have received training by government and NGOs, both age group (younger and older generations) mentioned that they got training regarding rangeland management, vaccination, stable building with good aeration. But there was a difference that younger generation mentioned that they received training on rotational grazing as well. For more information see Table 4.6.

Table 4.6. The traditional system of livestock grazing, training by Government and NGOs

Age group and area	10) Does your community have any traditional systems for livestock raising and management?		11) What trainings have you received on livestock management?				12) who provided the training?	
	Collective	Few household	Rangeland management	Vaccination	Stable building	Rotational grazing	Government	NGO
18-35								
Close to district center with NGO or government interventions	6	0	5	5	2	1	7	6
Close to district center with no NGO or government interventions	6	0	0	0	0	0	0	0
Remote area with NGO or government interventions	7	0	4	6	3	1	6	7
Remote area with no NGO or government interventions	6	0	0	0	0	0	0	0
18-35 Total	**25**	**0**	**9**	**11**	**5**	**2**	**13**	**13**
35-70								
Close to district center with NGO or government interventions	6	0	6	5	3	0	7	6
Close to district center with no NGO or government interventions	5	0	0	0	0	0	0	0
Remote area with NGO or government interventions	4	2	4	3	1	0	7	5
Remote area with no NGO or government interventions	5	1	0	0	0	0	0	0
35-70 Total	**20**	**3**	**10**	**8**	**4**	**0**	**14**	**11**
Grand Total	**45**	**3**	**19**	**19**	**9**	**2**	**27**	**24**

Both age groups in the areas which they have received training mentioned that they learned some methods of raising livestock such vaccination and building a better stable for winter. As well learned some grazing system like rotational grazing and quarantine of some area for two to five years to allow the rangeland to regrowth and then use it as rangelands Figure 4.1. Those communities have received training, currently practicing those methods they learned such as rotational grazing, vaccination, quarantine, and rangeland reseeding. Furthermore, those communities established rangeland committees to manage some of those activities. For more information see Table 4.7.

Figure 4.1. Fenced area for five years and not allowing grazing in Khushkak valley, Bamyan district cente

Table 4.7. The learned training, and communities' activities they practice.

Age group and area	13) What did you learn?					14) Does your community have any activities on livestock management that NGO or government have provided?					
	Quarantine	**Vaccinations**	**Rotational grazing**	**Rangeland reseeding**	**Stable with good aeration**	**Rotational Grazing**	**Quarantine practice**	**Vaccines**	**Stable with aeration**	**Rangeland committee**	**Reseeding**
18-35											
Close to district center with NGO or government interventions	1	5	3	1	4	3	2	3	2	1	0
Close to district center with no NGO or government interventions	0	0	0	0	0	0	0	0	0	0	0
Remote area with NGO or government interventions	2	7	2	1	3	4	2	4	1	0	1
Remote area with No NGO or government interventions	0	0	0	0	0	0		0		0	0
18-35 Total	**3**	**12**	**5**	**2**	**7**	**7**	**4**	**7**	**3**	**1**	**1**
35-70											
Close to district center with NGO or government interventions	0	5	4	1	2	5	0	4	0	3	0
Close to district center with no NGO or government interventions	0	0	0	0	0	0	0	0	0	0	0
Remote area with NGO or government interventions	1	3	2	0	2	4	1	2	2	0	0
Remote area with No NGO or government interventions	0	0	0	0	0	0	0	0	0	0	0
35-70 Total	**1**	**8**	**6**	**1**	**4**	**9**	**1**	**6**	**2**	**3**	**0**
Grand Total	**4**	**20**	**11**	**3**	**11**	**16**	**5**	**13**	**5**	**4**	**1**

The villages in a remote area which have received training both age groups are interested to raise livestock in the future. But the communities in a remote area which they don't have received training the younger generation have less interest to raise livestock in the future. But communities close to district center which they received training and did not receive training both generations mentioned that they are interested to raise livestock in the future because the livestock is important parts of their livelihoods. The answer to the question do you want your children to raise livestock? The answer of remote communities which they received training and did not receive training was the same and majority of them mentioned yes, they want their children to raise livestock. But in communities' close to district center in both communities which they received and did not receive the training most of the younger generation don't want their children to raise livestock. But this answer for older generation was different and most of them want that their children raise livestock. For more information see Table 4.8.

Table 4.8. Livestock raising for the future and acceptance for children to raise livestock in future

Age group and area	15) Do you want to raise livestock in the future?		16) Do you want your children to raise livestock?	
	Yes	**No**	**Yes**	**No**
18-35				
Close to district center with NGO or government interventions	6	1	3	4
Close to district center with no NGO or government interventions	7	0	1	6
Remote area with NGO or government interventions	7	0	5	2
Remote area with no NGO or government interventions	5	1	5	1
18-35 Total	**25**	**2**	**14**	**13**
35-70				
Close to district center with NGO or government interventions	7	0	5	2
Close to district center with no NGO or government interventions	7	0	5	2
Remote area with NGO or government interventions	7	0	5	1
Remote area with no NGO or government interventions	6	0	5	1
35-70 Total	**27**	**0**	**20**	**6**
Grand Total	**52**	**2**	**34**	**19**

All the surveyed villages are collecting bushes for cooking and heating. Except for few people from villages close to district center, they mentioned that they are not collecting bush from mountains. All respondents think that bush collection has a negative impact on the environment. The younger generation from the remote village which there were interventions by government and NGOs mentioned that bush cutting will cause flood increase (5 out of 7), land cover loses and land is getting barren (4 out 7 people). But the elder generation from the same area mentioned that bush cutting causing land cover loss (5 out of 7 people), and flood increase. Furthermore, it is harmful to health when burning for cooking and heating. The Respondents from the remote villages without government and NGOs interventions both age groups think bush cutting cause land cover loss and an increase the barren land. On the other hand, in the communities' close to district center which there were interventions and there was no intervention the older generation elaborated that bush cutting cause soil erosion (4 people out of 7), loses of palatable plants, and land cover loses. But the younger generation in the same communities' think it causes land cover loss (3 out of 7) and causes, flood increase and an increase of barren land. For more information see the Table 4.9.

Table 4.9. The bush collection, causes of bush collection to environment

Age group and area	17) Do you collect bushes from the mountain		18) Why do you collect bushes?	19) Does bush collection have any impact on the environment? How?					
	Yes	**No**	**Cooking and heating**	**Land cover loses**	**Palatable plant**	**Flood increase**	**Bad for health**	**Barren land**	**Soil erosion**
18-35									
Close to district center with NGO or government interventions	7	0	7	4	1	3	0	2	2
Close to district center with no NGO or government interventions	5	2	5	4	2	2	0	1	1
Remote area with NGO or government interventions	7	0	7	4	1	5	0	4	0
Remote area with no NGO or government interventions	7	0	7	4	2	0	0	3	0
18-35 Total	**26**	**2**	**26**	**16**	**6**	**10**	**0**	**10**	**3**
35-70									
Close to district center with NGO or government interventions	6	1	6	3	3	2	0	3	4
Close to district center with no NGO or government interventions	7	0	7	3	1	1	0	2	4
Remote area with NGO or government interventions	5	2	5	5	1	2	1	2	0
Remote area with no NGO or government interventions	7	0	7	2	2	3	0	2	0
35-70 Total	**25**	**3**	**25**	**13**	**7**	**8**	**1**	**9**	**8**
Grand Total	**51**	**5**	**51**	**29**	**13**	**18**	**1**	**19**	**11**

The respondent from remote villages which there were interventions by government and NGOs the younger generation (18-35) thinks bush collection can be reduced by tree plantation (5 people out 7), electricity introduction (4 out of 7), using coal and gas as well as village bakery, fuel-efficient stoves, gas tandoors. The older generation (35-70) thinks that bush cutting can be reduced by tree plantation (5 out of 7), fuel-efficient stoves (2 out of 7), and using coal, gas and village bakery. The younger generation from remote villages which there have not been intervention by government and NGOs think the bush cutting can be reduced by tree plantation (4 out 7 people), electricity introduction (4 out 7), and using coal and gas. But the older generation from the same communities' thinks the bush collection can be reduced by tree plantation, electricity, and coal usage. On the other hand, in the communities' close to district center with government and NGOs interventions, the younger generation think that bush cutting can be reduced by introducing electricity (5 out7) and using coal, gas, fuel-efficient stoves and tree plantation. But the older generation in the same communities' think that bush cutting can be reduced by the introduction of electricity, using gas, coal, tree plantation and fuel-efficient stoves.

Furthermore, in the village close to district center, which there are no interventions, the younger generation thinks that bush cutting can be reduced by electricity introduction to the area, and using gas, coal and tree plantations. In the same communities, the older generation thinks the bush cutting can be reduced by using coal, wood, gas, electricity and tree plantations. In the communities which were government and NGOs intervention the focus was on tree plantation and fuel-efficient stoves but in the communities which there was no intervention, the most focus was on electricity and coal usage as an alternative to the bush collection. All communities are interested in the programs for reducing bush collection such as having more fuel-efficient stoves, and alternative fuel sources like tree plantations etc. The answer to the question would you be interested in reducing bush collection through having village bakery programs? all younger generation from the remote community which there were interventions show interest. But in the same communities, three respondents out of seven from older generation show their disagreement. From remote communities' which there were no interventions from each age groups two people out of 7 people show their disagreement because of cold weather and scattered of houses. On the other hand, the communities close to district center which there was and wasn't intervention was agreed with village bakery for reducing bush consumption except for one person from old generation from the villages which there was intervention. For more information see the Table 4.10.

Table 4.10. The bush cutting reduction by some interventions

Age group and area	20) How do you think bush collection can be reduced in the area you live?								21) Would you be interested in a program for reducing bush collection such as through having more fuel-efficient stoves, alternative fuel sources, tree planting, etc. . .		22) Would you be interested in reducing bush collection through having village bakery programs?	
	Tree plantation	**Electricity**	**Gas tandoor**	**Village bakery**	**Wood**	**Fuel efficient stoves**	**Gas**	**Coal**	**Yes**	**No**	**Yes**	**No**
18-35												
Close to district center with NGO or government interventions	2	5	0	0	2	3	4	6	7	0	7	0
Close to district center with no NGO or government interventions	2	5	0	0	1	0	5	2	6	0	7	0
Remote area with NGO or government interventions	5	4	1	1	1	1	4	4	7	0	7	0
Remote area with No NGO or government interventions	4	4	0	0	0	0	2	3	7	0	5	2
18-35 Total	**13**	**18**	**1**	**1**	**4**	**4**	**15**	**15**	**27**	**0**	**26**	**2**
35-70												
Close to district center with NGO or government interventions	4	7	0	0	0	2	5	4	7	0	6	1
Close to district center with no NGO or government interventions	2	2	0	0	5	0	3	7	7	0	7	0
Remote area with NGO or government interventions	5	2	0	1	0	2	2	3	5	0	4	3
Remote area with No NGO or government interventions	5	5	0	0	1	0	1	5	7	0	6	2
35-70 Total	**16**	**16**	**0**	**1**	**6**	**4**	**11**	**19**	**26**	**0**	**23**	**6**
Grand Total	**29**	**34**	**1**	**2**	**10**	**8**	**26**	**34**	**53**	**0**	**49**	**8**

4.3 Result of fieldwork (without sharing the result of VISIT and land cover maps with local people)

The semi-structured questionnaires were asked from the local people that had received some intervention as well as from the people which had not received interventions.The results of VISIT and land cover map were not shared with them. Similarly, the respondent was divided into two age categories such as age groups between (18-35) and age group between (35-70).

Both groups are raising livestock for a livelihood support half younger generation (8 out 16) and (5 out 16) from elderly as well both group raise livestock for other economic support and thirdly, the overall products and inherited from their parents. For more information see Table 4.11.

Table 4.11. The longevity of livestock raise and reason of raising livestock

Age group and area	1) How long (years) have you been raising livestock?				2) What first made you interested in raising livestock?				
	10	**20**	**40**	**60**	**Products**	**Manure**	**Inheritance**	**Livelihood**	**economic**
18-35									
Close to district center with NGO or government interventions	6	2	0	0	1	0	1	4	2
Close to district center with no NGO or government interventions	3	5	0	0	2	0	0	4	2
18-35 Total	**9**	**7**	**0**	**0**	**3**	**0**	**1**	**8**	**4**
35-70									
Close to district center with NGO or government interventions	0	4	3	1	1	2	1	2	3
Close to district center with no NGO or government interventions	2	1	4	1	1	0	2	3	2
35-70 Total	**2**	**5**	**7**	**2**	**2**	**2**	**3**	**5**	**5**
Grand Total	**11**	**12**	**7**	**2**	**5**	**2**	**4**	**13**	**9**

Furthermore, the key motivation that local people raise livestock is their livelihood dependency which (17out of 32) people, and mostly explained by the older generation. But (7 out of 32) from both generation was raising livestock because of overall products and economic supports and two people out 8 from older generation mentioned that they raise the livestock for dung to use as fuel, see Table 4. 12 for more information.

Table 4.12. The main reason for livestock raise and reason that people like livestock raising

Age group and area	3) What are the main reasons that you raise livestock now?				4) What do you like about raising livestock?		
	Livelihood	**Economic**	**Dungs for fuel**	**Products**	**Products**	**Dairy**	**Easy to raise**
18-35							
Close to district center with NGO or government interventions	4	3	0	1	5	2	1
Close to district center with no NGO or government interventions	6	1	0	2	5	1	2
18-35 Total	**10**	**4**	**0**	**3**	**10**	**3**	**3**
35-70							
Close to district center with NGO or government interventions	2	2	2	2	5	0	3
Close to district center with no NGO or government interventions	5	1	0	2	7	1	0
35-70 Total	**7**	**3**	**2**	**4**	**12**	**1**	**3**
Grand Total	**17**	**7**	**2**	**7**	**22**	**4**	**6**

Similarly, they raise their livestock in the rangeland for three seasons but during the winter start indoor feeding. As well these communities graze their animals to near villages rangeland and high mountain far from living area. Mostly these villagers sell the livestock to market and village as well as during religious events. The majority of villagers sells the livestock in the fall season as well as based on the need for their expenses any time of the year. For more information see Table 4.13.

Table 4.13. The livestock grazing area and livestock market and marketing time

Age group and area	5)Where do you graze your livestock?	6)where do you sell your livestock?		7) When do you sell your livestock to the market?			
	Near villages and far mountain	**Village**	**Market**	**Fall**	**Anytime based on need**	**Religious events**	**Spring**
18-35							
Close to district center with NGO or government interventions	8	3	6	5	4	2	0
Close to district center with no NGO or government interventions	8	3	5	5	4	0	1
18-35 Total	**16**	**6**	**11**	**10**	**8**	**2**	**1**
35-70							
Close to district center with NGO or government interventions	8	1	7	5	3	0	0
Close to district center with no NGO or government interventions	8	3	8	6	3	0	2
35-70 Total	**16**	**4**	**15**	**11**	**6**	**0**	**2**
Grand Total	**32**	**10**	**26**	**21**	**14**	**2**	**3**

The answer regarding best management practice for livestock raising in the area, both groups (younger generation and older generation) which there was applied some interventions by government and NGOs or not applied any interventions. The younger generation 7 out of 16 thinks that good rangeland is suitable option to raise livestock and from older generation 7 out 16 thinks application of vaccine can help to raise better animals and 6 out of 16 from younger generation think sending animals to mountains far from living area is good option as well 6 out of 16 from older generation mentioned that good rangeland is the best option. Only 2 out of 32 people think that to decrease the number of animals will be good management practice.

On the other hand, half of younger generation (8 out of 16) people think, animals' diseases and lack of fodder (5 out 16) are the challenges to raise livestock and the older generation thinks that diseases (5 out of 16) and lack of grazing land (5 out 16) are the main challenges to raise livestock in the area. for more information see Table 4.14.

Table 4.14. The management practices and challenges for livestock raising

Age group and area	8) What do you think are the best management practices for raising livestock?							9) What are the challenges of raising livestock?				
	Good fodder	**Good rangeland**	**Less animal per rangeland**	**Vaccine**	**Proper place in the winter**	**High mountain**	**Good nutrition**	**Lack of grazing land**	**Less access to vaccines**	**Lack of fodder**	**Diseases**	**Cold weather**
18-35												
Close to district center with NGO or government interventions	1	4	1	1	0	3	0	2	0	4	4	0
Close to district center with no NGO or government interventions	3	3	0	2	1	3	0	2	0	1	4	1
18-35 Total	**4**	**7**	**1**	**3**	**1**	**6**	**0**	**4**	**0**	**5**	**8**	**1**
35-70												
Close to district center with NGO or government interventions	0	2	0	3	0	4	1	2	1	2	1	2
Close to district center with no NGO or government interventions	2	4	1	4	0	1	0	3	0	1	4	0
35-70 Total	**2**	**6**	**1**	**7**	**0**	**5**	**1**	**5**	**1**	**3**	**5**	**2**
Grand Total	**6**	**13**	**2**	**10**	**1**	**11**	**1**	**9**	**1**	**8**	**13**	**3**

The result of these questionnaires is similar to the result of those questionnaires which the result of VISIT model and land cover maps were shared in regards that communities have the tradition of share sheep keeping. As well the communities have received training in rangeland management, rotational grazing and stable building by government and NGOs. For more information see table 4.15.

Table 4.15. The traditional system of livestock grazing and training by Government and NGOs

Age group and area	10) Does your community have any traditional systems for livestock raising and management?		11) What trainings have you received on livestock management?				12) who provided the training?	
	Collective	**No**	**Few household**	**Rangeland management**	**Stable building**	**Rotational grazing**	**Government**	**NGO**
18-35								
Close to district center with NGO or government interventions	3	4	1	5	2	2	7	6
Close to district center with no NGO or government interventions	7	0	1	0	0	0	0	0
18-35 Total	**10**	**4**	**2**	**5**	**2**	**2**	**7**	**6**
35-70								
Close to district center with NGO or government interventions	7	1	0	4	2	3	7	7
Close to district center with no NGO or government interventions	7	1	0	0	0	0	0	0
35-70 Total	**14**	**2**	**0**	**4**	**2**	**3**	**7**	**7**
Grand Total	**24**	**6**	**2**	**9**	**4**	**5**	**14**	**13**

From 32 respondents from both generation 8 people mentioned they learned rotational grazing, 7 people learned stable building with good aeration and 2 people learned rangeland quarantine. As well as the communities apply rotational grazing (7 out 32) and quarantine (5 out of 32). For more information see Table 4.16.

Table 4.16. The learned training, and communities' activities

Age group and area	13) What did you learn?					14) Does your community have any activities on livestock management that NGO or government have provided?				
	Quarantine	**Vaccinations**	**Rotational grazing**	**Rangeland reseeding**	**Stable with good aeration**	**Quarantine**	**Rotational grazing**	**Stable with good aeration**	**Rangeland committee**	**Reseeding**
18-35										
Close to district center with NGO or government interventions	1	1	5	0	6	3	4	1	1	2
Close to district center with no NGO or government interventions	0	0	0	0	0	0	0	0	0	0
18-35 Total	**1**	**1**	**5**	**0**	**6**	**3**	**4**	**1**	**1**	**2**
35-70										
Close to district center with NGO or government interventions	1	0	3	1	1	2	3	2	0	0
Close to district center with no NGO or government interventions	0	0	0	0	0	0	0	0	0	0
35-70 Total	**1**	**0**	**3**	**1**	**1**	**2**	**3**	**2**	**0**	**0**
Grand Total	**2**	**1**	**8**	**1**	**7**	**5**	**7**	**3**	**1**	**2**

The older generation is more interested to raise the livestock in the future (14 people out of 16) and (9 out of 16) people from younger generation want to raise the livestock in the future. But half (8) of the younger generation don't want their children to raise livestock in the future but 10 people from older generation want their children to raise livestock in the future. For more information see Table 4.17.

Table 4.17. livestock raising for the future and acceptance for children to raise livestock in the future

Age group and Area	15) Do you want to raise livestock in the future?		16) Do you want your children to raise livestock?	
	Yes	**No**	**Yes**	**No**
18-35				
Close to district center with NGO or government interventions	4	4	3	5
Close to district center with no NGO or government interventions	5	3	3	5
18-35 Total	**9**	**7**	**6**	**10**
35-70				
Close to district center with NGO or government interventions	8	0	5	3
Close to district center with no NGO or government interventions	6	2	5	3
35-70 Total	**14**	**2**	**10**	**6**
Grand Total	**23**	**9**	**16**	**16**

From 32 respondents 2 people are not collecting bush and 30 people collecting bush for cooking and heating. The respondents think bush collection causing flood increase (10 out of 16 from the older generation) and (6 out of 16 from the younger generation) also 7 people from the older generation and 5 people from younger generation mentioned that bush collection causes land cover lose. As well as 3 people, out 32 people think it cause barren land and 2 people from younger generation mentioned it cause soil erosion. For more information see Table 4. 18.

Table 4.18. The bush collection, causes of bush collection to environment

Age group and area	17) Do you collect bushes from the mountain		18) Why do you collect bushes?	19) Does bush collection have any impact on the environment? How?				
	Yes	**No**	**Cooking and heating**	**Land cover loss**	**No palatable plant**	**Flood increase**	**Barren land**	**Soil erosion**
18-35								
Close to district center with NGO or government interventions	7	1	7	2	1	2	1	2
Close to district center with no NGO or government interventions	7	1	7	3	1	4	1	0
18-35 Total	**14**	**2**	**14**	**5**	**2**	**6**	**2**	**2**
35-70								
Close to district center with NGO or government interventions	8	0	8	3	3	5	0	0
Close to district center with no NGO or government interventions	8	0	8	4	1	5	1	0
35-70 Total	**16**	**0**	**16**	**7**	**4**	**10**	**1**	**0**
Grand Total	**30**	**2**	**30**	**12**	**6**	**16**	**3**	**2**

From all young respondent, 6 out of 16 think bush collection can be reduced by tree plantation, 9 people think to use coal as an alternative to the bush and as well wood, electricity, and gas can be alternatives. Similarly, 6 out of 16 people from older generation think tree plantation can help to reduce bush collecting as well using coal and gas can be other alternatives. Furthermore, all respondents are interested in the programs for reducing bush collection such as through having more fuel-efficient stoves, and alternative fuel sources such as tree plantation. On the hand, 25 people from both generations are interested in reducing bush collection through having village bakery programs and 7 people mentation that is not practical in their village because the household is scattered in their area. For more information see Table 4.19.

Table 4.19. The bush cutting reduction by some interventions

Age group and area	20) How do you think bush collection can be reduced in the area you live?							21) Would you be interested in a program for reducing bush collection such as through having more fuel-efficient stoves, alternative fuel sources, tree planting, etc. . .		22) Would you be interested in reducing bush collection through having village bakery programs?	
	Tree plantation	**Electricity**	**Village bakery**	**Wood**	**Fuel efficient stoves**	**Gas**	**Coal**	**Yes**	**No**	**Yes**	**No**
18-35											
Close to district center with NGO or government interventions	5	2	2	2	2	4	3	8	0	6	2
Close to district center with no NGO or government interventions	4	4	0	4	0	2	5	8	0	6	2
18-35 Total	**9**	**6**	**2**	**6**	**2**	**6**	**8**	**16**	**0**	**12**	**4**
35-70											
Close to district center with NGO or government interventions	3	1	2	3	1	2	3	8	0	7	1
Close to district center with no NGO or government interventions	5	2	0	2	0	3	4	8	0	6	2
35-70 Total	**8**	**3**	**2**	**5**	**1**	**5**	**7**	**16**	**0**	**13**	**3**
Grand Total	**17**	**9**	**4**	**11**	**3**	**11**	**15**	**32**	**0**	**25**	**7**

4.4 Discussion

The results of field work, VISIT model, and land cover maps shows that land degradation and loss of land cover due to overuse of natural resources such as overgrazing and bush collections are a big problem for now and for the future of Bamyan. The result of interviews with organization and local people demonstrate that land degradation due to population increase and overuse of natural resources is widespread concern and this result consists with (Bedunah 2006) statements as explained, that rangeland state is important for policymakers due to various products and value supplies by rangeland and this products and values comprises forage and grazing land for livestock and wildlife, fuel, biodiversity, clean water, carbon sequestration and aesthetic values. Moreover, the lower plateau rangeland and areas closer to the larger populated area were suffering most important erosion damages. This has related to local overgrazing and shrubs collection for fuel. Furthermore, an important correlated concern is the influence of the human use of fuelwood such as trees and shrubs and it has been recognized that forest cover and woodlands are highly impacted by human practices, particularly through the last several decades. In addition, uprooting shrubs as fuel for cooking and heating is a very serious and extensive problem, it is not only matter of villagers' use, but traders also arrange the uprooting and buying the shrubs from a remote area to offer urban markets.

Based on interviews with governmental and non-governmental organizations in Bamyan there is not a policy to reduce the number of livestock, even though the overgrazing and land degradation are some concerns. The reason was that the livelihood of many farmers depends on livestock and agriculture in the current situation is difficult to reduce the number of livestock. Fitzherbert (2006) concluded, livestock highly contribute to rural livelihoods in Afghanistan by supplying source of protein and fiber to the household as well as in income source for households who own appropriate animals to produce a surplus to internal necessities. Furthermore, their livestock is a transferable asset which exists few alternatives and the time of necessities and emergency they can be changed into cash.

The results of semi-structured questionnaire reliable with above statements as younger and older generation from villages there was interventions and villages which there were no interventions by government and NGOs they raise the livestock as part of their livelihood.

The livestock owner sells their livestock to the market and villages, but most of the younger generation are interested to sell their livestock to the market especially from communities which they received training. Furthermore, most of the respondent sells their livestock at fall season and this result is supported by an explanation of (Thomson 2007), livestock possessor is aware of livestock seasonal values, that livestock price is increasing in autumn. Additionally, the respondent answers show some communities close to the center without any intervention mention that they sell their livestock in religious events.

When the result of simulated scenarios by VISIT and land cover maps were presented, the perception regarding good practices for livestock rising as well manage land to avoid degradation has changed by local communities especially the younger generation. Then the younger generation had more interest that the number of livestock should not exceed based on rangeland capacity. From 28 people 35.7 % of them which 60.7% were educated young and they showed their interest to limit the livestock based on rangeland capacity. On the other hand, 7.1% of older generation mentioned that to limit the land cover change the number of animals should not be more than rangeland ability which 50% of them were educated. The differences in regard perception change can be concluded that most of the younger generation had education that helped their understanding of land cover change and management scenarios. On the other hand, the younger generation is not as responsible as an elder for livelihood support and they can accept the decrease of animals, as well as the younger generation is more optimistic for the future and they have more chance to change their income sources. Moreover, the occupation of these two group has an impact on their choice and management scenarios, which the younger generation have a more diverse occupation but most of the older generation are involved in farming and raising livestock. Figure 4.2 shows the occupation and education level of respondents.

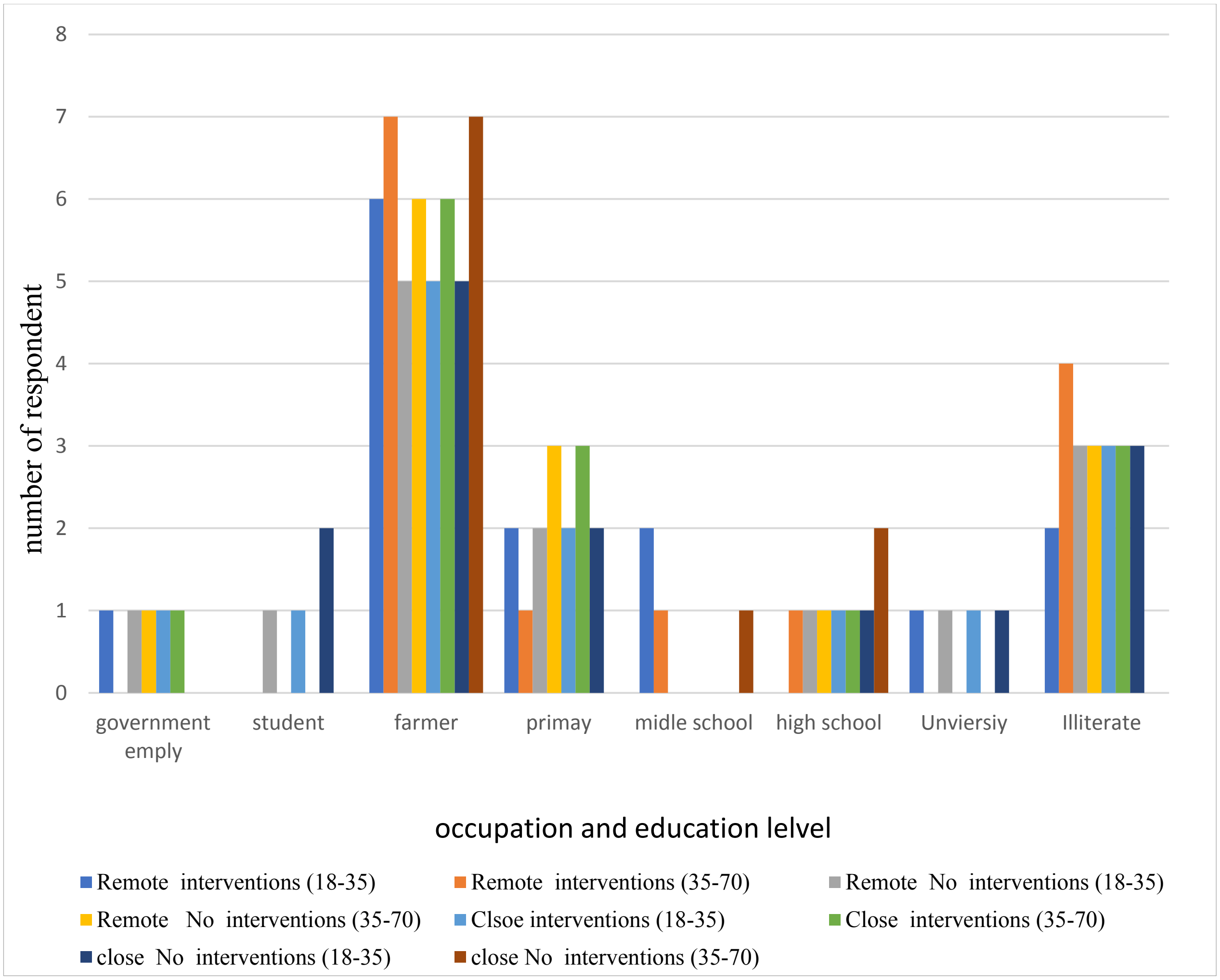


Figure 4.2. Occupation and education level of respondents.

In addition, for livestock and rangeland management some community far from the center as well close to district center has received training and those communities are practicing some methods they learned such as rotational system. Briske et al. (2008) explained that rotational system has been designed to restructure grazing pressure such as fodder accessibility, forage demand in time and space for somewhat given stocking like livestock number per area/time. Furthermore, Blanchet et al. (2000) argued that a rotational system delivers a break occasion for forage plants consequently, the plant may regrow more rapidly. The rotational system, endorse healthier pasture fodder utilization and affords an opportunity to transfer livestock based on feed growth and extend the grazing season. On the other hand, Crose et al. (2001) stated that the timing of rotations must be significantly selected to be reliable on the state of the grazing land.

The result illustrates villages which have received the training they are more interested to raise livestock without a difference in age categories. But the younger generation especially close to city center they are not interested that their children raise livestock and they want to them to change to another job. But the older generation perception is different and they have interests that their children could raise livestock in the future. All community's close to district center and remoter area agreed with the result of VISIT model and land cover maps that land degradation and loss of rangeland are problems and will be bigger problems for the future. Some community member argued that the number of the animal should be fewer in grazing land. This statement was mostly elaborated by the communities' close to district center (populated area) especially the younger generation. Figure 4.3 show in the community have been intervention the younger generation have the idea that the numbers of the animals should be according to rangeland capability, but the older generation in the remoter area have emphasized on good fodder.

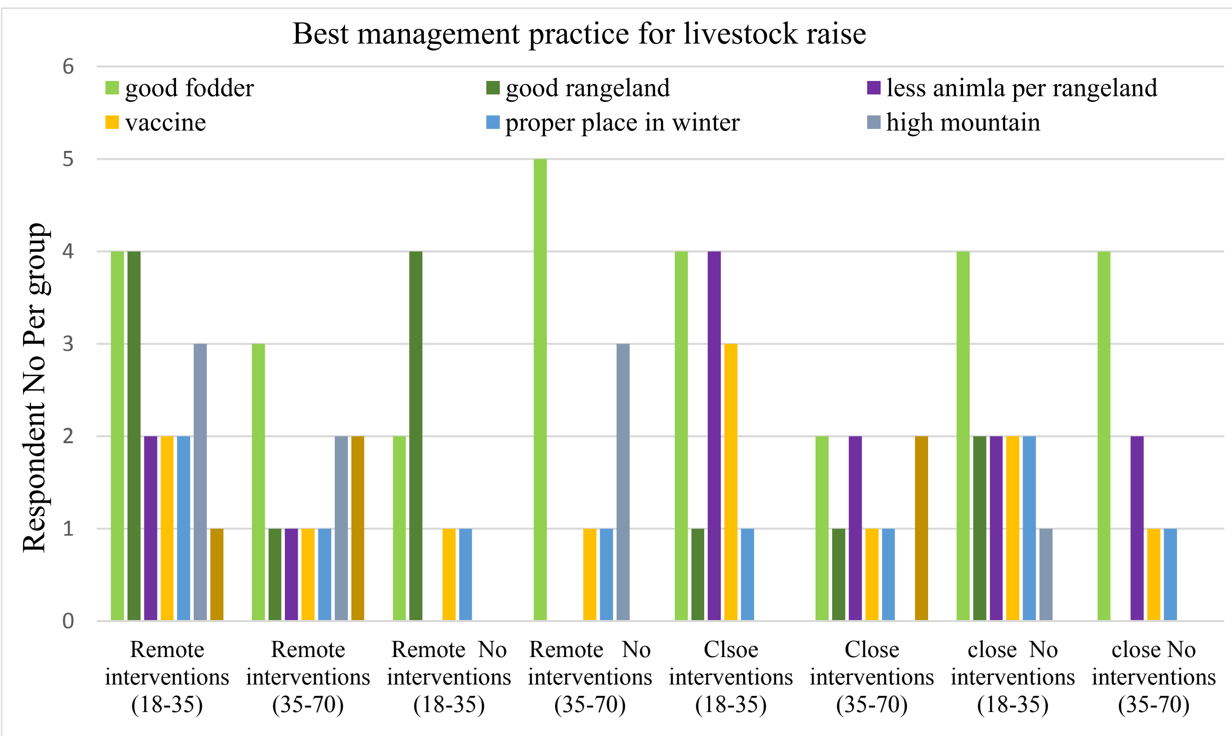


Figure 4.3. Best management practice for livestock raising

As the head of Khushkak village council explained "by seeing the images (VISIT results and land cover maps) I will not increase my livestock number and will suggest the same issue with my villagers to don't increase the number of animals and we most graze the rangeland according to its capability” (personal communication at 21 September 2017). Consequently, I can argue that if there are enough awareness and methods to manage livestock according to rangeland carrying capacity the communities will accept. But based on current condition of Bamyan district center people are not ready to reduce the number of livestock.

Although in Bamyan people collecting bush for cooking and heating, as well as the surveyed villagers except, few respondents from villages close to the district center are not collecting bush and the reason they mentioned that there are not enough bushes in the mountain to collect. The villagers know some damages that bush cutting causes such as land cover loss, flood increase, and soil erosion. But there are differences between the younger generation and older generation perception regarding damage of bush cutting to the environment. The older generation thing bushes cutting cause soil erosion and loss of palatable plants. But the younger generation thinks bushes cutting causes land cover lose and flood increase. Consequently, the bush cutting and overgrazing caused land cover loss and gradually soil erosion and land degradation.

This is issues reflected in fifth National Report of Afghanistan to the United Nation’s Convention on Biological Diversity by NEPA (2014) as most of Afghanistan mountain area is dominated by thorny cushion-shaped shrubs and this plant community consequently shaped from thousands of years of animal grazing on land that possibly had been typically grass-Artemisia steppe. The shrubs and dungs are the major source of fuel for most of rural Afghanistan. Shrubs are uprooted and burned for cooking and heating, as the population is increased areas near settlement are becoming uncovered of shrubs and the people who collect the shrubs must travel farther area to collect it. Loss of shrubs is a specific concern because these plants provide protective cover. Loses of shrubs intensify soil erosion by water and wind. Based on some communities, disastrous landslides and floods linked with spring rains and snowmelt have become progressively common in recent years.

I can say, the older generation has more experience and they witnessed the change of land cover and occurrence of land degradation. But the younger generation witnessed the land cover change and flood frequency as ANDMA mentioned that flood frequency is increased in recent years, therefore the younger generation is more conscious of that.

As the bush collection is an important issue and causes environmental problems. The government with their partner NGOs has applied some intervention in different villages for natural resources management. The communities which there were applied some project by government and NGOs had more focus on tree plantation, electricity introduction, and fuel-efficient stove. But the communities without government and NGOs interventions think best alternative to the bush collection can be electricity, using coal and gas. From these finding, we can understand that in the communities which have been interventions for natural resource management, people get more awareness specifically about tree plantation as an alternative source for bush collection and fuel-efficient stoves.

When the result of VISIT model and land cover maps shared with them all of them point it out that they understand that land cover is changing and land is degrading in the future we will have more problem than now. All communities are highly interested in the program to reduce bush collection through having alternative sources. Such as fuel-efficient stoves, tree plantation programs and village bakery except in remote communities from older generation mention due to cold weather during the winter village bakery is not practical, because besides cooking bread it warms our houses during winter. Figure 4.4 show proposed alternatives by communities' members in the communities' close to the center and have been intervention the younger generation think tree plantation as an alternative but in the close communities without interventions thinks coal is the best alternative to the bush collection. In general, the results of aforementioned studies affected their perception regarding bush collection.

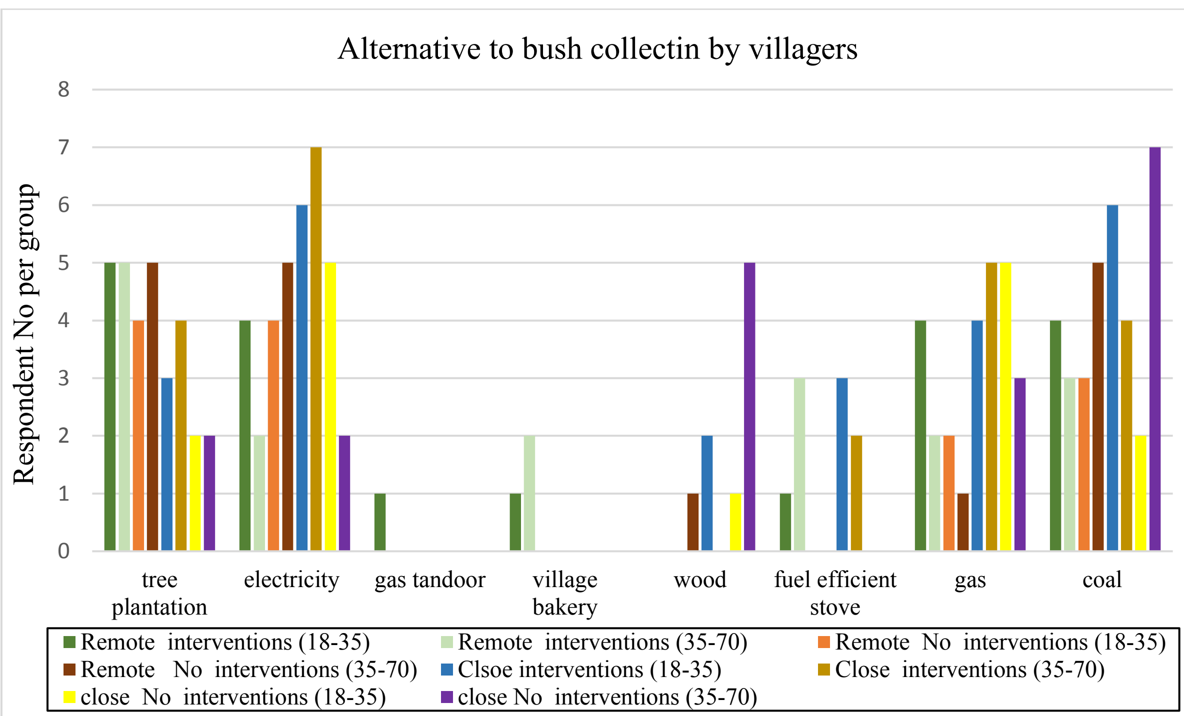


Figure 4.4. Alternative to bush collection by villagers

4.4.1 Differences in perception of people which the result of VISIT and land cover maps were shared with them and not shared

As Bamyan local people and farmers are raising the livestock for their livelihood and economic purposes and they sell their animals to the market and villages. They sell their livestock in the fall season as well based on need any time of the year such as religious events and livelihood support. The perception regarding livestock raising and land use practices between people who seen the result of previous studies and not seen the result of those studies can be explained as: from 56 respondents who seen the result of studies 28 (50%) thinks good fodder, 23 % good rangeland, 21% less number of animal per rangeland area, 23% vaccine, 18% proper place in the winter, 20% sending the animals to high mountains and 7% thinks good nutrition are good practices, in against that 6 people out 32 (19%) who not seen the result of studies thinks good fodder, 41% good rangeland, 6% less number of animal per rangeland area, 31% vaccine, 3% proper place in the winter, 34% sending the animal for grazing to high mountain and 3% thinks good nutrition is good practices. Consequently, the people who seen the result of VISIT model and land cover maps are more interested to reduce the numbers of animals according to rangeland capacity and providing good fodder but the people who not seen the result they are less interested to reduce the numbers of animals and they think have good rangeland and sending the animal to high mountains are good practices. The Figure 4. 5 shows the results.

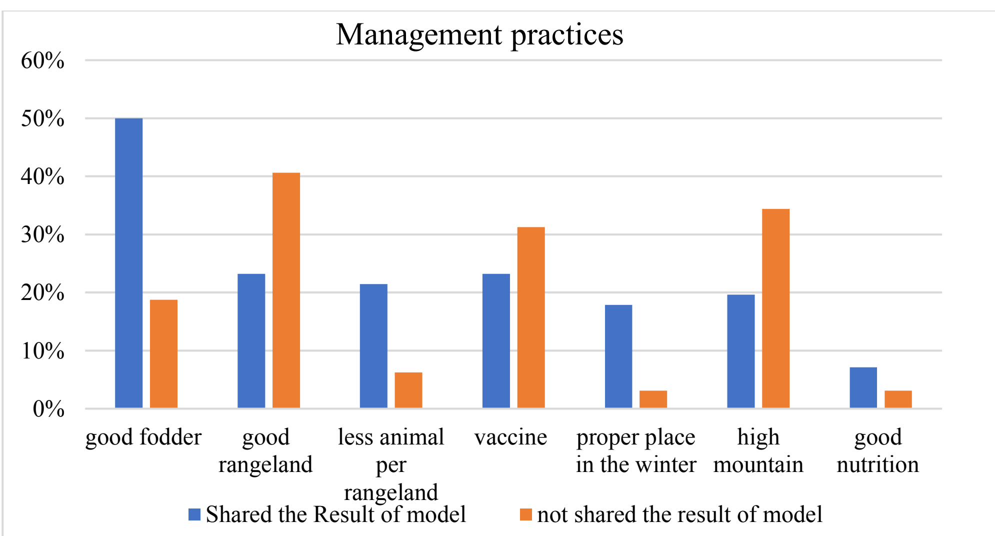


Figure 4.5. Differences in the answerers of people before and after sharing the results for management practices.

As many Bamyan people livelihoods depend on livestock, the challenges which are elaborated by people for raising livestock is different between people they saw the result of VISIT model and land cover maps and people they did not see the results. The people which result was shared with them, think that lack of palatable plant (11% out of 56 people), 43% lack of grazing land, 36% lack of fodder and 54% think diseases are the challenges. On the other hand, the people not seen the result of the model and land cover maps, 28% out of 32 people thinks lack of grazing land, 25% lack of fodder and 41% diseases are the challenges ahead of raising livestock Figure (4.6). Subsequently, the result of scientific studies affects the perception of people which they think about the loss of palatable plants, lack of rangeland and fodder availability in comparison to those people they have not seen the results of studies. The effect is statistically significant and the overall regression was significant, $F(1,4) = 57.4$, $P = 0.0016$, $R^2 = 0.93$

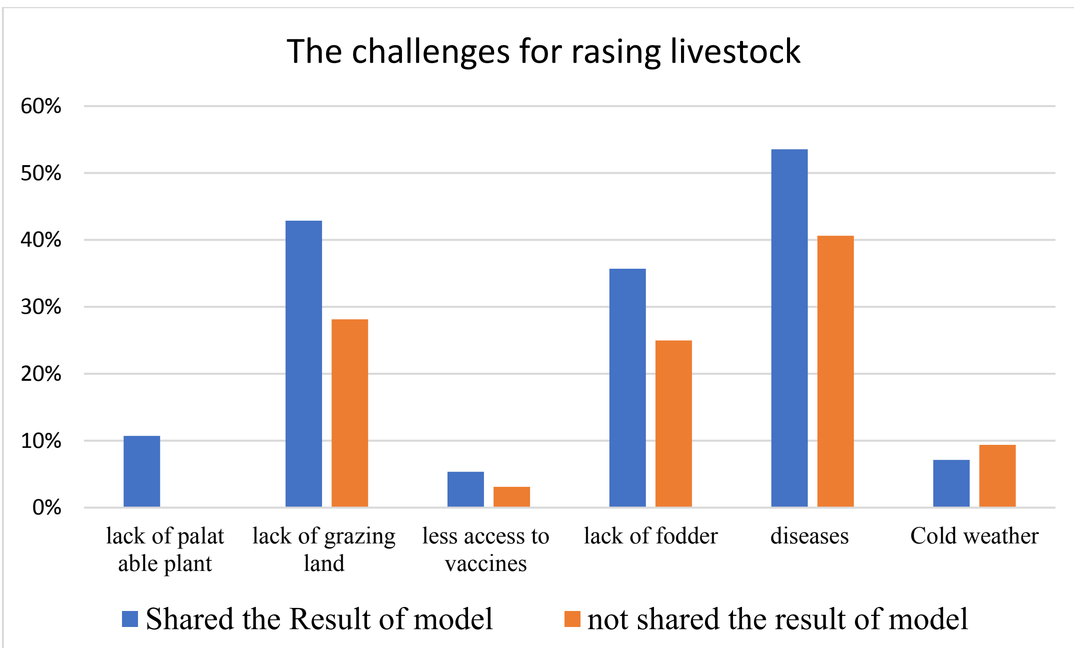


Figure 4.6. The differences in challenge of livestock rising

In Bamyan, most people, especially in rural areas, use the bush for cooking and heating which this issue causes some problem for the environment. The perception of people who saw the result of aforementioned studies and people who not seen the result of studies are compared. The people saw the results (52% out of 56 people) thinks that it causes land cover loss, 23% decrease of palatable plants, 32% flood increase, 29% barren land increase, and 20% soil erosions. On the other hand, the people they did not saw the result 38% out 32 people think it causes land cover loss, 19 % decrease the palatable plants, 50% flood increase, 9% barren land increase, and 6% soil erosions Figure 4. 7. Finally, I can say that the result of the model and land cover map had an effect on people perception and understanding regarding the impact of the bush collection, specifically on land cover lose, barren land increases and soil erosion issues. This effect is statistically significant with overall regression $F(1,5) = 48.4$, $P < 0.001$, $R^2 = 0.90$

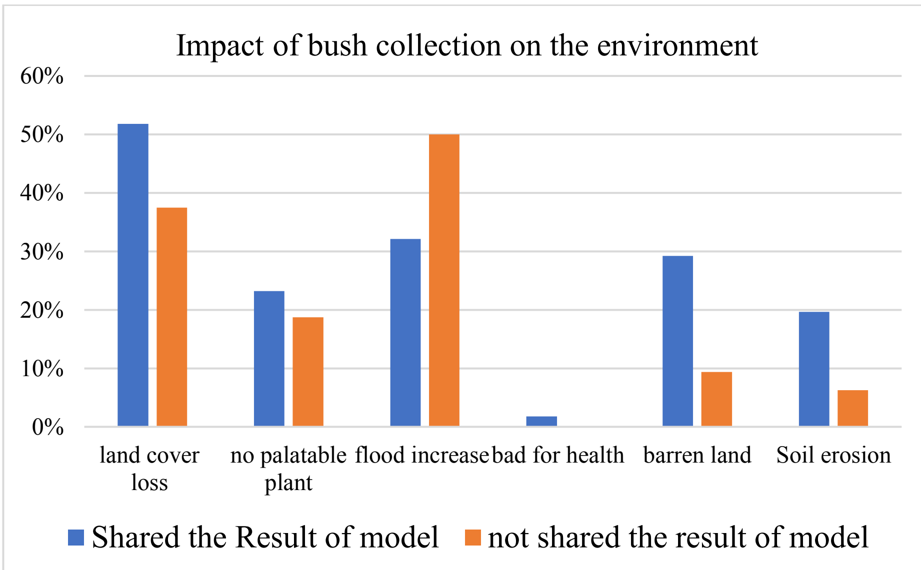


Figure 4.7. Differences on impact of bush collection in environment

Both community members which the result of VISIT model and land cover maps shared and not shared with them are interested in reducing the bush collection through having some alternatives such as tree plantation, introducing fuel-efficient stoves and other alternative sources. The people who saw the result of VISIT model and land cover maps have more interest on tree plantation 52% out of 56 people, electricity 61%, village bakery 4%, fuel-wood 18%, fuel-efficient stoves 14%, gas 46% and coal 61% as alternatives to reduce bush collection. The people not seen the result of VISIT and land cover maps 38% out of 32 people suggest tree plantation, 28% electricity, 9% village bakery, 34% wood, 9 fuel-efficient stoves, 34% gas and 50% coal, as alternatives to reduce bush collection, Figure 4.8. Lastly, the people who saw the result of studies had more focus on tree plantation, electricity, coal, gas and fuel-efficient stove. But the people have not seen the result of studies they suggest the wood and village bakery in a higher percentage than those people have seen the result of studies. The differences in people perception are statistically significant and the overall regression was significant, F (1,6) =13.27, P= 0.01, R^2 =0.68. It supports that we can say that result of studies effects the people perception.

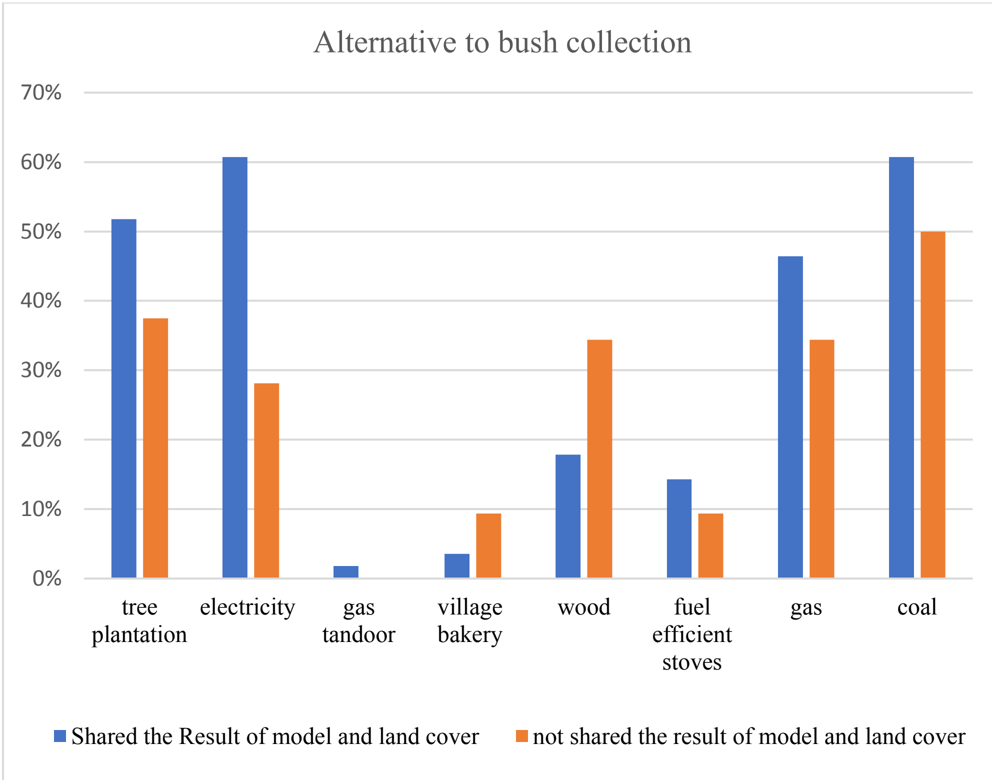


Figure 4.8. shows differences of alternatives to bush collection

4.5 Conclusion

Afghanistan natural resources spoiled over years of conflict and lack of management and lost its tradition management strategies. Majority of Afghanistan people live in rural area and they are reliant on natural resources for their daily needs. Some unsustainable practices such as overgrazing, deforestation, removal of shrubs for cooking and heating and high steep cultivation have damaged the natural and semi-natural environment of this country. Most of Afghanistan area is characterized as rangeland which provides grazing space for livestock and habitat for wildlife as well supply fodder for winter and fuelwood for cooking and heating. On the other hand, this rangeland due to nature of Afghanistan has low fodder productivity. In Bamyan livestock is the traditional source of livelihood and livestock raising weakened due to loss of rangeland. In addition, rangeland of

Bamyan's is the source of livestock raising and bush collection for cooking and heating. This rangeland has changed to agricultural land, settlement and barren wastelands.

VISIT model applied to simulate Land degradation and LAI changes from 2000 to 2050. The simulations show the changes of LAI and land degradation area. The results of VISIT model and land cover maps were shared with the governmental and non-governmental organization as well as with local communities. The local communities and governmental organization and NGOs also shows their concern regarding land degradation and overuse of natural resources. According to governmental organization and NGOs in Bamyan is not a specific policy about land degradation. On the other hand, the governmental organization with NGOs have intervention in some villages of Bamyan district center to improve rangeland, livestock raising, and limit bushes collection. The villagers from different villages were interested to limit the bush collection through having alternative sources such as tree plantations and a fuel-efficient stove, village bakery and reseeding of rangeland. Furthermore, when the result of VISIT model and land cover maps shared with local communities the villagers show their interests to do not increase the number of livestock due to future land degradation increase and land cover changes.

While the Government does not have any policy regarding limiting the number of livestock in Bamyan, due to the dependency of many people living on livestock. Consequently, the villages close to district center thinks the land cover has changed and lead to soil erosion as well the remote communities had concerns about land cover change and lack of rangeland and decrease of palatable plants. Moreover, collecting bushes and overgrazing lowering down the LAI and decrease the rangeland carrying capacity and lead to land cover change and land degradation. These issues indirectly impact their economy and cause barren land intensification and increase flood risks.

While there are differences in perception of the people who saw the result of VISIT model and land cover maps in people who did not saw the result of model and land cover maps. The people which saw the results are pointed that overgrazing and bush collecting will cause land cover loss, flood risks, soil erosion, land degradation and disappearing of palatable plants for livestock. But the people who did not saw the results are less conscious about land cover lose, soil erosion and land degradation in the area.

The finding demonstrates that when the results of VISIT model and land cover maps were showed to communities their perception has changed and they show more concern on future negative change, while the concern was stronger among the younger generation. Therefore, the communities are interested and ready to apply some initiatives to limit the overuse of natural resources such as overgrazing and bush cutting, once they find awareness's and having alternative sources such as electricity, gas, coal (for current situation), tree plantation, rangeland reseeding, village bakery and passive solar houses.

Chapter 5

General Discussion and Conclusion

5.1 Land cover change and land degradation prediction in Bamyan, Afghanistan

Land provides a group of functions that are vital to human life. Besides providing food, biomass, and raw material and serving as a home and gene pool, land similarly presents storing, cleaning and renovation, additionally serving as social and cultural roles and its function a significant part in the rule of natural and socio-economic developments that are crucial for human life such as water cycle and the environment system. Land degradation is an important injury to all these functions which happens both naturally and as consequences of anthropogenic impacts (Görlach 2004).

Land degradation has turned a world issue and it is happening in the majority of global biomes and agro-ecologies, in both low-income country and developed country. Furthermore, productive soils are a non-renewable resource by human life duration because their development and regeneration might take hundreds of years, that is why the human management of soil properties will have widespread values on human security for a generation in the future. It is critical that the majority of rural poor livelihoods are depending on the land. In addition, for the world population, food, fiber and additional terrestrial ecosystem goods are prepared from land. Therefore, the degradation of land has both direct and indirect influences on general human welfare. The price of land degradation for the reason of land use land cover change records for 78 % of the total global charge of land degradation of about 300 billion USD. Hence, signifying that top urgency must be specified to addressing land degrading land use and cover change. Land use planning and policy development is a necessity to assure that forests and other valuable biomes are preserved and sustain to supply ecosystem services for local and global communities. In Central Asia, changing of grassland and shrublands to barren lands is the main type of land degradation (Nkonya et al., 2016).

In Afghanistan as consequences of long years of conflict and social unrest, people migration, interruption of social structures and frequent drought had directed the over-exploitation of natural resources. Today due to natural and anthropogenic influences land lost it is bio-physical protection which accelerates wind and water erosion as well observed condition of biodiversity loss and land degradation. Soils losing its carrying capacity, the result of overgrazing, farming of inappropriate land and revealing of soils to wind and water erosion and consequently, it caused severe flooding, soil erosion, deforestation and decreases of rangeland quality and productivities. On the other hand, desertification in Afghanistan impacts further than 75% of the overall land area in northern, western and southern zones wherever extensive grazing and deforestation have decreased plant cover and generate faster land degradation (UNEP 2009).

Based on the global assessment of soil degradation (GLASOD) around 16% of Afghanistan's land area is extensively impacted by anthropogenic actions, and the country's susceptibility to desertification remains one of the highest in the globe (NEPA 2014). According to GLASOD assessment, 33% of Afghanistan agricultural land has been degraded by a 9,811,000ha light degradation and 2,597,000ha moderate degradation and 209ha strong degradation with a total area of 12,617,000 ha (FAO et al, 1994).

Afghanistan as a result of the socioeconomic condition, topographical environment, poor agricultural practices, changes in grazing pattern due to war and social instability significantly impacted by land degradation. Beside these factors, there are different direct and underlying causes to generate land degradation in Afghanistan. On the other hand, inadequate national policy and strategies, action plans and governance have further complicated the situation. This statement supported by UNEP (2008) As Afghanistan like other developing countries face to numerous direct and underlying causes of land degradation. But it has been complex by insufficient national policy, infrastructure, resources, and governance, besides sense of social instability, and period of war and conflicts.

5.2 Land cover change in Bamyan from 1990 to 2015 due to overuse of natural resources and lack of land management

Bamyan same as other parts of Afghanistan have a history of the anthropogenic destruction of the environment with a history of conflict and breakdown of the traditional system and coping strategies and institutional methods of natural resources management. Few studies have been conducted regarding the land cover change in Afghanistan, and these studies show the land cover in Afghanistan has changed dramatically. These issues complicated with insufficient policy strategy and action plans. But laws, regulation, and policies which concerning environmental issues are a new progress in Afghanistan but law enforcement and action plans are still weak.

UNEP (2003), used satellite images from 1977 and 2002 in northern provinces of Afghanistan and revealed that land cover has highly changed especially forest and woodland. Moreover, Shroder (2014) argued that causes of the land cover change are overuse of natural resources like overgrazing, deshrubification, over-plowing, changing to agricultural land, water shortage, climate change drought, deforestation and along with surface and subsurface water management.

This study investigates spatial and temporal changes of land cover in Bamyan Afghanistan from 1990 to 2015 with focus on human-induced factors. According to Najmuddin et al. (2017) to contribute sustainable land use management decisions it is important to understand the land use/cover. Especially, undertaking the recent changes of Afghanistan socioeconomic and climatic conditions and it is a particular need to recognize the relationship amongst land use drivers and land cover change and its consequences.

For this study Landsat images of 1990 1999, 2008 and 215 (Table 1.4) were used to investigate land use land cover changes. The result of field work survey and result of classified images shows that land cover has been changed rapidly in Bamyan due to human influences such population increases, overgrazing, bush cutting and lack of management. The outcome of the classified image shows the high percentage change of land cover in around Bamyan city, which population is rapidly increased. The rangeland has changed to barren land and the built-up area blown-up, natural resources overused and bare soil expanded. Meyer and Turner (1992) argued, human activities directly change land cover and humans are the driving forces. World population rises are presented key position in most environmental change since the resources are essential to support the demand of billions of people. Samie et al. (2017) stated, the worries about land use land cover change are well known. The human practices like population rise, urban expansion, and fast economic growth have obviously altered the world surface processes, and lead changes in environmental qualities at regional and global level. Understanding land use change is critical to environmental management since land cover change impacts the carbon cycling, greenhouse gas emission, radiation and water resources and people livelihood. Land use planning and management is an effort to obtain land use configuration by determining the dynamics of land use changes.

Changing rangeland to barren wasteland impacting the livelihood of many people in Bamyan especially those people their livelihood depends on livestock raising and bush cutting for heating and cooking and the loss of rangeland, directly and indirectly, disrupting their income source.

There is not sufficient study about land use/caver in Bamyan to help the policymakers and managers even though they know that land cover change is an important issue. The current study will support them to understand land cover change significances by numerical and it can be a reference for policy makers and land managers when adopting policies and strategies of land conservation in Bamyan as well the result of the land cover map as scientific knowledge has effect on people perception regarding land use and management.

5.3 land cover change and land degradation prediction and knowledge dissemination

The arid and mountainous nature of Afghanistan providing livelihood support for more than 80% of its population, which 45% of this territory is considered as rangeland. This area besides providing the grazing land also provides fodder for the animal winters as well as bushes for fuel. This rangeland has been overgrazed and shrubs are removed for long years. The rangelands in Afghanistan have low fodder productivity with high differences in each area. According to (Bedunah 2007 and Ali and Shaoliang, 2013) stocking levels in Afghanistan exceeded carrying capacity the rangeland condition will decline and leading to land degradation.

More than 69% of Bamyan population collecting bush for cooking and heating. Population raising rapidly and consequently bush collection beside overgrazing will lead rapid increase of land degradation. The VISIT model has been applied to estimate the land degradation and LAI change to Bamyan district center for certain period of time. VISIT is capable to simulate changes in the form and function of the ecosystem (Saito et al., 2011).

The result of VISIT model shows the increase of land degradation and a decrease of LAI, based on current situation continuation of overgrazing and bush cutting. It will be a future threat to the environment of Bamyan as well for their economy. Reduction scenarios for bush cutting and limit the number of animals applied to the VISIT ecological model the simulated result show the increase of LAI and decrease of land degradation. The result of VISIT and land cover maps were shared as scientific study with governmental organization, NGOs and local people and they were agreed with results and changes of land cover as well this result affected their understanding and perception regarding land cover change and land degradation and management policies which most of the local respondents shows the interests to reduce bush cutting and keep the animal based on rangeland capacity. Based on the current economic situation of Bamyan reducing livestock number is not very practical.

Viewing results of land cover change and land degradation, community members are willing to possess the livestock that the rangeland carrying capacity can afford. Therefore, if there are enough awareness and managerial programs that provide alternatives, the communities are prepared to take action. The government and NGOs have applied some project to support livestock raising and manage natural resources. In the areas where projects are applied, the younger generation is more conscious to raise the number of animals based on rangeland carrying capacity to not degrade the rangeland as well as it will facilitate better fodder quality. In addition, some of the communities have learned methods of managing rangeland. They are practicing those methods such as the rotational system of grazing to reduce the overgrazing. On the other hand, bush collection and uprooting is another concern which causes land cover loss and land degradation. According to (NEPA 2014) in the Koh-e Baba mountains, soil erosion is a distinguished problem. Overgrazing, unmaintainable systems of shrub collection and plowing the rangeland for rainfed agriculture on high slopes caused the important level of soil erosion. Furthermore, the bush collection brings environmental problems in Bamyan district center such as soil erosion, land cover loss, and flood increase. Communities, where have been interventions by providing information and training, are more interested to reduce bush collection through some alternative such as fuel-efficient stoves and tree plantation. Tree plantations can be used as an alternative of which the branches can be used as fuel and the trunks can support their income through selling to the market. It can also support the environment. Furthermore, the villagers are keen to reduce the bush collection through some programs as alternative energy sources.

A field work survey was conducted with 32 people and the result of VISIT and land cover maps were not shared with them to get their perception regarding natural resources uses such as overgrazing and bush collection for fuel as well as challenges and management practices. Then the result of the shared result and land cover maps and not shared the results were compared.

The result specifies that there are differences in people perception. The dissemination of scientific knowledge such as land cover maps, LAI maps, and land degradation maps of different years effected on the understanding of people regarding land cover change and land degradation. The people who saw the maps thinks that overgrazing, bush collection causes the land cover change, land degradation, soil erosion, flood risks and vanishing of palatable plants. The people who did not see the maps show fewer concerns about land cover lose and soil erosion and land degradation because they don’t know the future predicted change.

Finally, I can argue that when communities’ members seen the result of VISIT model and land cover maps, that affect their perception and they eagerly wanted to limit the land degradation and land cover changes by applying some initiatives. Results of the study influenced the perception of communities and organizations towards a situation of on management and natural recourse utility.

While asking for alternatives, the locals are willing to bring the changes. Consequently, the significant solution towards a sustainable management of resources and environment that can be achieved is through integrated methods of natural resource management, participatory natural resource management including working with local people, raising awareness, improving strategies and action plans.

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