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Science for resilient livelihoods in dry areas

The status of forage production in Afghanistan

Forage options for smallholder livestock keepers in water-scarce environments of Afghanistan

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TECHNICAL REPORT

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We provide innovative, science-based solutions to improve the livelihoods and resilience of resource-poor smallholder farmers. We do this through strategic partnerships, linking research to development, and capacity development, and by taking into account gender equality and the role of youth in transforming the non-tropical dry areas.

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Summary

This paper presents an overview of forages and feed resources in Afghanistan with a particular emphasis on crop–livestock production systems and forage resources; their utilization and conservation, forage seed production, major constraints of forage production, impact of climate change, and various strategies for increasing forage production. Afghanistan is predominantly an agriculture-based country, and this contributes about one-third of GDP, of which about half (14% of total GDP) is from the livestock sector alone. There has been a consistent increase in the livestock population during the last two decades, which can be attributed to an increased requirement for milk and milk products by an increasing population, and more requirements for pack animals in view of Afghanistan's topography. The major livestock production systems include the pastoral nomadic cattle and small ruminant production (practiced by the nomadic Kuchi tribe) and, in northern Afghanistan, Karakul sheep production for pelts.

The major forage resources are rangelands, cereal by-products and stubble, and cultivated fodders in rainfed and irrigated lands. Rangeland resources are among the most important, covering 45% of the country's geographical and 79% of the agricultural area, but certainly the most neglected and degraded agro-ecosystem in dry areas of Afghanistan due to overgrazing and overexploitation. The predominant grazing vegetation in the country's pasture is *Artemisia* steppe, although site specific information on floristic composition is lacking. Land tenure for rangelands is also a contentious issue contributing to degradation of rangelands. Wheat straw, and to some extent barley straw, is an important source of feed in sedentary production systems and makes substantial contributions to stall-fed ruminants especially during winter.

Vetch, barley (*Hordeum vulgare*), grass pea (*Lathyrus sativus*), and oat (*Avena sativa*) are the most common cultivated fodders in rainfed conditions, whereas in irrigated areas they are lucerne (*Medicago sativa* L.), shaftal (*Trifolium resupinatum* L.), and berseem (*Trifolium alexandrinum* L.). In general, productivity of these leguminous fodders and others is low due to low input conditions. Multi-cut fodder sorghum (*Sorghum bicolor*), sorghum × Sudan grass (*Sorghum bicolor* × *S. bicolor* var. *Sudanese*), pearl millet (*Pennisetum glaucum*), maize hybrids, and oats have also shown promise in certain provinces. A number of fodder shrubs (*Albizia lebbek* [L.] Benth., *Cercis griffithii* Boiss., and *Alhagi canescens* [Regel] B. Keller & Shap.), and trees such as mulberry (*Morus serrata* Roxb. and *Morus alba* L.), willow (*Salix* spp.), poplar (*Populus* spp.), Russian olive (*Elaeagnus latifolia* A. Rich.), and coffee bush (*Leucaena leucocephala* [Lam.] de Wit) contribute to the forage resources in Afghanistan. Intercropping and alley cropping are some of the practices adopted for production of forages. Hay, straw, and silage are the major practices for conservation and utilization of forages. The concept of cooperative fodder banks is also being implemented and assessed for its feasibility under the socio-economic conditions of Afghanistan.

The paper also gives insight into forage seed production and marketing, constraints limiting forage production and productivity, and impact of climate change on future fodder production. The country exports more than 150 tonnes of lucerne seed yearly valued at US$0.25 million. Many short- and long-term strategies focus on development of short-duration and high-yielding fodder varieties to knit them in various cropping systems, their quality seed production, popularizing new potential fodder crops and their production technology, and adoption of improved production technology of existing fodder crops for enhancing fodder production in Afghanistan. Some of the projects and programs of various organizations already under implementation are discussed.

1. Introduction

Afghanistan is an extremely poor and conflict-ridden country with more than half of its population of 30 million living below the poverty line of US$1 per day. In recent years, the number of poor and undernourished has increased by 10–15% per year, a result of frequent droughts and increases in the price of food and feed, all of which were compounded by the global food and economic crisis (FAO 2008; WFP 2009). Calorie deficiency rates vary from less than 15% in Parwan, Nangarhar, Sar-i-Pul, and Jawzjan to more than 60% in Badakhshan and Laghman (World Bank 2011).

Agriculture is the main livelihood that provides resilience to the poor rural people and is a major contributor to the Afghan economy; however, availability of land and water resources for vulnerable smallholder farmers is limited and marginal at best. Approximately 75% of the Afghan population lives in rural areas where they subsist by crop and/or livestock farming (GIRoA 2009). Livestock are essential for the livelihoods of rural Afghan families, who keep small ruminants and dairy cows as a source of food, income, and a 'safety-net' in times of need. Livestock production is a significant contributor to the Afghan economy, accounting for about half of agricultural GDP (ACIAR 2011; AusAID 2011). Insufficient feed availability and production for ruminants are the key constraints for the livestock sector (GIRoA 2009). The lack of forage of sufficient quality limits productivity, and the effects worsen during years of drought or where fodder imports from neighboring countries are restricted.

The demand for livestock products within Afghanistan and neighboring countries is likely to rise as populations and incomes grow. This presents a significant opportunity for livestock farmers in Afghanistan to improve household income and food security. The recent Afghan Livestock Workshop, organized by the Advancing Afghan Agriculture Alliance, identified 'Feed, Forage and Nutrition' as key for the development of the livestock sector (Motamed 2008). Achieving increased productivity and reducing seasonal feed gaps for livestock will require an increase in forage and fodder productivity, production, and diversity. ICARDA, under its International Fund for Agriculture Development (IFAD)-funded project on women's livelihoods through small ruminant raising in the marginal areas of Afghanistan and Pakistan, concluded that availability of forage/fodder was critical for keeping animals during the winter season. It also concluded that the unavailability of forages forced poor people to sell their assets. The final report reiterated "Further research-for-development intervention is needed to increase the feed resource base with varieties suitable for resource poor farmers" as one of the lessons learned (ICARDA 2010).

Afghanistan covers an area of 65.3 million ha of extremely steep and mountainous land (Table 1), but only 37.91 million ha of the total geographical area is available for agriculture. Rangelands or grazing lands occupy the largest land cover because most of Afghanistan is semi-arid to arid. Of the total agricultural area, more than three-quarters is under permanent meadows and pastures. Out of the total agricultural area of 37.91 million ha, only about 5.5% is actually irrigated. However, the irrigated area accounts for 26.6% of the total arable land (7.79 Mha) in the country (MAIL 2005; FAOSTAT 2014). Crop production is mostly confined to pockets of irrigated land, with some rainfed areas in the north and at higher elevations. The cultivable land and pastures have been shrinking over the last three decades either through abandonment or owing to damage to irrigation systems or lack of water availability, urban development, and degradation due to soil erosion, salinization, or poor fertility (NEPA-UNEP 2009). Poor farmers are often forced to clear forest lands, cultivate sloping lands for crop production without conservation measures, over-graze pastures, and use minimum or no fertilizer (FAO, UNDP and UNEP 1994). Many productive rangelands in the country have virtually become wasteland (Stanfield et al. 2010). The degrading effects of greater human activity in many regions or zones are further worsened by climate change, especially recurrent droughts and floods and erosion.

Livestock is the most important farming component and about eight million farmers depend entirely on a crop–livestock system for their livelihoods. Within the agriculture sector, the livestock sub-sector plays a key role in economic development of Afghanistan and is an important priority in the life of farmers. The livestock sector provides income, food, employment, and other contributions to rural development. Out of 75% Afghans who live in rural areas, 85% keep some livestock (GIRoA 2009). Agriculture accounts for about one-third of the country's GDP, and livestock production contributes 14% (Table 2; ACIAR 2011; AusAID 2011; USDA 2011).

Table 1. Land use (Mha) in Afghanistan (2012).

Agricultural area	**37.91**
Area actually irrigated	2.07
Arable land	7.79
Temporary crops	3.45
Fallow land	4.34
Permanent crops	0.12
Permanent meadows and pastures	30.0
Forest land	1.35
Other land	26.03
Total land/country area	**65.28**

Source: FAOSTAT (2014)

Table 2. Livestock production in Afghanistan (2012).

Livestock product	Production (tonnes)
Meat beef and buffalo	139,000
Meat indigenous chicken	13,000
Meat indigenous goat	44,200
Meat indigenous camel	3600
Meat indigenous sheep	112,000
Meat indigenous cattle	139,033
Total meat	**316,057**
Milk whole fresh camel	5100
Milk whole fresh cow	1,507,700
Milk whole fresh goat	118,000
Milk whole fresh sheep	211,000
Total milk	**1,841,800**
Hides cattle fresh	15,440
Skins goat fresh	8500
Skins sheep fresh	17,500
Eggs primary	18,000
Honey	3000

Source: FAOSTAT (2014)

Afghan farmers are vulnerable to drought. Livestock numbers decrease in dry years and collapse during drought periods (ACIAR 2011; AusAID 2011). Even though the poorest farmers have at least one cow and a few goats or sheep to satisfy their basic needs for meat and dairy products, national productivity is not high enough to provide sufficient meat and milk for the growing population (Jacobs et al. 2012). The lack of fodder, especially during winter, is a major limiting factor for ruminant production in Afghanistan. The yield gap in fodder productivity between Afghanistan and neighboring India is quite wide. The average yields of berseem and lucerne (*Medicago sativa* L.) in India range within 60–110 and 60–130 t/ha respectively, but the corresponding figures for Afghanistan are only 54.8 and 32.5 t/ha (Bashir et al. 2007; Kumar 2013). There are a number of reasons for low productivity in Afghanistan. The lack of sufficient feed is associated with (i) limited access to land and water, (ii) lack of modern technologies (plant varieties and fodder production and conservation systems) and knowledge of ruminant feeding technologies, (iii) poorly developed input and output markets, (iv) lack of effective farm policies and effective institutions, and (v) continuous environmental degradation (Belaid et al. 2003; Motamed 2008).The need for increased fodder production was also highlighted by the Afghan Livestock Workshop, organized by the Advancing Afghan Agriculture Alliance (Motamed 2008). This concept was further supported by the USAID Afghan Water, Agriculture, and Technology Transfer (AWATT) program, where 'Forage Improvement, Demonstration, and Technology Transfer' was one of the key activities recommended to support the focus on 'Integrated Water Resources Management, Technology Transfer, and Policy Analysis' (Oushy 2011).

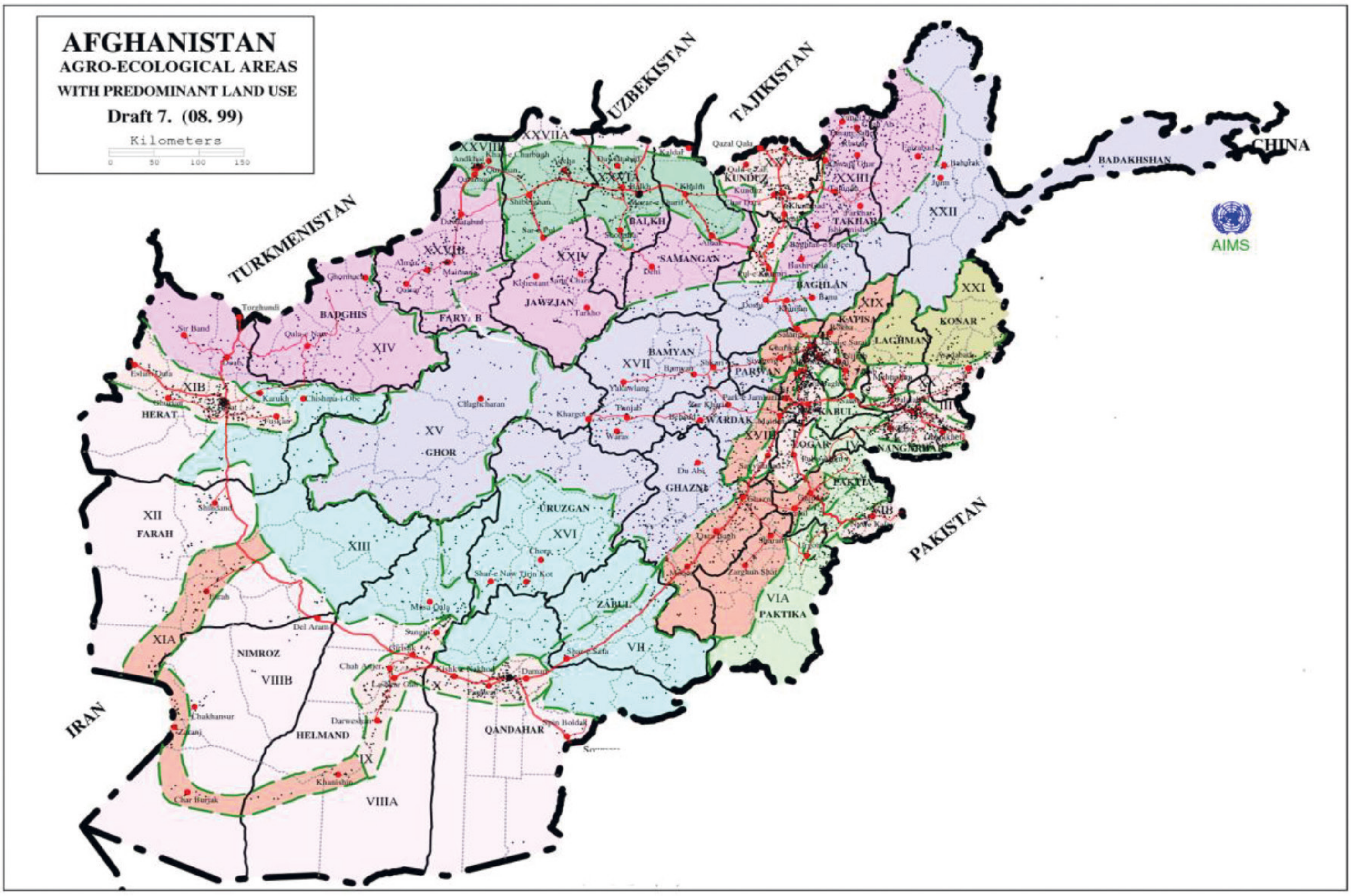
With the rise in living standards, the demand for meat consumption and animal products/food is also increasing. This has resulted in higher demand for better animal feed. The lack of quality forage limits productivity of livestock and the effect is further complicated during drought or when there is no possibility of fodder imports from neighboring countries. These constraints of the agricultural sector will continue to have a perpetuating effect on poverty in rural Afghanistan.

2. Climate and geography

Afghanistan is divided into 11 agro-ecological zones according to Dupree (1997), based on geographical zones, but only nine are of agricultural importance. Dupree (1997) suggested a simplified form of the geographic zones of Afghanistan: (1) Badakhshan (without Wakhan); (2) central and northern mountains; (3) eastern and southern mountains; (4) Wakhan Corridor and Pamir; (5) Turkestan plains; and (6) western and south-western lowlands (Figure 1). The north (Balkh, Samangan, Jowzjan, Sar-i-Pul, and Faryab Provinces) region is characterized by a continental desert climate. The north-eastern region (Baghlan, Kunduz, Takhar, and Badakhshan Provinces) is considered the food basket of the country (except for Badakhshan). The north-west region comprising Badghis, Herat, Ghor, and Farah Provinces is mostly rangeland and is characterized by rainfed production systems. The eastern region (Nangarhar, Laghman, Kunar, and Paktika Provinces) is famous for production of vegetables and agro-forestry. The east–central mountainous region (Bamyan, Parwan, Kabul, Panjshir, Dikundi, Logar, Wardak, Kapisa, and Ghazni Provinces) is characterized by cold winters. The lowland south-west region (Nimroz, Helmand, Kandahar, Oruzgan, and Zabul Provinces) has both arid and semi-arid climates.

Afghanistan is at the junction of several ecosystems: Mediterranean, Tibetan, and Himalayan. The vegetation toward the Pakistan border is usually influenced by the monsoon. The country is endowed with a diversity of natural resources such as plant and animal communities, and rangelands. The altitudinal range also further adds to diversity. The majority of the grazing lands in the country have a low rainfall that is concentrated in winter.

Figure 1. Agro-ecological zones of Afghanistan (Source: Afghanistan Information Management Service).



The climate is typical of arid or semi-arid steppe, with cold winters and dry summers (Figure 2). The mountain regions of the north-east are subarctic with dry and cold winters. In the mountains bordering Pakistan, the south-east monsoon carries tropical air masses that usually determine the climate between July–September. The highest temperature and the lowest rainfall usually prevail in the drought-affected and water-scarce southern plateau region, extending over the boundaries with Iran and Pakistan.

The country has such a geographical diversity that it has variable micro-climates and micro-watersheds, with frequent changes in weather conditions from one valley to another within a short distance (Maletta and Favre 2005). There are five major river basins: the Amu Darya, Northern River, Harirud–Murghab, Helmand River, and Kabul–Eastern Basins. The Amu Darya Basin accounts for about 14% of the area and about 60% of the water flow; whereas the Helmand River Basin has around 40% of the area and only 11% of the water flow (MAAHF 2005; MAIL 2005). The Hindu Kush is located in the center of Afghanistan and is its dominant mountain range. It generally runs in an east–west direction and separates northern from southern areas. The highest peaks of the Hindu Kush are slightly above 5000 m. There are deserts in southern, western, and northern Afghanistan.

Precipitation is highly variable – <100–300 mm in western and south-western parts to 300–800 mm in Badakhshan (without Wakhan) – throughout the year in all regions of the country (Figure 3). Sudden rainstorms quite often bring floods in rivers and streams. A northerly wind called the ‘wind of 120 days‘ blows during summer (June–September) in western and southern regions. This wind brings intense heat, drought, and sand storms, causing much hardship to the inhabitants of the desert and steppe lands. Dust and whirlwinds are common during summers

Figure 2. Mean annual temperature of Afghanistan (Source: ICARDA GIS Unit).

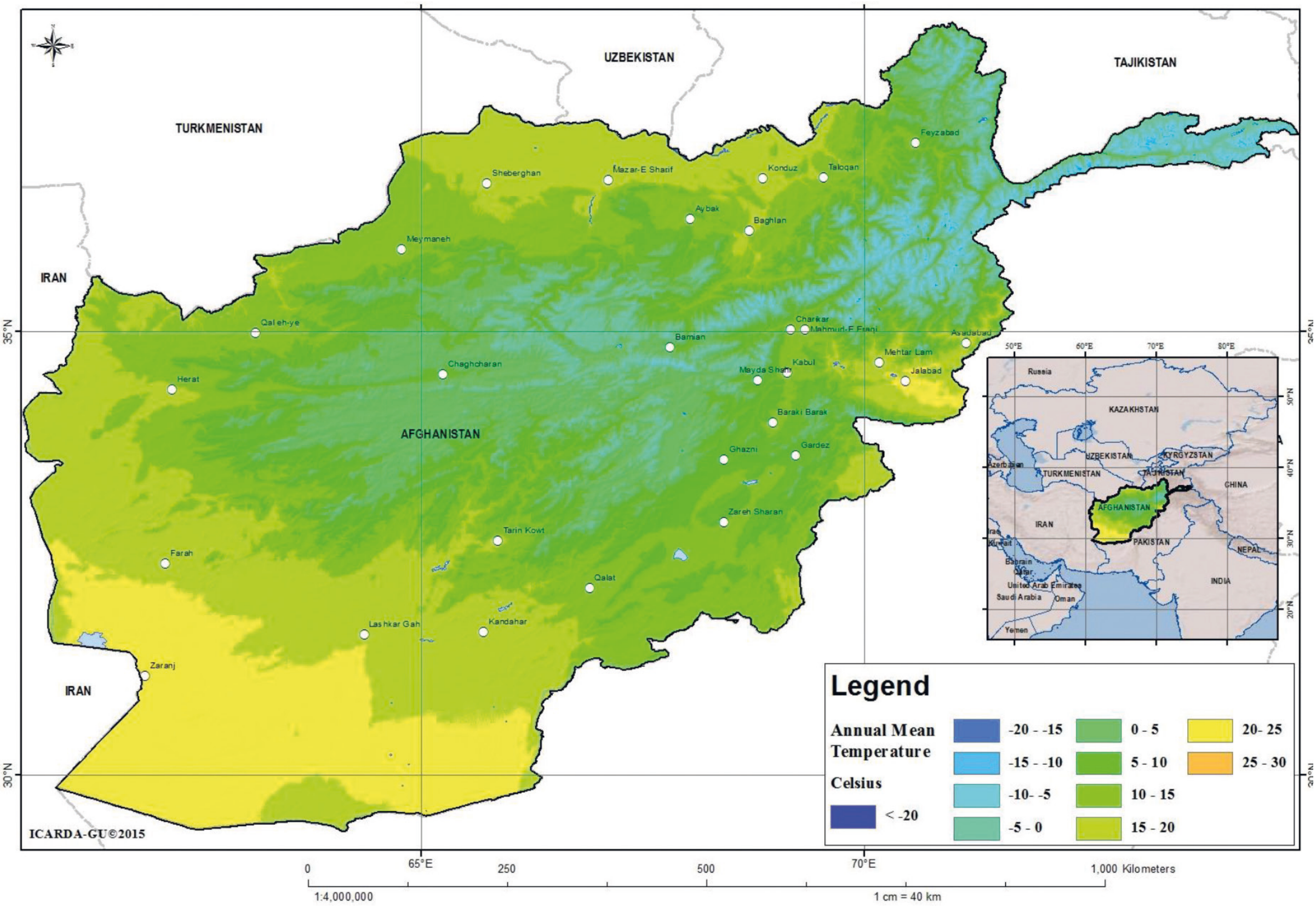
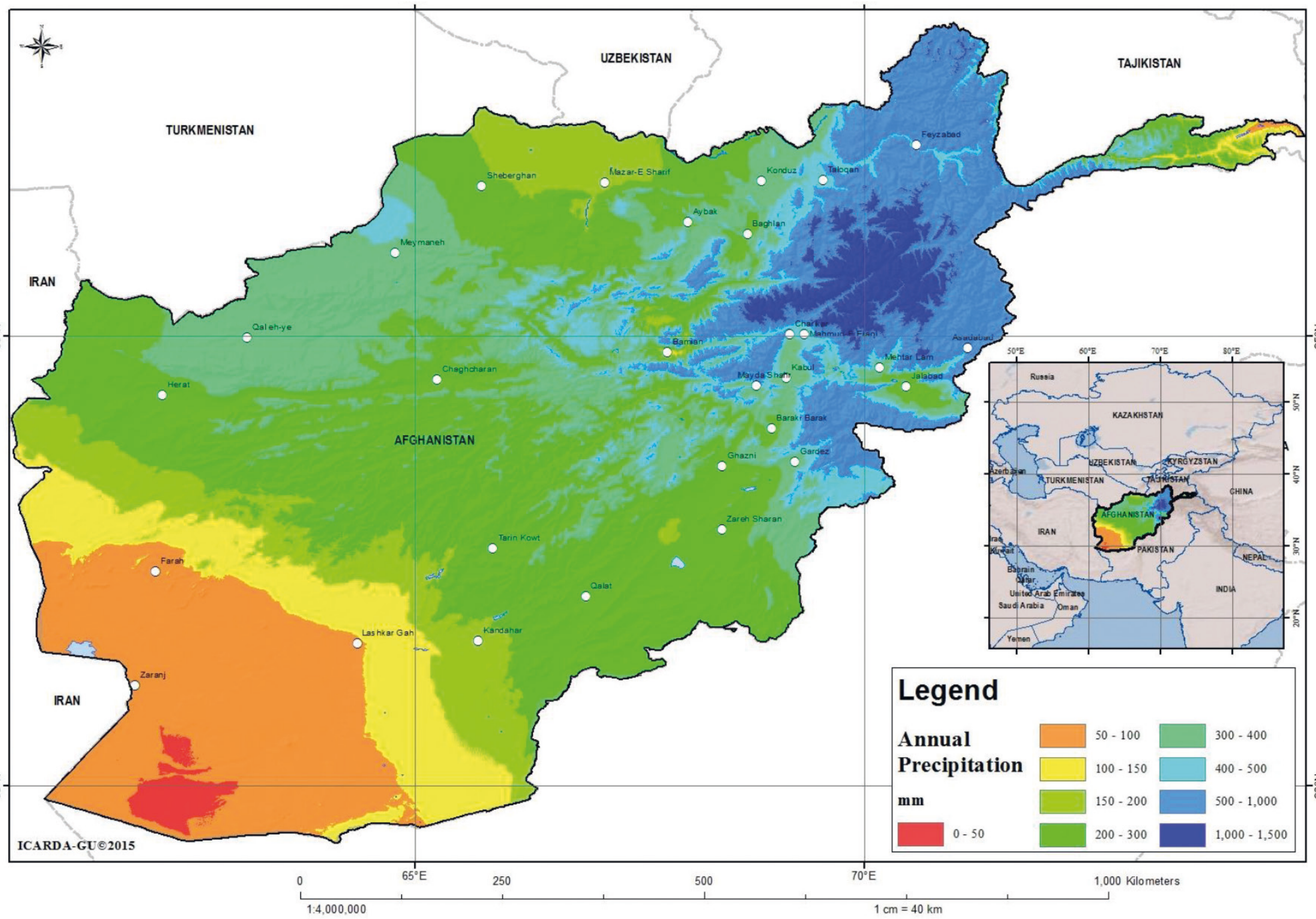


Figure 3. Rainfall map of Afghanistan (Source: ICARDA GIS Unit).



in the south of the country. The 'dust winds' usually rising at midday or in the early afternoon have wind speeds of 97–177 km/hour, leading to high clouds of dust.

There is another distinct climatic region surrounding the Central Mountains, with higher peaks moving upward to the Pamir Knot. From the Koh-e Baba Range to the Pamir Knot, the temperatures during January may plunge as low as -15°C or even lower in the highest mountain peaks. In contrast, temperatures in July may range within 0–26°C depending on altitude. The annual precipitation, usually in the form of snowfall, tends to increase eastward, with the highest in the Koh-e Baba Range, the western part of the Pamir Knot, and the Eastern Hindu Kush. These regions and the eastern monsoon area receive about 400 mm of annual rainfall. The eastern monsoon area comprises patches in the eastern border area with Pakistan, patchy areas in eastern Afghanistan from north of Asmar to just north of Darkh-e Yahya, and occasionally as far west as the Kabul Valley. The Wakhan Corridor receives <100 mm annual rainfall and experiences wide variations in temperatures ranging from 9°C in summer to below -21°C in winter. The highest mountain peaks have permanent snow cover, which can be more than 2 m deep during winter in the mountainous region adjacent to northern Pakistan. Valleys often become snow traps with high winds sweeping over the snow from mountain peaks and ridges. The climate of the Turkestan Plains extending northward from the Northern Foothills represents a transition zone between mountain and steppe climates. There is an increase in both aridity and temperature with lower altitudes, the highest being along the lower Amu Darya and in the western parts of the plains.

3. Cropping system and crop production

Wheat, maize, cotton, barley, pulses, vegetables, and fodder crops are the major crops grown in the different provinces. Other field crops, which are confined to a few provinces, are sugarcane, potato, rice, sesame, linseed, and millet. Wheat and barley are the principal rainfed crops. It is only possible to grow one crop per year in dry areas due to lack of water. In irrigated areas of Afghanistan, wheat is followed by rainy season maize, rice, mung bean, cotton, sugarcane, vegetables, and fodder crops.

As dual-purpose crops, wheat and barley are important in Afghanistan for food and fodder security. Wheat is the main crop under both rainfed and irrigated conditions and occupies the largest area (about 70% of the cropped area) among field crops in the country. Winter wheat is the most common wheat, but spring wheat is also grown in colder areas. Barley is used as stock feed. Dual-purpose barley provides both forage and grain for livestock. Maize, fodder sorghum, and millet can be fed fresh or converted into hay. Wheat crops are also harvested in the green stage in times of acute shortage of fodder during severe drought.

Wheat is the main staple cereal of Afghanistan and accounts for more than 70% of cereal production. It occupies about 2.55 million ha under both irrigated and rainfed conditions (FAOSTAT 2014). The average grain yield of 2 t/ha under irrigated and 1 t/ha under rainfed conditions is quite low and indicates the need for raising productivity through improved cultivars and adopting best agronomic practices (Kugbei et al. 2011). Maize is grown on about 142,000 ha. Some farmers also practice mixed cropping with chickpea, lentil, mustard, and cumin. In addition to the crops listed in Table 3, linseed, sesame, sugar beet, sunflower, rape, and mustard are grown on a limited scale in some provinces. Despite the importance of cultivated fodders in crop–livestock production systems in the country, no reliable data on area, production, and productivity of various fodder crops are available. The major field crops, excluding vegetables, along with their area, production, and productivity are given in Table 3.

Continuous cultivation of cereal or non-legume-based cropping systems such as cotton–wheat, maize–wheat, rice–wheat, sorghum–wheat, and pearl millet–wheat adversely affect soil health and factor productivity, as do fodder systems like fodder sorghum–fodder oats. The sustainability of lower-intensity crop production systems in the pre-chemical era could be sustained mainly because of organic manures and legume components in cropping systems. The inclusion of legumes in cropping systems not only helps maintain or enhance crop productivity, it also improves physico-chemical and biological soil properties, restores soil organic matter, and solubilizes various fractions of native soil phosphorus through acid root exudates (Ahlawat and Gangaiah 2004). Forage legumes are more potent than grain legumes in increasing the productivity of succeeding cereals due to longevity of the nitrogen (N)-fixation period. Legume fodder such as berseem may carry over N to the succeeding cereal in the range of 50–235 kg/ha out of the fixed N of 272–400 kg/ha (Williams et al. 1990). In a comprehensive review on potential of forages in diversifying cropping systems, Entz et al. (2002) indicated that wheat following lucerne produced significantly (~50%) higher yield compared with wheat after wheat. This increase in wheat yield was attributed to both N and non-N factors. In a similar study on durum wheat–forage (annual grass–clover winter binary mixture and perennial lucerne) cropping system under rainfed Mediterranean conditions, yearly gain in wheat yield after forage crops was 0.04 t/ha (Martiniello 2012). However, the benefits accrued through forage crops in topsoil were exhausted after three years of continuous wheat rotation. Inclusion of forage in the cropping system also improved the organic matter content compared to continuous wheat.

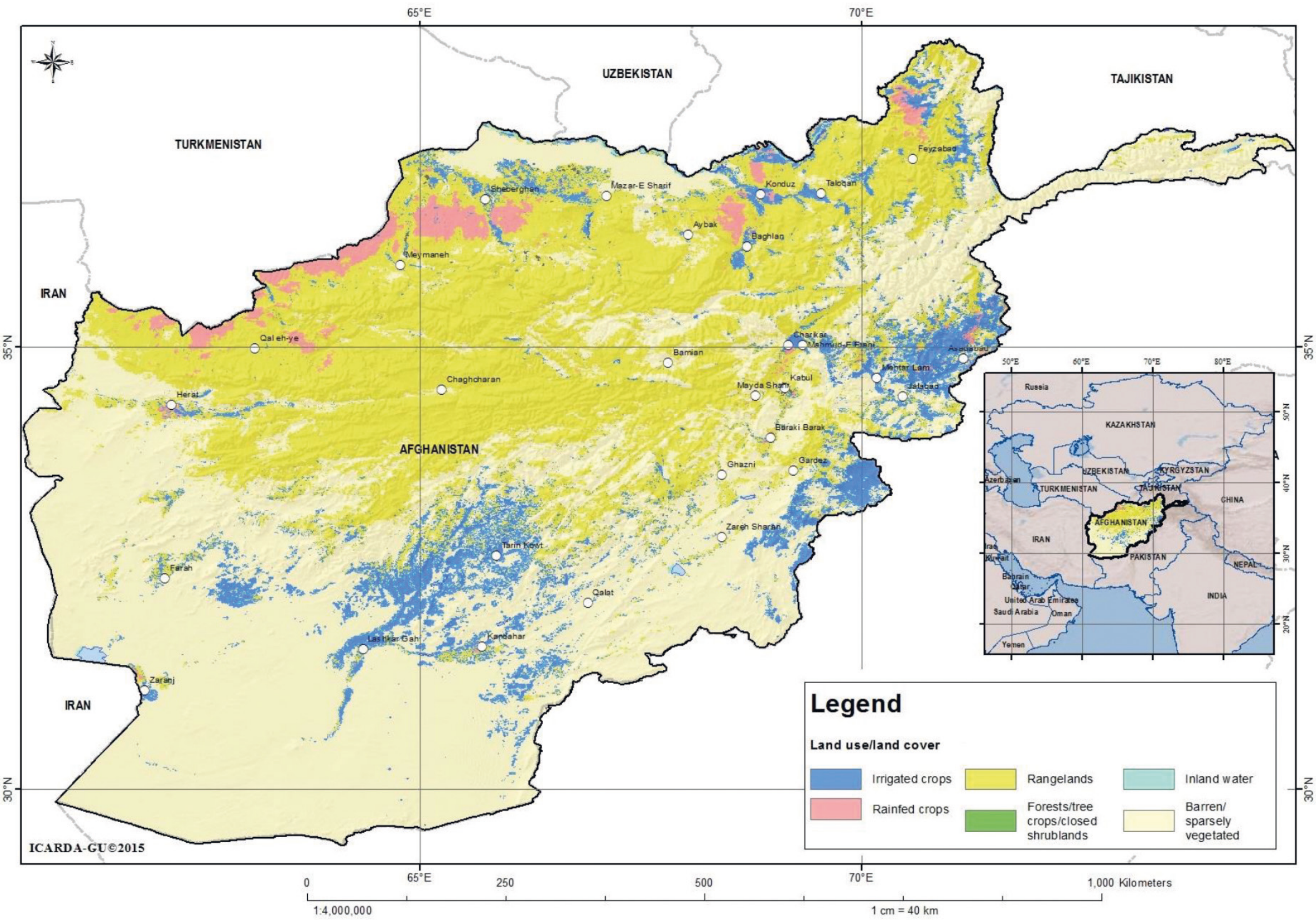
Table 3. Area, production, and yield of major crops of Afghanistan (2013).

Crop	Area ('000 ha)	Production ('000 tonnes)	Yield (kg/ha)
Wheat	2553	5169	2025
Rice	205	512.1	2498
Maize	142	312	2197
Millet	5	13	2600
Barley	278	514	1849
Pulses	74.1	50	675
Seed cotton	36.3	42.2	1162
Potato	23	303	13,196
Sugarcane	3.2	89.9	28,000

Source: FAOSTAT (2014)

The traditional wheat-based cropping systems in Afghanistan are rice–wheat, cotton–wheat, pulses–wheat, and melon–wheat (ASA 1992). Double cropping is only practiced in irrigated areas (Figure 4). Winter wheat and barley are usually planted from mid-October to the end of November depending upon the zone and harvested between May–June. Rice is planted in late April and harvested in October–November. The growing season of maize is May–September/October. Wheat–fodder (under-seeding of clover and alfalfa in wheat) is the most common irrigated cropping system in Afghanistan (Oushy 2014). Monsoon-season fodder crops such as multi-cut fodder sorghum and multi-cut fodder pearl millet can also be rotated with wheat. Sole crops of berseem or lucerne are usually sown in winter from mid-September until October. Some other wheat-based cropping systems occupying small areas in irrigated systems are pigeon pea–wheat, pearl millet–wheat, sorghum–wheat, groundnut–wheat, soybean–wheat, vegetables–wheat, fodder–wheat, and sesame–wheat. Fodders, especially berseem and lucerne, are an important component of cropping systems (Bashir 2014).

Figure 4. Land use and cover of Afghanistan (Source: ICARDA GIS Unit).



4. Livestock production systems

The prevalent livestock production systems in Afghanistan are sedentary villages, settled transhumance, and nomadic pastoral (Fitzherbert 2006). The transhumant sector comprises one-third of the small ruminants and most of the country's camels. Goats and sheep are usually raised in nomadic production systems with usual movements between summer and winter pastures. Cattle are still the main source of farm power and provide subsistence for dairy needs. Cattle, sheep, and goats are the main stock; however, camels, donkeys, and horses have specific importance. There are few yaks and buffaloes, and only in particular climatic conditions. Domestic fowls are integrated in all settled systems, but farmers also keep turkeys, ducks, partridges, and geese. Most camels in Afghanistan are the one-humped dromedary type, but in certain areas like Badakhshan and Wakhan, Bactrian camels are found. Most camels are used by Kuchis and are also hired to sedentary farmers. The population of water buffaloes is quite small and is mainly confined around Kabul and Jalalabad. The yak population is also low, are usually found in the Pamirs of the Wakhan, and used for milk production.

There are two main traditional production and management systems of livestock in Afghanistan, and both operate on little more than subsistence levels of production. Mixed crop–livestock farming is one of the two systems, adopted by sedentary farmers who possess small numbers of cattle, sheep, and goats with a cereal/horticultural crop production system. The products are mainly used for domestic consumption. Nowadays this system is being diversified, especially by progressive farmers, to explore new possibilities and opportunities for generating higher returns from livestock production, especially in peri-urban and urban areas. Semi-commercial dairy and poultry production is a good example of this diversification (GIRoA and MAIL 2012). Settled farmers are seldom involved in livestock trade, and usually keep livestock for regular sources of staple food and income including animal product processing and trade. The livestock of settled farmers comprises dairy cattle, sheep, goats, and poultry.

The pastoral nomadism of the Kuchi tribe is a dominant feature of the agrarian-based economy of Afghanistan and is largely based on sheep, goats, and camels with limited or small numbers of cattle. Extensive transhumant livestock production is still the preferred means of gaining an economic return from the country's large rainfed areas. This system is considered both as a form of economic sustenance and a way of life. It relies on seasonal variations to determine migratory routes of people (Sombroek and Sene 1993). The traditional pastoral systems have been reorganized to sustain people during the political turmoil and remained dynamic without any external assistance (Thieme 2006). In east Afghanistan, two distinct seasonal migrations take place and are well defined: utilizing lowlands in winter and highlands in summer. In Afghanistan, more than 70% of livestock is owned by around 1.5 million Kuchis or nomadic pastoralists who are the poorest ethnic group (Aziz and Yi 2013) and entirely dependent on livestock (Jacobs and Schloeder 2012). They are the most important livestock traders in the country, depending solely on a nomadic livestock raising system. With the changing times, Kuchis are facing several challenges in continuing their traditional pastoral/nomadic way of life such as limited access to veterinary and other extension services, markets, and credit facilities.

Numbers of livestock have changed considerably over the last 25 years (Table 4). While the sheep population remained relatively constant, there were significant

Table 4. Changes in livestock population (million) between 1990 and 2013 in Afghanistan.

Years	Cattle and buffaloes	Sheep	Goats	Horses	Donkeys	Camels	Mules	Poultry
1990	1.600	14.170	3.350	0.362	0.600	0.215	0.026	6.600
2000	2.900	15.000	7.300	0.104	0.920	0.260	0.030	6.856
2013	5.235	13.141	7.037	0.171	1.451	0.170	0.021	12.053

Source: FAOSTAT (2014)

increases in numbers of cattle and buffalo (291%), donkeys (290%), and goats (160%). However, there was a decline in the number of horses by 14.5%, mules by 9%, and camels by 15%. Poultry increased by about 190% (FAOSTAT 2014).

Dairy products like curd, buttermilk, ghee, qorut (dried milk), and cheese are important both for home consumption and marketing. Although sale of milk and milk products is quite common in the Kabul region and in northern Afghanistan, milk production is mainly for home consumption in eastern and southern Afghanistan. Afghanistan exported 1139 tonnes of fine hair and 266 tonnes of greasy wool in 2010 (FAOSTAT 2014). Afghanistan always dominated the trade of skins in the well-known Astrakhan skin market. It is estimated that 450,000 of these skins were produced from Karakul sheep in Afghanistan's northern provinces and marketed (Thieme 2006). In addition to sheep wool, cashmere wool fiber of medium fineness is also produced from goats in Afghanistan and marketed to the world through some dealers in Afghanistan. Wool strings for carpet production are imported from Pakistan and Iran. Animal manure is used as fuel and preparation of organic manure.

4.1 Cattle production

Cattle are important for cultivation, meat, and milk production in all regions of Afghanistan. Every farmer irrespective of social and economic status keeps at least one cow to meet their requirements for dairy products. In summer, dry cows, young stock, and male cattle are often taken to the hilly pastures for grazing, and are managed on a community basis. However, many milking cows are stall-fed throughout the year and never taken out for grazing. The cattle management is somewhat different in the northern provinces and the Herat area, where it is common to graze cattle on a community basis. In Nuristan and the Hazarajat in central Afghanistan, cattle are taken to hill pastures for the production of cheese and butter during summer months.

Generally, cows and bulls are kept together in community village herds for natural mating on the pastures. Artificial insemination is mainly confined to government farms but is now being introduced on a limited scale for farmers in Kabul, Kandahar, and Nangarhar Provinces. Cattle are usually kept inside the house during extremely cold winters and the hottest period of the day in summer. Unhygienic conditions of cattle houses in the eastern regions of Afghanistan are an animal health concern.

4.2 Small ruminant production

Larger flocks are more common in northern Afghanistan, particularly Faryab and Jowzjan Provinces. Like cattle production, the management of small ruminants also differs among regions. In village-based small ruminant production, sheep and goats of the villagers are usually grazed together for most of the year. Most flocks reach the highland pastures at the start of summer and come back to lowlands at the beginning of autumn. Small ruminants in Badakhshan and Nuristan usually remain out of villages until harvest of the crops (Bouy and Dasniere 1994). Studies at Herat revealed that flocks not migrating to highland pastures are usually in poor health with respect to weight gain during the year (McArthur 1980). The main summer grazing areas are in the Ghor and Ghazni Provinces, and the Dasht-i-Ish and Dasht-i-Shewa pastures in Badakhshan Province.

In winter, small ruminants are kept inside houses during the night and in bad weather. Concentrates and roughages such as hay, straw, and leaves are provided as supplementary feed during this period (Fitzherbert 2006). The most important roughage for goats in Nuristan is evergreen oak leaves. However, amount of feed and length of feeding period largely depend on factors such as region and prevailing climatic conditions. It is common to provide concentrates including maize or barley grain at 200–450 g/day as a supplement during two months of winter (Thieme 2006). Adult animals and young stock are kept in different flocks during spring and summer, and rams and ewes are also kept separate until the mating season, which is usually October–November.

The small ruminant production system practiced by the nomadic Kuchi includes the traditional migratory system of management, which takes into account efficient use of upland pastures and semi-intensive systems of animal management during winter. Income from the sale of animals and animal products is the main or only source of livelihood for the Kuchi (Jacobs and Schloeder 2012). There is a seasonal rotation of large flocks of sheep and goats between summer and winter pastures. To earn higher profits, Kuchis are turning to seasonal fattening of sheep and goats whenever meat prices in the market are attractive and feed prices are favorable. There are a number of factors forcing the Kuchis' gradual shift from pastoralism to agro-pastoralism and mixed farming. These factors include changing migration patterns owing to weakening of tribal authority, increasing population pressure and the conversion of rangelands into croplands, and shrinking grazing land and associated grazing rights (Azimi and McCauley 2002; ADB 2012).

In general, the annual greasy wool productivity of small ruminants is low, ranging within 0.5–2.0 kg per ewe. However, in north-east Afghanistan, Turki sheep have a relatively higher growth rate (McArthur 1980). Farmers owning small flocks usually slaughter lambs in autumn for dried mutton. The animals are usually not sold unless there is an urgent need for cash. Astrakhan pelt production from Karakul sheep, a highly specialized form of sheep production mainly confined to northern Afghanistan, became popular more than eight decades ago when Turkmen refugees from the then Soviet Union entered Afghanistan with their Karakul flocks (Grotzbach 1990). Afghanistan had major stakes in astrakhan markets until the 1950s, but subsequently lagged behind due to lack of proper marketing and management and breeding of Karakul flocks. There were about five million Karakul sheep in the northern provinces in 1996, of which one-third was owned by villagers. Karakul sheep produce meat and wool under very extreme agro-climatic and agro-ecological situations, and this characteristic helped them survive even in the worst period of war when pelt production did not remain important in international markets. Although no current reliable population data are available, the number of Karakul sheep may have reduced due to problems related to security and marketing of pelts.

5. Forage resources

Crop residues and rangeland grazing are the main source of feed, with fodder grown to supplement them. Coarse grains and some concentrates are also fed, especially during winter. In Afghanistan, grazing lands or pastures are located in a zone between the arable lands and barren plains or mountainsides. Arable land is generally land with some kind of irrigation for crop production, with there being dryland farming (*Lalmi*) of wheat in rainfed areas. This distinguishes between crop production and pastoralism.

5.1 Rangelands

Rangelands, the uncultivated fallow lands that provide grazing or browsing resources to livestock, occupy about 45% of the country's area (AIMS and FAO 2003; Thomson et al. 2003). Afghanistan's rangelands are quite diverse in nature, and this diversity is associated with topography of the country that influences rainfall pattern, climate, and natural productivity. Based on seasons, the rangelands of Afghanistan are divided into three categories: winter (16,210,000 ha), spring and autumn (16,030,000 ha), and summer (22,460,000 ha) pastures.

Rangelands have an essential role for agro-pastoralists and for large parts of the settled population whose livelihood entirely depends on animal rearing and employment in the livestock sector (Bedunah 2006). They provide about 70–80% of the total animal feed available for most sheep, goats, and camels and a large proportion for cattle and donkeys. The short growing-season perennial grasses provide reasonable amounts of good quality feed for a limited period during spring and early summer. Biomass production depends on a number of biophysical factors such as climate, rainfall, altitude, soil type, and erosion, and social factors such as the degradation caused by overgrazing and fuel harvesting. Average annual biomass production of the rangelands is approximately 750 kg of dry matter/ha (World Bank 1979). The yearly variable rainfall pattern significantly affects pasture production. This is clearly reflected in livestock population with rapid increases in the sheep and goat population in years of favorable rainfall due to higher reproductive rates, reduced mortality, and a fall in animal sales due to adequate feed supply (World Bank 1979).

5.1.1 Status and vegetation cover of rangelands

The vegetation types of rangelands vary from desert to sub-alpine and alpine types, from *Pistacia* and *Juniperus* woodlands to deciduous forest to temperate coniferous forest to riverine forests, and steppe to shrub lands (Flora Iranica 2009; Schloeder and Jacobs 2010). Sayer and van der Zon (1981) described vegetation types of Afghanistan as desert vegetation, steppe vegetation, riverbed and lakes, *Amygdalis* scrublands, *Pistacia* and *Juniperus* woodland, arid sub-tropical woodland, Himalayan deciduous forest, temperate coniferous forests of east Afghanistan, sub-alpine vegetation, and alpine and nivale vegetation. There is high-quality pasture in the upper alpine zones although for a short season only.

The variations in plant species toward Pakistan can be attributed to monsoon effects. Similarly, the vegetation cover of the great deserts of the west and south west comprise more or less similar flora to Iran and Balochistan. The main plant species of this vast grazing land is *Artemisia maritima*, which is associated with the viviparous grass *Poa bulbosa* and *Stipa* spp. throughout most of its range. There is also a short flush of annuals in spring, which does not last long and dries off quickly. Other sub-shrubs associated with *Artemisia* are *Astragalus* spp. (Leguminoseae), *Cousinia* (Compositeae), *Acantholimon* (Plumbaginaceae), *Acanthophyllum* (Caryophyllaceae), and *Ephedra* spp. (Ephedarceae). Grasses like *Chrysopogon*, *Heteropogon*, *Cymbopogon*, and *Aristida* are often associated with *Acacia modesta* Wall., and *Olea europaea* subsp. *cuspidata* (Wall. Ex G. Don) Cif is usually found in the eastern zone comprising Laghman, Kunar, Nangarhar, and Paktia, where rainfall is adequate (Thieme 2006).

Rangeland degradation is quite severe and a widespread problem in Afghanistan (ESCAP 1983). Overgrazing is a major cause of rangeland degradation in dry areas, leading to desertification (Sombroek and Sene 1993). The reduced plant cover due to overgrazing accelerates soil erosion and results in loss of fertile topsoil. This adversely affects the productivity as well as biodiversity of the land, and causes the spread of invasive species of non-native weeds. The destruction of rangeland vegetation of Afghanistan is not recent, and dates back hundreds of years (Pittroff 2011). In north-west Afghanistan, sand dunes are moving onto agricultural land in the upper reaches of the Amu Darya Basin because their path is cleared by the loss of vegetation cover due to overgrazing (Brown 2006). Heavy grazing and firewood collection together have reduced the vegetation cover, affecting the natural grazing with a loss of productivity and desertification, and further led to wind erosion due to destruction of forests and shrubs (Suttie et al. 2005).

There are cases where pastures were converted into cropland in rainfed areas. The shifting of large parts of northern and western rangelands and hill pastures to cropland led to environmental degradation as well as a reduction in grazing area (ADB 2012). Large populations of small ruminants have also put great pressure on rangelands. Because the concept or system of community grazing is being phased out slowly this is making protection of rangelands a difficult task. Furthermore, wars, political turmoil, and other human-induced activities have contributed significantly to land degradation.

Land tenure: Almost all the rangelands are owned by the Afghan Government, and pasture land rights are still being reviewed (Alden Wily 2009). The pastures are used by all communities who keep their herds throughout semi-arid lands. Grazing is usually free, but sometimes pastoralists pay some fees for grazing to those who claim ownership through traditional use rights. Such informal arrangements have long existed and often lead to disputes. Because the tenure of such land is not assured, farmers lose interest or motivation to invest in developing it.

Although an official mechanism has been developed to manage land affairs in Afghanistan, many issues pertaining to land transactions and tenure security are still mainly governed by *Jirga* and *Shura* (*Jirga* is traditionally an assembly of Pashtun leaders that makes decisions by consensus and as per teachings of Islam; *Shura* is a method of decision making in Islamic societies). The ownership and use of pastures in the Central Highlands of Afghanistan is commonly divided along the watershed boundaries (Ashley 2011). In most provinces, local ownership roles are maintained by village leaders. This helps every family of the village about their claims. Rangelands as common pastures are usually assigned to the nearest village. However, there are quite often disagreements on this issue. The livestock using the pastures are owned by both nomads and sedentary farmers (Suttie and Reynolds 2003). Conflicts between local communities and the Kuchi clans are also common regarding grazing rights claims to these pastures (Jacobs and Schloeder 2012). The land disputes in most provincial capitals are settled by *huquqs* (land judges).

However, most of such disputes in rural areas are still settled at the village level.

5.1.2. Rangelands management and improvement

Overgrazing and overexploitation of rangeland resources, rights to rangelands or land tenure issues, conversion of rangelands into rainfed cropping systems, and climate change including drought are the factors largely responsible for rangeland degradation. The rangelands can only be improved by adequately addressing these issues. The increasing demands for fodder and fuel wood from the rangelands due to increases in animal and human populations have exceeded the rangelands' productive capacity. This has further degraded the already overexploited natural pastures in the country. Afghanistan is highly susceptible to desertification, and the widespread overgrazing accelerates this process by exposing the soil surface due to loss of vegetation cover, consequently leading to reduced livestock populations, especially of small ruminants (MAAHF 2005). The cattle population declined after the drought of 1998–1999 but recovered after a few years. However, even in 2013, the population of sheep and goats had not recovered to the level of 1999. The recent phenomenon of highland pastures being used for 10–20 days more than in the past, due to rising temperatures, has put more pressure on the fragile ecosystem (Yi et al. 2012).

Restoration of vegetative cover is the most important task to check soil erosion, desertification, and flooding. There are no current policies for sustainable rangeland use in Afghanistan because the traditional systems have disintegrated due to the long wars. There is a need to develop national rangeland policy, which should focus on conserving rangelands for future generations, and also meet community needs. To make rangeland use sustainable, rights and land tenure policies need to be redefined, and local communities may be given the right to own and manage this natural resource. This would also help in halting overexploitation of rangelands.

Bedunah (2006) suggested strategies such as rangeland inventory and classification, drought preparedness, integrated natural resource management planning, rangeland monitoring, and capacity development (education and training) to develop a comprehensive policy for sustainable rangeland management. All these strategies are interlinked and should be taken up by the Department of Natural Resources at national, provincial, district, and village levels. Sayer and van der Zon (1981) also suggested several rangeland management programs based on precipitation zones, natural vegetation, forest cover, rivers and wetlands, soils, mammal distribution, and priority conservation areas to provide for better natural resource management.

Conversion of rangelands into rainfed cropping systems is unsustainable as it poses the risk of crop failures due to drought and cold, and will also substantially affect biodiversity and water resources. Undulating or sloping crop land is more prone to soil erosion; hence, it is essential to develop a land use classification for documentation of suitability of land resources for various uses. The frequency and severity of drought also calls for development of suitable strategies such as early drought warning, risk reduction, and drought intervention activities to mitigate the impact of climate.

Rangelands in the Himalayan region are fragile and very sensitive to climate change and inappropriate management. Sustainable management is important to sustain local populations and effectively maintain various services of rangelands. The primary use of the rangelands in the Hindu Kush–Himalayan region is grazing livestock. Competition among farmers for use of scarce productive rangelands is also increasing with time. There are meager data on the status of these rangelands and so strategies cannot be developed for their sustainable management. The International Centre for Integrated Mountain Development recently completed a country-wide rangeland area assessment in Afghanistan and other neighboring countries with the help of satellite images. There is now a need to monitor the changes in rangeland conditions with increasing climatic and anthropogenic pressure (Ismail 2012).

5.2 Cultivated forage production

Although no data are available on area and production of fodder crops in Afghanistan, some estimates suggested that forages occupied about 10% of the cultivated area in some parts of the country before the war period (Grotzbach 1990). The proportion of fodder in the rotation may range within 5–10% according to local conditions and farmers' needs (Suttie 2000). Most fodder production is used on-farm, and commercial fodder production is practiced only around cities such as Kandahar and Jalalabad for both on-farm use and marketing to urban dairies and horses (Thieme 2006).

Forage legumes are considered the traditional crops of Afghanistan, and are usually grown near settlements or residential areas. The role of legumes in cropping systems has been documented by several workers (Wilson 1978; Mannetje et al. 1980; Crowder and Chheda 1982; Norman 1982; Haque and Jutzi 1984; Agishi 1985). Legumes are included in cropping systems for soil fertility improvement and also economic gain. Forage legumes are used both fresh and as hay to supplement straw or other crop residues during fodder scarcity in winter. Where irrigation is available, lucerne is the most popular and widely cultivated fodder legume in Afghanistan (Jacobs and Schloeder 2012). Persian clover or shaftal (*Trifolium resupinatum* L.) is another important and popular fodder legume grown as a winter annual and gives two hay cuts in the spring. Berseem is grown in some relatively frost-free areas adjoining Khost and Jalalabad. In recent years it has become more popular due to its higher production potential (Bashir 2014; Oushy 2014). The cultivation of these forage legumes is largely confined to areas with adequate irrigation facilities throughout the year.

During summer, fodder availability is limited, and maize thinning is the only fodder widely used – maize crops are generally sown at higher seed rates and later thinned for stock feed. This practice is very common and widespread in the Himalaya–Hindu Kush region including Pakistan and India to Nepal. Multi-cut sorghum hybrids, multi-cut fodder sorghum (*Sorghum bicolor* [L.] Moench), multi-cut fodder millets (*Pennisetum americanum* [L.] Leeke), and a relatively cold tolerant elephant grass or Napier grass (*Pennisetum purpureum* Schumach.) can be successfully grown in Nangarhar, Kandahar, and Farah Provinces (Thieme 2006).

Fresh lucerne and/or clover (shaftal or berseem) is fed to stall-fed cows and also to cows going out for grazing in the evening around settlements during summer and spring. Feeds such as cereal straws particularly wheat straw, hay from grasses or legumes, and maize stalks are the main sources for winter feed of cattle throughout Afghanistan. Some other sources of winter feed are leaves in Badakhshan and camelthorn (*Alhagi canescens* [Regel] B. Keller & Shap.) in the northern Turkestan plains, but these are of regional importance only. Farmers make every effort to collect sufficient fodder particularly in areas with long winters such as in Badakhshan or the Hazarajat. They usually store large amounts of hay on top of the cattle houses. Wheat straw and to a very limited extent barley straw and legume hay is often mixed in areas characterized by long winters. Bouy and Dasniere (1994) calculated that an average per day availability of 9 kg of straw and 1.8 kg of legume hay per animal unit (300 kg) is adequate for stall feeding for three and a half months in Badakhshan. Milking cows and working oxen usually also receive supplementation with concentrates like cotton seed cake or maize or barley grain during winter.

The northern plains are sufficiently warm in winter to grow clovers and non-dormant lucerne cultivars. In this region, the dairy industry is well developed, and hay is also required for winter feeding of sheep. This is traditionally a fodder production area and availability of water for irrigation and economics of fodder production are major considerations. The most preferred fodder is lucerne, which has long been cultivated in this region. Lucerne cultivars grown here are strongly perennial and winter dormant, and can withstand intensive grazing. Shaftal is commonly raised as a winter annual near Mazar-i-sharif, whereas it is grown as a summer fodder crop after wheat in Badakhshan. Being a legume it is considered a soil-fertility restorer. Although the plains around Mazar-i-sharif and on sides of the road leading to Sheberghan have extensive irrigation systems, the area is only cropped in alternate years due to limited water resources. The fallow is used to raise a pure crop of a leguminous sub-shrub camelthorn, which is cut at the knee-high stage in late spring, dried, and stored as winter feed for small stock and camels.

In the eastern lowlands, where winters are relatively mild, non-dormant lucerne and berseem are grown successfully. Lucerne is, however, not grown in Khost, but shaftal is widely cultivated. Lucerne is grown on a commercial scale as fodder around Jalalabad. The climatic conditions in Khost and Nangarhar for fodder production are generally similar and these lowlands are warm enough in winter to grow berseem. Although well adapted to the area, shaftal and berseem do not fit into the double-crop system (Thieme 2006).

Western and south-western lowlands are arid and entirely dependent on irrigation. This zone is climatically favorable for winter clover and non-dormant lucerne varieties. In Kandahar, lucerne is used as a cover crop in orchards or vineyards. American lucerne varieties and a few varieties from Iran were also introduced in this region (Thieme 2006). Lucerne is used fresh and also as hay to supplement crop residues in winter. Lucerne is commercially cultivated as a cash crop for seed production in Herat. Legume fodders are preferred because they grow well under harsh conditions without fertilizer, particularly N application, and supplement the roughages. Being a perennial, lucerne continues growing for up to 7–8 years from one seeding. Shaftal is an annual and is planted as a second crop and harvested in spring. An average crop of lucerne yields about 7–9 t/ha from four cuttings per year, whereas shaftal yields around 2.5–3.5 t/ha (ASA 1993).

The Central Highlands region is characterized by severe winters. The important fodder crops of the region are lucerne and shaftal, depending upon water availability for irrigation during summer. Lucerne is under-sown in wheat crops and the stand is maintained for up to 10 years. There are high-yielding varieties of lucerne producing four cuts annually, and much of the harvested produce is converted into hay for winter use (Rao 2014). However, more information is required to determine the best variety of lucerne (Bonnier 2007). Shaftal is sown in autumn and overwinters (under snow) for use in spring and early summer. A second crop is sown in autumn as a catch crop in wheat fields at the last irrigation before harvest. Clover is mainly used green, but sometimes as hay.

Vetch (*Vicia sativa*) and grass pea (*Lathyrus sativus*) are seldom grown in rainfed farming systems. In the higher altitudes of central Afghanistan and in the Kabul area, common vetch and fodder beet (*Beta vulgaris* L.) are cultivated on a smaller scale. Some field demonstrations were conducted on farmers' fields to explore the potential of new varieties of fodder beet and autumn-sown Hungarian vetch (*Vicia pannonica* Crantz) for fodder production in this area (Thieme 2006). New grass pea lines such as *Lathyrus sativus* 445 and 476 were introduced by ICARDA, Syria, and evaluated at Baghlan in northern Afghanistan. Both lines give much higher grain and straw yields than local cultivars. Similarly, common vetch cultivars *Vicia sativa* 2064 and 2556 showed better performance than local varieties (Larbi et al. 2008).

Forage cereals such as wheat, barley, and oat are also grown in both rainfed and irrigated areas. Wheat and barley are often cut as green fodder during feed scarcity periods in spring. Oat, however, is much superior to wheat and barley in terms of fodder production (FAO 2004). Two multi-cut oat varieties showing good performance in Pakistan were successfully introduced in Kandahar, Farah, Nangarhar, and Kabul Provinces (Thieme 2006). The Food and Agriculture Organization of the UN (FAO) introduced new varieties of berseem, oats, lucerne, and hybrid sorghum, and also conducted many demonstrations and a few trials of millets, fodder beets, elephant grass, sainfoin (*Onobrychis vicifolia*), red clover, and sorghum. New multi-cut cultivars of fodder oats showed great promise and became popular as an alternative to wheat and barley. Berseem and lucerne yields were greatly affected by growing season and number of cuts (Bonnier 2007).

5.3 Fodder shrubs and trees

Fodder trees and shrubs are valuable supplemental fodder resources for livestock especially during the dry seasons and fodder shortages (Le Houérou 1980; Otsyina and McKell 1984; Dicko and Sikena 1992; Lefroy et al. 1992; Atta-Krah 1993). In the early years of establishment of orchards, intercropping of fodder crops is common (APRP 2013) because trees do not have much canopy during their initial 2–3 years. Being a perennial, lucerne is the preferred fodder intercrop, but clovers can also be used. This intercropping has many benefits such as soil protection, weed control in the early life cycle of trees, monetary gain from intercrops, improving soil fertility through biological N fixation, and biological pest control (lucerne is an alternative host to some predators of orchard pests).

On-farm tree planting for fodder purposes is also common in irrigated areas of Afghanistan. There are no specific trees for fodder production and several on-farm trees can be used to provide feed for livestock (Fitzherbert 2007). The choice of tree species for alley cropping is extremely important because this determines success or failure of the system. Dhyani and Tripathi (1999) observed favorable effects of legume intercrops on growth of alder (*Alnus nepalensis* D. Don), albizia (*Paraserianthes falcataria*), and cherry (*Prunus cerasoides* D. Don) in agro-silvicultural systems. Common trees used for fodder purposes are mulberry (*Morus serrata* and *Morus alba*), willow (*Salix* spp.), poplar (*Populus* spp.), and Russian olive (*Elaeagnus latifolia* A. Rich.) (Rao 2014). Oaks (*Quercus* spp.) and olives (*Olea europaea* subsp. *cuspidata*) are cut for fodder and browsed on hillsides. *Leucaena leucocephala* is a promising species in Afghanistan (Kang et al. 1990) and is commonly grown in humid/sub-humid zones on alkaline soils (Kang and Reynolds 1986). *Flemingia macrophylla* (Willd.) Merr. is relatively more successful under humid/sub-humid conditions (Kang et al. 1991), and the tree *Erythrina peoppigiana* (Walp.) O.F. Cook performs well on acidic soils (Kass et al. 1992). There is still a need to identify a wider range of tree species suitable for low activity, acid, and less fertile soils.

Planting of maize, soybean, wheat, fodder, vegetables, and many more field crops between rows of pecan (*Carya illinoensis* [Wangenh.] K. Koch) or black walnut (*Juglans nigra* L.) is a good example of alley cropping. This practice helps in conserving soil and increases farm production (Neely and Fynn 2010). Perennial pigeon pea (*Cajanus cajan* [L.] Millsp.) and *L. leucocephala* are commonly used in alley cropping. Russian olive and black locust (*Robinia pseudoacacia* L.) are promising fodder trees suitable for alley cropping throughout Afghanistan (USDA 2013; UCDavis 2013). Many leguminous crops such as pigeon pea, *Cyamopsis tetragonoloba* (L.) Taub., *Desmodium cinereum* (Kunth) DC, *Flemingia macrophylla* (Willd.) Merr., *Indigofera tinctoria* Linn., and *Tephrosia candida* (Roxb.) DC. are grown as hedges to protect field boundaries and for nutrient recycling. These crops can also serve as good sources of feed for livestock. Rao (2014) suggested the use of leguminous trees in alley cropping for improving soil fertility as well as providing fodder.

5.4 Crop residues and agricultural by-products

Crop residues and agro-industrial by-products are important components of integrated crop–forage production systems, and make a substantial contribution to livestock feeding. Both of these feeds complement each other in ruminant nutrition. Crop residue is one important source of feed in sedentary production systems (Fitzherbert 2007). Haulms of various pulses (except pigeon pea) and groundnut are also used as fodder. Wheat straw and to some extent barley straw is the main roughage for winter feeding of livestock. Wheat straw contributes significantly to the fodder requirement for stall-fed animals especially during winter. Rape straw and groundnut husk are, however, very poor in nutritive value compared to wheat straw. Maize husk is superior to gram husk in nutritive value (Ranjhan 2001). Maize and barley grains are sold to transhumant herders as animal feed for winter use. Cotton stem with leaves may be grazed or used as feed and firewood. Nothing is wasted – crop residue, stubble, weeds, and fallen leaves are all utilized for livestock feeding. Stubble and crop residues are generally open to all in the community for the period between harvest and subsequent tilling of land. Production of crop residues and agricultural by-products are not usually reported in national or international statistics but quantitative estimates are possible with some approximation by using relevant crop data and a factor (grain straw ratio, ratio of raw and finished product) specific to each crop.

The waste from processing pulses, cereals, oil seeds, cotton seeds, fruit, and vegetable products are categorized as agro-industrial by-products – and these are rich in digestible nutrients and are good animal feeds. Cotton seed cake is the best example of a nutritious agro-industrial by-product. These by-products are usually less fibrous, more concentrated, highly nutritious, and less costly compared with crop residues (Aguilera 1989). By-products from the sugar industry and from forests are also used for some livestock feed; however, their availability is quite limited in Afghanistan. Nevertheless, their use can reduce the feeding cost to some extent, especially for small farmers.

6. Constraints of forage production

The major constraints and limiting factors responsible for low productivity and production of fodder in Afghanistan are discussed in this section.

Limited area under fodder crops: Afghanistan has a comparatively small arable area of 7.8 million ha, out of which about 50% is cultivated. The area under fodder crops is less than 10% of the cultivated area (USAID 2012). The increasing human population requires more food to ensure food security of the country. Under such a situation, there is practically no scope for horizontal expansion of fodder crops.

Cultivation of low-yielding fodder varieties: Most of the seed and planting materials were lost during the long period of conflict. Development agencies are now making efforts to develop and/or introduce fodder varieties suited to Afghanistan conditions from neighboring and other countries, and demonstrating them in farmers' fields.

Low adoption of improved technologies for fodder production: Farmers are still following their traditional practices for cultivation of various crops, and fodder crops are no exception. During the period of crisis, the agriculture sector remained neglected, and therefore development of improved technologies and their dissemination by extension agencies was not pursued vigorously.

Lack of research-based knowledge on fodder production and management: Even before the conflict there was never a strong research network on fodder production in Afghanistan (Bashir et al. 2007). The entire infrastructure related to research and extension ceased functioning during the conflict, and is now resuming slowly with the help of partner countries. It will take some time to develop suitable high-yielding fodder varieties in the country.

Poor soil fertility and inadequate irrigation practices: Soil fertility is generally poor in Afghanistan. Dung of livestock and crop stubbles are mainly used as fuel. Crops are usually grown under low input conditions, resulting in poor yields. Irrigated land is mainly allocated to crops such as wheat, maize, sugarcane, and horticultural crops (USAID 2012).

Low rainfall and frequent drought conditions: Agriculture in Afghanistan is largely rainfed and frequent droughts are common (ICON Institute 2009). The fodder crops are usually grown at high plant densities and therefore require relatively more water for proper growth and development.

Poor control measures of insect pests, diseases, and weeds: Most of the fodder crops suffer from numbers of diseases and insect pests, but farmers usually do not use plant protection measures. Undesirable weeds infest fodder crops and adversely affect fodder growth and yield. Integrated plant protection measures to control diseases, insect pests, and weed flora are little known and rarely practiced in Afghanistan.

Limited use of chemical fertilizers: Fertilizer use in fodder crops in Afghanistan is quite low compared with neighboring and other countries. Cereal-based fodders are very responsive to high rates of fertilizers, especially N. Some of the soils are also deficient in secondary nutrients and micro-nutrients. The fertilizer consumption irrespective of crop type is very low (5 kg/ha) compared with neighboring countries India, Pakistan, Bangladesh, and Sri Lanka which use 100–200 kg/ha. Even smaller countries like Bhutan and Nepal use 3–5 times more fertilizer in crop production (World Bank 2015).

Lack of quality fodder seeds: Most of the fodder seed in Afghanistan comes either from on-farm production or bartering among farmers. The seed of lucerne and berseem available in the local market is generally not of good quality, and is also usually contaminated with weeds and other seeds. Although some crop seed-related projects are operating, a forage seed sector is absent from the country (Oushy 2011).

Poor adoption of proper and efficient cropping systems: Farmers usually adopt cropping systems based on their requirements and economics, without any consideration for maintaining soil health and sustaining crop productivity. Therefore, productivity of crops in general, and fodder crops in particular, is low. Most of the agricultural products produced by farmers are consumed by their families or other villagers (Groninger et al. 2013).

Poor management of pastures: The pastures are owned by the state, but used by the communities for grazing, and are quite often overgrazed without proper intervals between grazing events. There is also no security of tenancy and the users are not interested and motivated to invest in improving these lands (USAID 2012). There is a need to prepare the policy and regulatory framework to introduce and adopt a community-based approach in forestry, rangeland, and wildlife management as well as to develop the capacity of communities to organize, operate, and sustain the improved measures with a minimum of outside support (USAID-Afghanistan 2006). No improvement in rangeland production can be realized unless effective measures of control of both livestock and the users are developed (World Bank 1979). The pasture and fodder related institutions of Afghanistan became almost non-functional during the troubles and even now no national infrastructure or facility for research and development is fully operational. However, ICARDA has developed and promoted drought tolerant cultivars and matching agronomic practices for forage crops that have shown promise in terms of productivity and economic returns to farmers (ADB 2002).

No access to rural finance: There are no institutions providing rural finance to farmers to purchase inputs for crop production, and so fodder crops are only grown under low input conditions.

Limited options for fodder production: In Afghanistan, about 80% of the population is concentrated in rural areas and most are subsistence farmers. Agricultural production is quite often insufficient to meet family requirements (Groninger et al. 2013). Therefore, the priority crops for meeting day-to-day needs and farm income are wheat, vegetables, and fruit (Walters et al. 2012). In rainfed areas, farmers depend mainly on common land resources to support fodder needs.

7. Conservation and utilization of forages

The availability of feed for livestock production in Afghanistan is particularly low during winter. In higher altitudes, characterized by low temperatures and snow cover, stall feeding is common practice for all kinds of livestock. However, in south and east Afghanistan, all livestock remain outside throughout the year and depend on grazing, except during periods of scarcity, when they are provided with fresh fodder or hay. The forages are commonly conserved as hay, straw, and silage to provide livestock feed when fresh fodder is not available.

Fodder is generally conserved as hay in areas experiencing cold winters. Berseem, shaftal, and lucerne are the major fodder crops mainly fed to large ruminants. Berseem is invariably fed fresh, and shaftal and lucerne both fresh and as hay (ASA 1992). In some regions, particularly the northern plains, camelthorn is also converted into hay for camels and small ruminants (Suttie 2000). The green tops of groundnut in warmer areas are also used as hay.

Grasses and legumes are traditional hay crops in most areas, but in the sub-tropics hay is usually made from maize and sorghum. However, it is now mostly confined to small-scale farming situations. When making hay from pasture, the fields are still grazed during weather that is not ideal for making the hay. Thereafter, the forage is left to reach the right stage for haymaking. Long hay is an age old, common, popular, and traditional form. The stage of crop maturity and expected weather conditions mainly determine the time of haymaking, hence crop cultivation is organized to coincide with favorable haymaking weather conditions. The frequency of cuts per year for haymaking depends on many factors. For example, it is only possible to have one cut on natural pastures either from the spring or summer growth, whereas sown pastures and fodder crops may provide several cuts (Suttie 2000). Irrigated crops in semi-arid areas usually have better haymaking weather conditions.

The quality of hay is mainly affected by maturity of the crop and also other factors. A compromise between yield and quality of crops is often made. In general, crops harvested during early to mid-flowering have acceptable hay quality. Cereals are, however, harvested at a later stage of grain development. The time of haymaking usually depends on availability of suitable herbage and the weather conditions of the location. Farmers are often forced to make hay from a poor quality crop to meet shortages during forage-scarce periods of winter. In tropical and sub-tropical conditions, herbage can be cut-and-carried on the same day, but several days of good weather is required under humid temperate conditions. There are, however, certain problems associated with haymaking, especially the climate and prevailing weather at harvest time. Drying is too slow in humid and sub-humid temperate conditions. In contrast, there can be shattering of finer parts of plants and loss of vitamins at high temperatures.

Forages and roughages include grasses or legumes that are grazed or harvested and preserved as low-moisture hay or high-moisture silage. Silage is one of the best options to conserve forage crops, especially if it is not possible to dry the forage quickly to convert into hay. High-moisture silages comprising whole-crop maize or cereals are used extensively as feeds for ruminants in many regions. Silage is preferred for feeding animals during periods of fodder scarcity. It is not easy to make hay under dry conditions due to the curing time needed, hence ensiling is the best option in such situations.

Another advantage of silage or ensiled forage is that it can be kept for a very long time without deterioration in quality. Silage usually has 2–4% more digestible nutrients than hay, making it a better option. Feed value of barley and maize silage is very similar, but greater than of wheat, oats, triticale, and rye. The small-grain crops are generally harvested for silage from the booting to early dough stages. The inter-seeding of field pea or other similar legumes with small-grain crops for silage is desirable to improve the relative feed value of silage.

An initiative was taken by the MAIL (Ministry of Agriculture, Irrigation and Livestock) under the Rural Microfinance and Livestock Support Programme and support from IFAD to establish cooperative fodder banks to provide quality feed and fodder to its members during fodder scarcity in winter and autumn. At present, there are 10 fodder banks located in five provinces: Badakhshan, Takhar, Kunduz, Baghlan, and Bamyan. An assessment of the program revealed that many issues such as guidelines and criteria of establishment, need-based training, cooperation, and coordination among various stakeholders need further examination and fine-tuning. There is still a need to identify the gaps and problems in establishment and operational aspects of the fodder banks (Anwary 2014).

8. Forage seed production and marketing

The development of the Afghanistan seed sector can be divided into three contrasting phases: establishment of the formal seed sector (1978–1992); conflict period (1993–2002); and post-war reconstruction and rebuilding phase (after 2002). There was practically no organized seed sector for supply of improved seeds in Afghanistan until the late 1970s. The first government-owned seed company known as the Afghan Seed Company was established in 1978 to take up the functions of seed production, processing, distribution, and marketing. It was later renamed the Improved Seed Enterprise (ISE), with centers located in various provinces of Afghanistan. The Ministry of Agriculture Irrigation and Livestock, FAO, UNDP, and ISE operated several joint seed projects during 1982–1992.

During the conflict, all existing facilities pertaining to seed production, processing, training, and seed testing laboratories ceased functioning. After 1992, FAO moved its base to Pakistan and operated two seed projects with the help of NGOs and local communities. Efforts were made to rebuild the Afghanistan seed industry during 1997–2002 through the support of UNDP Poverty Eradication and Community Empowerment (PEACE) by FAO.

After 2002, many international organizations such as ICARDA, USAID, the Future Harvest Consortium, national and international NGOs, and French cooperation jointly made efforts to rebuild agriculture in Afghanistan through establishing agricultural research stations and seed testing laboratories. In 2002, the Future Harvest Consortium to Rebuild Agriculture in Afghanistan led by ICARDA and supported by USAID, intergovernmental organizations such as FAO, and national and/or international NGOs played a significant role in rebuilding the agricultural and seed sector. ICARDA assisted in the rehabilitation of the agricultural research centers and seed testing laboratories across Afghanistan. ICARDA also, through successive projects, supported an integrated adapted research, participatory technology demonstration and seed production and marketing of wheat, rice, mung bean, and potato technologies. These activities led to the release of several cereal (wheat and barley) and legume (chickpea and mung bean) varieties and associated agronomic practices as well as their seed production and marketing by village-based seed enterprises (VBSEs). Some of these VBSEs developed into full-fledged medium-scale seed enterprises and continue to provide seed, contributing to increase in agricultural production and productivity, and thus improving national food and nutritional security. The FAO again moved its base to Kabul in 2002. Moreover, FAO implemented the EU supported projects ‘Strengthening National Seed Production Capacity’ (2003–2006) and ‘Variety Development and Seed Industry Regulation’ (2007–2011) which have played a key role in re-establishing and laying the foundation of the seed sector in Afghanistan.

The MAIL adopted a National Seed Policy in September 2005 (revised in 2012), which is now in effect and implemented under guidance of the National Seed Board. This policy is intended to provide an enabling environment for sustaining and enhancing the growth of the Afghanistan seed industry by defining appropriate strategies for seed legislation, agricultural research, and seed sector development. The Government of Afghanistan enacted the Seed Law in 2009 which covers certified seeds and vegetatively propagated planting materials and regulates all seed-related activities in the country. At present, there is a National Seed Board with its affiliated bodies such as the Seed Certification Agency and the Variety Release Committee.

The FAO and ICARDA promoted the private sector seed industry. The FAO/EU extended support to a number of pilot seed projects and ICARDA/USAID established a good number of VBSEs. The MAIL has the leading role in coordinating the seed distribution and promoting the use of certified seed among farmers. Despite such efforts in the seed sector, there are still numerous constraints such as availability of high-yielding new varieties, effective enforcement of seed laws, promoting a competitive commercial seed market, and promoting diversification of seed crops.

In the pre-war era, Afghanistan produced large amounts of lucerne seed for export because of suitable climatic conditions. Currently fodder seed comes mostly from on-farm production or farmer-to-farmer exchange. Seeds of lucerne and berseem are available in the local market but are generally not genetically pure and are also contaminated with weeds and other seeds. Berseem seed is now imported from Pakistan, Iran, and Turkmenistan by Afghan traders.

All formal sector efforts are geared toward wheat with little attention on crops such as food legumes and forage crops. Introduction and development of improved forage crops and establishment of forage seed production programs in Afghanistan may offer many opportunities for small farmers to improve their livelihoods. Achieving self-sufficiency in forage seed production and producing seeds for future use is the key for sustainability and growth of the agricultural sector. At present only lucerne seed is produced in excess of the domestic requirement. In 2010 and 2011, Afghanistan exported about 167–177 tonnes of lucerne seed valued at about US$0.25–0.27 million (UN Data 2014).

The AWATT program of USAID-Afghanistan is actively involved in promoting forage production through various demonstrations and training programs. This program also includes the foundation seed production of forages (Oushy 2011). Based on the response of this program, it was suggested to develop a new National Afghan Forage Research and Extension program. During 2009–2011, the AWATT Forage Technology Transfer Program initiated and established many activities on capacity building for the quality seed production of improved varieties, and multiplication and certification to meet the emergency seed requirement of the country. Some AWATT activities include 547 forage demonstrations in farmers' fields; 10 forage foundation seed production sites in Balkh, Kabul, and Herat Provinces; general training for 17,560 farmers, extension workers, faculty members, teachers, and students on foundation seed production; specialized training for 329 MAIL extension workers and researchers; production of 2.62 tonnes of forage foundation seed during 2009–2010; recommending forage pearl millet as a new forage crop in the MAIL seed system; production of about 46% of foundation seed in farmers' fields; and greater emphasis on the forage crops pearl millet, Sudan grass, and cowpea.

9. Climate change and its expected impact on fodder production

Afghanistan has no reliable long-term record of meteorological data. However, some trends and projections were derived from data of neighboring countries and revealed that mean annual temperature rose by 0.6°C since 1960 with an average rate of 0.13°C per decade. Further, large variations in rainfall in various regions are also expected owing to complex topography. Precipitation has decreased by about 0.5 mm/month since 1960 (DFID 2009). Some studies indicated that the region including Afghanistan is experiencing faster rises in temperature than the global average (Tami 2013). The upper catchment of the Kunduz River Basin has experienced a long-term average rise in temperature of twice the average increase in global temperature and consistent with temperature rises elsewhere in Central Asia (Mercy Corps 2007).

Afghanistan is particularly vulnerable to climate change owing to glacial melting, floods, droughts, and erratic rainfall patterns. Climate change is expected to adversely affect crop production (ADB 2009). Rising temperatures will reduce snow cover, affecting the water supply downstream for crop production and leading to drought conditions. Semi-arid regions of the country will be worst affected by climate change (UNEP 2010). North and central plains will be relatively warmer than rest of the country (DFID 2009). It appears that drought will be routine after about 2–3 decades. This will severely impact not only crop production but also the growth and harvestable yield of rangelands in Afghanistan (Mercy Corps 2007; UNEP 2008; ADB 2009). Forage traits such as yield, and nutritional quality of cultivated crops, are sensitive to climatic parameters. Any change in these parameters can significantly affect rangeland resources in Afghanistan.

Climate changes leading to drought will have a great impact on productivity of rainfed fodder crops. This trend will affect smallholder livestock more in drought prone areas of Afghanistan. Cropping systems may be modified to increase the resilience of production. Crop varieties that are bred for future climatic conditions, modifying sowing/planting and harvesting periods, cropping systems, and water and nutrient management practices are some of the options for increased resilience.

Several projects are working on climate change adaptation, including the Global Environment Facility project to reduce the risks of climate change and variability (GEF 2012), and a National Adaptation Program of Action for climate change adaptation in the field of agro-forestry and agro-silvi-pastoral systems, rangeland management, and improved livestock production (NEPA 2011).

10. Future thrusts: elements of a strategy for forage production in Afghanistan

Permanent and temporary grasslands are the two major sources of forage for livestock production. In Afghanistan, rangelands are a precious resource for the livestock sector and contribute more than cultivated fodders. Hence, enhancing rangeland productivity through suitable agronomic intervention and effective management will go a long way in securing the feed and nutritional security of livestock. All developments in the agriculture sector will fall short unless appropriate attention is paid to degrading rangelands. Factors such as increasing population, lack of community management systems, and poor government support are mainly responsible for the present state of Afghanistan's rangelands. Effective rangeland management in Afghanistan should have a multi-disciplinary strategy involving clear rangeland rights and responsibilities, promote community participation and adaptive grazing management, enhance productivity, identify and develop alternate energy and livelihood options, and increase education, training, and research on rangeland management (Ismail et al. 2009). Ali and Shaoliang (2013) also stressed the increasing of fodder production, developing alternate sources of energy, strict monitoring of highland ranges, suitable policies for sustainable use, and climate change adaptation for effective range management in Afghanistan. At present, there is a national plan for Sustainable Rangeland Management under the National Agriculture Development Framework whose recommendations will facilitate the MAIL planning and execution of necessary actions and activities in this direction.

Fodder production in Afghanistan was one important component of farming systems in the pre-war era. The production of crops including fodder crops suffered a lot during the war period, but is slowly resuming. There appears to be little scope for horizontal expansion of fodder crops as forages compete with field crops for land and water resources in Afghanistan. Thus, the only option available is vertical expansion through intercropping, alley cropping, and under-seeding in crops such as wheat.

This could be possible with the appropriate forage crop, variety, and agronomic management. In the present situation, legume fodder crops seem to be the best option in view of limited land and water resources. These are traditional crops of Afghanistan and farmers are quite familiar with their production technology. Furthermore, legumes such as lucerne and shaftal could also be used as excellent hay for winter. Thus, a greater focus is needed on the development of cultivated fodder crop varieties possessing characteristics such as drought tolerance or resistance, high water use efficiency, shorter duration, fast and vigorous growth, and high forage yields. There is a need to popularize and disseminate the available technologies for adoption to enhance fodder production and productivity. Some of the important ones are:

1. Production technology of quality seed of fodder crops in general and lucerne in particular is available. Breeders' seed may be produced by international organizations working in the country or supplied from neighboring countries. The government farms may produce the foundation seed. Certified seed may be produced in farmers' fields including through VBSEs. The VBSE approach has been successful in Afghanistan to deal with most seed-related issues such as introduction and multiplication of newly developed fodder varieties. However, there has been more emphasis on seed of wheat, rice, mung bean, and vegetables. Each of the 21 VBSEs produced more than 100 tonnes of seed of various crops. Providing quality certified seed of forage crops is also one priority of the existing National Priority Programs. At present, the seed replacement rate of fodder crops is quite low; however, no reliable data are available.
2. Fodder crops such as multi-cut oats, multi-cut fodder sorghum, hybrid sorghum, fodder millet, fodder beet, and Hungarian vetch have shown promise in field demonstrations under different agro-ecological conditions. These crops along with their cultivars and matching agronomic practices may be popularized among farmers through frontline demonstrations. Field visits by farmers should be arranged at the locations of frontline demonstrations. There appears to be a need for aggressive transfer of available technology.
3. Promoting the use of phosphate application and efficient strains of *Rhizobium* and phosphate-solubilizing cultures in leguminous fodders for enhancing productivity.
4. Promoting practices of mixed cropping, intercropping, under-seeding, alley cropping, and their appropriate agronomic management for additional fodder production.
5. Adoption of agronomic and grazing management for long-term sustainability of rangelands.
6. Enhancing fertilizer and water use efficiency through appropriate technologies such as mode of fertilizer application and irrigation at critical stages under irrigated production systems. Conservation of moisture in rainfed land through mulches and use of organic manures should also receive attention.
7. Training programs may be arranged for farmers by MAIL functionaries to create awareness of new fodder crops, their varieties, and technologies of production.

In addition, the following technologies could be introduced and tested for feasibility under various agro-ecological conditions in Afghanistan:

1. A vast area in the country is either completely rainfed or has limited irrigation facilities. Introduction of micro-irrigation systems like drip and sprinkler irrigation and fertigation will not only increase water productivity and crop yield, but also cropping intensity, with the same water resource.
2. Short-duration and high-yielding varieties with wider adaptability could be introduced from neighboring countries and tested in demonstrations in farmers' fields with their appropriate package of practices. This process may be continued until the country can pursue the breeding program on its own with the cooperation of international organizations working in the country.
3. There should be greater emphasis on integrated nutrient management systems not only in fodder crops and rangelands, but also in crops that contribute substantially in the form of crop residues and by-products for livestock feeding. Fertilizer use in Afghanistan is miserably low, and any increase in this input will positively impact crop production. To make appropriate recommendations of fertilizer (macro- and micro-nutrients) requirements of crops in general, and fodder crops in particular, will require fertility mapping of the entire cropped area of the country.
4. Suitable farm implements for farm operations under various agro-ecosystems of the country need to be designed to reduce costs of production.

5. The testing of shrubs and trees as a long-term measure, although important, has limited scope for on-farm tree planting as it is possible only with assured or regular water supply throughout the year. Most of the adapted and existing fodder trees in Afghanistan are non-leguminous – *Morus*, *Ficus*, *Salix*, and *Populus* spp. Possibilities for planting fodder trees may be explored in those areas only where their adverse effect on field crops can be avoided. Further, most of the farm trees are deciduous and produce leaves during the period when fodder is not a serious problem.

Most of the technologies available for adoption could be transferred and popularized by MAIL through their network. If necessary, further field demonstrations could be arranged with active participation of farmers. The technologies to be introduced and tested would require technical and scientific input and assistance. Therefore, international institutions located in Afghanistan in partnership with MAIL could develop the appropriate technology with its feasibility and impact among Afghan farmers for further large-scale dissemination by the MAIL network.

A good number of projects from FAO, USAID, and partner countries already operate in the country to gather information and suggest strategies to boost forage production. A FAO project 'Livestock Development for Food Security in Afghanistan' is gathering information on the available varieties of fodder crops and their performance and the agronomic practices followed in different areas. Simultaneously, field demonstrations and on-farm trials are conducted with selected crops and their cultivars in neighboring countries. The Afghan Livestock Workshop organized by the Advancing Afghan Agriculture Alliance identified 'Feed, Forage and Nutrition' as the key areas for offering opportunities to Afghan farmers through the livestock sector. The impact of these projects on forage production will, however, be visible only in the future.

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