Deforestation: A Continuous Battle—A Case Study from Central Asia and Other Countries

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Chapter 4
Deforestation: A Continuous Battle—A Case Study from Central Asia and Other Countries

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Abstract Deforestation is a plague that is not new to the earth, but it has certainly accelerated in the past few decades. A reduction in the number of forest canopies has increased at an alarming rate. Forestry is important because of its eminent use as biofuels, as source of food and earnings, and in mitigating climatic changes. This global problem needs to be addressed, controlled, and coordinated in an efficient manner. The chapter focuses on the policies practiced in the Central Asian states and other countries in the world being practiced to eradicate and control deforestation rates. Forest management practices focus on balancing rate of deforestation and growth, increasing product yield, and enhancing services obtained from forests. Measures such as legality of forest lands, establishment of public frontier institutions, forest management certification, and provision of incentives can result in implementation of forest management practices on ground level.

Keywords Deforestation · Climate change · Degradation · Implementation · Conservation

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4.1 Introduction

Ever since the invention of agriculture, forests have been cut down for thousands of years. In many regions over the world, crops cannot be grown, and neither can livestock graze until forests have been cleared away. Not only does agriculture require the removal of shrubs and weeds, but the trees also need to be cleared away. Regardless of various benefits of forests, fundamentally, there has always been a conflict between forests and agriculture (Ozturk et al. 1991, 2010a, b, c, 2017a; Olagunju 2015). In this era, deforestation continues, even though the societies in which it occurs have shown great changes. Satellite imaging has changed our views on deforestation, as they can clearly show the clearing of forests and allow detailed analysis and comparison. When this information is combined with detailed on-the-ground study, a very vivid picture of deforestation is brought forward. This has also led to the coining of a new term "forest degradation."

Deforestation, strictly speaking, is the complete clearance of a piece of land from trees. This is easy to detect via satellite imaging. But there are also some other important changes that are hard to detect through satellite imaging as most of the tress and canopy remain, even though the forest below has been depleted, hence the term forest degradation. Elimination of trees and loss of carbon occur, but the forest canopy isn't removed. Various factors can lead to forest degradation. It can be caused by a fire that sweeps through the understory, livestock grazing, or trampling over saplings and seedlings. Selective logging can also be a reason, where most tree species lack commercial value, so only a few large trees are removed, leaving the forest canopy unharmed (Asner et al. 2005; Olagunju 2015).

Degradation proves to be more challenging to study as compared to deforestation as it is not only hard to keep the track of rate of degradation, but the possible outcomes are also hard to predict. On one hand, if the forests are left undisturbed, the trees that were cut can be replaced hence neutralizing the loss of carbon and canopy depletion over time (Rice et al. 1997). On the other hand, forest degradation can continue, eventually widening the canopy and gradually turning degradation into eventual deforestation. Moreover, degraded forests have been shown to have a higher likelihood of being completely deforested as compared to intact forests in subsequent years (Foley et al. 2007). Thus, the impact of forest degradation, which is already difficult to predict, can range from mild to devastating.

Deforestation and forest degradation are the primary causes of climate change, responsible for approximately 15% of global warming pollution (www.ipcc.ch). The simple reason to this inference is that trees contain extremely large quantities of carbon, up to almost 50% of the wood's weight. On cutting the tree, this carbon is released into the atmosphere as carbon dioxide. This can be a result of burning, rotting, or even conversion to paper; the only difference is the time it takes for the carbon to be converted to carbon dioxide (DiNicola 1997; Dolgikh et al. 1997; FAO 2010; Ozturk et al. 2010c; Mirzabaev 2013; Li et al. 2015).

4.2 Deforestation: Past and Present

A common misconception regarding deforestation is that it's a recent occurrence, gaining momentum in the tropical regions of the world since around 1950. However, in reality, its history stretches far back into the corridors of time when humans first occupied the earth and learned how to control fire—probably half a million years ago. All that has changed is the rate of acceleration of this ancient practice resulting in environments being irreversibly damaged as compared to the old ages. Possibly as much as nine tenths of all deforestation occurred before 1950 (Williams 2001). The Carboniferous rainforest collapse (Sahney et al. 2010) was an event that occurred 300 million years ago. Tropical rainforests were devastated by climate changes, leading to the extinction of many plant and animal species. The change was abrupt and skewed the climate toward cooler and drier conditions that were not favorable for the growth of rainforests and most of the biodiversity they harbored. Rainforests now became fragmented and greatly shrunk in size (Ebeling and Yasué 2009; Syuharni et al. 2014; www.wrm.org.uy).

Rainforests once covered around 14% of the earth's surface; now they cover a mere 6%, and experts have estimated that if forests continue to be cleared at the same alarming rate, the last remaining rainforest could be consumed in less than 40 years (Taylor 2004). Small-scale deforestation is an ancient practice of various societies, even before proper civilization began (Flannery 1994). The first evidence of deforestation comes from the Mesolithic period (Brown 1997). It was probably carried out to transform closed forests into more open ecosystems, which would prove to be more favorable for game animals (Flannery 1994). With the dawn of agriculture, larger areas underwent deforestation, as fire became the primary tool to clear land for cultivation of crops. Mesolithic foragers utilized fire to create clearings for red deer and wild boars. In Great Britain, according to the pollen records, shade-tolerant species of trees such as oak and ash were replaced by brambles, hazels, grasses, and nettles. The removal of forests led to decreased transpiration; hence upland peat bogs started to form. There was a widespread decrease in elm pollen in Europe between 8400–8300 BC and 7200–7000 BC, which may represent land clearing by fire at the dawn of the Neolithic agriculture. The Neolithic period also saw extensive clearing of forests for farming land. Advancement of tools used to cut trees also led to an increase in the rate of deforestation in this era. Evidence of deforestation has been also collected from the Minoan Crete, e.g., the Bronze Age saw the severe deforestation of the Palace of Knossos (Neolithic Age from 4.000 BC to 2.200 BC or New Stone Age) (www.en.m.wikipedia.org).

The pre-industrial era caused a further increase in the rates of deforestation, along with intermittent pulses of soil erosion that had not been experienced before. Easter Island is a classic example of a civilization that declined due to extensive deforestation and overexploitation of almost all the resources. The disappearance of the island's trees seems to coincide with the decline of its civilization, which was around the seventeenth and eighteenth century (Hogan 2007). This became a trend

in most regions, where cities were often built in forested areas, which provided wood required by the inhabitants. However, when deforestation occurred without proper replanting, local wood supplies would become insufficient. This would then lead to the city's abandonment, as evident in case of Easter Island. From 1100 to 1500 AD, an increase in deforestation was observed in Western Europe. The main reasons were the expanding human population and the introduction of a new use of wood—as charcoal. The use of charcoal at an industrial scale has been a main accelerant of the rate of deforestation, as the demand of wood increased manifold (Cantor 1994).

The industrial era introduced steamboats around the nineteenth century, which became the major cause of deforestation of banks of major rivers. One of the environmental results of this was increased and more severe flooding. Wood was cut from the riverbanks on a regular basis to fuel the steam engines (Norris 1997). This process led to many rivers changing their lateral course. Moreover, crews attempted to improve navigation by the use of snag pullers, which often led to clearing large trees 100–200 ft. back from the banks. This caused the flooding and abandonment of several cities. The widespread clearance of woodland to create agricultural land can be seen in many parts of the world, such as the central forest-grasslands transition and other areas. Specific parallels are seen in the twentieth century when deforestation occurred in many developing and developed countries (www.en.m.wikipedia.org).

Deforestation has never been an irrational act, considering the contexts in which it occurs. The clearance of forests by people and organizations is often carried out for good or considerably beneficial reasons, usually economic in nature. However, this may not always lead to long-term benefit as the economy is embedded in a vortex of political and cultural aspects that may lead to clearance of forests even when it is not the most profitable choice. This matter because the agents of most deforestation today are various businesses. Deforestation has changed from being a "state-initiated" process to an "enterprise-driven" one (Rudel et al. 2009). Deforestation is now being considered as an economic alternative by corporations, which consider it as being advantageous in terms of cost. Therefore, reductions in deforestation in one area, by limiting supply and increasing prices, can increase the pressure for forest clearance elsewhere. Sometimes, the same corporations, like multinational timber companies, can move from one forested area to another, thus nullifying the net effect (Lambin and Meyfroidt 2011). This does not equate that deforestation never decreases, it simply moves from one region to the other. Nevertheless, success is not unattainable. The world can achieve development without deforestation. Despite the global spread of the drivers of deforestation, they can be defeated. Strong action by governments and civil societies can pressurize these corporations to choose alternatives for deforestation. With continuous efforts, the loss of forests can be eliminated altogether. After thousands of years of clearing, mankind is surely able to make deforestation history.

4.3 Global Trends in Deforestation

The rates as well as the causes of deforestation have been found to vary from one region to the other. In 2009, two thirds of the world's forests were in Russia, Brazil, Canada, the USA, China, Australia, Congo, Indonesia, Peru, and India (Al Gore 2009). Tropical dry forests experienced the highest rate of deforestation on planet earth (Peña-Claros et al. 2009; Janssen et al. 2018). The world's annual rate of deforestation is estimated to be 13.7 million ha, equal to the area of Greece (www1.american.edu). During 1990–2015, total forest area of the world decreased from 4.28 to 3.99 billion ha, with the percent global forest cover dropped from 31.85 to 30.85%. The area of planted forests increased from 167.5 to 277.9 million ha or 4.06–6.95% of total forest area (Payn et al. 2015). Barely half of this deforested area is compensated for by growing new forests. Major deforested regions of the world will now be discussed.

According to the United Nations Environment Programme (UNEP), Africa's rate of deforestation is twice the global deforestation rate. It has been noted that almost 90% of West Africa's original forests have been wiped out by deforestation (www.independent.co.uk). Deforestation has been accelerated in Central Africa (www.scidev.net/global). Among all the continents, the highest percentage of tropical forests was lost in Africa from the 1980s to the early 2000s according to the report of FAO (2008). Also, according to FAO's figures from 1996, over 87.2% of West Africa's moist forests have been degraded (www.mongabay.com). Within just 15 years (1990–2005), 81% of Nigeria's old growth forests have been lost. Massive deforestation has now started to pose a threat to the food security of a number of African countries (Mweninguwe 2010). A major contributor to the high rates of deforestation in African countries is the use of wood as fuel for heating as well as cooking (Yvonne 1998). Rates of illegal logging in Africa vary from 50% in Equatorial Guinea and Cameroon to 70% in Gabon and up to 80% in Liberia (www.rainforests.mongabay.com). There are three major reasons that have contributed to deforestation in the Democratic Republic of Congo: unregulated logging, mining, and demands of subsistence activities of the poor population. In the eastern side of the country, over three million people live within a short range of Virunga National Park. Most of these people use wood from the park as lumber for construction, firewood, and to produce charcoal. This is a major threat to the park in general but also poses a serious threat to the habitat of almost endangered mountain gorilla (Anon 2007). The main driving force of deforestation in Ethiopia is a growing population and its ever-increasing demand for agriculture, fuelwood, and livestock production (Sucoff 2003). Low education and inaction from the government (Mccann 1999) has also contributed to deforestation in this country, although the new government has taken steps to tackle this problem (Maddox 2006). Organizations like Farm Africa have joined hands with the federal and local governments to initiate a system to look after forest management. Shortage in rain and depletion of most of its natural resources are the cause of Africa's third largest country by population to be hit by famine many times. The already low rainfall has been further declined due

to increased deforestation and thus has led to extensive erosion. The last 50 years have witnessed the loss of 98% of Ethiopia's forested region. Approximately 420.000 km^2 (35%) of Ethiopia's land was covered with forests when the twentieth century began. However, it has been indicated by recent reports that forests now cover a meager 11.9% of Ethiopia's land as of 2005 (www.rainforests.mongabay.com). A loss of 14% of the forests, or 21,000 km^2, has been observed between the years 1990 and 2005. Almost 94% of Madagascar's previously productive land has been affected with deforestation resulting from desertification, water resource degradation, as well as soil loss (www.mongabay.com). Humans first arrived in Madagascar 2000 years ago, and since then it has lost over 90% of its original forested regions. Most of this deforestation is a consequence of Madagascar's freedom from the French, as that was when people first started to use the slash-and-burn agriculture practice for subsistence (www.mongabay.com). Deforestation is a major factor contributing to the country's inability to provide its fast-growing population with adequate amount of food, freshwater, and sanitation facilities (www1.american.edu). As stated by FAO, the world's highest rates for deforestation of primary forests have been observed in Nigeria, where almost 90% of the original forests have been destroyed. Main causes of this high rate are the collection of wood for fuel, logging, and clearance of land for agriculture.

Approximately 12 million km^2 of boreal forests are distributed in Russia. These are the largest forested area compared to other places on our earth. These forests contain more than 50% of the total global conifers and contribute more than 10% to the biomass of earth. The deforested land in the country has been summed up to lie around be 20.000 km^2. The areas bordering China have been greatly affected by deforestation, as the main market for timber is in that area. The damage caused here by deforestation is tremendous when compared to other regions. The forests here have a short growing season due to harsh winters. Similarly Southeast Asia is the world's second greatest biodiversity hotspots; however, forest loss is tremendous. Vietnam is only second to Nigeria as far as the highest primary deforestation rates are concerned. More than 90% of the Philippine archipelago's old-growth forests are lost to deforestation. The mangrove forests have depleted at a rate of more than 0.15% a year during 2000–2012 (Donata et al. 2011; Syuharni et al. 2014; Richards and Friess 2016).

4.4 Economic and Environmental Perspective of the Forests

Forest provides solution to disasters (Sumithrabai et al. 2011) and can be considered as "safety nets." They play a great role in climate change adaptation and mitigation. They provide food when crops are damaged by floods and other natural calamities. They are also a source of food for livestock (East et al. 2007). In rural areas, their products are commercialized to earn money under unexpected circumstances. They are a source of self-insurance for rural people living in remote areas (Karahan et al. 2015; Ozturk et al. 2017b). Forests planted in crop areas maintain crop production

during dried and wet conditions due to their characteristics like their extensive root system absorbing water and nutrients from soil, increased soil porosity leading to increased water retention during conditions of water stress, and trees having highest transpiration rate keeping soil fully aerated (Verchot et al. 2007). Tree-based systems usually generate crops of better value. Recently, species named *Melia volkensii* is being considered best species so far for agroforestry (www.worldagroforestry.org). Government should support small-scale farmers of developing countries to plant trees and promote agroforestation (Guariguata 2009).

Forests are best reservoirs of carbon and are reported to store about one third of carbon dioxide released by fossil fuels each year. Forests are best reservoirs of carbon only when they are allowed to grow properly to their age of maturity (Pan et al. 2011). Cutting down forests for different purposes can reduce the amount of carbon stored in them. Slow regeneration of forests can overcome loss of carbon but loss cannot be completely overcome as the rate of carbon reduction is reported to be more (Werf et al. 2009). Tropical forests, savannah systems are good reservoirs of carbon as carbon storage persists in them even when they are not fully mature. Forest sinks mitigate climate change caused primarily by release of CO_2 from fossil fuels affecting the global carbon cycle. Peat lands and mangroves have a higher carbon storage capacity than tropical forests. Their conservation should be given prime importance (Donata et al. 2011).

Wild animals are a source of bush meat for people living in rural areas (Nasi et al. 2011). Wild animals are a rich source of protein and are essential to overcome food deficiency in rural areas mostly across tropics. Deforestation has both direct and indirect impact on food security. It directly leads to loss of biodiversity, which is a source of food and indirectly causes soil degradation reducing the production of food (Olagunju 2015).

Animals such as tapir, duikers, deer, pigs, peccaries, primates, larger rodents, birds, and reptiles are mostly extracted from forest ecosystems and provide benefit to indigenous people in terms of food and livelihood (Nasi et al. 2011). Some species are near extinction from forest ecosystem due to excessive hunting, whereas other species are able to maintain harvesting pressure by adopting different strategies like altering their biological factors or occupying habitats of extinct species (Hurtado-Gonzales and Bodmer 2004). Bush meat is not always attributed to elimination of species from ecosystem. Alternative sources of nutrition like beef will require a massive deforestation to convert tropical forest in to grazing lands (Nasi et al. 2008). Data has shown that Brazilian beef production is responsible for 50 million ha of deforestation. Better substitution of bush meat is poultry or pig stocks in rural areas as these species can easily survive on remains of Kitchen ingredients and crops (East et al. 2007). Urban users have many sources of obtaining their protein meat, but their choice of protein food depend on their personal preference and the cost (Wilkie et al. 2005). Forests like mangroves grow near aquatic ecosystem and maintain fish species (Donata et al. 2011).

Forests play a role in agricultural zone as it maintains livestock survival by providing them fodder and shade. It is a place where many agricultural pollinators

like bees and bats make their homes. A study has shown that coffee plants give low yields when planted in areas far away from forests due to absence of agricultural pollinators (Ricketts et al. 2004). Forests also regulate the amount of water and quality of water required to maintain agricultural production and control the process of sedimentation in agricultural areas (Guariguata 2009).

Forests provide a role in conservation of biodiversity (Gücel et al. 2008; Sunderland 2011; Altay et al. 2012; Ozyigit et al. 2015; Sezer et al. 2015; Ozturk et al. 2008, 2010a, b, c, 2011, 2017c). Destruction of biodiversity has led to loss of available genetically different forms of crop plant and has led to oversimplification of diet. A data showed that India and China has lost many rice landraces and Mexico has lost more than 80% of genetic diversity of maize crop. Loss of disease-resistant livestock species has also been increased at a very high rate globally. Availability of a few genetic forms of dietary crops makes society prone to disease, which ultimately lead to famine. The decrease in biodiversity of cereal crops in developing countries has led to deficiency of micronutrients. Worldwide, one billion people are reported to suffer from micronutrient deficiency due to genetic uniformity (Sunderland 2011).

Forests make up one third of household income of people living in rural areas near forests (Angelsen 2010; Karahan et al. 2015). Increased global trends toward deforestation to meet global agricultural needs have contributed a little in meeting agricultural needs globally. Recent data shows that increased deforestation only make up 0.3% of agricultural needs particularly in developing countries (Angelsen 2010). Deforestation in hectares of land in Brazilian Amazon by cattle farmers has resulted in raising only a single cow (CFIOR study). But a survey conducted in Indonesia showed that oil palm has taken the place of rubber and rice crops previously used for rural livelihood. Farmers make collaboration with companies and banks and earn their livelihood. Major limitations in this strategy are unawareness of policies, their rights, and rules and regulation. Farmers accustomed to grow rubber crops previously are also ignorant of growth conditions and growth requirements of oil palm crops (Feintrenie et al. 2010). Although improved livelihood of farmers has been observed in many instances, sometimes selling their land to big companies does not result in huge benefits for them. They may lose access to forest-based household income (Baños et al. 2011).

4.5 Forests and Biofuels: Source of Charcoal and Fuel Energy

Deforestation is the obliteration of natural forests and woodlands. Global warming, population explosion, and depleting energy reserves are diverting trends toward biofuels. Biofuels can reduce greenhouse gas (GHG) emission effect. First-generation biofuels are obtained from various crops like sugarcane, oil palm, and soya bean (Sumithrabai et al. 2011; Ozturk et al. 2017a). Forests suffer due to

expansion of first-generation liquid biofuels in terms of land usage (Searchinger et al. 2008). As GHG emission effect increases due to frequent land usage, the emission of carbon or carbon debt resulting from conversion of forest land to agricultural lands takes approximately 100–1000 years depending upon particular ecosystem involved in this land conversion incident. However, recent evidences suggest that apart from agricultural expansion, there are also other factors supporting land usage effects. These factors are harvesting of timber, building of infrastructure, and converting land to promote agricultural growth. Both direct land use change (clearing specific land as a part of chain of biofuels production) and indirect land use change (clearing random land for biofuel purpose) are increasing GHG emissions. Application of suitable crop management practices can reduce GHG emission effect due to direct and indirect land use change. Among various practices, analysis showed that no-till practice with winter cover crops is so far the best strategy for reducing effect of land use change (Sumithrabai et al. 2011). Forests are sites of carbon storage, but upon disturbances like wildfire, forest harvesting can lead to the possible danger of carbon emission stored in them (Ozturk et al. 2010c; www.thegef.org).

However, carbon emission effects from forests are a matter of debate. Scientists suggest that existence of trees preserving carbon for more than 1400 years and their continual growth is depicting their suitability for carbon storage. Moreover, increased plant yield and decreased decomposition rates of plants in high CO_2 presence in various experiments are supporting their carbon storage capacity. Second-generation biofuels from forest and agricultural residues have not yet been commercialized. Forest residues can promote development of rural countries in developing countries. Utilization of other biomass sources require high production costs and need of large-scale facility which appears to be a major hindrance of their implications in developing countries (Searchinger et al. 2008). However, scientists consider second-generation biofuels as a sustainable source of energy (Sumithrabai et al. 2011).

Charcoal is a feasible source of energy as it is easily accessible. Forests have been used to produce charcoal to meet energy needs and reduce environmental effects caused by emission of greenhouse gases. The quality of charcoal depends mainly on factors like species of plant and type of kiln used and process of carbonization carried out. Cracked firewood obtained from Brazilian Kiln has shown to increase charcoal production. The international standard of charcoal production is to break charcoal before packing to obtain good quality of charcoal. Wood pellets and wood chips are the most convenient sources of biomass and fuel energy. These forms can easily be transported to long distances promoting trade among countries (Veronica et al. 2012). Forests are used at domestic level as a source of cooking and heating particularly in developing countries. Data suggest that more than 90% of wood energy is being utilized at domestic level mainly for heating and cooking purposes. The use of fuelwood energy in African countries, particularly as a source of carbon neutral energy, requires a massive financial investment (Kaimowitz 2003).

4.6 General Causes and Types of Deforestation

According to the United Nations Framework Convention on Climate Change, the major cause of deforestation globally is the removal of trees for the agricultural expansion purposes. In poor countries, the subsistence agriculture is responsible for 48% of deforestation, commercial agriculture for 32%, commercial logging only for 14%, and charcoal and other fuelwood cleaning for less than 6% (www.phys.org). Another cause of deprivation of forest ecosystems is for economic incentives, which make forest conversion more profitable than forest conservation. Substantial deforestation arises due to lack of property rights security and absence of a system ensuring the effective implementation of conservation policies. These factors are primarily seen in developing countries, and in some cases, corruption and terrorism are parallel factors in deforestation.

There are two main causes of deforestation. The primary and most common reasons for deforestation are known as the direct causes. Logging, overpopulation, urbanization, and dam construction are the direct causes. The other main cause of deforestation is natural since it is brought by the Mother Nature. Rapid population growth has resulted in the conversion of forest areas to non-forest lands for settlement and farming. Together with this are urbanization and residential area expansion. This takes a significant loss of forests for harvesting forest products as more people need more lumber to build their houses and for requiring greater area for building their houses, malls, and business centers. Forests are cleared to make way for the construction of the transport networks. Clearing of large areas of forest is also done for raising cash crops. Roads and railway tracks also make it easier for people and companies to enter the forest to extract resources. Dams and harvesting of hydroelectric power in forests such as the Amazon destroy trees through flooding, resettling of people to the area around the dam, and cutting down trees on the shoreline of the dam (www.eoearth.org). An increase in population also means an increase in produce consumption. Thus, rainforests are destroyed and converted to cattle pastures to supply the burgeoning demand for meat. In the Central America, almost half of rainforests have been slashed and burned for cattle farming in order to comply with the foreign demands. Twenty-five percent of the Amazon's forests have also been destroyed for cattle ranches (www.stopearthdestruction.com).

The lack of government legislation for land reforms has also cleared the forests especially in developing countries of South East Asia. The people in that region are among the poorest and are desperate for a piece of land. Unequal distribution of resources has led these people to find their way by exploiting the forests (Butler 2012). The majority of rural population has wood as the only fuel to cook food and provide heat in chilly winters. Firewood collection contributes much to the depletion of tree cover. The most important causes of deforestation are due to human activities (www.phys.org). Deforestation is a great threat to life worldwide. We can only hope that the natural forces causing deforestation would not do great damage. However, right decisions and appropriate actions must be taken to address the problems caused by the hands of people.

Cleaning of land for grazing purposes; Expanding the production of crop; Timber harvesting and commercial categorization (logging); Slash-and-burn forest cutting

for farming subsistence and Natural disasters such as: Volcanic eruptions, Stand wind-throw from hurricanes, Catastrophic fires in forests, Changes in local climate, and Rainfall system. Volcanic eruption is one of the several natural forces capable of causing damage to forests (Butler 2012).

Wind damage to forests is determined by numerous factors. In July 1999, catastrophic windstorm hit the Boundary Waters Canoe Area. The levels of damage varied from 29.5 to 86.8% of basal area fallen and 23.3 to 63.4% of stems fallen. In all sites, the disturbance reduced mean trunk diameter of standing trees (Butler 2012). Drought initially weakens canopy plants by the reduction of local humidity and rainfall; storms can cause extensive damage in the rainforest through tree falls (www.climateandweather.net). Natural forest fires occur in rainforests, in smaller fires, ground vegetation, shrubbery, saplings, and smaller trees are eradicated (Butler 2012).

Estimates on the contribution of deforestation to carbon emissions vary but are commonly held to be around 19% of global emissions—greater than the emissions produced by the whole global transport sector. The bulk of emissions from deforestation arise when land is converted to agricultural production, particularly if forests are first cleared with burning (Butler 2012). Research indicates that deforestation results in warmer and drier conditions. Deforestation may pose the same effects to global warming as burning of fossil fuels (Lawrence and Vandecar 2015).

The potential for forests to become even greater sources of carbon emissions due to deforestation and degradation is massive (www.eoearth.org). Examples can be found from forest areas across the globe, including Russia's boreal forest, the forests of the Congo Basin, and Sumatra's peat swamp forests.

Deforestation is continuing at an alarming rate. Once distributed over half the planet, forests now cover only a quarter of its land surface—and forest loss, particularly in the tropics, is continuing at an alarming rate. Figures released by the UN FAO in 2005 indicate that the rate of natural tropical forest loss is about 13 million ha each year—equivalent to 36 football fields a minute (www.climateandweather.net). Deforestation is an important factor in global climate change. Climate change is because of a buildup of carbon dioxide in out atmosphere, and if we carry on cutting down the main tool, we have to diminish this CO_2 buildup, and we can expect the climate of our planet to change dramatically over the next decades (Butler 2012; Ozturk et al. 2015). It is estimated that more than 1.5 billion tons of carbon dioxide are released to the atmosphere due to deforestation, mainly the cutting and burning of forests, every year. Over 30 million acres of forests and woodlands are lost every year due to deforestation; causing a massive loss of income to poor people living in remote areas who depend on the forest to survive (Butler 2012).

4.7 Deforestation and Its Effects

Deforestation in the long run is causing climatic changes globally, where increase in global warming is seen with prevailing deforestation trends worldwide. Moreover, it is noted that the loss of habitat and forestry is inadvertently causing a loss of

important animal, plant, and wildlife in important forests and basins such as Amazon, Congo Basin, and Russia's boreal forests. However, not only forests are affected, but this trend also results in soil erosion resulting in loss of arable lands for agricultural purposes. There is also some evidence about coral reef loss and decline due to siltation and soil erosion around mangroves.

Forests have a critical role to play in combating global warming as researches have clearly pointed out the significance of global warming incidences linked with worldwide deforestation trends. It must be noted that forests are the largest storehouse of carbon after the oceans. However, when forests are destroyed by activities such as logging, forest clearing for roads and settlements, and land conversion for agriculture, they also become a source of release of large quantities of CO_2 and other greenhouse gases into the atmosphere.

It is now widely recognized through extensive research that rising concentrations of greenhouse gases (GHGs) are driving changes in the earth's climate patterns, resulting in catastrophic weather events, such as hurricanes, global warming, heat waves, droughts and floods, and glacier melting, thereby threatening plant and animal life. Forests play an important role in protecting the earth from extreme climatic changes by regulating climate patterns: the trees—trunks, branches, and roots—and shrubs, grass, and plants in general, even soil, absorb and store CO_2, acting as a natural reservoir for GHG. It is recorded that the earth's vegetation and soils currently contain the equivalent of approximately 7500 gigatons of CO_2. It is more carbon than is contained in all the remaining oil stocks on the earth and more than double the total amount of carbon currently in the atmosphere. However, when forests are destroyed or degraded by human and natural activities, they release large quantities of CO_2 and other GHGs into the atmosphere, to become a significant (and for developing countries, a major) source of GHG emissions hence a contributor to climate change (wwf.panda.org).

Forests play an important role in recycling rainwater and groundwater on a global scale at continental and intercontinental levels (Ellison et al. 2012). Deforestation in one part of the world can reduce rainfall in another part. The water evaporated from forests of Eurasian continents is responsible for 80% of water sources in China. Similarly, rainfall in Sahel is caused by moisture evaporating from Congo Basin. The penetration of water in tree roots makes them giant reserves of water, and about 75% of water is stored globally. The water stored in roots of trees is slowly released to provide supplies during dry periods. They have a role in removing pollutants from soil and convert these into less harmful substances. They also reduce soil erosion and sediment formation, so the areas, where forests are removed, are subjected to more soil erosion and sediment formation. The water-storing capacity of forests makes them highly valuable. A study conducted on forests of China has shown that the water-storing capacity of forests in China costs 7.5 trillion Yuan (Rudi et al. 2010). Similarly, a study of Kenyan forests has shown that water-storing capacity of forests saved national economy for more than USD 20 million. The world's most developed areas including New York, Jakarta, and Singapore rely on forested areas for their water supply (Ellison et al. 2012).

4.8 Habitat for Species and Forestry

The importance of biodiversity and forest and its adjoining wetlands as a habitat for a diverse population of species can be seen by the following quote: "Certain species may live in a forest but depend on a nearby grassland or wetland for a food source" (Elizabeth Brown). Deforestation, as previously discussed has the eminent negative effects on the biotic aorta overall. The most dramatic impact of deforestation is a loss of habitat for millions of species. According to statistics, 70% of earth's land animals and plants live in forests, and many cannot survive the effects of deforestation that are destroying their natural habitats. Removing trees deprives the forest of major portions of its canopy, which serves to block the sunlight during the day and hold heat at night. This disruption leads to more extreme temperatures changes that can be harmful to plants and animals residing in the vicinity of these canopies (Ellis 2003–2012).

A single tree means thousands of species. Not only the plants, trees and forested area serve as a habitat but it also acts as a source of food to an enormous amount of plant and animal life. Any basic tree, anywhere in a wood, can provide high branches for birds, vegetation for insects to reside, and animals to eat. It also acts as a shelter for shade plants and burrows for animals such as squirrels, toads, birds, and foxes. It helps to maintain balance between the exchange of beneficial nutrients from the soil and species connected with a single tree in the vicinity. When deforestation occurs, a high percentage of local plants and animals disappear because the environment cannot support their existence. According to the study carried out by the International Union for Conservation of Nature and Natural Resources (IUCN), many species face extinction, and the primary reason is attributed to deforestation (www.wisegeek.com).

Many of the major areas of the world suffering from deforestation are the reservoirs of species habitats, also possessing the most life-filled environments on the planet. The Amazon rainforest in South America is considered to be one of the biggest hotbeds of species diversity on earth, yet this fertile and immense forest is a major target for lumber, agricultural land conversion, and industrial clearing. Experts from the IUCN, World Wildlife Fund, and other environmentalist groups believe that the statistical data show the planet has already lost hundreds of thousands of species largely due to the horrendous effects of deforestation and may lose thousands more (www.wisegeek.com).

In the middle of South America, amid the Amazon bowl to the north and west and the temperate grasslands of Argentina in the south, locale two of the most astonishing ecosystems on the planet. The Atlantic Forest and the Gran Chaco both prop an incredible diversity of fauna and flora that matches that of the far extra Amazon rainforest. Yet beyond South America, most people have never ever heard of them, nor do they understand that they are amid the most intimidated habitats on earth (www.pulsamerica.co.uk).

The Atlantic Forest stretches along the Atlantic coasts of southeastern Brazil and Uruguay inland to eastern Paraguay and the northernmost isthmus of Argentina. It

is the world's most beautiful tropical and subtropical forest and known as one of the most biodiverse habitats on the planet and a designated world biosphere reserve. The forest includes a number of species found nowhere else such as the golden lion tamarin, the maned three-toed sloth, the woolly spider monkey, and the critically endangered Itatiaia highland frog, as well as hordes of bird and insect species. However, it is alarming to note that only 7% of the Atlantic forest remains today. This shocking statistic doesn't even begin to cover the full extent of the damage to its native fauna and flora. Instead of being one single, untouched stretch of wooded refuge, the forest consists of hundreds of small vulnerable fragments, which further functions as a competitor for survival of these extremely rare and precious species (www.d.umn.edu; www.pulsamerica.co.uk).

Extinction Debt, the Forests, Habitats, and Climate—Are All Linked Up?

The species extinction, like global warming and even nuclear blast effects, cannot be seen instantaneously. Loss of forest species in the past may not be apparent yet today; hence estimation of specie loss to deforestation might not be predicted now. Ward (1997) used the term "extinction debt" to explain such long-term extinction of species and their declining populations long after habitat changes. "Extinction debts are hence bad liabilities, and after they become a part of our system, the globe will become a terrible place" (www.rainforests.mongabay.com).

For example, the vanishing of critical pollinators will not cause the instant demise of tree species alongside existence cycles measured over course of centuries. Similarly, a study on West African primates resulted in findings that there is a liability of extinction, above 30% of the finished primate fauna as a consequence of significant deforestation (Ward 1997). This suggests that nowadays merely the protection of still conserved forests in these spans could not be sufficient to stop extinctions provoked by past habitat loss. At present, we could be able to forecast the results of the extinction of a little species; we understand little relative to the large bulk of species capitulated to deforestation to create reasonable projections. Hence, the unanticipated elimination of unfamiliar species will have a magnified result above the tiny protrusion of period in adjacent future. The intricacy of the rainforest creates additional hazard to anticipate how, which, and when species will disappear (www.rainforests.mongabay.com).

At present, it is noted and well acknowledged that the tropical species are not merely intimidated undeviatingly by deforestation but additionally by global meteorological conditions change. Even if species endure deforestation stress in protected reserves, they could perish as a consequence of rising marine levels and climactic changes. Countless tropical species are adapted to steady, year-round conditions of temperature, weather, aridity, and humidity. They are however not adapted to meteorological condition change even if it is as tiny as 1.8 °F (1 °C). Adjustments in seasonal length, rain, and intensity and frequency of great events that might transpire to the earth could powerfully affect biodiversity in seasonal tropical forests and cloud forests. Studies suggest that infrequent and fluctuating meteorological conditions can eventually result in populace variations of countless forest animals (www.rainforests.mongabay.com).We have often overlooked the consequence of increased temperatures in the spread of illness amid wild, feral

animals. The spread of these illnesses to upland forest as a consequence of temperature fluctuation should plausibly mean the eventual extinction of countless endangered bird species (www.rainforests.mongabay.com).

Besides losing exceptionally rare species, we are losing an incredible pool of genetic diversity. We are perhaps now heading in the direction of a mass extinction of common wildlife and glorious beasts: ferocious tigers, armored rhinos, brilliant macaws, hunters and deers, pandas and penguins, and frogs and toads. As these species vanish from the globe, the globe will be a poorer place to live in (Butler 2012; www.rainforests.mongabay.com). The general pattern associated with deforestation and soil erosion and its impact on the habitat and species loss (with particular importance to research and science) is as follows:

Top soil accumulates slowly → erosion → unusable land → disastrous flooding → loss of scientific possibilities, i.e., identification of species and in them cures for deadly diseases. The loss of trees, which anchor the soil with their roots, causes widespread erosion throughout the tropics and forests. Only a minority of areas are left with good soils, which, after clearing of trees, are quickly washed away by heavy rains. Thus, crop yields decline, and people must spend income to import foreign fertilizers or clear additional forest. The rate of increase of soil loss after deforestation is proportional to the rate of forest clearing; a study in Ivory Coast established that forested gradient regions lost 0.03 tons of soil per year per hectare; cultivated gradients almost annually lost 90 tons per hectare, while bare gradients lost 138 tons per hectare. After heavy tropical rains fall on cleared pastures and forest lands, the runoff passes soil into local canals, creeks, and rivers. The rivers carry the eroded soils downstream, causing major problems. Siltation process also raises riverbeds, increasing the occurrence and severity of floods, and creates shoals, silt bars, and sandbars that make river movement far more problematic. The increased sediment rate of rivers smothers fish breeding and decreases fish eggs hatchery, causing lower hatch rates of prawns and other water life. Coastal fisheries are affected not just by the loss of coral reefs and their communities but also by the damage inflicted on mangrove forests by heavy siltation rates. Deforestation-induced erosion can have detrimental effect on roads and highways that cross through the forest (www.rainforests.mongabay.com).

4.9 Research on Deforestation

Deforestation has a huge impact on soil's physical and chemical properties (Hajabbasi et al. 1997). Quantification of soil quality adjustments pursuing deforestation by measurable soil qualities is vital to hold conservation process. A discovery was commenced in 1994 to assess the results of deforestation in Iran according to which deforestation and clear-cutting of forests in the central Zagros massifs resulted in a lower soil quality therefore cutting the usual productivity of the soil. Elevated population rate and consequent need for more food and fiber need extra earth to farm; consequently every year, hundreds of hectares of forests in

northern and central Zagros of Iran are deforested and modified to croplands and agrarian areas. Deforestation results in a lower soil quality in nearby locations as determined by examining its physical and chemical properties. Cutting soil organic matter and aggregate size, rising soil bulk density, and changing the center rank of the soil were found to be inevitable and detrimental aftermath of the deforestation.

Cultivating and cropping in the stand forest is one more exercise of crop creation in the span that additionally cut the soil quality to a little extent, but not as much as completely deforested method. Several underlying indicators of deforestation include forest cover, per capita income, poverty, agricultural production, food, governance, and population growth (Khuc et al. 2018). Therefore, it is noted in the research that cropping amid the forest trees could be the most feasible and suggesting method of crop creation; by that the moderately elevated populated span will be nourished because the usual resources like forest trees and soil will moderately stay conserved.

GHG emission effect has been increased due to deforestation. Deforestation causes climate change leading to loss of stored carbon in trees. A scheme to reduce GHG emission effect due to deforestation is "compensated reduction (CR)" (Gitz and Ciais 2004). This scheme involves giving stored carbon in trees a financial value, creating an incentive to reduce deforestation and protection of forests from cutting (Santilli et al. 2005). Using CR, underdeveloped countries provide government agencies and other private investors their annual deforestation rate and carbon certificates. On gaining carbon credits, these underdeveloped countries release stored carbon and are bound not to go above and below the level of their annual deforestation rate (Gitz and Ciais 2004).

A set of practices known as SFM (sustainable forest management practices) has been suggested to reduce negative impacts caused by timber harvesting practices. The common layout of all these practices is to balance harvesting and growth, induction of proper plans of harvesting process to increase yield of products obtained from forests, and to enhance services obtained from forests. Most of the forest management practices are focused on tropical forests (Boscolo et al. 2009). Tropical forests are places where about 98% of species survive (large biodiversity) and which have large sources of stored carbon and also provide hydrological services. Worldwide data suggest that 96 million ha of tropical forests have management plans and 2.5 million are suggested to be well managed, while ten million are certified by third parties like Forest Stewardship Council (Siry et al. 2005).

These forest management practices are collectively called elements of reduced impact logging (RID). Common goal of policies is to extend concession rights, change criteria of stumpage fee collection, collect it on basis of area, and implement public bidding systems for using public forest lands. Some of the practices are implemented before harvesting like agreement of cutting trees, vine cutting, and planning of road, while some are implemented after harvesting including directional falling. These RID practices are estimated to reduce damage to forests and increasing profit from logging procedures. These practices improve the methods with which forest operations are carried out. Better law enforcement can lead to better adaptation

of practices. Many organizations showed consensus to commercial tress after the enforcement of law in 1996 and up to 1998, about 80% of organizations adopted this practice. Bolivia forestry system is improved by implementation of SFM practices through law and by increasing awareness among timber producers regarding the benefits of SFM (Holmes et al. 2002). Apart from Bolivia forestry systems, forest management practices in many other tropical forests systems are lacking. There are many factors affecting implementation of these practices. One of the reasons is people indigenous to forest systems are more concerned with commercial benefits and are least interested in environmental concerns. A study revealed that, in the Brazilian Amazon, total GDP in 2006 was 28 billion of which 23 billion is obtained from timber industry. High cost associated with forest management practices is another major hindrance in adaptation of these practices by timber harvesters (Nasi et al. 2011). Forest management certification is a costly process, and these certificates are not long-lasting and get expired mainly due to hurricanes, low volumes of harvesting, and acquisition of very few commercial benefits by selling certified wood in markets of country (Barry and Taylor 2008). Lack of policies for giving land tenures to local communities and small-scale stakeholders is a problem. Giving land tenures to deserving communities might solve problem to some extent, but some small communities do not have a proper control over informal logging within their region. In Mexico, boundary disputes are also seen which are affecting forests operations in these regions. These policies in the long-term cause commercial logging (Larson et al. 2008). Complexity of these policies makes them hard to understand by local communities. These forest policies are unaware of ground problems faced by local communities and indigenous forest users and are generally being disregarded in Brazil, Peru and Mexico. Implementation of policies at public level is hard to monitor (Enneker 2008). Recently, a case was reported in Brazilian Amazon in which about 100 government personnel are arrested, who were involved in illegal logging practices (Keller et al. 2007). Another factor in hindrance of proper forest management practices is lack of proper trained staff ensuring compliance of forest management practices (Durst et al. 2006). According to an estimation, if national REDD+ targets have to be met in Brazilian forests, then approximately 27,000–33,000 trained forest officers are required (improving sustainable tropical forest management). Similarly, in Mexico, the trend of changing technical staff after every 3 years leads to organizational memory loss and causes repeated high cost of training individuals for forest operations (Bray et al. 2006). In addition, inefficient timber harvesting practices lead to time loss, and sufficient quantity of timber cannot reach markets. The data suggests that timber loss practices have increased to 30%, and only 50% of high-quality swan timber species are able to reach the market (Keller et al. 2007).

Many solutions have been proposed to overcome problems faced in forest management practices. Measures should be taken to improve legality of forest lands. Establishment of public institutions in frontier regions and improvement of forest management certification can also improve the situation. Forest products should be legally verified and funds should be given to region, where carbon mitigation effects have been observed (CIFOR's Poverty and Environment Network study). Another

step that can improve situation is giving incentives to timber harvesters. These incentives are in the form of performance bonds. These bonds are refundable and are deposited to accounts of government. On completion of proper forest management plan by timber harvesters, the bond is returned to them. If some disobeying of practice is seen, then due fine is detected from bonds. These refundable bonds are a source of income for harvesters and can contribute to reduce harmful effects of deforestation. Forest certification gives many benefits to users including implementation of forest regulations by government, accessibility of land tenures, and availability of financial incentives, but this forest certification is not affordable by small-scale holders. REDD+ funds can be used to support forest certification for these small holders and local communities (Richards and Costa 1999). Degraded forests can be regenerated naturally after 30–40 years or artificially by active management to restore degraded areas. Some researchers use approaches promoting restoration of degraded forests. This approach involves factors like blocking illegal logging, promoting forest management practices, reducing damage from grazing animals, and protection from wildfire. An alternative approach to enhance process of natural regeneration of forests is by planting seedlings and to allow natural species participating in natural regeneration process (Peña-Claros et al. 2009). Giving forest areas to local communities which are dependent on forests for their livelihood can preserve forests (Ebeling and Yasué 2009). Public forest areas should be given with a right of long-term access to concessionaries. These concessionaires can exercise forest management practices even in areas where human population is scarce (Drigo et al. 2008). One approach to minimize timber wasting during harvesting procedures and to ensure proper quantity of timber reaching markets from harvest areas is to take taxes from timber harvesters. These taxes are calculated on the basis of total volume of standing trees or on the basis of volume felled. Either approach requires corrupt-free officers to monitor the implementation of these procedures (CIFOR's Poverty and Environment Network study). Reduced impact logging (RIL) is more beneficial than conventional logging practices as former leads to rapid degeneration of forests and reduce CO_2 emission by 0.58 GT per year, but RIL can lead to reduce timber yields. Research has shown that marking of trees before and after logging and elimination of marked trees from local competition lead to their rapid regeneration (Vanclay 2008). Rules and regulations regarding forest management should be simplified and should be in compliance with ground problems faced by timber harvesters. Proper training of staff monitoring forest management should be ensured (Putz et al. 2008).

Technology is playing an important role in agricultural lands near forests. Use of appropriate technology with encouraging political and economic environments helps farmers, policymakers, and small-scale holders to enforce forest management practices. New technologies involving elastic products enhance deforestation. These crops are exported, and increased supply of these crops decreases their cost in local markets, suppressing farmer's income. This aspect makes use of new technology an undesirable practice. New technologies increase productivity of agriculture products, which create employment avenues in many other sectors. These new opportunities of employment in other sectors protect forests near agricultural lands

from massive deforestation. Technologies which are labor-free facilitate farmers to expand agricultural lands and cause migration of labor to other agricultural areas, whereas technologies which depend on labor limit deforestation as these labor-dependent technologies affect number of labor families and increase wages of labor (Murdiyarso et al. 2000). Farmers mostly prefer labor-free technologies, which is a harmful aspect of technology use. Farmers are financially strengthened by progress in technology and invest money in activities associated with agricultural expansion like deforestation. Some farmers promote forest conservation by saving money due to technological progress. They invest their money in forest conversion. Progress in technology in more labor intensive agricultural lands cause elimination of resources in small amount and make demands of agricultural lands to be simpler. These extra resources can then be applied to expansion of agricultural lands, which ultimately results in increasing demand of agricultural lands (Kaimowitz and Angelson 1998).

One of the important factors in reducing deforestation rate is the reduction in greenhouse gas emission rate. Deforestation is a global problem, and it needs to be addressed, controlled, and coordinated in an efficient manner. International agencies, national conservation resources, and government organizations need to take steps to control and eradicate deforestation.

1. To enhance dissemination, transparency, and effective use of deforestation data by government agencies and civil society
2. To develop and implement functional, credible market mechanisms that provide financial incentives for conservation and sustainable use of tropical forests
3. To contribute to the development of public policies that will scale up the incentives for conservation and sustainable use in deforestation (www.monitoramento.sema.mt.gov.br)

4.10 Diversity and Ecological Significance of Forests

4.10.1 Central Asia

There are four major zones: irrigated, rainfed, rangeland, and mountainous areas. Four sources have triggered land degradation processes in the region: abandonment of massive areas formerly under rainfed crop production in Kazakhstan; continued desiccation of the Aral Sea; conversion of a sizable share of barren lands into other land uses, mainly shrublands and grasslands; and increases in the forested area across the region but especially in Kazakhstan. Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan are strongly affected by land degradation (Fig. 4.1) (Ozturk et al. 1996a, b; Bekturova and Romanova 2007; Pender et al. 2009; Klein et al. 2012; Nkonya et al. 2016).

It is a major development challenge in the region. Annual cost of land degradation in the region is about six billion USD, mainly due to deforestation (0.3 billion dollars) and other factors. There is a lack of published studies identifying the extent

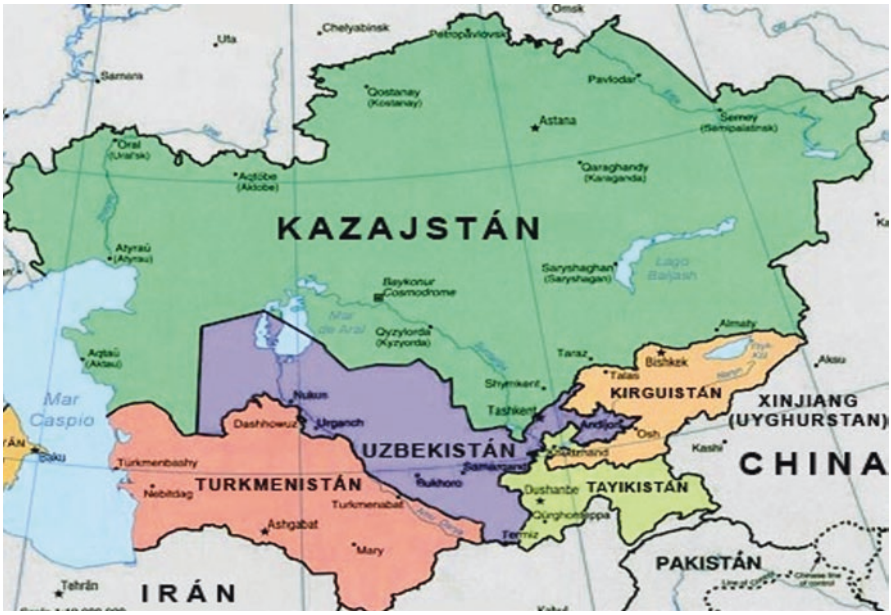

Fig. 4.1 A general map showing the Central Asian Republics (Image Google Maps)

of land degradation in the region using observed data at national or regional scales (Ji 2008). Existing studies are mainly on the extent of land degradation in Central Asia, but based on qualitative estimates (Gupta et al. 2009). But there are a growing number of localized case studies based on detailed soil surveys or remote sensing data (O'Hara 1997; Buhlmann 2006; Dubovyk et al. 2013; Akramkhanov et al. 2011; Akramhanov and Vlek 2012; de Beurs et al. 2015; Nkonya et al. 2016).

The drivers of land degradation in the region are numerous (Pender et al. 2009; Nkonya et al. 2016). The main areas affected are concentrated in the north of Kazakhstan, continuing toward Eastern Kazakhstan, also covering Kyrgyzstan, northwest of Tajikistan, and south of Uzbekistan and Turkmenistan. In Uzbekistan annual costs associated with land degradation are estimated to be about one billion USD (Sutton et al. 2007; Nkonya et al. 2016). Degraded areas are localized in the lowlands of Xorazm and Karakalpakstan and in Bukhara, Navoi, Kashkadarya, and Fergana provinces. Area of rainfed rangelands has considerably decreased due to overgrazing and deforestation (Pender et al. 2009; Nkonya et al. 2016).

Mountainous ecosystems in the region occupy 10% of the total territory and are ecologically diverse. Land degradation in such areas has their own characteristics (Nkonya et al. 2016). Bai et al. (2008) has analyzed land degradation as a negative linear trend and found that land degradation ranges from 0.3% of the territory in Turkmenistan to 17.9% of the territory in Kazakhstan. Le et al. (2014) reports relatively higher share of land in the region. The extent of degradation, according to Le et al. (2014), ranges between 8% in Turkmenistan and Uzbekistan and 60% of the total area of Kazakhstan. The land degradation hotspots are concentrated in the

north of Kazakhstan and stretch over Eastern Kazakhstan to the southern part of Central Asia, covering Kyrgyzstan, the northwest of Tajikistan, and the southern parts of Uzbekistan and Turkmenistan. The major drivers of land degradation in mountainous areas are population pressure leading to cultivation of sloping, easily erodible lands without sustainable soil conservation protection technology, and poor extension services (Gupta et al. 2009; Pender et al. 2009; Nkonya et al. 2016). Other change includes doubling of forested areas, from 2.3 million to 4.5 million ha, mainly through shifts from woodlands and grasslands to forests in Kazakhstan mainly Almaty and Eastern Kazakhstan provinces. Deforestation is leading to about 0.32 billion USD in annual losses; other sources of land improvement include afforestation on additional 2.2 million ha (Nkonya et al. 2016).

4.10.2 Kazakhstan

The country is poorly forested, covering only 4.5% of the country. The forests are unevenly distributed, with nearly 80% of the wood stock in the northern and northeastern areas. Forests in Kazakhstan are a carbon sink, and three categories of forest management activities have been identified as potentially decreasing CO_2 emissions: management for conservation, management for storage, and management for substitutions. Possible mitigation measures include promoting improved logging practices to reduce the damage to residual trees and the soil; encouraging agroforestry activities to contribute to sustainable development; promoting forest expansion; improving legal and policy framework, using technical exchange programs on environmental impact assessment and mitigation, and improving environmental planning; encouraging use of long-lived forest products; providing financial incentives for new afforestation activities; and controlling air pollution effects on forests (Kushlin et al. 2003; Baitulin et al. 2010; FAO 2010b; www.fao.org).

Haloxylon spp. occupy over 60% in the general forest area in the country. Current standing wood stock is around 375.8 million m^3, including 140 million m^3 of mature and overmature wood; the cutting volume has been reduced from 2.5 to 1.2 million m^3 during the last few years (Mátyás 2010). The contribution to the economy has been only around 2.5% of the gross national product. The standing forests represent a positive carbon stock with conifers like pine, fir, cedar, juniper, and similar species; softwood deciduous trees like birch, aspen, alder, and poplar; and hardwood deciduous trees like oak, ash, maple, and elm. In addition we come across *Haloxylon* (saxaul) forests including both black and white saxaul. Other woody taxa are apricot, plum, apple, and few others. The bushes include dwarf birch, hawthorn, and others. *Haloxylon* spp. occupy more than 65% of the forest area represented by 14.9 million m^3. The conifers and softwood deciduous trees form over 90% of the total standing wood stock (Kushlin et al. 2003; FAO 2010b).

The coefficient for the average annual gain of woody biomass in the country equals to 1.6 m^3 per hectare. The quantity of carbon absorbed by the forests has been estimated to be 2335 Gg CO_2. GHG emissions from forest fires and woodcutting

have been recorded to be 493.1 Gg CO_2. These values have been estimated to be 1961.3 Gg CO_2 absorption, 39.8 Gg CO_2 emission, and a net gain of 1961.3 Gg CO_2. Ban on cutting down of conifers and *Haloxylon* spp. plantings has proved positive for preservation and restoration of woods (Baitulin et al. 2010; Mátyás 2010).

Kazakhstan stands low in the global list in terms of percentage of forest land, although the area per person is 0.77 ha. With a possible move to the south in mountain regions, the resistance of forest ecosystems implies ecoclimatic zone boundary disturbances (Baitulin et al. 2010; Mátyás 2010). The temperature and humidity changes are causing unsuitable conditions for conifers. Lower limit of spruce in the mountain regions is moving up by 100–120 m; giving way to deciduous softwood species, the fir plantings may disappear from some areas and remain only in a small area of East Kazakhstan (Yesserkepova 2008; Mátyás 2010).

Forest ecosystems are highly vulnerable to climate change. It is explained as the conifers at the southernmost border of area are very sensitive to temperature and humidity regimes. Junipers grow on the northern border of area but are capable of reacting to changed climatic conditions (Mátyás 2010). Percentage of woodlands in Kazakhstan together with *Haloxylon* spp. and bushes is around 5%. Forests play an important role in soil protection, in climate and water regulation, water protection and in recreation. New rules plan to create forests on 145,180 ha in the country (Yesserkepova 2008; Mátyás 2010). Electronic databank for forest ecosystems can permit to monitor woods, define volumes for sustainable forest use and their reproduction as well as control of activities by establishing forest management projects. Carbon sequestration by the forests may be significant because huge territories with trees are outside the system of forest accounting. There is a need to improve the inventory of the forests in Kazakhstan (Mátyás 2010).

4.10.3 Kyrgyzstan

Not much work has been done on the climate change in forest functions like productivity, survival ability, or loss of plantations (Mátyás 2010). The forests in the country are under the status of protected natural areas. They form unified state forests including both areas actually covered by forest and areas uncovered by forest but designated for forestry needs. Recent official assessment reveals that the total area of the state forestry lands is around 3.533.100 ha, including 932.100 ha covered by real forests. Vertical zonation and varying climatic zones have resulted in considerable diversity in forest-forming species and lead to rather low forest coverage (Blaser et al. 1995; Orlov et al. 2003; Vengelovsky 2006).

The country has limited forest cover, which is unevenly distributed and dominated by walnut (41,000 ha), spruce (124,100 ha), juniper (archa tree) (303,500 ha), and other (48,300 ha) forests. The pistachio and almond plantations grow at altitudes between 1300 and 1800 m. However, some of the mountain ridges are covered by a solid mass of walnut forest. *Juglans regia* is the most valuable species among

the great variety of tree species and is the dominant species in the walnut forests (Blaser et al. 1995; Orlov et al. 2003; Vengelovsky 2006; Mátyás 2010).

In the northern parts of the country over the slopes of the Kyrgyz ridge, the dominant forest species is Tian Shan spruce (*Picea schrenkiana*) (Imanderdieva et al. 2018a, b), with an area of 128,200 ha. This comes to around 14% of the entire forest cover in the country. The spruce forests together with archa forests cover the steep slopes of the mountain ranges regulating mountain river runoff and direct surface runoff into subsurface runoff, attenuate erosion processes, and stabilize the soil against mud-and-stone landslides which have been the cause of severe disasters and devastation (Blaser et al. 1995; Orlov et al. 2003; Vengelovsky 2006).

The juniper forests (locally known as archa) and the associated dwarf forms are very important. These forests are widespread on the dry and harsh conditions of the Altai crest, covering 303,500 ha, which is nearly 33% of the country's forests. The largest area is concentrated in the regions of Oshsky and Batkensky, on the slopes of Turkistan and Altai mountain ranges. It is also extensively found in some other regions (Orlov et al. 2003; Vengelovsky 2006).

Other forest species in the mountain regions are located along the bottomland and shores of large rivers as well as along many small rivers, occupying about 48,300 ha which is nearly 6% of the country's forests. They typically have water conservation functions. There are narrow, broken forest strips in some mountainous areas, frequently forming riparian woods (tugais) composed of *Populus nigra*, *P. diversifolia*, *Salix alba*, *S. cinerea*, *Elaeagnus angustifolia*, *Tamarix laxa*, and *Hippophae rhamnoides. Ulmus* spp. and poplar forests grow along the shores of Talas River (Orlov et al. 2003; Mátyás 2010).

Among a wide variety of forest ecosystems, archa and spruce are in the highlands, walnut species on the mid-mountains, and tugai species in the low terrains. The dominating tree and shrub vegetation has low biomass growth coefficient, and the country's carbon absorption potential is relatively low. If forest cover expands by 8%, the additional annual accumulation of carbon in the forest reserves will be around 784 Gg CO_2 (Mátyás 2010). The forests mainly include mature and declining stands. There is a gradual transition from one age group to an older group. The area of young plantations is stable; the mature and declining stands cover over 40%. During the next two to three decades of forest aging, mature and declining stands are expected to occupy over 50%, and tree losses in spruce forests will increase due to tree die-off (Podrezov and Titova 2002; Orlov et al. 2003; Mátyás 2010).

The spruce forests as moisture-loving plants are distributed mainly between 1600 and 2900 m of altitudes. The changes in temperature and precipitation patterns are dependent largely on altitudinal changes. For their vertical range, there is a significant vegetation distribution and lack of homogeneity. If temperature increases the lower boundary of these forests, they may ascend by 150–200 m (Orlov et al. 2003).

The Central Asian plains are rich in widespread archa forests, occupying a narrow, thin band, distributed between 1200 and 3200 m. The area of archa forests has decreased by approximately 20% during the last two decades, and the rate of degradation has reached nearly 1% a year (Mátyás 2010). Only the area of sparsely closed

stands has increased by more than 30% nearly by 12,000 ha. Soil erosion is increasing, and avalanches and mudslides have resulted in high damage in the economy. Decrease in soil water is due to the reduction in mountain forests (Orlov et al. 2003; Mátyás 2010).

The forest degradation reasons are industrial wood harvesting and wildfires, heavy livestock grazing, population and livestock growth in the mountainous areas, and increased recreation. Increase in summer temperatures on the archa forest ecosystem will mean gradual move to higher places. It could be 150–200 m higher than present in 2100 (Orlov et al. 2003; Mátyás 2010).

Forest restoration plan covering walnut forests and their development has been developed in the light of global warming, which includes effects on the growing conditions of walnut forests and cultivating walnut trees as well as other useful species, such as apple, pear, quince, jujube, plum, and almond (Mátyás 2010). There is considerable increase in the evaporation in comparison with precipitation as per the analysis of bioclimatic potential results. This is worsening the natural humidity regime in the area. CO_2 increases in the atmosphere; the wetter zone borders are going to shift upwards, by 100–200 m and may be 400 m in certain areas. An increased bioclimatic productivity is observed in the well-watered areas of walnut forests at altitudes of 1400–2300 m in the southwestern region. In the dry steppes and in the semidesert areas covered by pistachio and almond plantations at 800–1400 m, productivity will change or may even go down due to anthropogenic impacts (Blaser et al. 1995; Podrezov and Titova 2002; Orlov et al. 2003; Vengelovsky 2006; Mátyás 2010).There is need for an improvement of forest rules, national adaptation measures to climate change, institutional reform in the forests, sustainable forest management criteria and indicators and improvement of public awareness (Mátyás 2010).

Kyrgyzstan's forest sector is expected to face several threats. Climate change will contribute to the altitudinal advance of the deserts toward the upper border by 400 m. Steppes may advance by 250 m, forests by 150 m, and the subalpine cover by 100 m, leading to changes in many plant types and the main forest-forming species (Mátyás 2010). The lower limit of the European walnut will rise by 100–150 m due to increased soil moisture requirements. This will be conditioned by the increase in the active temperature (Orlov et al. 2003; Mátyás 2010).

The area of drought-resistant bushes like rose hip, hawthorn, and honeysuckle will change in the ecological niche of walnut forest. The pistachio, almond, and jujube can adapt to the increased temperatures and move up by 100–200 m (Mátyás 2010). Degradation of lands will go up in the vicinity of populated areas, with increased possibility of landslides, caused by excessive livestock grazing on the pastures near the villages. Worsening of the survival ability of forest plantations is insufficient financing for use in reproduction, protection, prevention of illegal forest harvesting, and fighting pests and diseases (Orozumbekov et al. 2009; www.forclimadapt.eu). The "Tian Shan Ecosystems Development" project has started as a continuation of the Central Asian transborder study on the preservation of the Western Tian Shan's biodiversity. This will contribute to the improvement of ecosystems management and sustainable forestry in Kyrgyzstan. It will be helpful

in the application of ecological objectives like preservation of biodiversity and mitigation of the climate change through greenhouse gases (accumulation and entrapment) in the forests (Orlov et al. 2003; Mátyás 2010). The Institute of Forest and Walnut Cultivation of Kyrgyzstan is studying bioecological conditions of the forests in order to increase productivity of forest resources by improved management, supporting forest preservation measures and forest protection measures, increasing public awareness, development of sustainable forest management criteria and indicators, and increasing forest resources productivity. Walnut forest upgrading can deliver greater crop yields and provide local populations with more income while reducing damage to forest plantations (Blaser et al. 1995; Vengelovsky 2006; Orozumbekov et al. 2009; Mátyás 2010).

4.10.4 Turkmenistan

Turkmenistan is located in the west of Central Asia, bordered by Kazakhstan, Uzbekistan, Iran, and Afghanistan with an area of 491,200 km^2. The climate is extremely continental, except for the Caspian Sea coast and in the mountains. Maximum temperatures reach 48–50° in the central and southeast Karakum Desert. Average rainfall is 398 mm, with lowest values in the Kara-Bogaz-Gol Bay, averaging 95 mm. One of the largest deserts in the world is Karakum. It occupies the whole central part of the country; four fifths of the country is flat, but mountains and hills are mostly in the south and southwest (Mátyás 2010). Nearly 282.420 km^2 are desert. Water resources are distributed unequally, with more than 90% coming from Amu Darya River. The remaining 5% come from other rivers, streams, and springs. The southern Murghab, Tedzhen, and Sumbar rivers, and the smaller rivers of the foothills of the Kopet Dag, are fully exploited for irrigation (Popov 1994; Gintzburger et al. 2005; Pomfret 2008; www.tm.undp.org).

More than four million hectares are covered by forests, all classified as primary. Forests in the arid climate are of great ecological importance, and their importance is increasing. The timber used is between 30 and 50.000 m^3 per year. There is a reduction in unauthorized felling due to natural gas supply. The paper factory produces around 50,000 tons of paper annually, using cotton plant material and corn chaff as raw materials. Cattle grazing is restricted in areas where it could damage forest growth and development. Unique conditions are conducive to the growth of a range of plants, particularly trees and shrubs, from the Caucasus and Mediterranean regions, as well as from the western Tien Shan. There are extreme continental climatic conditions leading to a range in diversity between the forests of the mountains and foothills, and those of the sandy desert areas. Turkmenistan forests although have suffered negatively and efforts to conserve and protect them began only within the last few decades. Forest conservation in natural areas has been made possible by limiting human use of forest resources and national traditions (Atamuradov and Karryeva 2005; Mátyás 2010).

Turkmenistan has gained experience in forest cultivation using introduced species. The hardy *Pinus eldarica* grows under adverse climatic conditions and continues to grow. Much efforts are made on the planting of coniferous seedlings, and recreational forest area is increasing every year. Forest parks around the capital and in the foothills of the Kopet Dag are noteworthy. All sectors have been mobilized to establish forest parklands in the foothills of the Kopet Dag. More than 30 million saplings and seedlings of nearly 100 species of evergreen and deciduous trees and shrubs have been used (Mátyás 2010). Forest fire prevention organization and tackling diseases and pests have been developed due to the alleviation of climatic conditions and the establishment of forests. There has already been an increase in the number of wild animals and birds in forest parkland areas. Regular irrigation, drinking, and foraging sources for wild animals have increased. These are helping as additional factor in preserving forest biodiversity. In Karakum Desert, Altyn Asyr Lake has been constructed, which collects all drainage water from across the country. Saxaul trees, saltwort, *Ephedra*, desert *Acacia*, and other sand-tolerant species are expected to create conditions for 12 months pasture source for cattle. It will improve the conditions for winter grazing. A national forestry program is being developed to organize forest inventories and organize international and regional exchanges of experience and new practices and technologies in forest management and other organizational issues (Popov 1994; Atamuradov and Karryeva 2005; Mátyás 2010).

4.10.5 Uzbekistan

The total forest area includes 8.661.200 ha, including forest-covered areas, open artificial plantings, sparse forests, fire sites, perished stands, cut sites, groves, and abandoned sites. Forests are divided into mountain, floodplain valley, and desert forests. Approximately 80% of the distribution is of aridity-tolerant species, like *Haloxylon persicum* and *H. aphyllum*, *Salsola richleri*, *S. paletzkiana*, and *Calligonum* spp., together with some desert-type forest vegetation. The mountainous coniferous species occupy 11% of all the forest area, but nuciferous and wild fruit trees occupy around 3% only. Juniper forests are composed of *Juniperus seravshanica*, *J. semiglobosa*, and *J. turkestanica* (Botman 1999, 2008, 2009; Mátyás 2010).

Tugais occupy periodically flooded floodplains and river deltas, dominated by *Elaeagnus angustifolia*, *Populus euphratica*, and *Tamarix* spp., forming 5% of the forest area. Almost 80% of forests are found in Karakalpakstan, Navoi, and Bukhara regions, less than 1% in Sirdarya, Samarkand, and Fergana valley. Forest productivity is very low. The stocking density per hectare of mature and overmature forests on average basis is at 6 m^3, coniferous forests at 29 m^3, hardwoods 6 m^3, and saxaul forests 3 m^3 (Botman 2009; Djanibekov et al. 2012a; Mátyás 2010).

The forests of the country have huge protective importance, as sustainable ecosystems, highly adapted to specific soil-climatic conditions, help in maintain-

ing biological diversity of the fauna and flora. In the mountains, they prevent erosion and other adverse factors. The forest stands mitigate conditions of habitat in deserts, fixing moving sands, protecting economic objects from sand movement, serving as local sources of fuelwood, and increasing productivity of desert pastures. Tugai forests help and play a role in the bank and water protection. Forest stands serve as protection from adverse actions of water and wind erosion in the irrigated plain lands and hot dry winds. They are the source of non-wood forest products like walnut, pistachio, almond, apple, pear, cherry plum, apricot, hawthorn, barberry, as well as mushrooms and berries, herbal medicines, and tanning and dyeing agents. The impacts of climate change on basic forest-forming species like juniper, floodplain valley, and desert saxaul forests have been assessed. The desert forests are around 78% of all forest-covered area, and saxauls account for over 65% of all forests. If habitat conditions become arid around 2080, climate will be warmer and dryer with smaller fluctuation of climatic indices. Climate changes will not affect much the conditions of saxaul stands, but still a decrease in productivity and deterioration of saxaul stands can be expected (Botman 1999, 2008, 2009; Mátyás 2010).

Floodplain and valley forests include forest plantations on irrigated and conditionally irrigated lands. In Uzbekistan, these stands grow only on irrigated or conditionally irrigated lands. Main factor limiting forest growth is access to moisture, which is assured or not assured by human intervention. Tugais occupy periodically inundated floodplains; their remains can be observed along modern riverbeds on surface terraces, if they are flooded from time to time. The remains of degraded tugai vegetation are found in the depth of desert in old river zones where moistening of soil currently depends only on precipitation. However, this vegetation suffers mainly from uncontrolled felling, uprooting with the purpose of agricultural reclamation of such lands, lack of high waters in natural terms due to overregulation of river runoff (regulated flow), lowered groundwater levels, etc. (Mátyás 2010; Djanibekov et al. 2012b).

Mountain forests like *Juniperus* formations need to be studied well during climate change. They are expected to be shifted toward dryer and colder climates. More constricted will become the area of preferred habitat of juniper, especially by 2080. The lower boundary level of Zeravshan junipers (*Juniperus seravshanica*) is expected to rise more, 1000–1050 m, in 2080. Upper boundary of Zeravshan junipers will rise by smaller values, 800–900 m. Semiglobular junipers (*J. semiglobosa*) will go up by 650–750 m and the upper boundary of Turkestan juniper (*J. turkestanica*) by 500–650 m (Botman 1999, 2008; Mátyás 2010). Outcome of such shifts in juniper-growing zones will mean reduction in the breadth of the juniper belt. In general, the juniper belt extent will decrease by 350 m (2080). This area will contract because the higher the hypsometrical level of the soil surface, the smaller its area. Increasing altitude above sea level results in substantial worsening of soil conditions as there is more coarse material, stone screes, shallow soils, etc. This will substantially reduce productivity of woodlands in new habitats and complicate work for their establishment (Botman 1999, 2008; Mátyás 2010). The semiglobular juniper and Turkestan juniper in Gissar-Darvaz forest-planting district may be lost as

forecast according to scenario for 2030 and 2050 (Botman and Agafonova 1999; Botman 1999, 2008; Mátyás 2010). At least younger age classes should be able to transform to tree-type form in future, if situation will not suffer a permanent change. Most vulnerable to climate change are mountain forest stands (Botman and Agafonova 1999; Botman 2008; Mátyás 2010).

Strategies for adaptation of forestry to climate change include national forestry characteristics, forest inventory, database, monitoring, climate change aspects, improvement of forest management, development of forest farms, enhancement of effectiveness of forestry planning, grazing regulation, mitigation of anthropogenic pressures, development of applied scientific research/programs using knowledge gained for interrelation of science with production, legislative initiatives, and institutional changes (Botman and Agafonova 1999; Botman 2008; Mátyás 2010).

Threats for forestry development expected in the near future are lack of objective and detailed information on the conditions of forests, planning of scientifically based forestry development, decrease in the survival rate in regeneration, conditions of existing forests because of lack of material and financial resources, application of truncated technologies, uncontrolled grazing, illegal tree felling, fires, pests, diseases, as well as new and increasing negative climate change impacts, change in forest planting conditions in mountainous areas under the influence of changing climate, spatial shift in current forest areas, a shift upwards of growing boundaries for trees and shrubs, biodiversity loss, reduction in the area of forest-covered lands, reductions in species composition-forest density-productivity, age structure changes in forests because of traditional reasons as well as global warming. Tugai forests are becoming endangered especially *Populus euphratica*. Global warming will lead to increased water consumption in all needs. The reduction of water yield and river sink regulation is also threatening as these unique forests depend on this. The field-protective forest stands may disappear except for coppice linear plantings of mulberry and willow (Botman 2009; Mátyás 2010).

During the last decade, the projects were started on the creation of forest plantations in two forest farms including reconstruction of young forest plantations in order to increase their density in the valley zone of Djambai forestry farm of Samarkand region as well as Zamin forestry farm of Djizzak region in collaboration with locals for better CO_2 sequestration and climate change mitigation, improving methods of reforestation, managing current forests, creation of foundation for future initiatives, and improving existing models of tree growth calculations and assessment models of CO_2 sequestration. It has an indirect connection to climate change but with good sequestration potential due to large afforestation volumes. This project is expected to add to the ecosystem stability on degraded lands in Karakalpakstan and the Kyzylkum Desert. Detailed information on project preparation documents, practical implementation of projects, distribution of benefits from implementation, and rights and obligations of participating parties (Mátyás 2010). Reorganization of forest regulation and statistics is needed. Currently due to unsatisfactory condition of the forest regulation services, available statistics are not trustworthy. There is need for reliable and real statistical data (Mátyás 2010). This, in particular, also refers to statistical data required for undertaking GHG inventory in forestry.

Training in modeling of forest stand productivity in changing climatic conditions can be followed. The forestry sector of Uzbekistan has little experience in modeling, but overgrazing can be observed, as a basic factor due to its impact on the degradation of forest ecosystems. Creation of sustainable models of forest utilization in the mountains and deserts as pastures should be given a priority. Impact of global warming knowledge in forestry among specialists and the general population is a must (Botman and Agafonova 1999; Mátyás 2010).

4.10.6 Tajikistan

Tajikistan covers a total area of 143.000 km^2. The territory stretches 700 km from east to west and 350 km from north to south. It is a mountainous, landlocked country that borders Afghanistan, Uzbekistan, Kyrgyzstan, and the People's Republic of China. Over 70% of the country is high mountains, more than half of which rise 3.000 m above sea level. The east is covered by the Pamir Mountain range; across the north stretches the Alay Range. Only in parts of Khatlon province and in the Ferghana Valley, near the border to Uzbekistan, are small portions of intensively farmed lowland areas (www.pamir.at; www.naturalresources-centralasia.org). Overgrazing and deforestation are disrupting high-altitude ecosystems. This will have disastrous results with erosion signs visible everywhere. Ecologically sound and sustainable pasture and forestry management is a must. Suitable instruments to combine the two forms of land utilization are available but not part of regional planning (Pomfret 2008; Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

Pamir Mountain chain with Pik Ismoil Somoni, rising 7.495 m as the highest peak, lies in the east of Tajikistan. This chain is formed of Tian Shan, Karakoram, Kunlun, and Hindu Kush ranges. Most of the range in Tajikistan, in the Gorno-Badakhshan area. Average elevation is between 3.600 and 4.400 m. There are many glaciers such as "the Fedchenko glacier" 80 km long. It is one of the longest glaciers outside the polar region with a depth of 800 m and an enormous water reservoir. The glaciers contribute to the network of fast-flowing streams, most of which empty into Tajikistan's major rivers the Syr Darya and the Amu Darya. These are the main sources of the Aral Sea. Climate is continental, subtropical, semiarid, and arid. The country is highly vulnerable to global warming as confirmed in recent reports (Pomfret 2008; Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

Agricultural production capacity of the country is not good, forestry can help increase the land value, as its potential has been neglected. Precipitation and forest vegetation grow to the timberline (about 3.700 m) almost everywhere in the country. The forest vegetation can be expanded, which officially is around 410.000 ha. The livestock numbers and management considerably influence forest composition, which is an essential factor in forest degradation in Tajikistan. Elaboration of forest management plans and silvicultural systems should mitigate the livestock factor through better pasture management and/or improvement of pastures. Sustainable

access to grazing can be an incentive to protect forest areas; local communities can be drawn into forest management (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

Forestry needs to be considered as an important part of the economy due to its environmental and ecological impacts. The individuals rely on timber imports, which effect negatively on the country's economy. Most important energy source is firewood. The existing forest resources cannot meet the demand. A comprehensive afforestation program is needed which will meet the needs for production of wood for fuel and construction. Nontimber forest products are important for contributing to the livelihood of rurals. The country's forest resources are relatively small as more than two thirds of the population lives in rural areas. The forest resources are major economic, social, and environmental factors in the livelihood and well-being of rurals. More ecological-economic aspects of forests can alleviate and even stop different types of erosion. Removal of forest cover results in various types of erosion, for example, tugai forests are characterized by thick undergrowth that grow along rivers; if these are destroyed, dangerous mudflows occur more frequently, threatening human lives. Proper protection, preservation, and management of forest resources can reduce risk management. Commercial logging has been prohibited in Tajikistan long back as such, there is need for lowering the country's dependence on timber imports, increasing forest resources, these should be envisaged and will positively impact the trade balance. A nationwide afforestation program is necessary (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

There is no timber industry at present in Tajikistan, and none of the woodworking industries are operating. Tajikistan used to import 400.000 cu^3 of timber from Russia four decades back. Out of this 350.000 cu^3 was processed to create products with added value, while some 50.000 cu^3 was used for fuelwood. Timber for construction is a precious product with high demand, because building typical Pamiri style houses require a lot of wood and 4 × 4 cm wood strips of relatively poor processing quality (conifers) cost much, while 1 cu^3 of construction wood (*Populus* sp.) is very expensive (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

Cutting any commodity from forest areas do not only imply tree harvesting; they include game animals, furbearers, seeds and nuts, berries, mushrooms, oils, foliage, medicinal plants, peat, fuelwood, honey, and the production and sale of seedlings. Nontimber products play a major role in the rural economy. These are essential for daily lives of Tajiks. They contribute to their subsistence and are also traded for cash. Survival of state-owned forests depends on these nontimber forest products. The lezkhoz in the country depends on the harvesting and sale of these products to survive financially. The production of fruit trees in the state-owned nurseries, which are sold to private costumers or planted on lezkhoz land, as nursery revenue is crucial. The demand for fruit trees is higher than that for forest trees, seedling production is of exotic tree species in state-owned nurseries which uses obsolete technology. Seedlings are not raised in containers and are usually sold fairly large and planted bare root. The fruit tree plantations are recorded as "forests" in Tajikistan's official statistics (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

Nearly 70% of the country's population depends on firewood, which is used for cooking and heating. It is in high demand in the country because fuelwood is the most important energy source for rural households and demand is higher than supply. The fuelwood is collected from the woody vegetation and used immediately without drying. However, properly dried fuelwood could significantly increase the efficiency of this energy source. Tajikistan needs 168,000 cu^3 of fuelwood a year; nearly five million Tajiks use fuelwood as their primary source of household energy leading to an average per-capita consumption of 0.03 cu^3. Because of the poorly insulated houses and inefficiency of many stoves, annual demand for fuelwood in the country is higher lying around 15–20 million cu^3 used during the long and cold winters (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

The existing forest cover is not enough to provide so much fuel; locals use dry wood and burn dung. The consumption of fuelwood per year per head is around 3–4 cu^3. A normal populated village will need a plantation area between 270 and 360 ha to meet the immediate fuelwood needs. The availability of good technological sources can reduce fuelwood consumption. The usable forest area in the country should be urgently increased to satisfy the energy needs of its rurals. The establishment of fuelwood plantations around the villages can be a solution to protect the remaining natural forests and reduce the negative impacts of wind and water erosion. A crucial point here is that primary economic value and practical use of forests is for fuel. This issue must be solved by the government, as economic and social importance can be integrated into national planning for forestry (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

Rosa canina juice plays a great role at some places interlinked with the animal diversity like markhor and chukar in these areas together with the forests. Similarly wild boar and the Bukhara deer prefer woodlands and forests. However, it is difficult to consider wildlife from the point of view of forestry. The urial is a species which uses habitats interlinked with forests (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

It is very difficult to get reliable scientific data on the forest areas, up-todate maps are lacking, stocking volumes, species composition, and annual forest-destruction rates in Tajikistan. The data is nearly two decades old. Authentic data has been found in two sources (Akhmadov 2005, 2008). The data is not confirmed through satellite images, aerial photographs, and/or ground inventories. Average annual deforestation rate should be taken into consideration. (www.naturalresources-centralasia.org).

Nearly 25% of Tajikistan was covered by forests nearly a century back. Tugai forests were cut for cotton production, which greatly reduced the forests of the country. Further cutting of forests is forbidden; these have been declared as protected nature and anti-erosion and anti-mudflow zones. The few remaining forests are managed and protected according to the annual plans of government. These plans were implemented for a decade and updated and served another decade as the most important instrument for forest management. These plans have been discontinued after independence leading to an increase in the human pressure on forest resources. Earlier rural households were not guaranteed coal, oil or gas for their daily energy

needs, which led to the ecological disaster of the near-total destruction of forests in the country (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

The forests in Tajikistan are state property. FAO statistics state that the forest area in the country has increased from 408.000 to 410.000 ha during 15 years up to 2005. There is no central database for forests and forestry, because reliable information on forest resources is not available, monitoring of forest resources is inadequate, and all the cartographic material is outdated. Illegal cutting, conversion to agricultural land, fuelwood harvesting, and overgrazing are four major factors in deforestation. Looking at the annual deforestation rate of 2%, some 172.000 ha of forests have been destroyed. Tajikistan's current forest area is estimated at some 250.000 ha. The few remaining forests are heavily degraded, and the stocking volume does not exceed 30 cu^3 per hectare. They are limited to very small relicts in remote and sparsely populated areas (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

Major issues in the forestry are open access which triggers the exploitation of forest resources-for fuelwood and through overgrazing. Fuelwood is in high demand during the winter in rural areas. Inefficient heating and cooking devices in poorly insulated houses add to the pressure on forest resources. The land tenure security and forest ownership awareness are lacking, and legal framework is not clear. Lezkhoz has generally weak administrative and managerial capacities. These are inadequate to overcome these issues. The law enforcement capacities are weak, and forest policies need to be organized to actual development. Sustainable forest management schemes are long overdue, and such reforms trigger impacts on the global and local environment. The establishment of sustainable forest management schemes in Tajikistan cannot be separated from the issues of pasture and fuelwood (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org). All forests in the country are classified as "protective forests." These are essential part of the country's watersheds. Natural forests are divided into five types: broad-leaved mesophilous forests, hard-leaved xerophilous light forests (shibliak), small-leaved microthermous mountain forests, juniper forests, and tugai forests (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

Juglans regia, *Malus* sp., *Acer regeli*, *A. turkestanicus*, and *Platanus orientalis* comprise the broad-leaved forests. Their ecological optimum lies between 1.200 and 2.300 m. The species composition changes from place to place; in some stands, *Acer* sp. predominate, while in others *Juglans regia* prevails. The forests are interlarded with grassland at higher altitudes, growing alongside *Juniperus*. These forests are under threat, but overgrazing prevents natural regeneration and negatively influences the biodiversity of this important ecosystem. For a natural regeneration of these forests, a pasture management system and participation of the rural population are a must. Hard-leaved xerophilous light forests consist of deciduous trees and shrubs, mainly occurring in light stands with a pronounced grass cover. These "shibliak stands" are well adapted to long, dry summers with a brief hibernation period. *Amygdalus bucharica*, *Pistacia vera*, *Calophaca grandiflora*, *Cercis griffithii*, and *Rhus coriaria* are the dominant species in these forests. Pistachio formations occur extensively on slopes and foothills in the southwest of

country. The fuelwood gathering and uncontrolled grazing destroy young seedlings and prevent natural regeneration. Small-leaved forest associations have a dominance of deciduous mesophytic and microthermophilous trees, widespread in the flood belts next to the rivers in all the mountain ranges, from 1.500 m to the timberline. *Betula*, *Populus*, *Salix*, *Hippophae*, and *Fraxinus* are found in the small-leaved forests, which are often invaded by some shrubs and other grassland vegetation forming fairly thick, impenetrable vegetation. These forests have great biodiversity, providing habitat for a wide range of mammals and birds. In the Western Pamirs, remnants of these forests still exist. Small-leaved forests are under heavy pressure, mostly from fuelwood gathering and overgrazing. Their potential to produce firewood is considered great because of high annual increment and the ability of tree species (*Salix* sp. and *Populus* sp.) to coppice (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org). These forests should be included in the priority list for a comprehensive forest rehabilitation program in Tajikistan (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org). These forest resources can stop water erosion and serve as the principal energy source for rural households.

Juniperus forests are dominated by conifer species. Some endemics are *Juniperus sibirica*, *J. turkestanica*, *J. seravschanica*, *J. semiglobosa*, and *J. schugnanica*. The stands do not grow taller than 15 m, forming dwarf forests. They prevent soil erosion and protect hillsides from landslides and soil from being washed away. These forests are drought resistant and light-loving, with either semi-sparse or dense stands. *J. turkestanica* stands are also seen in mixed forests with other locally adapted species (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

In the early nineteenth century, one million hectare of alluvial tugai forests in Tajikistan formed an unusual system of dense forests with thick undergrowth along rivers, but most have been converted to agricultural use with cotton cultivation, which are currently under heavy pressure due to overgrazing, firewood cutting, and illegal felling. These forests are the best natural instrument to reduce the risk of mudflows and flooding. The protection and sustainable management of this important ecosystem should be listed as a priority in regreening the country. Handing over tugai forests to communities residing in the immediate neighborhood is the best solution (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

The remaining forests are deteriorating due to poor management, and many of these are in a bad condition. They are unable to perform normal ecological functions as they are degrading from inside and loss of forested areas is increasing (www.naturalresources-centralasia.org). This poses the danger from natural disasters like floods, landslides, and droughts. The disappearance of vegetation is reducing the biodiversity. Both plants and animals are losing ground. The ecological experts see little future for forests due to poor economic situation of the public. They still rely on timber for heating and cooking in many areas of the region. In southern Jalalabad region, deep hillside logging could lead to landslides hitting at any moment and threatening human settlements. The best recommendation includes increasing the number and area of the nature reserves. Somebody should explain it to the people living in the vicinity of forests, why their preservation is in their own interest. The inhabitants in the region should understand that destroying forests is like burning

their own home. The heavy rain and hail have caused mudslides and floods in southern Tajikistan. Farmlands, more than 3.000 ha of cotton plantations, and roads and bridges have got damaged (Kirchhoff and Fabian 2010).

Tajikistan's few remaining forests are under severe threat due to overexploitation and uncontrolled grazing. These continue to reduce the country's remaining forest cover. The purpose should be to identify principal sector constraints; evaluate the lessons learned; compile reliable data on the forestry; make recommendations regarding policy changes, institutional reforms, capacity building, and financial investments; and prepare the groundwork for more donor participation in the forestry (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

Sustainable, managed forests are a necessary part of the development strategy in Tajikistan. Reliable information on the state of forestry and its resources is indispensable for making decisions about policies, strategies, and programs, as well as developing forestry sector in a sustainable way. This will allow the government, international donors, and other stakeholders to make strategic decisions to stop forest degradation and destruction in the country, with the ultimate goal of sustainable management of countries forests (Kirchhoff and Fabian 2010; www.naturalresources-centralasia.org).

4.10.7 Karakoram

The forests of Karakoram Range bordering Central Asian states are under tremendous threats due to climate change and anthropogenic activities such as overgrazing, increase in population, demographic pressure, household dependency on fuelwood, unscientific pastures beyond capacity, forest fires and storms, lack of financial inputs, and decline in traditional knowledge of sustainable use of forest trees (Faiza et al. 2017). The government of Pakistan needs to develop policies for enhancing the awareness for sustainable harvest of plants, reducing the grazing pressure, sharing equitable resources, increasing the marketing of products, and effective management of trees (Shedayi et al. 2016).

4.10.8 Other Countries

Russia, with approximately 12 million km^2 of boreal forest, has the largest forested area as of any other state on earth. Russian forests contain 55% of the world's total conifers and contribute 11% to the earth's biomass. The estimated deforested land in Russia has been summed up to be 20.000 km^2 (Soja et al. 2007). The areas closer to China have been affected greatly by deforestation, as the main market for timber is in that area (Samarrai 2011). The damage caused by deforestation in Russia is greater as compared to other regions as forests have a short growing season owing to the harsh winters; therefore the forests take a longer time to recover.

As of 2008, if the present rate of deforestation sustains, Indonesia would be wiped clear of its tropical rainforests in 10 years (China is black hole of Asia's deforestation 2006). By 2005, Indonesia had lost over 72% of its intact forests and 40% of all forests completely. Thirty-seven out of 41 national parks are victims of illegal logging, which costs up to US$ 4 billion per annum (Alley 2011).

Ever since the Vikings settled in Iceland in the ninth century, Europe has undergone massive deforestation. This has led to the degradation of vast regions of vegetation and land, soil erosion, and even desertification. Overexploitation, overgrazing under harsh climatic conditions, and logging have destroyed as much as half of the forested regions. Twenty-five percent of Iceland was once used to be covered by thick forests, out of which over 95% has been lost. However, afforestation and revegetation have restored a small part of this land. Sicily is often quoted whenever man-made deforestation is mentioned. Deforestation has been occurring in Italy since Roman times, when it was made an agricultural region, and has never stopped till this day (Porter and Prince 2009). This gradually started to affect the climatic conditions of Italy, leading to a decrease in rainfall and the consequential drying of rivers. One of the direct consequences of this ever-increasing deforestation is that the entire central and southwest provinces of Italy are currently devoid of forests (Trabia 2002). This has also led to a major negative impact on the island's wild fauna, of what little is left inhabits the inland's pastures and crop fields (Porter and Prince 2009).

Southeast Asia is the second world's greatest biodiversity hotspots. However, forest loss is acute in this part of the world. According to the 2005 report of FAO, Vietnam is only second to Nigeria as far as the highest primary deforestation rates are concerned. Over 90% of the Philippine archipelago's old-growth forest has been lost to deforestation. From 2000 to 2012, mangrove forest depleted at a rate of 0.18% per year. Some of the major drivers of loss of mangrove forests are rice agriculture and palm oil expansion (Richards and Friess 2016).

Canada underwent an estimated 56.000 ha of deforestation in 2005, which affected around 0.02% of Canadian forests. The major causes for deforestation in Canada are clearing for agricultural land, pasture, urban development, infrastructure development, hydroelectric development, and recreation. About 75% of this deforestation occurred in the boreal forests of Canada, mainly in Saskatchewan, Alberta, and Manitoba (www.cfs.nrcan.gc.ca). Before 2000, less than 8% of the boreal forests were protected in Canada, and over 50% were allocated to logging companies (Global Forest Watch Canada 2000).

Before the European Americans arrived, over half of the land area of present-day USA was covered with forests, approximately a million km^2 (990 million acres) in 1600. Over the next 300 years, the land was cleared for agriculture, mostly, at a rate that paralleled the population growth. For one person's addition to the population, 1–2 ha of land was cleared of forests for agriculture. This trend faded in the 1920s when, despite of population growth, the amount of crop land had stabilized. In due course, abandoned farmland started to revert to forests, and the forested regions increased from 1952 and peaked in 1963 (approximately 3 million km^2). Since 1963, the forested area has decreased steadily, with the exception of 1991, when

some gain was observed (Myers and Tucker 1987). Most Central American countries have witnessed various cycles of deforestation and reforestation. Intensive agriculture by the Mayan civilization had considerably thinned the forests of Central America in the fifteenth century. Before the arrival of the Europeans, approximately 90% of the region was covered (Myers and Tucker 1987) with thick forests. Eventually, they cleared the land to sustain their demands of wood for exportation of primary products. However, since the 1960s, the main reason for land clearing has become cattle ranching. Though the main driving force in Brazil is debatable, a wide consensus exists that the clearance of land for ever-expanding croplands and pastures played a major role (www.mongabay.com). Certain areas like the Atlantic Rainforest have been reduced to barely 7% of their initial size (Olson et al. 2001; Olson and Dinerstein 2002). Despite many efforts to conserve these forested regions, only a few national parks have truly been protected. Even after all these efforts, almost 80% of logging in the Amazon Forest is illegal (Toyne et al. 2002). In 2008, a record increase was seen in the deforestation rates in the Amazon, which spiked up by 69% of what it was only a year ago (www.foxnews.com). WWF's new report states that if the current deforestation rates are not controlled, almost 60% of the Amazon could be completely wiped out or severely damaged by the end of 2030 (www.guardian.co.uk).

Australia was colonized relatively recently, which is why it has undergone high rates of deforestation, especially for agricultural purposes. Most of the clearing in recent years has occurred in Queensland and Tasmania (McAlpine et al. 2009), but the rates are expected to decrease once the new legislation has been implemented. Deforestation is thought to be responsible for almost 12% of Australia's total carbon emissions in 1998 (www.fpa.tas.gov.au). The expansion of urban areas is an additional factor that has contributed to loss of forests in Australia. The Littoral rainforest has also been victimized due to urban development, especially due to ribbon development (www.pittwater.nsw.gov.au). For 800 years that humans have occupied New Zealand, it bid farewell to almost 75% of its forests. Deforestation was initially carried out through wholesale burning of the forests by the Maori and Europeans, but the remaining forests were cleared to suffice the lumber demands of the increasing population. However, by 2000 all logging of the native trees was stopped in the public land (McAlpine et al. 2009). One of the world's largest rainforests is found in Papua New Guinea. It had the highest rate of illegal logging in the world in 2007, out of which 70–90% were estimated to be carried out for timber export (Alley 2011).

4.11 Conclusions

Trees are a source of oxygen, and if they vanish, so does clean air. Not all deforestation is intentional. A small portion of it is due to usual catastrophes like forest fires and overgrazing that halt trees from growing. Deforestation can be resolved merely if every single individual cooperates to stop people from vandalizing

animals homes. It is the individual effort with regard to halting deforestation trends that can ultimately save the planet. Deforestation can be controlled using drastic measures including demarcation of forest boundaries, land use control policy, and afforestation campaign (Nazir and Ahmad 2018). Food sufficiency depending on forests is to be reduced to protect the forests. Moreover, afforestation must be started with planting of man-made forests on a large scale (Erb et al. 2016). The rate of deforestation can be reduced by enhancing awareness in the general public about the benefits of forests and establishing regulations to protect forests (Getahun et al. 2017).

Deforestation is a major issue in all of the Central Asian countries, which also leads to the loss of habitat and biodiversity. Due to increasing anthropogenic pressures, forests are deteriorating. In the Central Asia, around 30% population of rural areas lives near forests and depends on forest products. Studies show a tremendous increase in deforestation in this region. As of 2006, Tajikistan has the least amount of forests, 3.9%, whereas Uzbekistan has the highest percentage of forest covered land, which is 10.1%. Kyrgyzstan, Kazakhstan, and Turkmenistan have 6.2, 7, and 8.8% of forests and woodland covers, respectively (Djanibekov et al. 2015). Welfare in Central Asia largely depends on the mountain ecosystems of Pamirs, Tien Shan, and Altai, and they are under a great threat. These areas experience increase in deforestation and erosion together with other environmental degradations. There is an uncontrolled livestock grazing, illegal logging, and the plowing of slopes. All these have increased number of landslides, mudflows, and erosion in general. Overexploitation of natural resources, unsustainable land practices, and deficiencies in forest management are the major causes in this connection. The degradation of ecosystems has and is leading to a significant loss in biodiversity. The number of species and plants, which have disappeared or are endangered to become extinct, is constantly growing with irreversible consequences in some cases (www.ec-ifas.org).

Ecologists warn that if logging continues unabated in the region, all of middle Asia will face dire consequences such as water scarcity, health problems, and more frequent natural disasters. With forests shrinking together with the rate at which glaciers melt, main source of water in Central Asia is facing serious threats. The reports mention that only 4.3% of the mountainous territory is now forested. It was between one half and two thirds of the area 50 years ago. Nearly five decades back, the area was 6–8% in Kyrgyzstan alone. The deforestation rate has been worst during 1940–1950. Those times people here used to cut down timber for heating and cooking. Over the last 15 years, deforestation has increased as a result of economic crisis. There has been no commercial logging industry; still the forests have been damaged badly. The official figures show that 50.000–55.000 m^3 of trees were cut per year till 2006. From then onward, a 3-year moratorium was imposed on felling trees in particular valuable tree species in virgin forests. As a result of this, the legal logging has got reduced to 15.000 m^3 per year. This has raised hopes for the survival of remaining woods in the region. However, in spite of all these, deforestation is still an acute problem.

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