The Economics of Ecosystems and Biodiversity for the Forestry Sector of Adjara Autonomous Republic, Georgia

Prepared by Dr. Luke Brander, Mr. Chansopheaktra Sovann, Dr. Davit Kharazishvili and Ms. Nino Memiadze on behalf of WWF-Caucasus Programme Office

December 2016

Table of contents

Executive Summary

- The Economics of Ecosystems and Biodiversity (TEEB) is an international initiative promoting sustainable economies in which the values of biodiversity and ecosystem services are fully reflected in decision-making.
- This document describes a TEEB study that was conducted for the forestry sector of Adjara Autonomous Republic. The study assesses the economic value of forest ecosystem services under alternative scenarios for future forest management, focusing on ecosystem services that are of high importance and potentially threatened, and prepares relevant policy recommendations.
- The Autonomous Republic of Adjara is located in southwestern Georgia on the coast of the Black Sea. It has a population of 333,953 spread over 2,880 km^2. Adjara is predominantly mountainous and has highly varied climate conditions. It has the highest density of forest cover of any region in Georgia, covering 66 percent of the territory.
- Adjaran forests provide a range of ecosystem services including timber, fuel wood, non-timber forest products (NTFPs), tourism and recreation, hunting and fishing, regulation of natural hazards such as flooding and landslides, and global climate regulation through storage of carbon. Following stakeholder discussions, the following ecosystem services were identified as the focus of this study: fuel wood, NTFPs, carbon storage and landslide regulation.
- Three alternative descriptions of future forest management paths for the period 2015-2035 are developed and assessed:
    - Business-as-Usual Scenario represents the region as narrowly oscillating around current capacities and interests. Present conditions continue into the future and there is no appreciable change in forest quality or quantity.
    - Degradation Scenario represents a region in crisis. There are intertwined economic and political pressures, from within and outside which buffet Adjara, leading to reduced budgets for forest management and less international cooperation. Localised over-exploitation of forest resources results in an 18% decline in forest cover close to population centres by 2035.
    - Managed Use and Restoration Scenario represents the full implementation of the Adjara Forest Agency Strategic Plan (2015). Degraded forests are restored and communities no longer harvest their own wood for social uses and their needs are supplied by the Forest Agency. Forest cover in the vicinity of villages is increased by 16% through the restoration of pasture, scrub and sparse vegetation.
- The purpose of the scenario analysis is to provide useful reference points for policy development. The Degradation and Restoration scenarios are assessed relative to the Business-As-Usual scenario to understand how the provision and value of ecosystem services changes with changes in forest management. Land use changes under each scenario are modelled in a GIS and the resulting changes in the flows of ecosystem services are modeled using the InVEST tool. Changes under each scenario are assessed at two points in time (2020 and 2035) in order to enable the evaluation of short term and long term impacts on ecosystem services. The economic value of changes in the flows of ecosystem services are subsequently estimated using a selected set of valuation methods.

- The changes in the economic value of forest ecosystem services in Adjara are represented in Figure E1. Under the Degradation Scenario, there is an annual loss in welfare of almost US$ 1.3 million in 2035. Over 50% of this loss is due to increased landslide damages. Under the Restoration Scenario, there is an annual welfare gain for Adjarians equivalent to just over US$ 300,000 in 2035. These gains are mainly due to increased provision of fuel wood and reduced landslide damages. An additional potential benefit of almost US$ 400,000 per year could be obtained if the additional carbon captured by increased forest cover could be certified and carbon credits sold.
- The results suggest that there is a strong economic case for well-conceived policy interventions that can improve forest conditions and increase forest cover in Adjara. To facilitate the design and implementation of such policies in Adjara, it is necessary to address several underlying constraints, including: 1. knowledge deficit regarding the value of forest ecosystem services; 2. gaps in the framework of laws and regulations for forest management; 3. capacity constraints in the Adjara Forest Agency; 4. lack of empowerment for local decision making; and 5. lack of reliable sources and data on forest condition.

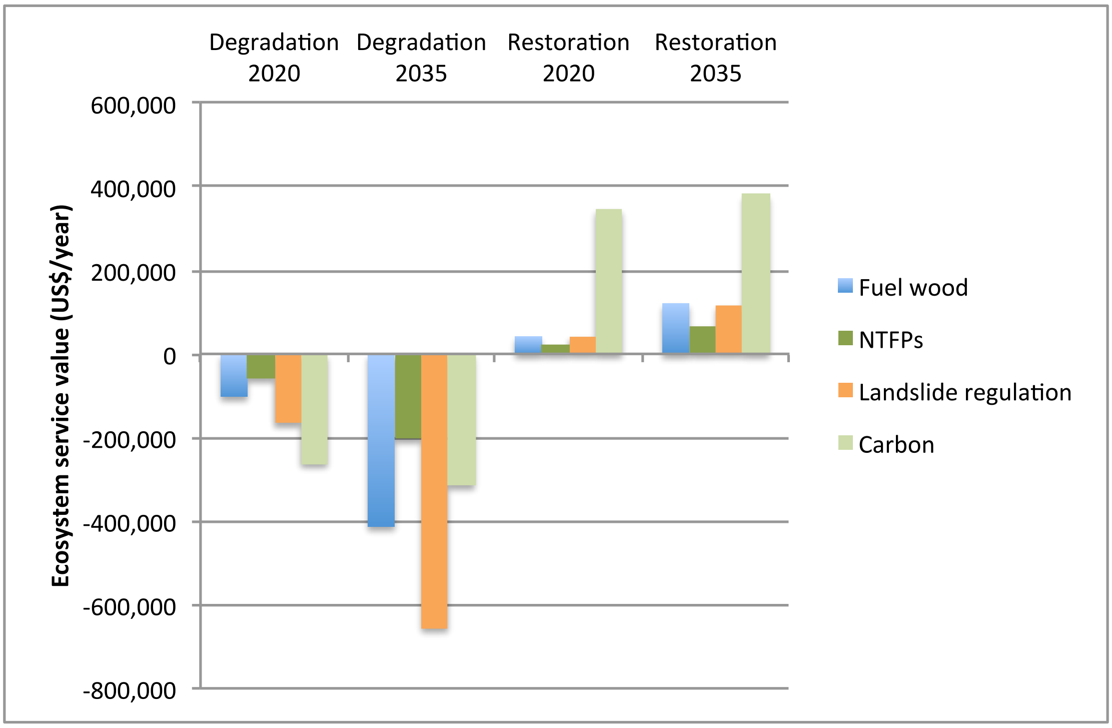

Figure E1. Changes in annual ecosystem service values from Adjaran forests (US$/year)

1. Background

Project Background

The European Union funded "European Neighborhood and Partnership Instrument (ENPI) East Countries Forest Law Enforcement and Governance (FLEG) II Program" aims to support the participating countries to strengthen forest governance, policy, legislation and institutions. The Program is implemented in seven countries: Armenia, Azerbaijan, Belarus, Georgia, Moldova, Ukraine, and the Russian Federation. It is carried out over a four-year period, ending in December 2016. Its implementation is led by the World Bank, working in partnership with the International Union for Conservation of Nature and the World Wide Fund for Nature (WWF).

The Austrian Development Agency (ADA) provides additional funds to support Program activities in Armenia and Georgia. The main Program activities which are implemented by WWF-Caucasus Programme Office (WWF-CauPO) with the support of ADA in Georgia include evaluation of biodiversity and ecosystem functions of forests, promoting sustainable forest management, restoration of natural forest landscapes and conservation of forest biodiversity.

The Economics of Ecosystems and Biodiversity (TEEB) is one of the important components of the Program. TEEB is an international initiative promoting sustainable economies in which the values of biodiversity and ecosystem services are fully reflected in decision-making. In 2007, the German Federal Ministry for the Environment and the European Commission initiated work on TEEB. In 2013, as a joint effort of the Government of Georgia, United Nations Environment Programme (UNEP) and WWF–Caucasus Programme Office (WWF-CauPO), the "TEEB Scoping Study for Georgia: Main Findings and Way Forward" was produced. The study assessed five sectors of the Georgian economy – energy, tourism, agriculture, mining and forestry, demonstrating that these sectors largely depend on natural ecosystems. The need for a full-scale TEEB study was also identified.

In the framework of the FLEG II Program, it was decided (based on the agreement with the key stakeholders, including respective state forestry authorities) to conduct a full-scale TEEB study for forests and the forestry sector of Adjara Autonomous Republic (Georgia). Main reasons were the high percentage of forest cover and the essential protective (ecological) and socio-economic functions of forests in Adjara.

This first interim report of the TEEB study for the forestry sector of Adjara Autonomous Republic provides details of the scoping phase of the study. Specifically, it provides a summary of discussions at the kick-off stakeholder workshop; summary of discussions at subsequent (individual) stakeholder meetings; a refined set of objectives for the study; a list of the key ecosystem services to be assessed in the study and the assessment methods to be applied; an outline of the forest management scenarios to be assessed; a list of data needs and the means of collection; and an outline for the TEEB study report.

Background: Historical, Political and Economic Contexts

Located at the intersection of Asia and Europe, Georgia straddles the Caucasus mountains which formed when the Arabian plate collided with the Eurasian plate 25 million years ago. To its west lies the Black Sea, to its south Turkey and Armenia, to its southeast lies Azerbaijan and to its north lies Russia. Although it is not densely populated—Georgia has about 3.9 million people spread over an area of approximately 70,000 square kilometers—it is a fairly diverse country. They are divided into 11 administrative units comprising of 9 provinces, the capital city Tbilisi and the Autonomous Republics of Adjara and Abkhazia.

After peaking in political and economic power in the 12th century under the King David and Queen Tamar, Georgia remained for centuries dominated by its much larger neighboring empires. Till the 18th century, the Islamic Ottoman and Persian empires were the main contenders over this territory. After the mid-18th century, the Russian empire began to emerge as the main power in the region. Over the following decades, the territory of Georgia was gradually absorbed into the Russian empire. Revolution in Imperial Russia and the ensuing chaos led to a brief period of Georgian independence in 1918-1921. In 1921, the country was invaded by the Red Army and Georgia was absorbed into the Soviet Union as the Soviet Socialist Republic. After the dissolution of the Soviet Union, Georgia became independent again in 1991.

Civil, political and economic turmoil followed the dissolution of the Soviet Union and paralyzed Georgia's post-independence progress. Fissiparous tendencies suppressed during Soviet times re-emerged in the entire South Caucasus region leading to enduring and still unresolved territorial conflicts. Economic output also suffered with the rapid dismantling of economic ties existing in the Soviet period. Consequently, by 2010, Georgian GNP remained less than what it had been during Soviet times.

The Rose Revolution in 2003 was the beginning of Georgian efforts to restructure and modernize its governance and economy, moving away from its Soviet underpinning. A series of subsequent economic reforms and anti-corruption measures swiftly implemented by the Georgian government gained notable mention in the international press and in publications such as those of the World Bank. This was followed by a period of sustained economic growth in which foreign investment played a prominent role. Gross Domestic Product (GDP) increased from about US$ 3 billion to US$14 billion and GNI per capita increased from US$ 750 to US$ 4,160 between 2000 and 2015 (Figure 1). As an indicator of this progress, Georgia was recently reclassified by the World Bank from a lower middle income country to an upper-middle income country (World Development Indicators).

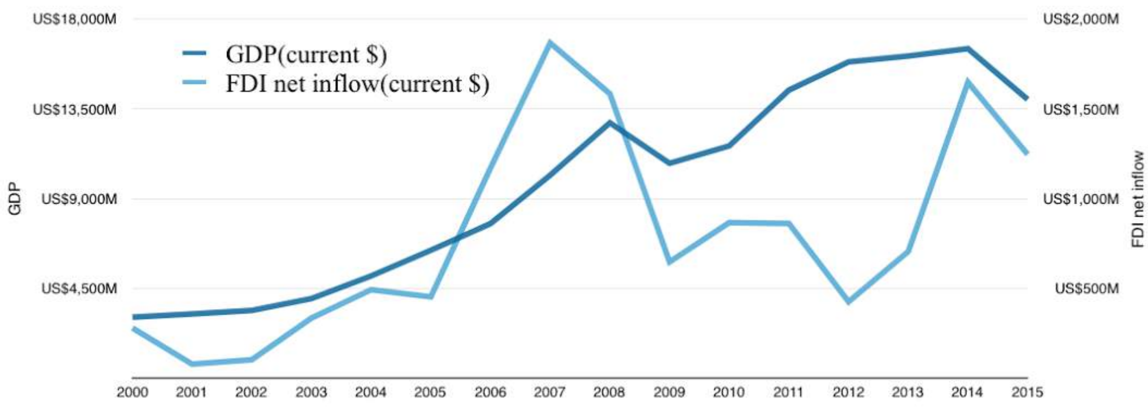

Figure 1: Georgia GDP and FDI net inflows 2000-2015. Source: World Development Indicators

However, this period of growth came only after major economic decline in the 1990s, during which Georgia's GDP had halved (Figure 2), which means that so far the country has only made up lost ground. The annual GDP growth rate peaked in 2006-07 (at 12.3 percent), corresponding with a massive ten-fold rise in FDI from 2002 to 2007. External shocks, i.e. the armed conflict with Russia and global financial crisis between 2008-09, led to a dip in the GDP growth in 2009. Although the economy recovered in the subsequent years up to 2014, FDI inflows have not recovered to their previously high levels. GDP growth slowed down once again in 2015 due to recessions in major trading partner countries such as Azerbaijan and Russia.

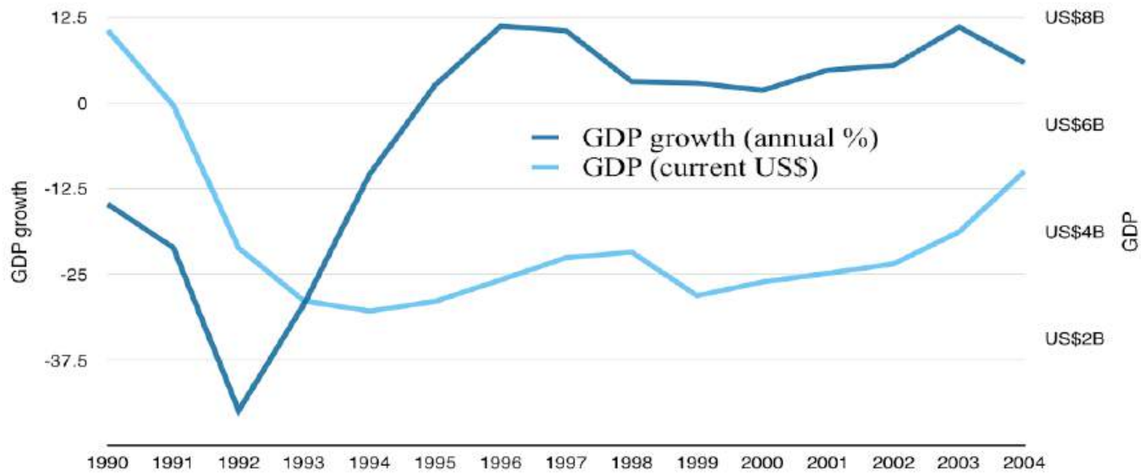

Figure 2: Georgia GDP and annual growth rate, 1990-2004. Source: World Development Indicators

Despite these travails, Georgia is starting to consolidate its political and economic modernization. Political power was relatively smoothly transferred from the ruling party to the opposition after the elections of 2012. The economy is also diversifying. Trade and industry are the largest sectors of the economy (16.5 percent each), followed by Transport and Communication services (10.7 percent), and Public Administration (9.3 percent). Agriculture, Forestry and Fishing (9.2 percent), and Construction (8.0 percent) are the other important sectors of the economy (Figure 1, Geostat 2015). Tourism is one of the fastest growing economic sectors in Georgia – total contributions accounting for 23.5 percent of GDP and 20.1 percent of total direct and indirect employment in 2015. The sector also currently provides as much as 36.4 percent of total export earnings. Georgia's major industrial activities include mining, energy production, and manufacturing metals and machinery. In agriculture, livestock breeding and cultivation of grapes, hazelnuts, and citrus fruits are the main activities (UNEP & WWF 2013). A per capita GNI was US$ 4,160 in 2015 (World Development Indicators).

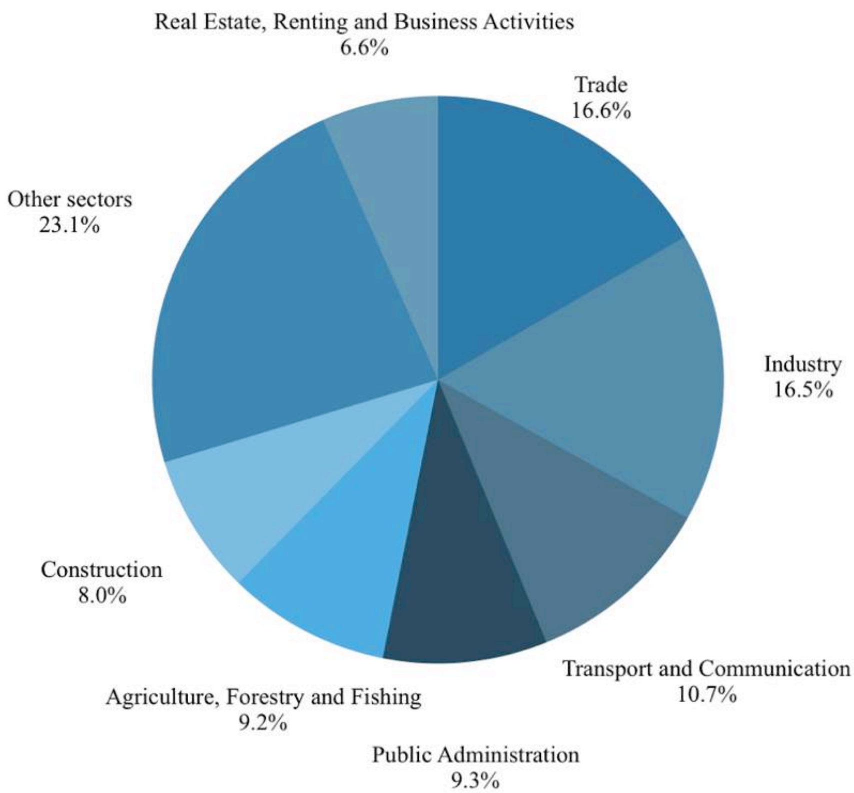

Figure 3: Georgia GDP Structure in 2015. Source: Geostat (2015)

2. Introduction

This chapter sets out the objectives of the study and provides a brief overview of the Ecosystems Services approach; The Economics of Ecosystem Services (TEEB); the state of the environment and forests in Adjara; and the key challenges facing Adjaran forests.

Objectives of this study

The main objective of this study is to conduct a full-fledged TEEB study for the forestry sector of Adjara Autonomous Republic and prepare relevant policy recommendations. The study will contribute to the fulfillment of the FLEG II Program Development Objective “Review or revise forest sector policies and legal and administrative structures; improve knowledge of and support for sustainable forest management and good forest governance (including the impact of related EU regulations) in the participating countries”. The outcomes of this study should help achieve sustainable forest management in Adjara. To this end the specific objectives of the study are to:

1. Develop alternative future scenarios for forest management and forest condition in Adjara.
2. Assess the economic value of forest ecosystem services under alternative scenarios for future forest management, focusing on ecosystem services that are of high importance and potentially threatened. The analysis should represent spatial variation in pressures and ecosystem service values and examine their implications.
3. Develop policy recommendations for forest management in light of the results of the economic analysis.

Ecosystem Services

Human Well-Being & Ecosystem Services

Ecosystem services have been gaining increasing interest from policymakers and research communities in recent years (Costanza et al. 1997; Millennium Ecosystem Assessment (MA) 2005; TEEB for National and International Policymakers 2009; De Groot et al. 2010; Costanza et al. 2014). Nature provides a wide range of indispensable services including food, water, and climate regulation that contribute to the health, livelihoods, and security of communities across the world. Until population and industrial pressures started putting severe pressure on ecosystems, little attention was paid to the value they provided to society. Once carrying and absorptive capacities began to be visibly stressed in the latter half of the 20^{th} century, interest in ecosystem services and how to safeguard them began to permeate policy agendas.

Since ecosystem services are generally not traded, conventional markets do not reflect the true value of these services and they are often ignored in the financial and economic calculations that guide decision making. This leads to a bias against protecting the environment, which is usually not apparent or visible in the short-term but can have major deleterious effects in the longer term on human health and the economy. As a result, 60 percent of ecosystem services are “being degraded or used unsustainably” (MA 2005). To illustrate this tendency, the TEEB Guide for National and International Policymakers (2009) highlights that:

- Over the last century, the planet has lost 35 percent of mangroves, 40 percent of forests and 50 percent of wetlands.
- More than a billion people in developing countries rely on fish as a major food source, yet 80 percent of the world's fisheries are over-exploited.
- Deforestation is a major problem, accounting for between 18-25 percent of global CO_2 emissions, yet the global net loss of forest area between 2000-2005 was 7.3 million hectares/year.
- Studies estimate costs up to $500 billion by 2010[1] as a result of failure to stop biodiversity loss.

Policy interventions based on more accurate information provided by valuation of ecosystems serves are needed. In the 1990s, a series of innovative studies made the first attempts to estimate the value of ecosystems services (Costanza et al. 1997, Daily 1997). The results of these studies indicated the extent of our dependence upon the natural world. More recent estimates suggest that ecosystems services are now providing as much as US$ 145 trillion annually (Costanza et al. 2014).[2] These studies also suggest that ignoring ecosystems services will lead to a significant decline in human well-being and economic wealth (MA 2005, TEEB for National and International Policymakers 2009).

Ecosystem Services & Conceptual Frameworks

The concept of ecosystem services provides a useful means to identify the economic importance of the natural environment to humans. The term "ecosystem services" has been defined in a number of different ways (see definition box 1) but put most simply, they are the variety of benefits that people obtain from the environment.

[1] estimated value of ecosystem services that would have been provided if biodiversity had been maintained at 2000 levels

[2] $ 125 trillion/year assuming updated unit values and changes to biome areas, $145 trillion/year assuming only unit values changed (Costanza et al. 2014)

Definition Box 1: Ecosystem Services

A number of different definitions of ecosystem services have been developed through different initiatives. These include:

Ecosystem services are the benefits that ecosystems provide for people (Millennium Ecosystem Assessment – MA, 2005).

Ecosystem services are the direct and indirect contributions of ecosystems to human well-being (The Economics of Ecosystems and Biodiversity – TEEB, 2010)

Ecosystem services refer to those contributions of the natural world that are used to produce goods which people value (UK National Ecosystem Assessment – UKNEA, 2011).

Ecosystem services are the contributions that ecosystems make to human well-being (Common International Classification of Ecosystem Services – CICES, 2012).

Similarly there are a number of different classification systems for ecosystem services including those developed by the MA (2005), TEEB (2010), and CICES (2012). All classifications make a distinction between "provisioning", "regulating" and "cultural" services. The Millennium Ecosystem Assessment classification also includes the category "supporting" services.

Provisioning services are the "tangible products obtained from ecosystems". Examples include food, timber and fuel.

Regulating services are the "benefits obtained from the regulation of ecosystem processes". Examples include water flow regulation, carbon sequestration and protection from storms.

Cultural services are the "non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences".

Supporting services "are necessary for the production of all other ecosystem services". Examples include nutrient cycling, soil formation and primary production.

The distinction between supporting services and other ecosystem services is related to the distinction between "intermediate" and "final" ecosystem services, which can be defined as:

Final ecosystem services are the last item in the chain of natural processes that provide inputs to the generation of products (goods and services) that are used by humans. Some ecosystem services are used as inputs in the production of manufactured products (e.g. trees used to make timber) whereas others are consumed directly (e.g. a natural area used for recreation) (UKNEA, 2011).

Intermediate ecosystem services are natural processes that contribute to other ecosystem functions, but do not directly input into the production of goods consumed by humans (UKNEA, 2011)

The concept and understanding of ecosystem services and their economic values has been greatly advanced during the past decade through a number of international initiatives, most notably the Millennium Ecosystem Assessment (MA, 2005) and The Economics of Ecosystems and Biodiversity (TEEB, 2010a) – both supported by the United Nations Environment Programme (UNEP).

The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative focused on drawing attention to the economic benefits of ecosystem services and biodiversity. TEEB presents an approach that can help decision-makers recognize, demonstrate and capture the values of ecosystem services and biodiversity. The TEEB initiative was started in 2007 by the environment ministers of the G8+5 countries who wanted to "initiate the process of analysing the global economic benefit of biological diversity, the costs of the loss of biodiversity and the failure to take protective measures versus the costs of effective conservation."

TEEB identifies three tiers for using economic valuation of ecosystems and biodiversity (TEEB 2010b). The first is *recognising* value or a qualitative acknowledgement of the benefits that ecosystems and biodiversity provide. The second tier is *demonstrating* value and requires quantifying ecosystem services in monetary terms. The third and final tier is *capturing* value, which consists of a detailed economic analysis for policies that provide incentives for ecosystem conservation. For each decision making context the need for detail in the economic assessment of ecosystems and biodiversity will be different. In some cases the recognition of value may be sufficient to initiate conservation efforts, whereas in other cases a full economic assessment that demonstrates and captures ecosystem service values may be needed to align the interests of all parties involved.

The TEEB framework can be used to achieve a variety of goals. One is to make people in general and policy makers in particular explicitly aware of the benefits they obtain from natural resources. Many ecosystem services are taken for granted, such as the benefits of a stable climate but also of going out to fish or collect wood for a fire. Another goal is to illustrate whose livelihoods will be affected by a change in ecosystems. The loss of a large section of mangrove forest may be lamentable to those who value its biodiversity, but the landowner who acquired the rights to develop the area is unlikely to accept a delay or decrease in his return on investment.

The TEEB framework for demonstrating and capturing economic value consists of six steps:

1. Specify and agree on the problem.
2. Identify which ecosystem services are relevant.
3. Define information needs and select appropriate methods.
4. Assess expected changes and risks for the flow of ecosystem services.
5. Identify distributional impacts of policy options.
6. Review, refine and report results.

The TEEB guidance manual for country studies (TEEB, 2013) provides detailed guidance on these six steps together with illustrative case studies.

Economic valuation of ecosystem services

The rationale for economic valuation of ecosystem services is to support decision making. The reasoning is as follows. Ecosystem services contribute substantially to human welfare and in some cases are fundamental to sustaining life (e.g. climate regulation, nutrient recycling). The natural resources from which these services flow are, however, finite and cannot necessarily be regenerated or replaced. With growing human populations and consumption per capita increasing over time, it is highly likely that human use of natural resources will outstrip their availability (i.e. human use of the environment will be unsustainable). These simple realities of resource limitation mean that choices have to be made between alternative uses of available resources; and every time a decision is made to do one thing, this is also a decision not to do another. In other words, values are implicitly placed on each option. This valuation is unavoidable and is the essence of decision making. So if valuation of alternative resource uses is unavoidable in making decisions, it is arguably better to make these values explicit and ensure that they are well informed in order to aid decision making. The economic valuation of natural resources and ecosystem services attempts to do this.

The economic value of ecosystem services is a quantitative measure of the contribution of these services to human wellbeing (Pascual et al., 2010). Economic values for ecosystem services are generally expressed in monetary units so that they can be directly compared with other economic values in decision-making processes. In market-based economies, economic values for goods and services are conventionally observed as market prices that reflect the benefits of consumption (demand) and the costs of production (supply). For most ecosystem services, however, markets do not exist due to their open-access nature and so economic values are not readily observable. In such cases, economic values can be estimated using so-called non-market valuation methods.

The concept of Total Economic Value (TEV) of an ecosystem is used to describe the comprehensive set of utilitarian values derived from that ecosystem. This concept is useful for identifying the different types of value that may be derived from an ecosystem. TEV comprises of use values and non-use values. Use values are the benefits that are derived from some physical use of the resource. Direct use values may derive from on-site extraction of resources (e.g. fuel wood) or non-consumptive activities (e.g. recreation). Indirect use values are derived from off-site services that are related to the resource (e.g. downstream flood control, climate regulation). Option value is the value that people place on maintaining the option to use an ecosystem resource in the future. Non-use values are derived from the knowledge that an ecosystem is maintained without regard to any current or future personal use. Non-use values may be related to altruism (maintaining an ecosystem for others), bequest (for future generations) and existence (preservation unrelated to any use) motivations. The constituent values of TEV are described in Table 1 and represented in Figure 4.

It is important to understand that the "total" in Total Economic Value refers to the aggregation of different sources of value rather than the sum of all value derived from a resource. TEV is a measure of total value as apposed to partial value. Accordingly, many estimates of TEV are for marginal changes in the provision of ecosystem services but "total" in the sense that they take a comprehensive view of sources of value. The main purpose of estimating TEV is to show the marginal effect on ecosystems arising from policy changes, and the resultant benefits or costs for wellbeing. The TEV and ecosystem service concepts are complementary, and their relation is shown in Table 2.

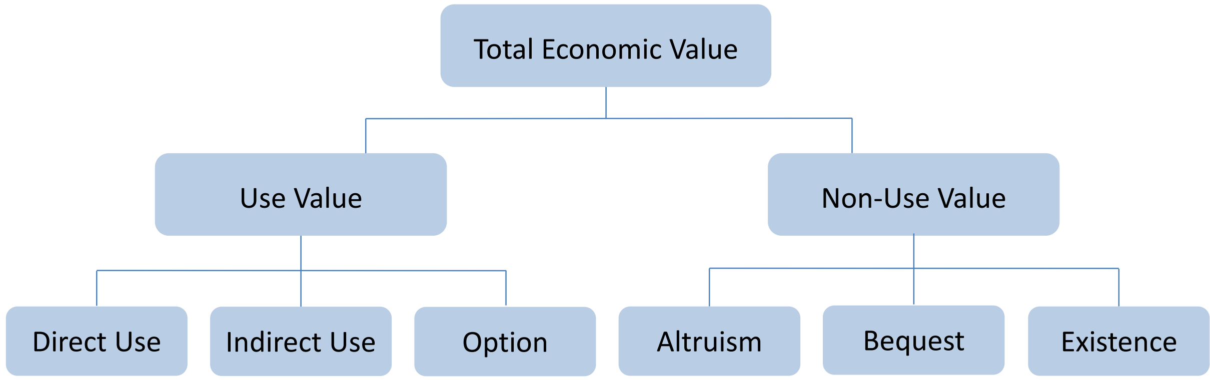

Figure 4: The components of Total Economic Value

Table 1: The components of Total Economic Value. Source: TEEB Foundations 2010

Value type	Value sub-type	Meaning
Use values	Direct use value	Results from direct human use of biodiversity (consumptive or non consumptive).
	Indirect use value	Derived from the regulation services provided by species and ecosystems
	Option value	Relates to the importance that people give to the future availability of ecosystem services for personal benefit (option value in a strict sense).
Non-use values	Bequest value	Value attached by individuals to the fact that future generations will also have access to the benefits from species and ecosystems (intergenerational equity concerns).
	Altruist value	Value attached by individuals to the fact that other people of the present generation have access to the benefits provided by species and ecosystems (intragenerational equity concerns).
	Existence value	Value related to the satisfaction that individuals derive from the mere knowledge that species and ecosystems continue to exist.

Table 2: Correspondence between ecosystem services and components of Total Economic Value. Source: Adapted from TEEB Foundations (2010)

	Total Economic Value			
Ecosystem service	Direct use	Indirect use	Option value	Non-use
Provisioning	X		X	
Regulating		X	X	
Cultural	X		X	X

Broadly, there are three approaches for methods of economic valuation – market valuation, revealed preference, and stated preferences (TEEB Foundations 2010). The first approach, direct market valuation includes methods that rely primarily on data from actual markets regarding costs and benefits. The second approach is termed the revealed preference approach and relies on observations of individual choices in existing markets. Finally, in absence of any markets related to the ecosystem service, the stated preference approach can be used to get data from surveys regarding hypothetical markets.

The market valuation approach can further be divided into price, cost, and production based sub types. Price based methods measure the value of an ecosystem service for which there is well functioning market, so that the price is a good indicator of its value. Production based methods estimate the effect of ecosystem services on goods traded in the market with the aim of bringing out the linkage between improvements in ecosystems and economic outcomes.

Cost based methods estimate the costs incurred if the services have to be replaced by artificial means (Garrod and Willis 1999 in TEEB Foundations 2010). In cost based methods, there are multiple techniques that can be applied. The *avoided cost method* accounts for the costs that would be incurred in the absence of given ecosystem services. The *replacement cost method* aims to measure the costs of replacing ecosystem services with artificial technologies. The *mitigation/restoration cost method* estimates the costs of restoring damaged ecosystem services or mitigating the effects of their loss/damage.

Selection of a valuation approach and method is linked to the MA and TEV frameworks. For example, the valuation of cultural services is typically through stated or revealed preferences methods given the lack of markets for this type of services. On the other hand, provisioning and regulatory services are typically valued in market approaches due to the ability to access or generate data on costs of production or consequences of damage.

Consider the example of valuation methods used for ecosystem services in forests. The methods that have been used in these valuations differ considerably depending upon the type of ecosystem service of the forest being studied. For cultural services, the majority of studies use a revealed preference approach (57%), followed by a stated preference approach (37%) (TEEB Foundations 2010). When it comes to provisioning services, most studies use either a cost based (30%) or production based (30%) approach with the most commonly used technique being the factor income method. Regulating services are almost always valued using the cost based approach (69%), with avoided cost, replacement cost and damage cost being the most commonly used valuation methods. Finally, supporting services are usually valued using the stated preference approach (50%) and occasionally through the revealed preference approach (36%).

Thus, there are several options for valuation of ecosystem services, and the selection of an appropriate valuation approach and method depends on the nature of the ecosystem service being studied and the type of value being measured.

State of the Environment and Forests in Adjara and Georgia in General

The Autonomous Republic of Adjara is located in southwestern Georgia on the coast of the Black Sea. It has a population of 333,953 spread over 2,880 km^2 (2014 Census). Adjara is divided into 6 administrative units – Batumi city, Qeda, Khelvachauri, Khulo, Kobuleti, and Shuakhevi Municipalities (districts). Adjara, due to its status, enjoys more autonomy than other Georgian regions.

Ecological Conditions

Georgia is well known for its highly diverse ecology. It is mostly a mountainous country. Forests cover about 40 percent of the total territory, which is the highest proportion in the Caucasus region. The climate varies by region, with a continental climate in southern regions, humid subtropical climate in the west, and a moderately humid climate in eastern Georgia. Its diversity in natural conditions corresponds with a richness in biodiversity that is of global significance. For this reason, Georgia is on the list of 200 ecoregions identified by WWF across the globe (WWF 2007 in UNEP & WWF 2013). In addition, Georgia is part of two of the 34 global biodiversity hotspots—areas with a high concentration of endemic biodiversity and a high degree of vulnerability to environmental threats (Mittermeir et al. 2005 in UNEP & WWF 2013).

Like the rest of Georgia, Adjara is also predominantly mountainous. Mountains comprise 80 percent of its territory, while foothills and lowlands cover only 15 percent and 5 percent respectively. The mountainous relief itself is quite diverse. The highest mountains of Adjara have an altitude of less than 3,000m and do not have a permanent snow shield, but on the Goderdzi pass (2,025 meters) and on the hills of some other mountains remain snow covered for 7-8 months of the year. The Meskhetian, Arsiani and Shavshveti hills are at an altitude of 1,000 to 2,000m on average, while the eastern part of the range is 200 to 1,000m in altitude. There are low-lying regions and mountain slopes in the coastal region, between 100-200 meters of altitude (UNDP 2013).

The climate conditions in Adjara's regions are varied. The temperatures differ significantly between the coastal and mountainous areas with the average coastal temperate of around 14^0 C and going as low as 2.4^0 C in Goderdzi Pass. Adjara receives the highest amounts of precipitation in Georgia as well as the Caucasus with an average of 1,500 to 2,500 mm annual precipitation and a maximum in excess of 4,000 mm. The highest precipitation is in the coastal areas, particularly Batumi, and decreases at greater heights. The overall high level of precipitation indicates an abundance of water sources.

Adjara is home to many protected species of flora and fauna (Adjara Regional Development Strategy 2011). The flora in Adjara covers almost 1,900 species from 138 families. This includes 13 narrowly endemic species. Adjara is similarly rich in fauna as well, with a total of 1837 wild species of which 20 are protected under the Red List in Georgia, including those classified by the IUCN as under extinction alert and as vulnerable species. The forest ecosystems house a large number of these flora and fauna species, further highlighting their importance in preserving biodiversity in this region.

Georgia, including Adjara, faces several environmental threats, primarily regarding land degradation and natural hazards, and also in terms of deteriorating air quality and waste management. Forests have been massively depleted over the years with estimates indicating that canopy cover has reached critically low levels in more than half of the total forest area (NBSAP-1 2005 in UNEP & WWF 2013). Natural disasters have had a devastating impact - between 1995 and 2010, the national environment agency recorded 164 flood events in Georgia, including in Ajara. Finally, the climate patterns are shifting notably, with a 10-15 percent increase in precipitation in lowland areas and at the same time a 15-20 percent decrease in sensitive mountain areas in Georgia (World Bank 2015). Another worrying trend is visible in the mean annual temperature which has increased between 0.2 and 0.3 degrees Celsius from the 1990's onwards, and is projected to 1.6 to 1.7 degrees in Georgia by 2050 (UNDP 2013).

Overall description of Adjaran forests

Adjara has the highest density of forest cover in Georgia (MENRP 2015), with Forest Fund covering around 66% (nearly 192,500 ha of the 290,000 ha total area) (UNDP 2013). The majority of this forest cover comprises of natural forests. Artificial forests, pastures, and forest farms make up the rest of the area, along with burned groves, hayfields, and vineyards which cover a negligible portion.

Adjara's forests are home to a wide range of tree and shrub species, with more than 400 in total. The dominant species are beech, chestnut, spruce, and fir (Figure 5). A notable factor is the average age of these species, with most of them over 70 years old, and some species like fir and beech averaging more than 120 years (Table 3).

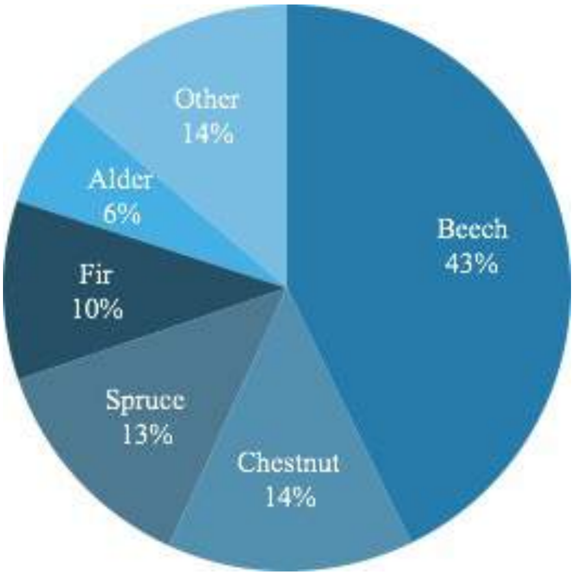

Figure 5: Main Woody species in Adjaran Forests. Source: UNDP in Georgia (2013)

Table 3: Tree species and cover in Adjaran Forests. Source: UNDP in Georgia (2013)

Species	Total area, ha	Percentage area	Average age, year	Total stock of phyto-mass, thousand m^3
Fir	19,213	10.24%	120	12,735
Spruce	24,223	12.92%	84	14,086
Pine-tree	1,587	0.85%	53	542
Beech	80,255	42.79%	130	42,484
Oak	6,807	3.63%	70	1,205
Hornbeam	6,656	3.55%	70	2,091
Chestnut	26,324	14.04%	71	10,127
Alder	11,818	6.30%	52	2,845
Rhododendron	8,683	4.63%	29	403
Cherry-laurel	1,988	1.06%	41	56
Total	187,554	100%		87,572

The majority of vegetation cover is between 1000m to 2000m above sea level (50 percent), while about 12 percent of vegetation lies above 2000m (Table 4). The accessibility of the forests is difficult given that more than 60 percent of the forests are located on slopes with an inclination of more than 25 degrees and of this about a third lie on slopes of more than 35 degrees inclination (MENRP 2015).

Table 4: Vegetation Cover by Elevation in Adjara. Source: MENRP (2015)

Elevation (m)	Vegetation Cover	Adjara	Georgia
0 - 250	Humid Subtropical vegetation- Colchis Oak, Imeretian Oak, Colchis Holly and etc	3%	3.9%
251 - 500		9%	1.6%
501 - 750	Colchis wide-deciduous species - Alder, Eller, Chestnut tree	11%	3.4%
751 - 1000		14%	6.4%
1001 - 1250	Beech forest	17%	13.1%
1251 - 1500		20%	16.8%
1501 - 2000	Spruce and Fir tree forest	14%	39.2%
> 2000	Subalpine Species- Birch, Maountain Maple, Fir-tree and etc.	12%	15.6%
Total		100%	100%

Adjara has four protected areas: Mtirala national park, Machakhela national park, Kobuleti (Ispani) protected area, and Kintrishi protected area covering a total area of about 40,000 hectares (Table 5). The main function of these protected areas is to preserve the unique flora and fauna species of Colchis. The Kintrishi protected areas and Machakhela national park are mostly forest areas with an extremely high number of relict, relict-endemic, and endemic species. The Mtirala national park has diverse landscape and is divided into 3 areas – a strict protection zone with sensitive ecosystems, a visitor's zone, and a traditional use zone where the locals continue controlled traditional uses of forests. Kobuleti protected areas mainly consist of wetlands with biological significance, such as the grassy marsh Ispani-2, preserved in its natural state (UNDP in Georgia 2013).

Table 5: Protected Areas in Adjara. Source: UNDP in Georgia (2013)

Protected area		Established in	Area, ha		Location
Kobuleti (Ispani) Protected Areas	Kobuleti Nature Reserve	1999	238.03	603.47	Kobuleti Municipality, adjacent to city of Kobuleti
	Kobuleti Managed Reserve	1999	365.44		
Kobuleti Protected Areas	Kobuleti Nature Reserve	1959	10703	13893	Kobuleti Municipality, in 20-25 km from Kobuleti, in R. Kintrishi gorge, between vil. Tskhemlovani and Mt. Khino. Lower
	Kobuleti Managed Reserve	2007	3190		
Mtirala National Park		2006	15806		Kobuleti-Chakvi Range, in 12 km from the sea, covering Kobuleti, Khelvachauri and Keda municipalities
Machakhela National Park		2012	8733		R. Machakhelistskali basin, Khelvachauri and Keda municipalities

Ecosystem Services from Adjaran Forests

Timber

Forest in Ajara is rich in wood with the total stock estimated at more than 51 million m^3 (Table 6). The wood stock amounts to 266 m^3 per hectare. Growing annually at 2.7 m^3 per hectare, the total annual increment is about 519,700 m^3.

Table 6: Adjara Timber Resources Overview. Source: MEPNR (2015)

Total Forest cover (ha)	Timber stock (m^3/ha)	Total Timber stock, m^3	Average annual increment, m^3	Average density
192488	266	51202000	519700	0.56

The forest areas with timber resources are particularly concentrated in the Qeda, Shuakhevi, and Khulo Municipalities (Table 7). Shuakhevi Municipality has the maximum forest cover as well as timber reserves estimated at around 14 million m^3, followed by Qeda which has reserves of around 12 million m^3. Khelvachauri has the least timber reserves among Adjara Municipalities, estimated at 3.8 million m^3.

Table 7: Timber Resources in Adjara by Municipality. Source: Adjara Regional Development Strategy (2011)

Municipality	Area, ha	Reserves (m^3)
Kobuleti	23,279	5,512,300
Khelvachauri	23,289	3,764,100
Qeda	37,133	11,977,900
Shuakhevi	39,330	13,954,400
Khulo	36,798	7,034,600

The authorized felling of timber in Adjara was estimated in 2015 to be 3,914 m^3, which is less than half of the total allowable cut (11,119 m^3). Most logging took place in Khulo and Shuakhevi Municipalities. The extent of actual logging volumes in the remaining three municipalities was limited.

Unauthorized and detected logging in Adjaran forests is limited, and estimated to total on 449 m^3 in 2009 (Adjara Regional Development Strategy 2011). It was mainly concentrated in Khelvachauri and Qeda Municipalities, followed by Shuakhevi. Kobuleti and Khulo had only limited amounts of officially revealed unauthorized felling (Adjara Regional Development Strategy 2011).

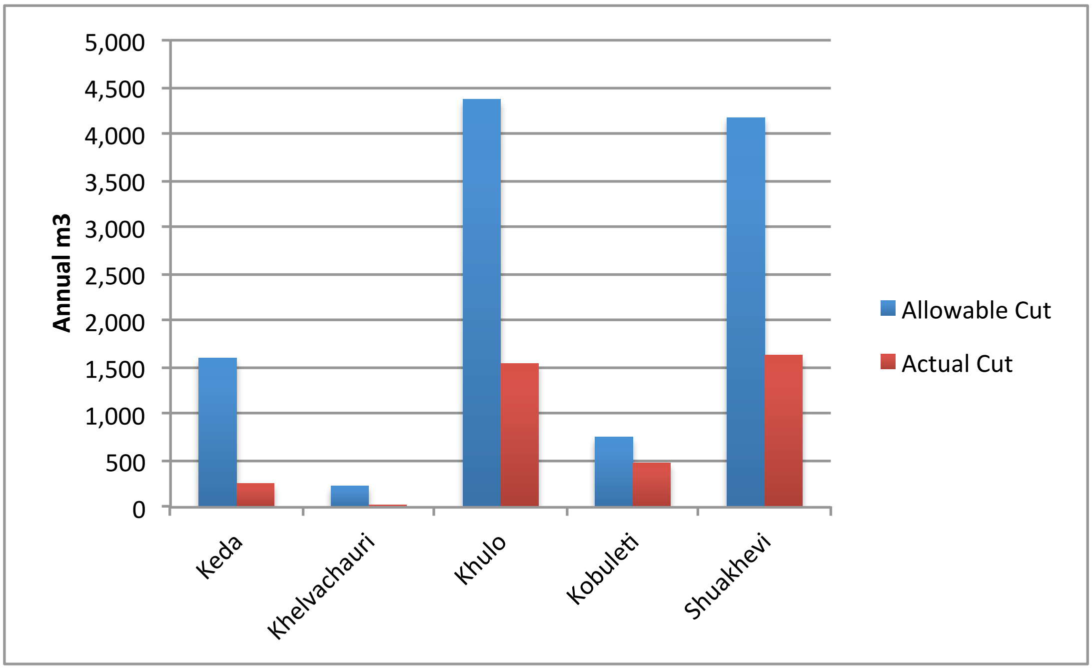

Figure 6: Use of Timber Resources in Adjaran Forests in 2015. Source: DEPNR of Adjara Autonomous Republic (2016).

Fuel Wood

More than 90 percent of all authorized tree felling in the region is for fuel wood. In 2009, it was estimated that of 130,478 m^3 of authorized felling, about 122,607 m^3 was for fuel wood. The bulk of this authorized cutting occurs in the Khulo and Qeda municipalities. The actual use of authorised fuel wood resources, however, is less than half of what is allowed (see Figure 6).

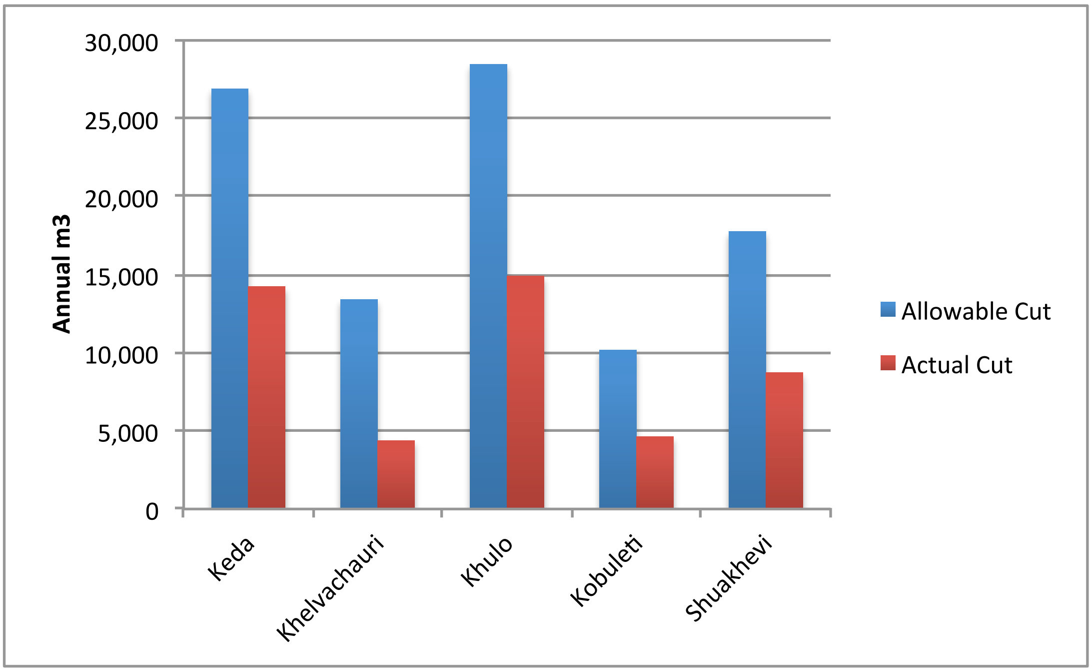

Figure 7: Use of Fuelwood resources in Adjara Forests in 2015. Source: DEPNR of Adjara Autonomous Republic (2016).

The amount of unauthorized logging of fuelwood was much higher than that for timber. Illegal cutting of fuelwood totalled 2,015 m^3, almost five times the amount of illegal felling of timber (Figure 8). This was highest in the Qeda area, but also high in Khelvachauri, Shuakhevi, and Khulo.

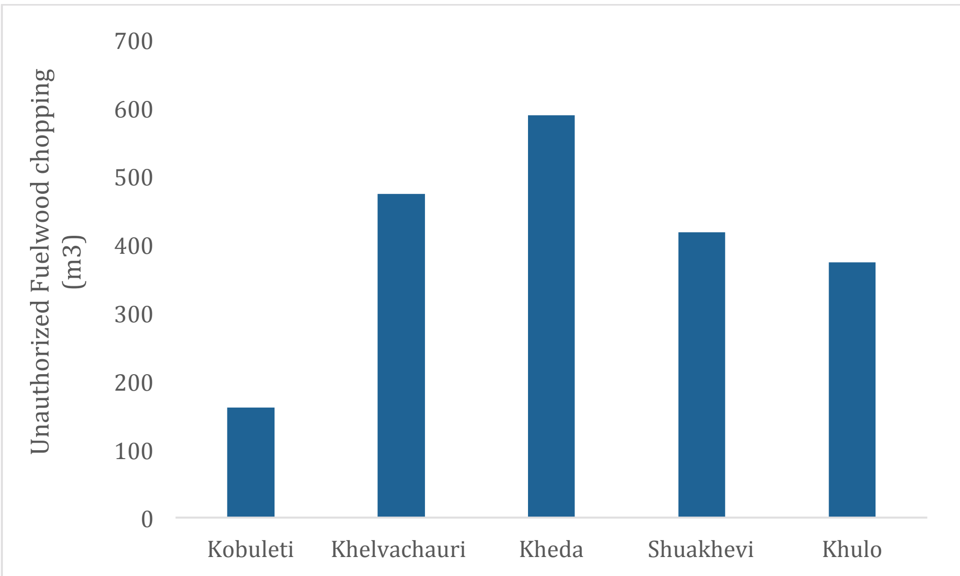

Figure 8: Unauthorized Usage of Fuelwood in Adjara Forests. Source: Adjara Regional Development Strategy (2011)

Recreation and Tourism

Tourism is an important industry in Adjara with over a million visitors coming to Adjara annually (Dept. of Tourism-Adjara). This industry has grown particularly rapidly since 2008, with various large investments in tourist infrastructure being made in the past several years. Most of the tourism is restricted to Batumi, but ecotourism, introduced only in 2007, is also becoming increasingly popular in recent years. Still, the numbers of visitors to the protected areas are relatively low, though it was estimated that in 2011 there were over 30,000 such visitors.

Regulation of natural hazards

Adjara's forests are fundamental to regulation of erosion and water and protection from landslides and natural hazards. More than two-thirds of the forests in Adjara are involved in soil protection and water regulation functions (UNDP 2013). The region of Adjara is highly susceptible to frequent landslides occurring 4-5 times a year. It causes damage to infrastructure and houses, leading to displacement among local community members and requirement of compensation from the government. Thus, protection from landslides is a key ecosystem service provided by Adjara's forests.

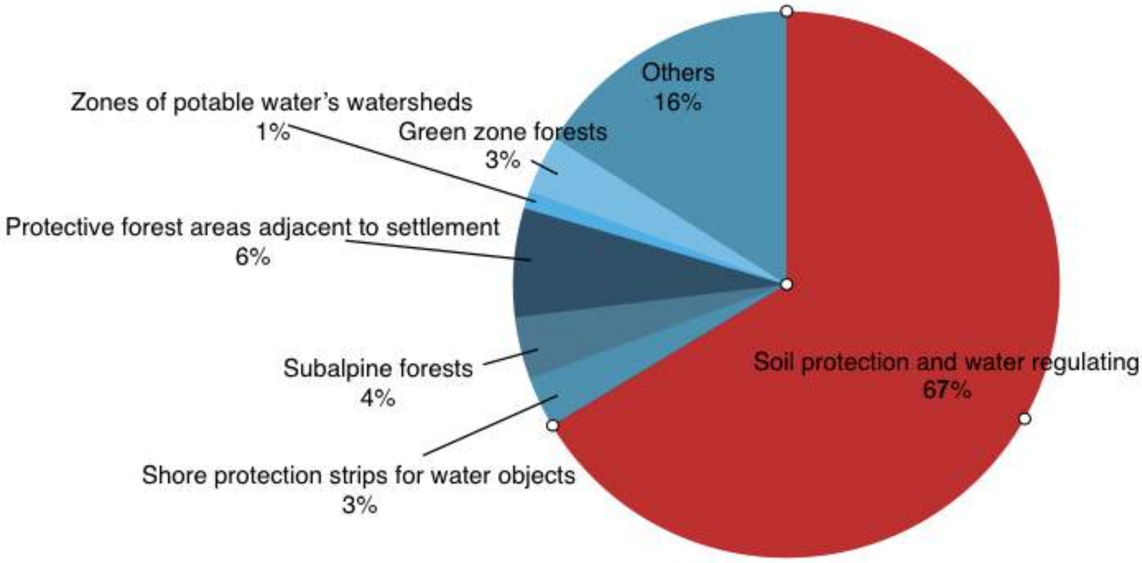

Figure 9: Functional Distribution of Adjara Forests. Source: UNDP in Georgia (2013)

Climate regulation

Further, Adjara's forests contribute to the global community through carbon sequestration, absorbing greenhouse gases such as carbon dioxide. Previous studies estimate that the forest cover in Adjara absorbs 167,000 tonnes of carbon dioxide annually (UNDP 2013).

Key Challenges

Policy Challenges Context

Policy decisions and interventions across multiple levels of governance are often taken without sufficiently considering the costs and benefits related to ecosystems. While there is a growing awareness of the importance of ecosystems and biodiversity, incorporating them fully in policy making is still a work-in-progress.

Policy interventions can deliver socio-economic outcomes more effectively and sustainably if they capture the economic value of ecosystem services. The impacts of undervalued ecosystem services leads not just to large scale environmental degradation but also works counter to economic development. Countering these negative impacts often requires expensive policy interventions at a later stage, even though the consideration of these free services in policy decisions could have helped avoid the necessity of these interventions, and at a lesser social cost.

Further, since the fundamental nature of policymaking involves making trade-offs, an economic valuation of ecosystem services would greatly aid in guiding policy decisions (Department for Environment, Food and Rural Affairs of U.K 2007). Policy choices can be made more efficiently when the costs and benefits are clear and measurable. Mapping the linkages between ecology and human welfare scientifically, interpreting the economics of these linkages, and including them in policy assessments would therefore lead to more optimal policy outcomes.

Forest Sector Challenges in Adjara

There are several challenges to sustainable forest management in Adjara such as the forest disease, overgrazing, and illegal logging. Although the precise scale of forest degradation is unclear, employees of the forest agency estimate that up to 60 percent of the forest is in a state of degradation and has lost the ability for natural restoration and self-generation. Current efforts to counter this trend, including production and distribution of saplings and fencing off certain areas have proven insufficient.

Table 8: Diseases and Forest Degradation in Adjara Forests. Source: UNDP in Georgia (2013)

Forestry	Total area, ha	Among them sick area/ ha	Eroded/ degraded area, ha	Thinned out area, ha	Composition	Taxation of accounted trees		
						Number (trees)	Mean diameter (cm)	Average stock (m3)
Kobuleti	23790.8	3800.0	32.0	245.0	cn, sp, ab	954825.0	-	57 4 915.0
Khelvachauri	23470.8	1800.0	-	132	cn	79489.0	-	56550.0
Keda	37679.5	1117.0	4.0	145.0	cn	125592.0	-	71420.0
Shuakhevi	39980.3	3754.0	-	662	sp, ab	720540.0	-	880664.0
Khulo	37182.2	1317.0	-	1605	sp, ab	143364.0		108066.0
Total	162103.6	11788.0	36.0	2789.0		2014810.0		1691615.0

Illegal Logging

The national statistical body Geostat estimated that in 2014, the amount of timber officially (legally) harvested from Georgian forests amounted to 670,241 cubic metres, from which about 11.6 percent or 77,981 cubic metres was harvested in Adjara. Social logging (i.e. logging of fuelwood and small-sized timber for personal consumption only) in Adjara is permitted with limits of 100 to 150 thousand m^3 of timber per annum (UNDP 2013). Logging in Adjara forests is mainly by the rural population rather than on a commercial scale due to a lack of economic viability.

Illegal logging is an issue although its levels have reduced in recent years. In 2013 there were more than 500 cases registered of illegal logging, where a total of 2646 m^3 of timber was cut down in Adjara (UNDP 2013). Logging has spillover effects as well. It increases the risk of landslides, and since a large portion of assimilated wood is not pulled out, it is left to decay and thereby reduces the carbon sequestration functions of the forest. Illegal logging is often done by local communities in order to use it as fuelwood given the lack of access to alternate energy sources. Studies have indicated that the levels of logging are not high per se but the problem is of felling trees in areas where it is not permitted. The issue is further complicated by the poverty of the communities engaging in these activities – their poverty and social vulnerability means that penalties in terms of fines cannot be effectively enforced.

Table 9: Unauthorised logging. Source: UNDP in Georgia (2013)

Name	Number of Cases of Unauthorized Chopping	Unauthorized Chopping (m^3)			Sequestrable Timber (m^3)		
		Total	Timber ing	Firewood	Total	Timber ing	Firewood
Kobuleti	79	202.39	41.37	161.02	17.50	1.01	16.49
Khelvachauri	129	617.18	143.28	473.9	66.3	15.92	50.58
Qeda	112	711	122	589	108.73	54.79	53.94
Shuakhevi	124	513	95.38	417.62	12.70	4.42	8.28
Khulo	78	420.46	46.86	373.60	-	-	-
Total	522	2464.41	449.2	2015.21	205.43	76.14	129.29

Climate change

Climate change further compounds these challenges and increases the vulnerability of the communities. The spread of disease in the forest trees is hastened by the rising temperatures and precipitation in Adjara. The municipalities with highest incremental rise in temperature have also experienced high incidents of disease spread. Further, climate change in Adjara is associated with the introduction of new diseases in the forests such as *Cameraria ohridella deschka* and *Cylindrocladium buxicola*, posing a great threat to biodiversity of endemic and relict host species. Increased precipitation has led to higher soil erosion and subsequently receding forest boundaries. There is also an increased risk of forest fires due to the drying up of Adjara's coniferous forests (UNDP 2013).

Overgrazing

The Strategic plan document of the Adjara Forest Agency identifies overgrazing as a central reason for this loss of ability of the forest to naturally restore itself, noting that the region is overburdened with cattle (AFA Strategic Plan 2015). This problem and its impacts are especially noticeable near population centres and along seasonal cattle migration routes.

Disease

Disease among the trees is a major issue since estimates show that it is spread across 6 percent of the total forest cover (UNDP 2013). This is partly because of the aging of the forest trees as most of the forest is on average more than 70 years old. It is mainly prevalent among chestnut trees in Kobuleti, Khelvachauri, Qeda Municipalities; and among spruce and fir species in the Kobuleti, Shuakhevi and Khulo Municipalities. As a result, the erosion and degraded forest area has increased and the forests density is reduced.

3. Stakeholders and Institutions

Overview of Forest Management in Georgia

Institutional and Organizational Evolution of Forest Management in Georgia

When Georgia was a part of Imperial Russia, forests were classified as state, private, church, and communal. After its integration into the Soviet Union in 1921, all forests were nationalized and classified as either state or collective farm forests. From the 1930s onwards, forests were used primarily for industrial purposes, mostly logging (Macharashvili, 2009). In the Soviet period, forests were managed in all of the republics by state agencies which mainly viewed them in terms of their commercial value. In the case of Georgia, and Adjara in particular, logging was somewhat controlled because of the inclination of the land and the relatively difficult access which made more sense for the Soviet Union as a whole to source timber from more easily accessible forests such as those in Siberia.

Immediately after independence in 1991, during the period of crisis, crime and corruption which followed, Georgian forests were degraded on a large scale. Illegal logging was the main problem and though there were regulations in place setting the upper limits for annual logging well below one million m^3, various sources indicate that the actual amount far exceeded this limit (Macharashvili 2009). No accurate figures were available. The estimates of actual logging ranged widely from 2.5 million to 6 million m^3. This level of logging was clearly unsustainable, but given that it was rooted in the socio-political structures of the time, with the involvement of high ranking government officials and employment of residents, there was little done to control it.

Following the dissolution of the Soviet Union, Georgians also had to suffer through a period of difficult access to fuel for cooking and heating, and therefore turned to fuel wood for these purposes. This meant that in addition to the trade in illegal timber, trees were cut down for fuel wood, especially by rural communities due to their inability to access other energy sources (Osepashvili 2016), resulting in the further degradation of forests.

A few attempts to improve management took place between 1992 and 1995, resulting in formation of a unified State Forest Fund, which also included forests within protected areas. The responsible authority for forests was the Forestry Department of the Republic of Georgia, whose name was changed in 1997 to State Department of Forestry of Georgia. This body remained in charge of forest management until 2004. Protected forests were managed by the State Department of Nature Reserves, Protected Areas and Game Farms.

The Forest Code of 1999 was one of the first initiatives to modernize forest management in independent Georgia. This legislation separated the commercial functions of forest management from its protective function and also attempted to decentralize forest governance by providing for the management of forests to be undertaken to some degree by local self-governments. One notable clause of the Code legalized the granting of licenses to the private sector for various types of forest use. The reforms regarding privatization and decentralization however remained more on paper than in practice (Macharashvili 2012). Forests were still mainly used for logging, based on 1 year licenses.

The Rose Revolution ushered in more legal and organizational changes, including the incorporation of the State Forestry Department into the Ministry of Environment Protection and Natural Resources (MEPNR). Two new departments were created under the MEPNR for forestry and protected areas: The Forestry Department and the Department of Protected Areas respectively. Other departments relating to management of biodiversity, including forests, were unified under the MEPNR (Macharashvili 2012).

These reforms, however, did not have many qualitative impacts on forest management in Georgia. The forest ecosystems continued to deteriorate due to a plethora of issues including a lack of preventive and restoration measures and unavailability and unreliability of forest resources and usage data. Systemic problems remained persistent in terms of illegal logging, corruption, and poor human resource management in forest sector organizations (Macharashvili 2009)

This sparked another round of organizational changes in 2007, primarily taking effect in terms of decentralization and personnel downsizing. The Forestry Department was renamed as the Forest Agency on the principle that the state should only retain licensing and control functions over the forests, releasing it from forest management functions. Decentralization meant cutting down the size of the central office and introducing 10 regional forest management institutions. The total number of Forest Department personnel went down from 1694 to 692, but this was accompanied with their salaries being more than doubled to an average of 400 GEL. In the new organizational set-up, each forest ranger was put in charge of about 5,000 hectares on average. Critics however note that several key components of these reforms such as transferring management rights to local governments and making functional differentiation of forests were not implemented (Macharashvili 2009).

From 2007 to the present, there have been a series of structural changes which culminated in the concentration of all forest management functions within Ministry of Energy and Natural Resources (MENR). Reflecting the Saakashvili administration's focus on economic growth, which it felt would be better facilitated by centralization and streamlining of approvals procedures, the MEPNR was divested of the responsibility of granting licenses in 2009 and this authority was transferred to the Ministry of Economy and Sustainable Development. The structural changes in 2011 resulted in the establishment of a MENR which handled environmental protection and forests. This clearly indicated a downgrading of environmental protection in the strategic plans of the government.

After the Georgian Dream coalition won the national elections in 2012, the MEPNR was renamed the Ministry of Environment and Natural Resources Protection. Many of its powers were restored and the Ministry regained control of forest related functions. Several new strategic documents on the forest sector and biodiversity were produced. These documents have mapped the current and emerging problems and issues in environmental management, but no major legislative or institutional changes have been implemented as yet.

In this manner, forest management practices, issues, and governance structures in Georgia have co-evolved with its economic and political history, reaching a crisis period during 1990s. While attempts have been made consistently since independence to address environmental management issues, most have had limited impact and a number of key challenges remain, which are discussed below.

Organizations in Adjara Forest Management

Stakeholders in Forest Management

The main sets of stakeholders in Georgia (including Adjara) Forest management are:

1. Adjara Regional Forest Management Organizations
    a. Adjara Forest Agency (AFA)
    b. Directorate of Environment Protection and Natural Resources of Adjara Autonomous Republic (DEPNR)
    c. Municipalities in Adjara
2. National Forest Management Organizations in Georgia
    a. Ministry of Environment and Natural Resources Protection (MENRP)
    b. National Forest Agency (NFA)
    c. Agency for Protected Areas (APA)
    d. Forest Policy Service, Biodiversity Protection service
3. Donor Organizations and Implementing Partners (this list is not exhaustive)
    a. European Union (EU) and Austrian Development Agency (ADA)
    b. World Wildlife Fund (WWF) for Nature, Caucasus Programme Office
    c. International Union for Conservation of Nature (IUCN)
    d. World Bank
    e. United Nations Development Program (UNDP)
    f. German Agency International Cooperation (GIZ)
4. Ecosystem Services Beneficiaries
    a. Local Communities in Adjara forest regions
    b. Loggers and Timber interests
5. Related Governmental Organizations in Adjara
    a. Ministry of Energy
    b. Ministry of Agriculture
    c. Ministry of Infrastructure and Regional Development
    d. Ministry of Health and Social Affairs
    e. Department of Relations with Administration Bodies of Government of Adjara Regional Republic.
    f. Department of Tourism of Adjara Regional Republic.
6. NGOs

Organizational Roles and Objectives

Regional Forest Management Organizations

The DEPNR of Adjara, the Adjara Forest Agency (which is incorporated into the DEPNR) and Agency of Protected Areas of Georgia are the main managers of forests in Adjara. Local government bodies such as the municipalities are responsible for the areas designated as "Local Forest Fund".

The Adjara Forest Agency (AFA) is the organization primarily in charge of implementing forest management functions in Adjara. Of the total area of 192,488 hectares under the forest fund in Adjara, almost 85% (162,103.7 hectares) is managed by the AFA.

The AFA is a legal entity of public law (LEPL) established on December 7, 2010 by the Decree №55 of the Government of the Autonomous Republic of Adjara. This decree further specifies that the AFA is a body within the DEPNR, subordinate to the Government of the Autonomous Republic of Adjara.

The main objectives of AFA are to protect, maintain and restore forests and promote the sustainable use of biodiversity components within the forest fund territory. Accordingly, its main tasks are to identify and verify the forest fund boundaries and manage and regulate the uses of the resources therein. In 2014, the AFA defined the following operational priorities:

a. Assisting the process of natural regeneration of degenerated sub-Alpine forests
b. Fighting against tree pests and diseases, rejuvenation of damaged forests and preventive measures against infection and infestation
c. Improvement of the Agency's material and technical base in order to make forest use by the population more convenient
d. Cultivation of energy forest plantations

To execute these tasks, the organizational structure of the AFA consists of three technical units (Forest Monitoring, Forest Management and Forest Pest and Disease Fighting) and two administrative units (Economic and Administrative). The organizational structure of the AFA is shown in the chart below. At the top level the AFA has a Head of the agency appointed by the Adjara government on the recommendation of the DEPNR. The head of the AFA has two deputies, one in charge of the forest functions and the other in charge of economic and administrative functions. The units under the chief forester include the forest monitoring unit, the forest management unit, and the forest pest and disease fighting unit. The economic and administrative units are managed by the other deputy head of AFA.

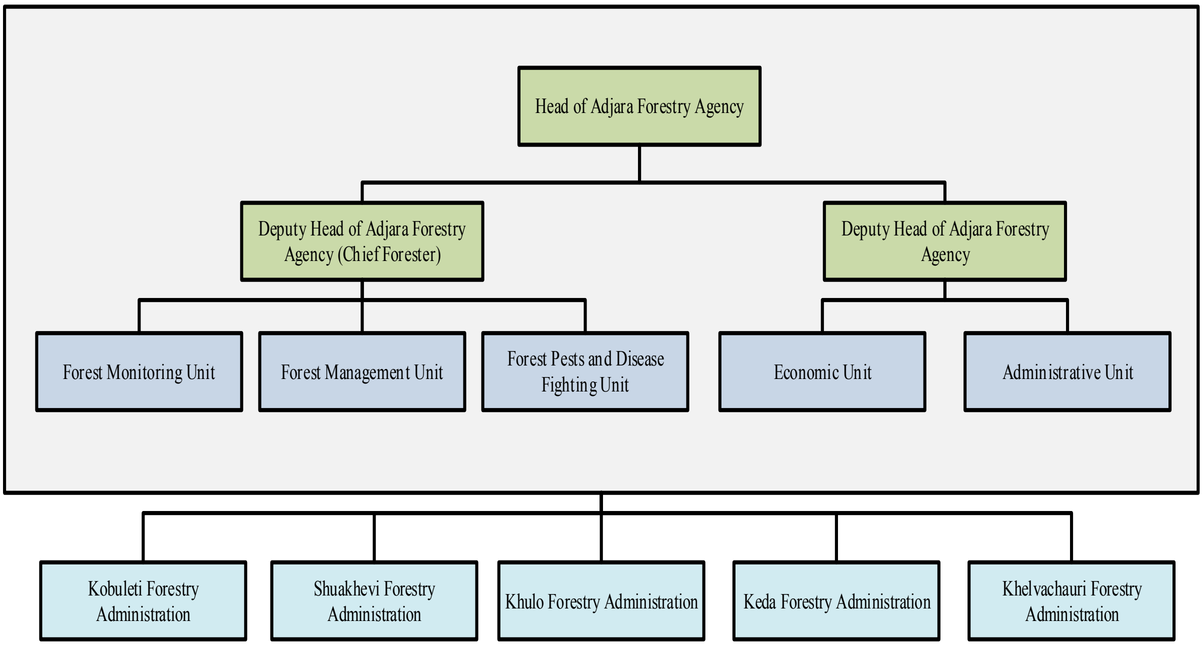

Figure 10: Organizational Structure of the Adjara Forest Agency. Source: Adjara Forest Agency (LEPL) Strategic Plan 2015

National Forest Management Organizations in Georgia

The management of biodiversity and ecosystems in Georgia, including the forest sector, is largely concentrated in the Ministry of Environment and Natural Resources Protection (MENRP) and several subordinate agencies. Its main function is the administration of environment protection and use of natural resources. Other functions of the MENRP pertaining to forest policy and ecosystem services are:

- Governance of protected areas
- Monitoring of biological diversity
- Ensuring accessibility of environmental information
- Supporting environmental education and environmental awareness raising
- Co-operating with international organizations and co-ordinating the fulfilment of environmental agreements, including those related to the European integration process

In addition, the following bodies under the MENRP are competent authorities regarding forest management –

- Agency of Protected Areas (APA): manages protected areas over Georgia, including the autonomous republic of Adjara
- National Forest Agency (NFA): manages most of the forest funds excluding protected areas and the autonomous republics of Adjara and Abkhazia.
- Forest Policy Service: supports the development and implementation of forest management national policy
- Biodiversity Protection Service: planning and coordination of the protection of biodiversity components (species, habitats, ecosystems) and the species listed in Georgian "Red List", management of biological resources (except for woody species), coordination/administration of issues related to species listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES); the latter has been recently merged with the Forest Policy Service
- Environmental Supervision Department: enforcement of environmental legislation: prevention, detection and suppression of the cases of illegal use of natural resources; monitoring execution of terms of licenses/permits
- National Environment Agency: determining quotas on extraction of natural resources and issuing of licenses on use of natural resources

Donor Organizations and Implementing Partners

The European Union, Austrian Development Agency (ADA) and German Federal Ministry for Economic Cooperation and Development (BMZ) are among the key donors with current large scale forest governance related projects in Georgia. For instance, EU and ADA-funded ENPI-FLEG II involves the implementing organizations of WWF, World Bank, and IUCN. The central goal of WWF is to stop the degradation of the earth's natural environment. Its branch in the Caucasus is the implementing body of the TEEB study of the forest sector in Adjara (Georgia).

Ecosystem Services Beneficiaries

The rural communities in and around the forest areas are the main beneficiaries of Georgian (including Adjaran) forest ecosystem services. The wood from the forests is used as a source of energy, and the forests are also the spot for grazing their cattle.

Concerning Adjara, excluding Batumi, almost 10 percent of residential energy supply comes from fuel wood. The main purpose driving the felling of trees is their utility as fuelwood. The forests reduce the vulnerabilities of surrounding communities to landslides and similar disasters. Adjara is particularly susceptible to landslides and the risk is high for residential housing, making the regulating functions of the forests of paramount importance to the locals in these areas.

Related Government Organizations in Georgia

Other Ministries that may have interest or relevance to forest management are –

- Ministry of Energy of Georgia, given the overlap of social logging issues with need for energy sources
- Ministry of Economy and Sustainable Development, due to the economic causes as well as implications of ecosystems and biodiversity issues
- Ministry of Infrastructure and Regional Development, since large portions of current and potential damage from natural hazards affects infrastructure such as roads
- Ministry of Health and Social Affairs; authority in charge of remunerating damage caused by natural hazards.

Regulatory Overview of Adjara Forest Management

Framework of Forest Legislations

List of Laws

The following are the main statutory acts governing the protection of forest biodiversity and use of forest resources (Matcharashvili 2012):

- Forest Code, 1999
- Law of Georgia “On “Red List” and “Red Book” of Georgia”, 2003
- Law of Georgia “On fees for use of natural resources”, 2004
- Law of Georgia “On licenses and permits” 2005
- Law of Georgia “On Forest Fund management”, 2010
- Government Resolution “On approval of regulations on the rules and terms of issuing licenses for use of forest” – No. 132, 11 August 2005
- Government Resolution “On approval of rules of establishing boundaries of state forest fund” – No. 240, 13 August 2010
- Government Resolution “On approval of rules of forest maintenance and restoration” – No.241, 13 August 2010, Tbilisi

- Government Resolution “On approval of rules of forest use” – No. 242, 20 August 2010
- Government Resolution “On approval of rules of timber transportation on the territory of Georgia and approval of technical rules for initial processing of roundwood (logs) facility (sawmills)”, 2014
- Government Resolution “On approval of rules of forest inventory, planning and monitoring”, 2013.

Hunting is governed through the bylaws of the “Law on Wildlife”, which set provisions such as the list of animals intended for hunting, the weapons and devices permitted for capturing animals, and the approval procedures.

Description of Laws

The most pertinent pieces of legislation are briefly described below:

Forest Code, 1999 - regulated legal relations regarding care, protection, restoration and use of Georgia’s forest fund and its resources. It defines forest ownership and classifies areas as state forests and the land and resources covered by this definition. This code declared the entire ‘forest fund’ as state property and left the process of denationalization to be undertaken through subsequent legislation.

Law of Georgia “On “Red List” and “Red Book” of Georgia”, 2003 – defines the Georgian “Red List” and “Red Book” which list endangered wild animals and plants. It defines the structure of Red List, procedures for selecting species, drafting, approving and updating (revising) the Red List. It also regulates the issues related to endangered species, planning and financing the activities for their protection, extraction, restoration and preservation.

Law of Georgia “On fees for use of natural resources”, 2004 – provides for conservation of state owned resources by introducing payments for using the resources. A per unit fee is defined according to the specifics relating to the resource such as plants, mammals, birds, fishes, fossils, etc. It also defines penalty calculations in case of illegal extraction of the resources. The fees go to the budget of the locality where the resource was extracted.

Law of Georgia “On licenses and permits” 2005 – defines a set of activities pertaining to natural resources that require licenses or permits, and the type of the license/permit required for each activity. This covers mining, oil and gas prospecting and production, logging, hunting, commercial fishing, exporting fir, etc. Licenses are issued through auctions, and the law also governs the grant of environmental impact permits.

Law of Georgia “On Forest Fund management”, 2010 – the foundation for the creation of the Forest Agency replacing the Forest Department. This law defined the basic principles of its functioning, organizational and legal structure, authorities and main activities. The main objectives of the Agency were to care for and restore the forest, to ensure the sustainable use of biodiversity components on the forest fund area. Its main functions were defined as the determination of forest fund boundaries, control of forest fund territory, monitoring the forest fund and creation of a monitoring database, the prevention of fire, and the issuance of permit documents for forest use, including logging and hunting (except for migratory birds).

Law on changes to Georgian Forest Code (rs. No. 4677), 2011 – made several significant changes to the regulations set by the forest code. It introduced the concept of social cutting, defined as the implementation of appropriate arrangements of providing wood for non-commercial purposes to population, budget organizations, legal entities of public law and Georgian Orthodox Church. Further it set out general requirements for the transport and processing of logs and legitimized timber labelling, the registration and database maintenance of logs using electronic markers. This law changed the definition of long term use of forests, increasing it from 20 years to 49 years.

Definition of Forest Lands

Forest lands are defined primarily on the basis of the Forest Code adopted in 1999. The forest code defines a forest as "a part of geographical landscape, comprising trees attributed to forest by Georgian legislation, land under these trees, as well as shrubs, grass, animals, and other components biologically linked in the process of their development, affecting each other and the environment".

Other relevant terms in the forest code include State Forest fund, Usable state forest fund, and local forest fund. "State Forest" is defined as "forest owned by the State" and State forest fund is defined as the "integrity of State Forests of Georgia, as well as lands and resources attributed to these forests". "Georgian Forest Fund" is the integrity of forests and their resources owned by the "State Forest Fund" and forests under different types of ownership.

Local forest fund has multiple contradicting definitions based on the forest code and organic law of Georgia. The forest code defines local forest fund as "a part of the Usable State Forest Fund legally regulated by the local governing and self-governing bodies in accordance with this Code and Georgian legislation". However, in the current form of legislation there are no local governing bodies. On the other hand, the organic law provides for the municipality being the owner and manager of local forest fund without interference of other governing bodies (Matcharashvili 2012).

Division of Forest Management in Georgia

The governance of forest lands in Georgia is divided as follows (Green Alternative 2016):

- State Forest – Managed by either Agency for Protected Areas or the National Forest Agency
  a. Agency for Protected Areas manages the protected areas of forests, i.e. those defined as reserve, national park, nature monument, wildlife sanctuary, and Kintrishi and Tusheti protected landscapes. This includes protected areas in the territories of Autonomous Republics of Adjara and Abkhazia.
  b. National Forest Agency is in charge of forest area defined as Usable Forests
- Local Forest – managed by local self-government bodies (such as municipalities), including
  a. Forests in protected areas under the jurisdiction of local self-government bodies (Tusheti protected landscape, Pshav-Khevsure multiple use territory, Javakheti multiple use territory)
  b. Usable forests owned by local self-governments
  c. Forest owned by local self-government, and enjoying recreation zone status (e.g. Tbilisi)

- Forest of Adjara Autonomous Republic – managed by the Adjara Forest Agency, with the exception of protected areas in Adjara, which fall under jurisdiction of the Agency for Protected Areas

Strategic Directions

There are several policy documents laying down strategic directions for improving forest management in Georgia, including Adjara. Given below is a summary of the strategic directions set by the Adjara Forest Agency Strategic Plan, the Adjara Regional Development Strategy, and the National Forest Policy Concept.

National Forest Policy Concept

The Forest policy document for Georgia has the central goal of "establishing a system of sustainable forest management which will ensure improvement of quantitative and qualitative characteristics of the Georgian forests, protection of biological diversity, effective use of the economic potential of forests taking into account their ecological values, public participation in forest management related issues and fair distribution of derived benefits". In order to achieve this goal, it sets out five main guiding principles and four priority directions:

- Principle of Sustainable Management of Forests: meaning "the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil now and in the future, relevant ecological, economic and social functions at local, national, and global levels, and that does not cause damage to other ecosystems" (MCPFE 1993)
- Precautionary principle: to maintain protective functions of forests and their ecological balance
- All Forests are Local: priority given to needs of local population
- Separation of regulation, management, and supervision functions
- Forestry is an integral part of the sustainable development of the country

Priority Directions –

- Forest Management Planning – including restoration of forests, balancing economic and environmental functions of the forest
- Rational use – including update of forest inventories and developing monitoring systems
- Forest ownership, management and use rights – legislation for changing ownership structure of forests and reclaiming forests leased to private sector
- Adaptation to impacts of climate change – assessing vulnerabilities and forming mitigation and adaptation strategies

Key legal and management frameworks recommendations –

a. Legal Framework

- Preparing a new Forest Code that provides for the new or revised systems and mechanisms that will be implemented within the framework of the Concept

- Preparing the secondary legislation, including regulations that define forest management standards, and regulations governing relations between the forest owner and bodies responsible for managing forests (communities, private sector, the State, etc.);
- Amending other primary legal acts that contradict the new Forest Code.

b. Forest Administration

- Regulate forest use;
- Detect and suppress illegal forest use, including by reviewing the functions and capacities related to the administration and management of forests.
- Prepare and implement plans aimed at increasing the capacities of the authorized bodies to carry out their functions effectively.
- Broaden and strengthen participation in the development of the concept and policy instruments, including by developing mechanisms to involve forestry sector stakeholders in the development of the concept and policy instruments.

c. Forest Management institutions

- Prepare and implement a plan for the development of the forest management bodies, including a budget, technical assistance and an indicative financing and/or business plan.
- Develop a scheme for staffing and capacitating all institutions according to the requirements of the tasks. Securing sustainable funding from budget and non- budget sources (sales of products and services, compensations, etc.)

Adjara Forest Agency Strategic Plan 2015

The AFA Strategic Plan sets its vision as "*A forestry sector founded on the principles of stable forest management and rational use of forest resources, which ensures preservation of a healthy, ecologically safe environment and biodiversity, reduction of negative influence of climate change and anthropogenic factors, effective satisfaction of the population's social demands, increasing and strengthening the forest's functional workload*". Accordingly, its mission is the rational management of the region's state forest fund, tending, protecting and restoring it, preserving its biodiversity and raising the local population's awareness regarding forest management issues. Based on this vision and mission, the strategic plan lays out 4 strategic goals and defines objectives within each of these goals:

1. Introduction of principles of Sustainable Forest Management

1.1. Forest Management Planning – incorporate environmental risks in decisions, assign categories of functional zones in forests, co-operate with Ministry of Economy and sustainable development to draw forest boundaries

1.2. Protect Forests from Natural and Anthropogenic sources of degradation – minimize illegal woodcutting, regulate commercial use of non-timber resources, control overgrazing

1.3. Restore Degraded Forests – devise restoration and planting scheme, develop early warning system for natural hazards, etc.

2. Enhancing the efficiency of services

2.1. Design Effective service provision model – undertake study of market, forest resource consumers, technical capacities of forest sector organization, etc. for basis of appropriate model

2.2. Develop appropriate services to ensure effective use of forest resources – create new unit to process data and prepare reports on the forestry fund's opportunities

3. Increasing public awareness and support environmental education

3.1. Raise awareness of resource users about forest management – develop system for regular and effective communication with the local population

3.2. Support education in forest sector – training programs for staff, create apprenticeships

4. Increase organizational efficiency

4.1. Implement Modern human resource management system – develop and implement periodical appraisal and incentives system for employees, create professional development and retention systems

4.2. Align organizational structure with strategy – reorganize units by functions, create new units for new functions

4.3. Implement modern approaches of organizational management - create unified electronic management system, develop appropriate monitoring and evaluation tools

4.4. Develop organization's material-technical capacities and infrastructure – develop roads and fire prevention infrastructure, equip warehouses, etc.

Adjara Regional Development Strategy 2014

Based on objectives such as ensuring welfare of Adjara's population, improving the ecological environment and management of natural resources, the Adjara regional development strategy sets out the following strategic directions for the improving use of forest resources –

- Providing proper material and technical equipment to forest protecting personnel;
- Combatting forest diseases and pests, as well as taking forest restoration, renewal and fire- prevention measures in order to maintain diversity of forest ecosystems; providing favourable conditions to attract private investments;
- Drafting initiatives for the improvement of legislative basis related to the reforms in the system of a forest industry;
- Engagement in the process of elaboration of integrated strategy and action plan for guiding the process full forest stock-taking and detailed analyses of its agro-ecological, social and economic aspects, as well as local forest resources management and related sustainable forest industry;
- Building of new forest industrial roads in woodlots and forest blocks for securing local population with heating fuel wood at specified chopping places.

This information, summarized in Table 10, indicates that there are three major alignments in groups of stakeholders. One group is concerned primarily with improving the quality and extent of forests in Adjara, a second group is concerned with avoiding damage from natural events and therefore interested in the regulatory functions of ecosystems services, and finally the third group is interested in the provisioning services, particularly fuel wood. There is also some overlap in the constituents of these groups.

Table 10. Summary of stakeholder analysis

Stakeholder	Interests	Powers & Strategies
Adjara Regional Organizations		
AFA	Expand scope of forest management activities. Increase forest cover. Increase value of ecosystems service provision	Management authority. Local level on-the-ground knowledge. Field implementation of policies and regulations.
DEPNR	Increase forest cover. Reduce losses from environmental events.	Input into policy and regulatory processes.
Municipalities	Increase revenue from forest related activities. Increase managerial authority over local forests. Reduce losses from environmental events.	Have relatively limited power but are trying to have a greater say and control over local resources and revenue bases.
Ministry of Energy	Protection of energy infrastructure from natural events.	Input into policy and regulatory processes.
Ministry of Agriculture	Maintenance and expansion of agriculture activities, including cattle husbandry.	Influence on policy and regulatory processes.
Ministry of Infrastructure and Regional Development	Protection of infrastructure, especially roads and bridges, from natural events.	Input into policy and regulatory processes.
Ministry of Health and Social Affairs	Reduce losses and amounts of compensation from environmental events.	Influence on regulations.
Department of Relations with Administration Bodies of Government of Adjara Autonomous Republic.	Coordination between different public organizations and agencies.	Provide space for interdepartmental and inter-organizational discussions and joint decision making.

Stakeholder	Interests	Powers & Strategies
Department of Tourism	Increase and diversify tourism potential of Georgia, including in natural and protected areas.	Liaison and lobbying with other relevant stakeholders
Local Community Members/Ecosystem Beneficiaries	Increase in availability of ecosystem services and products, particularly fuel wood. Reduction of losses from environmental events. Increase in income generation activities. Minimize prohibitory regulations.	Voice and votes.
National Level Organizations		
MENRP	Regulation and protection of forests and natural resources.	Management of policy and regulatory processes.
NFA	Expand scope of forest management activities. Increase forest cover. Increase value of ecosystems service provision	Management authority. Field implementation of policies and regulations.
APA	Define boundaries of protected areas. Expand (properly) managed tourism in protected areas.	On the ground knowledge and inputs into policy processes.
Others		
Donors	Increase in forest quality and quantity. Reduction of poverty.	Project finance Connection to international networks of knowledge. Influence on policy and regulatory development
NGOS	Environmental and social quality issues. Contracts for consultancy work.	Lobbying

4. Scenarios for forest ecosystem services

Methodological framework

The general methodological framework for the economic valuation of ecosystem services from Adjaran forests follows that of Balmford et al. (2011), Bateman et al. (2011) and Brander et al. (2012b). In particular it incorporates several critical insights from the environmental economics literature by comparing future scenarios that are driven by alternative policy interventions; quantifying non-overlapping ecosystem services; and modelling spatially explicit variation in the values of ecosystem services. The general methodological framework is represented in Figure 11.

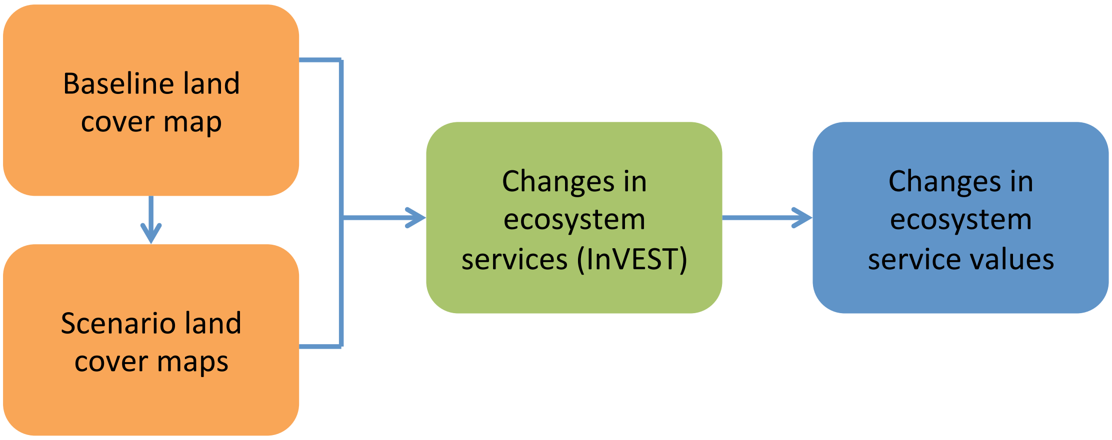

Figure 11. Methodological framework for assessing the value of changes in ecosystem service provision under alternative land cover scenarios.

To answer the main questions posed by this study (i.e., what are the economic values of ecosystem services and how will they change over time under alternative management regimes?), it was necessary to develop descriptions of the future (scenarios) for what alternative management paths might look like. Then it would be possible to assess the economic value of ecosystem services under each alternative "land cover scenario" relative to a "business-as-usual" or "baseline" scenario. The purpose of this scenario analysis is to provide useful reference points for policy development. In the context of the TEEB Adjara study, scenarios describe how forests will change and be managed over time.

The scenarios developed for this study are not predictions of the future (i.e. projections with estimated levels of likelihood); they are alternative storylines for what the future might look like in Adjara following different development and policy paths. The scenarios are therefore speculative and intended to enable the comparison of contrasting but plausible futures. The scenarios are to be used as reference points for the development of forest policy in Adjara.

For the TEEB Adjara study three alternative future scenarios are defined for the period 2015-2035. Land use changes under each scenario are modeled in a GIS and the resulting changes in the flows of ecosystem services are modeled using the InVEST tool V. 3.3.1 (http://www.naturalcapitalproject.org/invest/). Changes under each scenario are assessed at two points in time (2020 and 2035) in order to enable the evaluation of short term and long term impacts on ecosystem services. The economic value of changes in the flows of ecosystem services are subsequently estimated using a selected set of valuation methods.

The storylines underlying each scenario in terms of the development, institutional and policy change are described in the sections below.

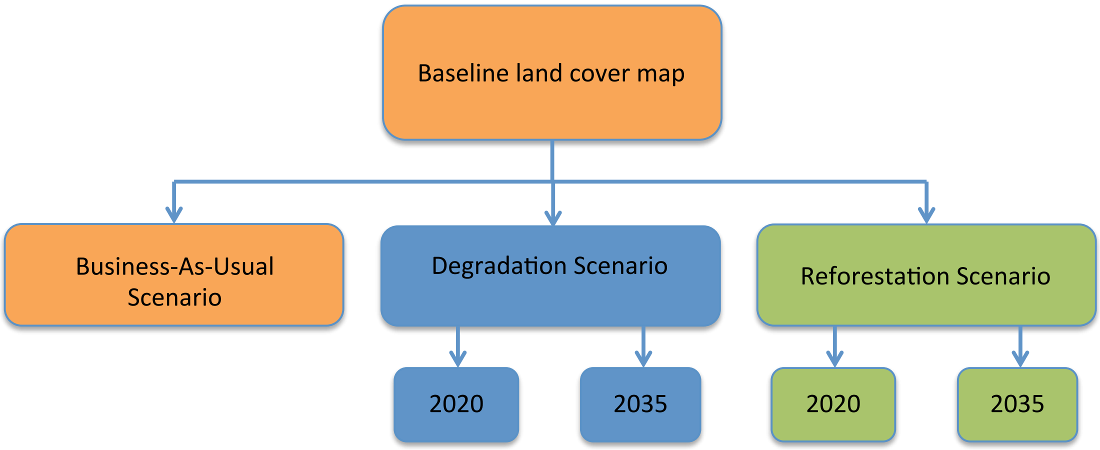

Figure 12. Scenarios for land cover change in Adjara.

Scenario 1: Business-as-Usual

Business-as-Usual represents the region as narrowly oscillating around current capacities and interests. The transitions that began with independence of Georgia are stabilizing. Before independence, the forest sector provided about 4-5% of Georgia's GDP, though the forests were better protected as wood was supplied from Russia rather than being cut on the sensitive steep slopes of Adjara. After independence, there was widespread deforestation in the region because of fuel shortages and political and economic chaos. With the return of political and economic stability, these tendencies have stopped.

The political system is competitive, and challenges around more fundamental political and administrative issues leaves little financial or policy attention to environmental issues. Forest management systems which abruptly ended at the time of independence have been incompletely rebuilt, with equipment, staffing, building and infrastructure and executing capacity all substantially constrained. A forest inventory for Adjara is still ongoing.

Policy frameworks are still in evolution and incomplete and often in conflict with sustainable forest management requirements. The Forest Code of 1999 which still governs the management of Georgian forests requires updating as noted in the 2013 National Forest Concept. This new concept will focus on sustainable forest management, the precautionary principle, greater involvement of local agencies in forest management and separating the regulation and management structures. The 1999 Code shifted commercial use of forest lands to the private sector through short (from 1-year) and long (up to 20-year) wood use rights, but this policy has had limited success and few private investors have emerged. Instead, much of the forest harvest is illegal or unofficial or inadequately planned, monitored or regulated.

Nevertheless, the rate of forest degradation is slowing because of less population and economic pressure. Rural to urban migration as well as a general population decline throughout the country has reduced the pressure on the forests as direct demand for fuel wood and pasture has declined. Moreover, it is cheaper to import most of the food items instead of producing them locally.

However, the post-independence fuel shortages, conflict, and lack of stable government have already led to widespread and unregulated forest cuts. This has degraded forests, especially around villages where the farmers harvested fuel wood, cut forests for expanding pastures or in some cases smuggled wood. By some estimates half of the forest canopy cover is in a state of severe degradation.

The largely stable commercial and tourist activity allows for only a basic municipal maintenance and upgrading but does not lead to government revenues which are sufficient to fund major public sector expansion in environmental areas. Donor funding is also relatively tight. The forest services are still short-staffed, with each forester responsible for around 5,000 ha of forests. Given vehicle and other equipment and financing shortages, the regulatory and management functions are inadequate to regenerating degraded forests, but because population and economic pressures have stabilized, further degradation of forests is not a significant threat.

Nevertheless, there are continuing damages and losses from soil erosion and landslides provoked by earlier forest degradation. With climate change, it is feared that the incidence of landslides will only increase, causing losses to the population and putting fiscal strains on the local government as it tries to compensate these losses.

Scenario 2: Degradation

Degradation represents a region in crisis. There are intertwined economic and political pressures, from within and outside. Political uncertainties and conflicts in neighbouring countries reduce tourism in Adjara and investments in it and other related sectors. Unemployment in Batumi increases and with it there is a reduction in rural to urban migration, and even some reverse migration as out-of-work Adjarians return to their villages.

These factors result in the decrease of tax revenues in Georgia, including Adjara, and public sector budgets are under pressure. Overall economic pressures may even lead to higher inflation. As government agencies have to work with limited and in many cases even reduced financing, budgetary cuts in personnel, equipment and activities become necessary. In the case of the Forest Agencies there is a 10 percent cut in budgets. Only the more essential public tasks are undertaken by organizations such as the Georgia and Adjara Forest Agencies. This means that patrolling and enforcement activities are curtailed. The AFA Strategic Plan is shelved. There are no budgetary allocations for purchasing the equipment needed to harvest wood to supply the local communities' social needs. Budgets cuts also lead to hiring freezes and a slow attrition of the workforce with longer term negative consequences for forest management. Budgetary pressures result in less expansion and maintenance of infrastructure, particularly roads. As a result, there is increasing pressure on more easily accessed forest areas, such as those around villages, and less of an emphasis on sound forest management.

Economic stagnation means that efforts to convert household energy use from wood to gas slow down. As unemployment rises, the economic alternatives for villagers are reduced, which increases their willingness to cut down trees for personal use as well as to supplement income. With reduced cash income, demand of fuel wood for heating and cooking may increase even in semi-urban areas. Demand of wood for construction also increases. Lower cash incomes may also lead to fewer imports and the need for more local production, leading to pressures to clear land immediately surrounding villages for food production needs.

Finally, economic and political crises lead to less international environmental cooperation. Difficulties of working in the region lead donor agencies to cut their financing and involvement in the region.

The combined impact of these trends leads to more woodcutting around villages. The existing and newly denuded areas increase the risk and incidence of landslides leading to damage of residential and agricultural assets, compensating which puts further fiscal pressure on the government.

The Degradation scenario represents a decline in forest cover and density relative to the business-as-usual situation. The decline in forest cover in Ajara is 1% per year. The land cover change is from forest woodland to scrub and sparse vegetation. In the short term (2015-2020), there is a 5% decline in forest cover. Over the time horizon of the scenario (2015-2035) there is an 18% decline in forest cover. These changes take place in areas close to population centres reflecting human use as the main driver of change. The changes in land cover are spatially located within a 5 km radius of villages.

Scenario 3: Managed Use and Restoration

The Managed Use and Restoration scenario represents a full implementation of the Adjara Forest Agency Strategic Plan (2015). Degraded forests are restored. Communities no longer harvest their own wood for social uses and their needs are supplied by the Forest Agency. The Forest Agency expands and develops energy forest plantations. It aims to reforest currently cleared forest at the rate of 2% per year at a distance within 5 km radius of rural villages. The targeted land use change is from pasture, scrub and sparse vegetation to forest woodland.

Managed Use and Restoration represents a region of relative stability where political institutions are maturing and the economy is growing. As a result, tax revenues are predictable and increasing and the political and administrative institutions are able to take on increasingly complex governance tasks including social and environmental obligations. The budgets, staffing and equipment of the Forest Agency are increased and they are able to undertake more strategic and long term planning for forests in Adjara.

Tourism, domestic as well as international, is more established and growing, including in the off-season, leading to an appreciation of preserving the general environment of the region among the different social groups. Higher cash incomes contribute to an ability and willingness in the community to spend in social and environmental arenas.

Because of the increased budgets, staffing and equipment, the Forest Agency is able to develop more sustainable forest management plans and a more comprehensive execution capacity. Included in the plans are developing energy forest plantations and a network of forest roads that help the Agency to patrol, monitor and enforce forest regulations as well as to do properly circulating forest cuts which preserve the integrity and overall density of the forests. By aiming to manage the cut more scientifically, the Adjara Forest Agency channels resources to centralize and professionalize the forest cut. It also obtains resources to reforest the degraded forest areas around the villages. The process of fuel wood harvesting and sale by the Forest Agency becomes an attractive service, overcoming the tendency of local community members to cut the trees themselves. As a result, forest cuts outside demarcated areas or of unmarked trees are largely eliminated, leading to a regeneration of currently denuded forests and maintenance of the larger landscape.

Pastures are reforested by improving grazing and feeding systems to reduce pressure on land. Areas cleared by fuel wood harvesting that have scrub or sparse remaining vegetation are allowed to regrow and become dense woodland. The better forest cover around villages reduces the risk and incidence of landslides, thus protecting habitations and farms and facilitating investments in rural production systems.

In quantitative terms, reforestation activities target regenerating cleared forest in the vicinity of all villages. In the short term (2015-2020), 10.5% of pasture and 8.3% of scrub and sparsely vegetated land is converted to forest. Over the time horizon of the scenario (2015-2035) 34.5% of pasture and 27.3% of scrub and sparsely vegetated land is converted to forest. This results in a 4.8% increase in forest area by 2020 and a 15.7% increase by 2035. These changes in land cover are spatially concentrated within 5 km radius of rural villages.

Scenario maps

To transform the above-mentioned scenario storylines into land use maps and subsequently into appropriate parameters for the input into the InVEST tool, certain methodologies have been applied. Generally, two applications have been employed in the mapping process: ArcGIS V.10.4 and QGIS V.2.14.1. The step by step process of preparing future scenario land use maps are described here.

In summary, the scenario storylines provide the following assumptions:

- Degradation 2020: 5% of forest area will be converted to scrub and sparse vegetation. This change is spatially allocated randomly across forests within 5 km radius of each village.
- Degradation 2035: 18% of forest area will be converted into scrub and sparse vegetation. This change is spatially allocated randomly across forests within 5 km radius of each village.
- Restoration 2020: 10% of both pasture and scrub and sparse vegetation will be reforested. This change is spatially allocated randomly across pasture and scrub/sparse vegetation within 5 km radius of each village.
- Restoration 2035: 33% of both pasture and scrub and sparse vegetation will reforested. This change is spatially allocated randomly across pasture and scrub/sparse vegetation within 5 km radius of each village.

To generate maps of future land use, random points are generated within the target areas (5 km radii of each village). For instance, to map the 5% of forest area converted to scrub and sparse vegetation, random points are generated within the forest areas in the study area. Each point represents the location of the forest area that will be converted into the scrub and sparse vegetation in the future. From the random points, 5% are selected randomly to represent the land cover in the future scenario. The points are then converted into raster format for further analysis. The steps are similarly applied for the other future scenarios.

Land use maps for each scenario are presented in Figure 13. Under the degradation scenario it can be seen that forested areas become more orange as the proportion of scrub and sparse vegetation increases. The area for each land use class under each scenario is reported in Table 11. The percentage changes in the area of forest, pasture, and scrub and sparse vegetation relative to the baseline are represented in Figure 14.

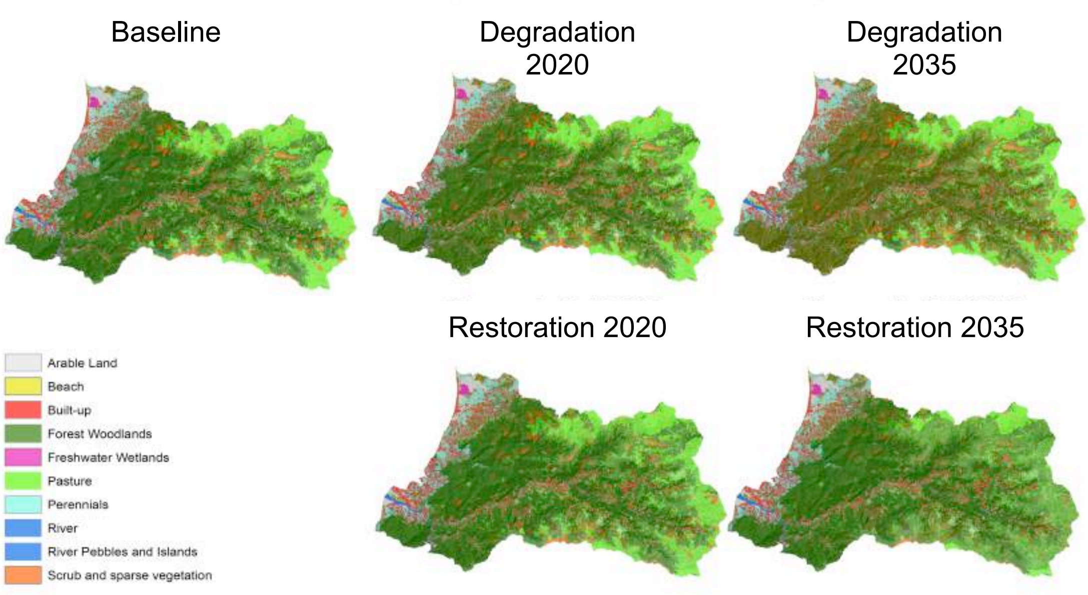

Figure 13. Baseline and future land use maps for Adjara

Table 11. Area (ha) for land use classes in Adjara under future scenarios

Land use class	BAU	Degradation 2020	Degradation 2035	Restoration 2020	Restoration 2035
Arable Land	11,516	11,516	11,516	11,516	11,516
Artificial Lakes	48	48	48	48	48
Beach	221	221	221	221	221
Bridge	10	10	10	10	10
Built-up	16,422	16,422	16,422	16,422	16,422
Canal	46	46	46	46	46
Forest Woodlands	160,141	152,134	131,316	167,783	185,359
Freshwater Wetlands	649	649	649	649	649
Gullies	1,182	1,182	1,182	1,182	1,182
Lake	21	21	21	21	21
Pasture	60,690	60,690	60,690	54,346	39,772
Perennials	12,630	12,630	12,630	12,630	12,630
Railways	28	28	28	28	28
Reservoir	1	1	1	1	1
River	2,976	2,976	2,976	2,976	2,976
River Pebbles and Islands	904	904	904	904	904
Roads	4,419	4,419	4,419	4,419	4,419
Scrub and Sparse Vegetation	15,727	23,734	44,552	14,429	11,428
Wind Breaking Lines	171	171	171	171	171

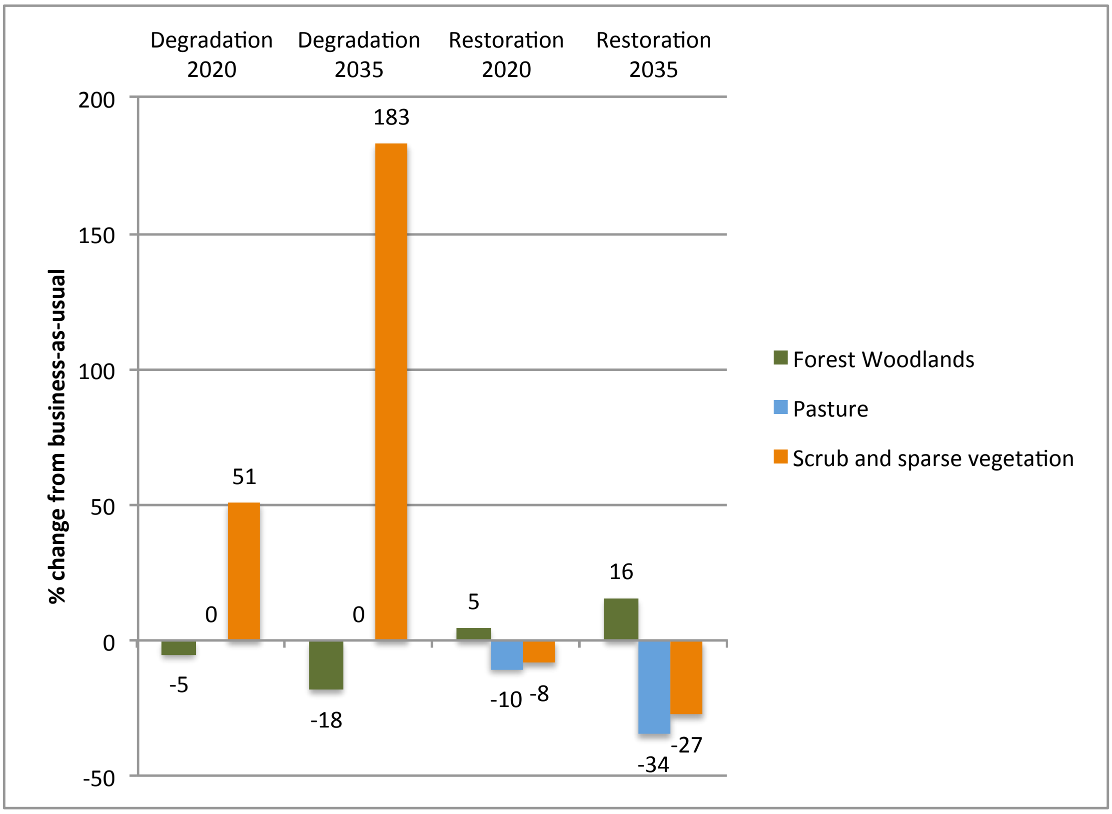

Figure 14. Percentage changes in area of forest, pasture, and scrub and sparse vegetation relative to business-as-usual land cover

5. Economic value of forest ecosystem services in Adjara

This chapter describes the methods and results of the economic valuation of forest ecosystem services in Adjara. As far as possible the distribution of benefits across locations and different stakeholder groups is also described.

Here the ecosystem services assessed in the study and the methods that were used to estimate their economic values are briefly outlined.

- Provisioning services: Fuel wood and non-timber forest products (NTFPs). The economic value of these services are estimated using a net factor income approach. This method involves computing the gross revenues for each service (quantity multiplied by price), minus the costs of production (quantity multiplied by unit cost).
- Carbon storage. This regulating service is valued in two ways: 1. As the potential net revenue from crediting and selling additional stored carbon; 2. As the avoided climate change damages resulting from the storage of additional units of carbon in forests. Fluxes in the quantity of carbon stored in forests under alternative future scenarios are estimated using the InVEST tool.
- Natural hazard regulation. The value of landslide regulation is estimated using the avoided damage costs approach. This involves assessing how the risks of damage events change with changes in forest cover; and then estimating the associated changes in expected damage costs. Physical changes in erosion control under each scenario is modelled using the InVEST tool. Expected damage costs are estimated using historic data on landslide frequencies and compensation payments.

Provisioning services

Forests in Adjara provide a number of important provisioning services to local people, particularly in rural areas. These services include the provision of fuel wood and non-timber forest products (NTFPs) such as mushrooms and berries. If forests are converted to other land uses or degraded, the level of provision is likely to decrease. If forests are well managed and degraded areas are reforested, the quantity of fuel wood and NTFPs is likely to increase. In this section changes in the provision of fuel wood and NTFPs under each scenario are quantified and valued.

The methodology for the assessment and valuation of provisioning services provided by forests in Adjara is represented in Figure 15. Each step is explained in detail in the text below.

Area of forest under each scenario

To obtain data on the area of forest in each scenario within a radius of 5 km of each village, the locations of all villages were fed into ArcMap application and 5 km buffer zones were generated. The future land use and land cover (LULC) were also processed using ArcMap to obtain only the information on forest area. Two sets of information were obtained: 1. 5-km-buffer zones from the villages in vector format; and 2. A raster containing information on forest area. These sets of information were fed to QGIS software to obtain the information of the forest areas within 5 km of each village. The above steps were applied to the LULC map for each scenario.

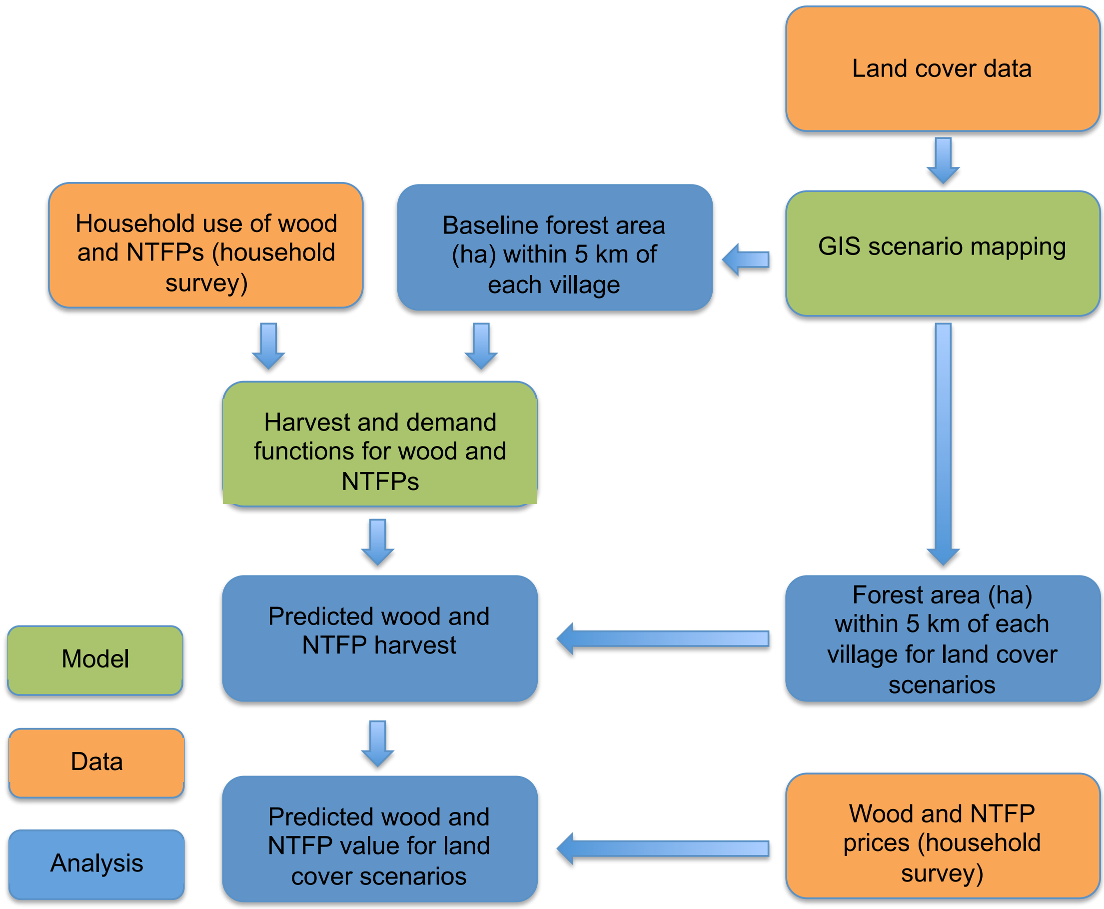

Figure 15. Methodology for assessment of provisioning services

Household survey of forest uses

A survey of households in Adjara was conducted in December 2015 to collect information on the use of provisioning services. In total, 73 households from 40 villages were interviewed. The distribution of the sample across municipalities is represented in Figure 16. This distribution is not proportionately representative of the population, with households in Khelvachauri and Kobuleti under-represented and households in Shuakhevi over-represented in the sample relative to the 2014 population census (GEOSTAT, 2016).

The questionnaire includes questions on wood use, quantity, source, cost, preference for wood to be supplied by the Forest Agency, and use of NTFPs. A copy of the survey questionnaire is provided in Appendix 2. The average quantity of wood used per household in a year is 9.5 m^3, with a minimum use of 4 m^3 and maximum of 15 m^3. The distribution of the quantity of wood used across the sample of households is represented in Figure 17. In terms of wood use, all respondents use wood for heating, just over 80% use wood for cooking, and 46% use wood for preparing animal fodder (see Figure 18). Almost all households cut wood themselves (95%) with very few buying wood at the market.

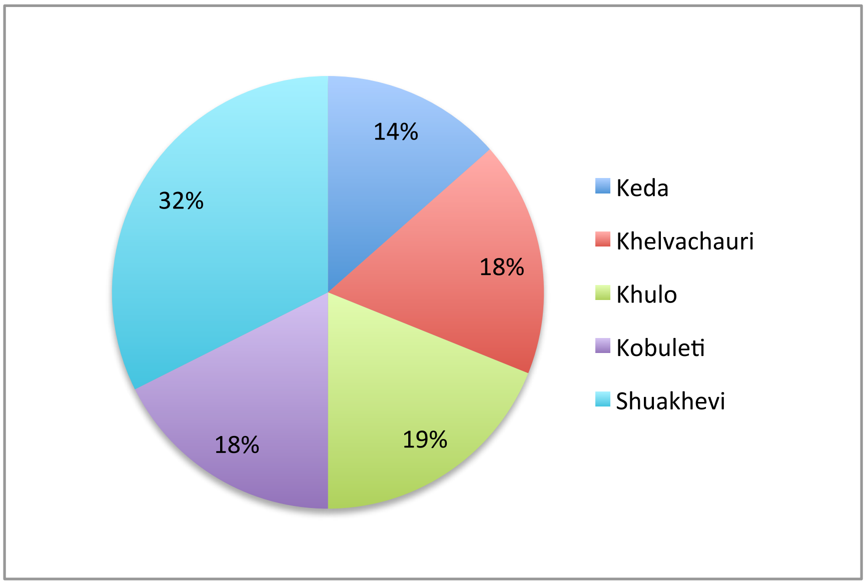

Figure 16. Distribution of sampled forest users across municipalities

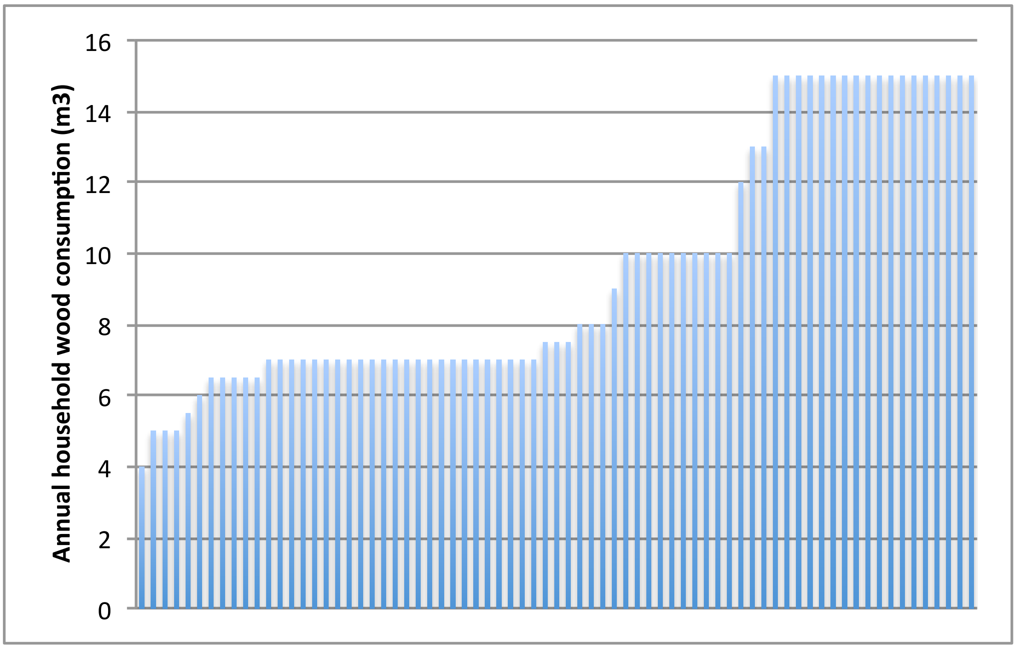

Figure 17. Annual consumption of wood by sampled households (m^3)

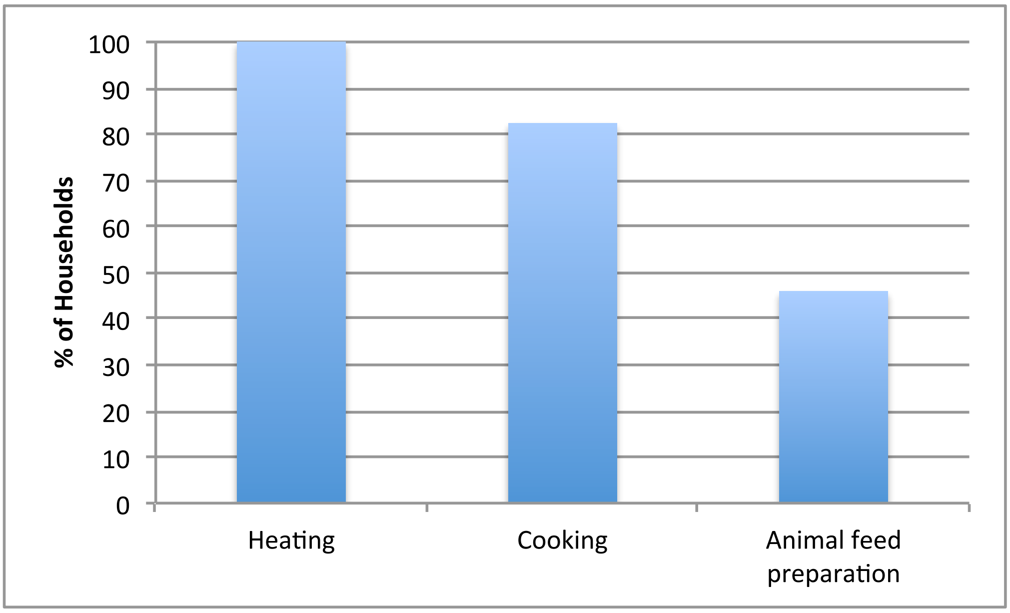

Figure 18. Uses of wood by sampled households

Respondents to the survey were also asked questions regarding illegal cutting of trees that have not been marked by the Forest Agency. Although respondents were reluctant to acknowledge that such practices take place, they were willing to express an opinion on why it takes place. 50% of respondents indicated that the reason is due to marked trees being inaccessible, 11% cited the low quality of marked trees, and 14% stated that the quantity of marked trees is insufficient – see Figure 19.

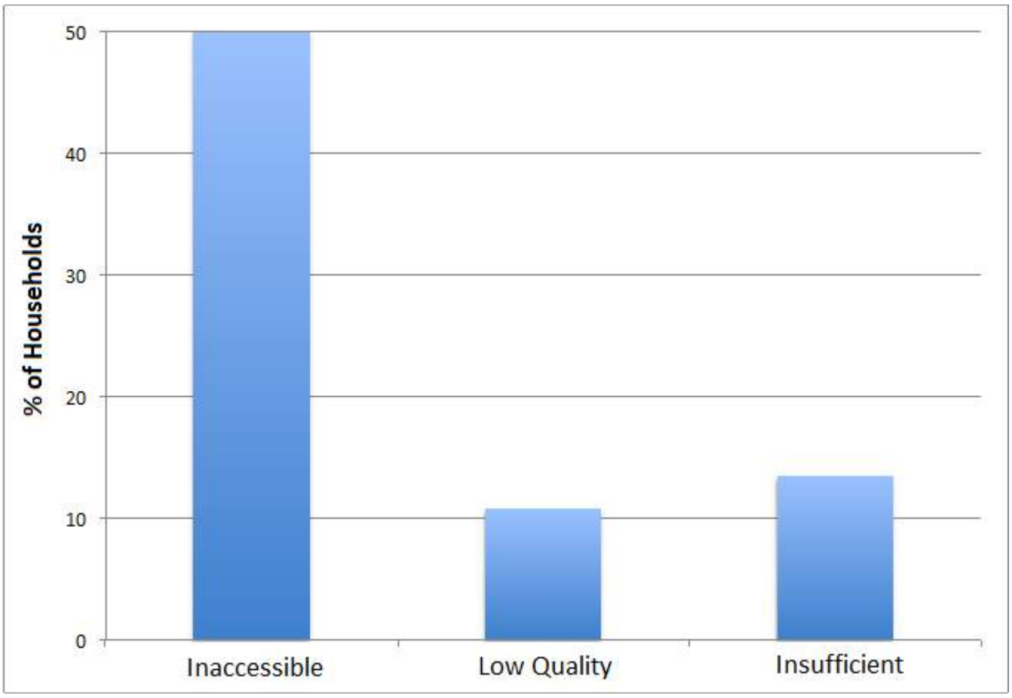

Figure 19. Reasons for illegal cutting of wood outside of areas marked by the Forest Agency

Respondents to the survey were asked whether they would be in favour of the Forest Agency prohibiting the cutting of trees and instead providing the public with sufficient fuel wood to meet their needs. Almost 90% of households were in favour of this proposal, mainly because they see the harvesting of fuel wood as a costly or difficult task and believe that the costs would be lower if the Forest Agency supplied their needs. Approximately 4% of the sampled households were against the proposal and 8% declined to answer (see Figure 20). Respondents were also asked to state their maximum willingness to pay (WTP) for the Forest Agency to supply all their fuel wood needs. The mean stated WTP for the sampled households is 19 US$/m^3, with a minimum of 3 US$/m^3 and a maximum of 77 US$/m^3. The distribution of WTP across the sample is represented in Figure 21.

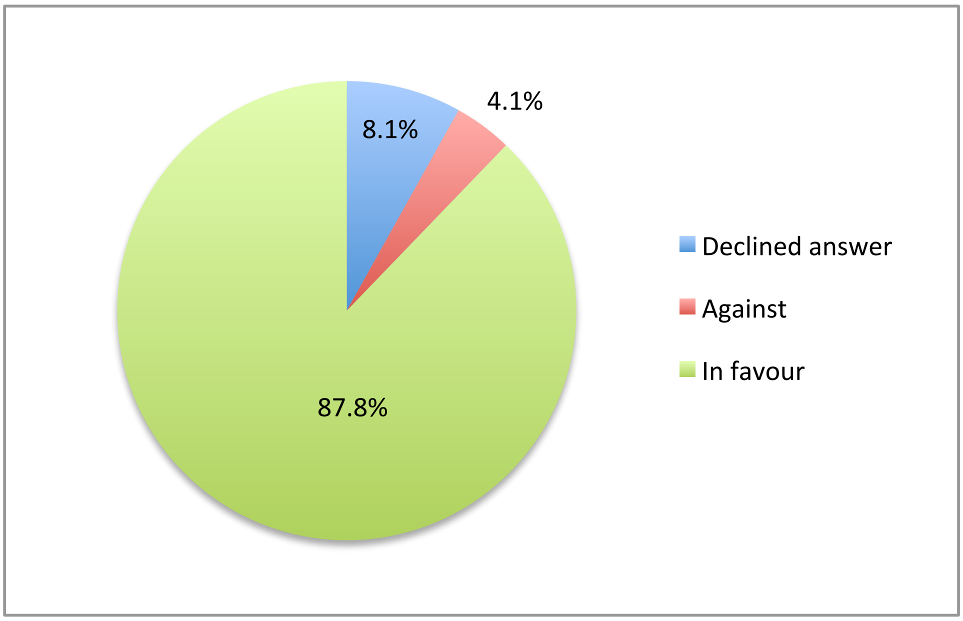

Figure 20. Respondents preferences regarding the Forest Agency supplying all fuel wood

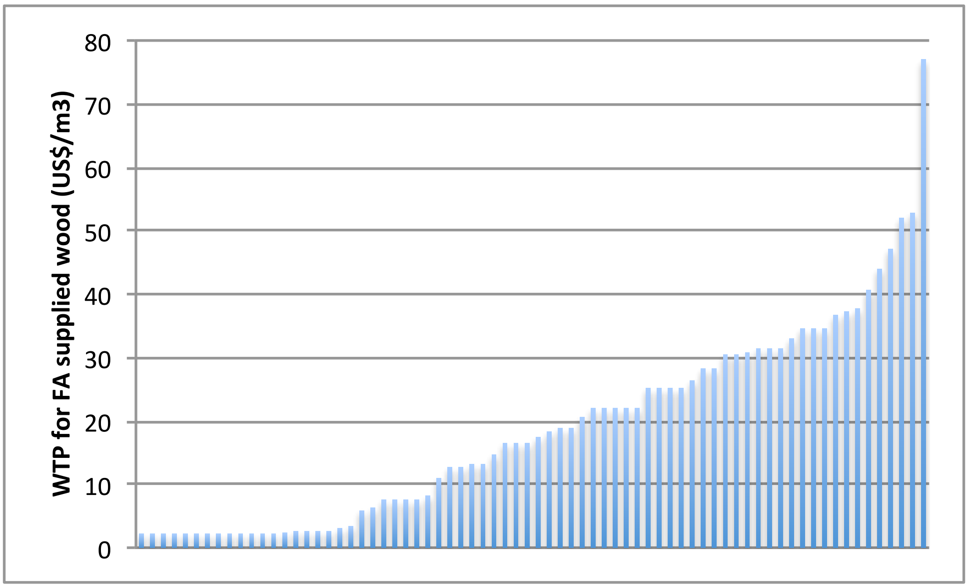

Figure 21. Willingness to pay for Forest Agency supplied fuel wood (US$/m^3)

Regarding NTFPs, 30% of households collect blueberries, 26% mushrooms, 16% blackberries and 7% chestnuts (see Figure 22). The majority of sampled households do not collect NTFPs.

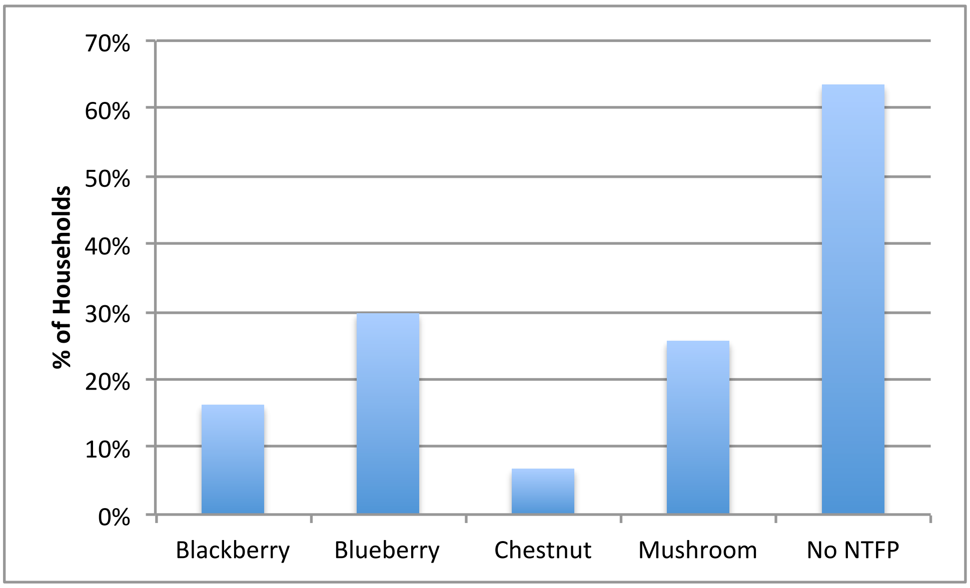

Figure 22. Collection of NTFPs by sampled households

Provisioning service harvest functions

In order to predict how changes in land cover under each scenario affect the quantity of provisioning services that are harvested, harvest functions are estimated for each forest product that relate the quantity of each product harvested to the area of forest. Data from the household survey are augmented with additional data on the area of forest in the vicinity of each surveyed household (measured in hectares of forest within a 5 km radius of the village in which the household is located). These data are then used to estimate bivariate linear regressions, with the quantity harvested by each household as the dependent variable and the area of forest as the explanatory variable. The estimated harvest functions are reported in Table 12.

Table 12. Harvest functions for provisioning services

	Fuel wood (m^3; ln)	Blackberry (kg; ln)	Blueberry (kg; ln)	Mushroom (kg; ln)
Constant	-1.453	-5.944*	-13.541***	-12.36***
Forest area (ha; ln)	0.436***	0.769**	1.743***	1.588**
SE	0.112	0.360	0.500	0.476
P	0.000	0.036	0.001	0.028
Adjusted R^2	0.165	0.047	0.132	0.122
N	73	73	73	73

***, **, * indicates statistical significance at the 1%, 5% and 10% levels respectively

The estimated coefficients on forest area are statistically significant at the 5% level or better ($P < 0.05$) in all harvest functions.[3] The adjusted R^2 statistics for each regression are not high indicating that there is a high proportion of unexplained variation in harvested quantities. In all

[3] It was not possible to estimate a statistically significant model for chestnut harvest and so this NTFP is excluded from further analysis.

harvest functions both the dependent and explanatory variables are included in natural logarithms. This enables the estimated coefficients on the explanatory variables (forest area) to be interpreted as elasticities, i.e. the coefficients measure the responsiveness of harvested quantity with respect to a percentage change in forest area. For example, in the case of fuel wood, households that live in areas with 10% more forest area than average, tend to harvest 4.4% more fuel wood than average.

These estimated harvest functions are used in combination with data on the area of forest in the vicinity of each village in Adjara under each scenario, to predict the quantity of each forest product that is harvested under each scenario. Note that the harvest functions predict the quantity harvested *per household* in each village, so this information is extrapolated to the village level by multiplying by the number of households in each village using data from the 2014 population census (GEOSTAT, 2016). The predicted changes in harvested quantities under each scenario are represented in Figure 23 (fuel wood) and Figure 24 (NTFPs). Under the degradation scenario (S2) there is a large predicted decline in both the harvesting of wood and NTFPs. In the year 2035, the decrease in wood harvest relative to the baseline is over 23,000 m^3. Under the restoration scenario (S3) there is an increase in harvests of forest products. In the year 2035, wood harvest increases by almost 8,600 m^3 relative to the baseline. It is noted that restored forests require a period of growth before they can be used for the harvest of fuel wood. Nevertheless, it is assumed under the restoration scenario that the Forest Agency of Adjara can increase harvesting volumes from mature forest stands to an extent equivalent to the area of restored forest.

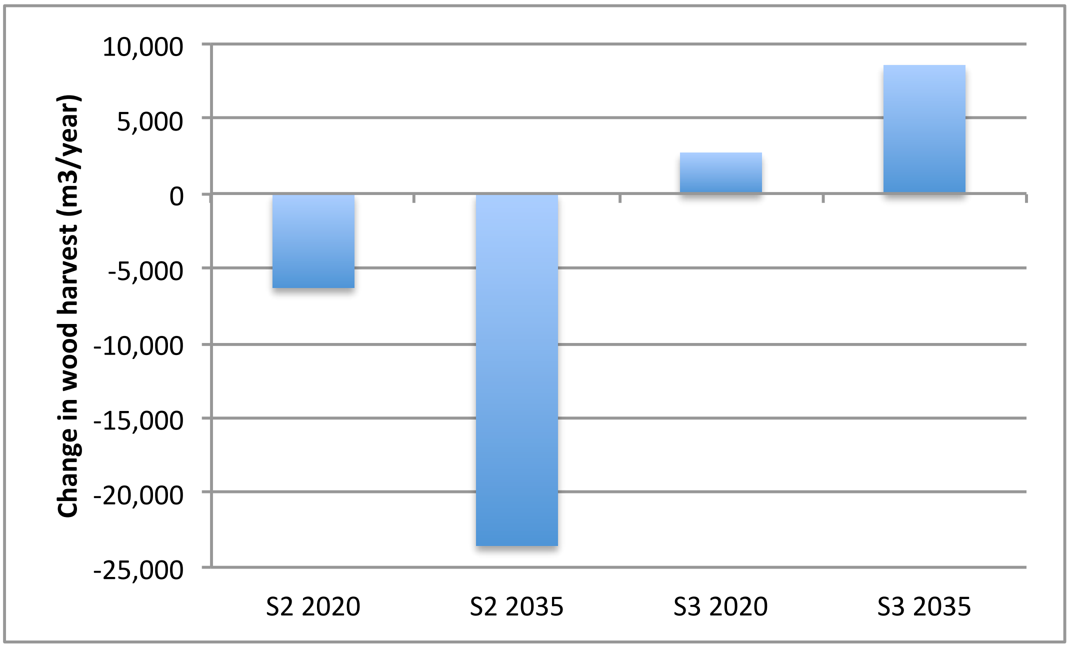

Figure 23. Predicted change in annual fuel wood harvest under each scenario relative to the baseline (m3/year).

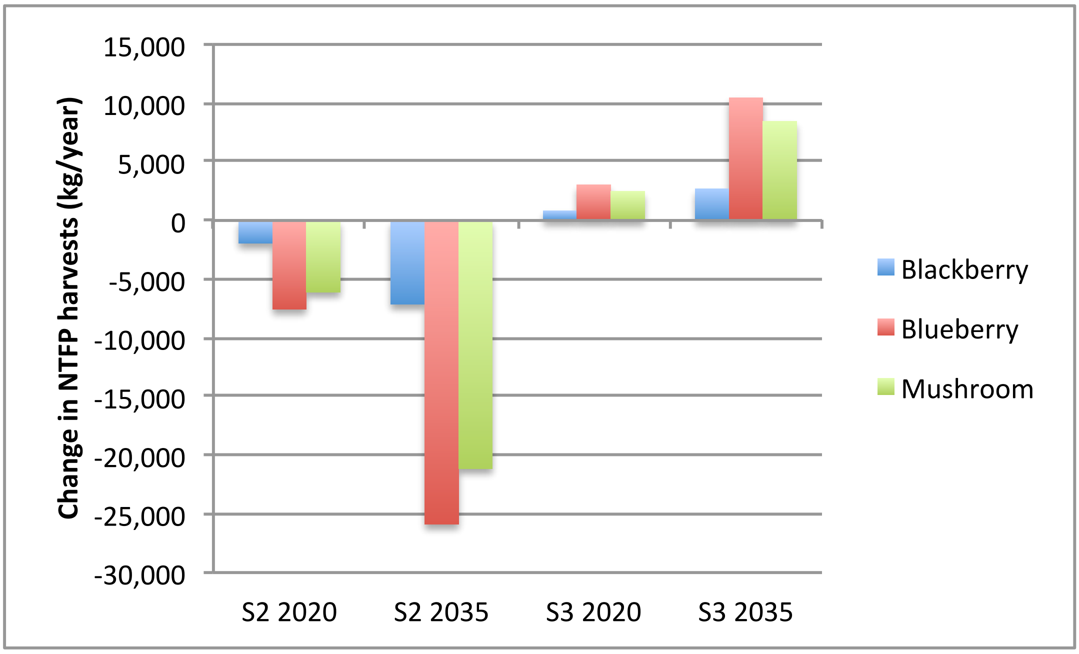

Figure 24. Predicted change in annual NTFP harvests under each scenario relative to the baseline (m3/year).

Demand functions for fuel wood and NTFPs

In order to estimate the economic value of changes in the quantity of harvested fuel wood under each scenario, a demand function that relates the household WTP for fuel wood to the quantity harvested is constructed. Data from the household survey on WTP for Forest Agency supplied fuel wood and quantities of wood used by each household in a year are used to estimate a bivariate linear regression. The dependent variable is WTP (US$/$m^3$) and the explanatory variable is the quantity of fuel wood used per year (m^3). These data and the demand function are represented in Figure 25. The estimated demand function is reported in Table 13. As expected, there is a statistically significant negative relationship between quantity of fuel wood and WTP. Households that consume more wood are willing to pay less per unit of wood. The demand function estimated on the bases of these data has a high R^2 statistic of 0.635, indicating that approximately 64% of variation in WTP is explained by variation in quantity.

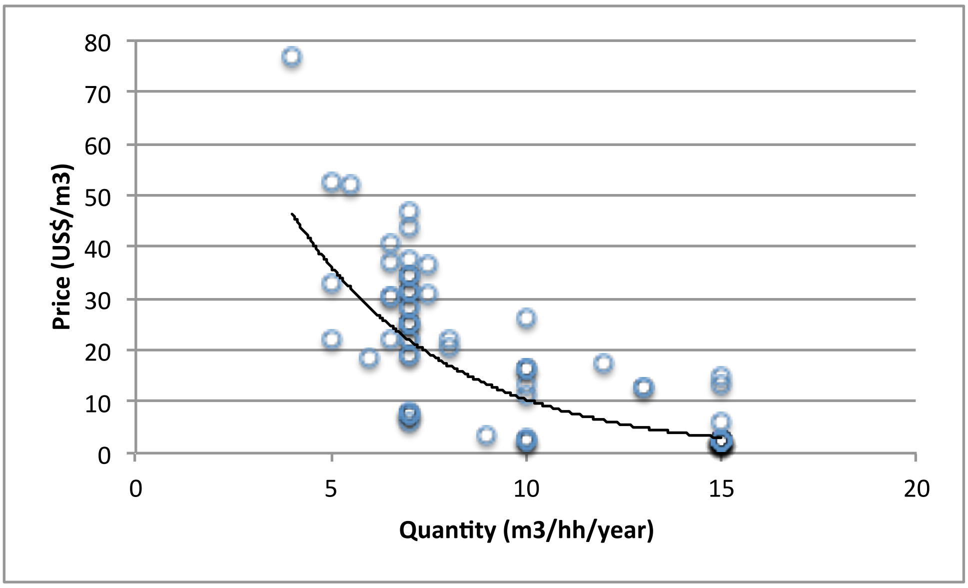

Figure 25. Demand relationship between quantity and price of fuel wood

Table 13. Demand function for fuel wood

	Coefficient	SE	P
Constant	7.815***	0.486	0.000
Fuel wood (m3; ln)	-2.449***	0.219	0.000
Adjusted R2	0.635		
N	72		

***indicates statistical significance at the 1% level

This estimated demand function is used in combination with data on the predicted quantity of wood harvested per household under each scenario (see previous step in the analysis), to predict the marginal WTP for fuel wood under each scenario. Note that the demand function predicts the WTP *per household* in each village, so this information is extrapolated to the village level by multiplying by the number of households in each village using data from the 2014 population census (GEOSTAT, 2016).

There is insufficient data to estimate equivalent demand functions for NTFPs. Instead, market prices were used for each forest product. The market prices used are reported in Table 14.

Table 14. Market prices for NTFPs (price per kg)

	GEL	USD
Blackberries	5 – 10	2.20 – 4.40
Blueberries	7 – 10	3.08 – 4.40
Mushrooms	5 – 15	2.20 – 6.60
Chestnuts	2 – 3	0.88 – 1.32

Value of fuel wood and NTFPs

The changes in economic value of forest products under each scenario are represented in Figure 26 (fuel wood) and Figure 27 (NTFPs). The value of changes in the availability of fuel wood is substantial. Under the degradation scenario (S2), the annual loss in value is just over US$ 100,000 in 2020, rising to over US$ 400,000 in 2035. This represents the potential cost of allowing forest degradation. The increase in availability and harvest of fuel wood under the restoration scenario (S3) also has substantial value. The annual benefit is just over US$ 40,000 in 2020, rising to US$ 120,000 in 2035. This represents the increased household wellbeing derived from fuel wood resulting from improved management and restoration of forests. Changes in the value of NTFPs are lower than for fuel wood but still economically significant, particularly for the smaller number of households that harvest NTFPs.

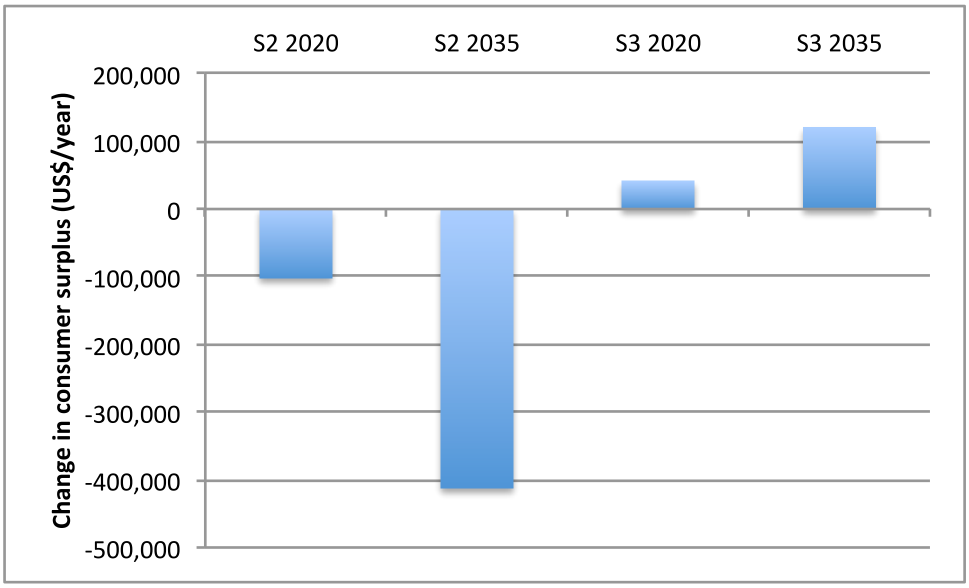

Figure 26. Change in economic value of fuel wood relative to the baseline scenario (US$/year)

The spatial distribution of changes in the economic value of fuel wood is represented in Figure 28. Each village is represented by a circle, the size of which indicates the scale of change in fuel wood value. The loss in value of fuel wood under the degradation scenario is fairly evenly distributed across all villages. Villages with larger populations are expected to face higher losses. The gains from restoration, however, are more concentrated in villages for which there are significant areas of scrub, sparse vegetation and pasture that can be restored to forest.

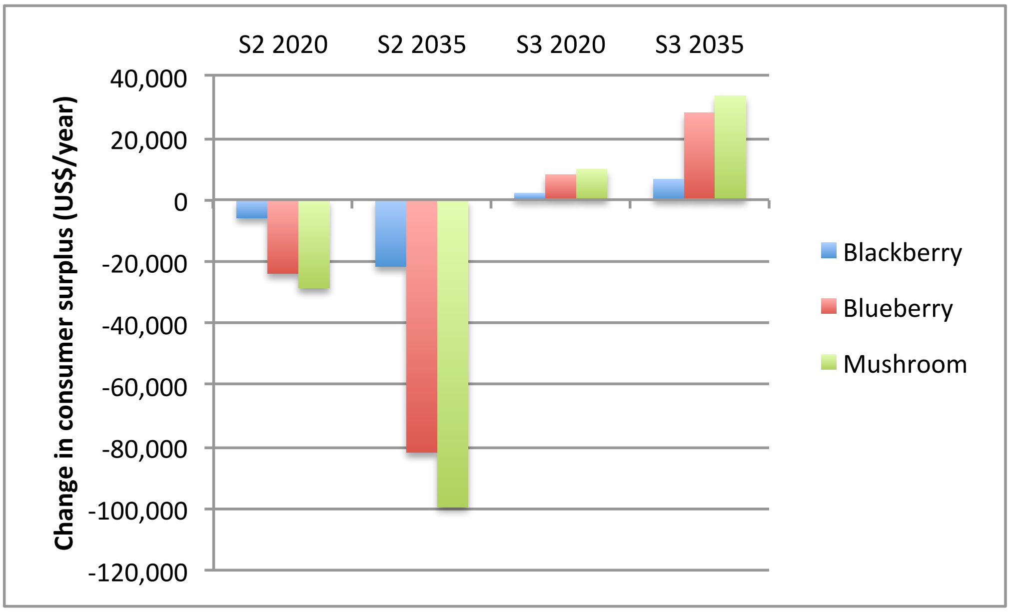

Figure 27. Change in economic value of NTFPs relative to the baseline scenario (US$/year)

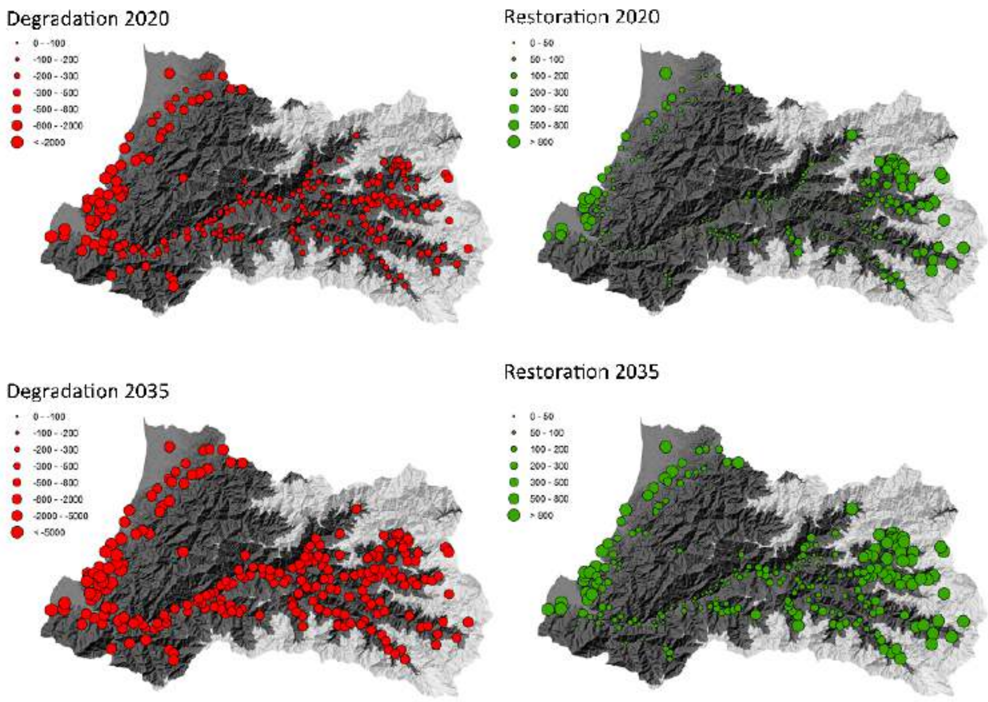

Figure 28. Spatial distribution of changes in the economic value of fuel wood (US$/year)

Carbon storage

Forests play an important role in global climate regulation by removing CO_2 from the atmosphere and storing it in living biomass and the forest soil. By removing this greenhouse gas from the atmosphere, forests reduce the rate and severity of climate change and the expected damages that are associated with it. If forests are converted to other land uses or degraded, they cease to sequester CO_2 and may release stored carbon into the atmosphere. If forests are well managed and degraded areas are reforested, the quantity of carbon stored can increase.

The methodology for the assessment and valuation of carbon storage by forests in Adjara is represented in Figure 29.

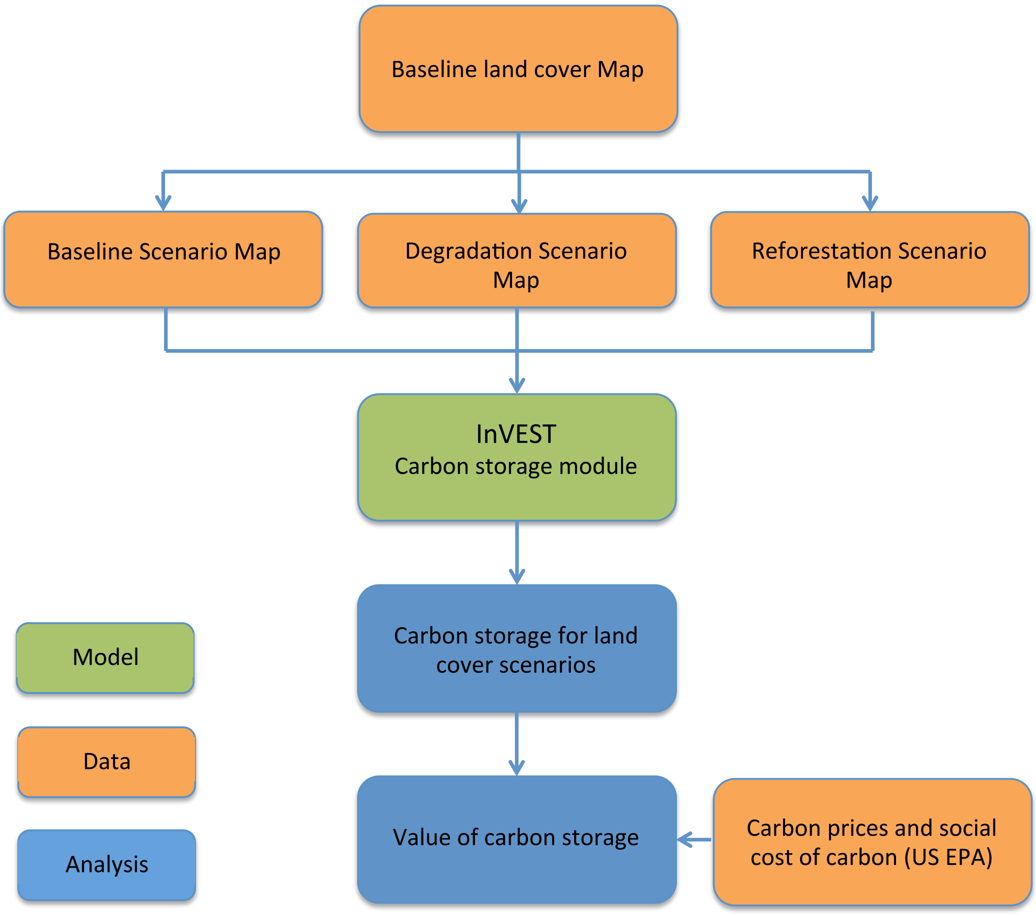

Figure 29. Methodology for assessment and valuation of carbon regulation

Bio-physical changes in carbon storage

Forests remove carbon dioxide from the atmosphere and store it in their fibres and in the soil. The amount of carbon that is captured from the atmosphere by different plant species can be quantified in terms of a rate of sequestration. If a tree or plant is destroyed or damaged, the carbon stored in the plant's cells is released as the biomass decays or burns. Carbon stored in the soil may be released over time if left un-vegetated, or released quickly if the soil is disturbed. The rates at which carbon is added to biomass/soil (sequestration rate) and any release of stored carbon can be used together to calculate the net change in atmospheric carbon dioxide in a given time period. The net amount of carbon sequestered by an ecosystem is the sum of the rate of sequestration of each species ($r_{s,t}$) and the amount of stored carbon that would be released if the ecosystem were damaged or destroyed ($q_{s,t}$) per a given time period.

$$Carbon\ Sequestration_t = \sum (r_{s,t} + q_{s,t})$$

The subscript *s* refers to the species; the subscript *t* refers to the length of time analysed, usually one year. Data on the rates of carbon sequestration by different ecosystems and the extent of those ecosystems can be used to estimate annual quantities of carbon sequestration. Data on the quantity of stored carbon in different ecosystems and changes in extent of those ecosystems can be used to estimate the annual quantity of carbon prevented from release or decay into the atmosphere. By convention, quantities of carbon are often expressed in terms of tonnes of CO_2-equivalent in order to allow comparison with other greenhouse gases. The conversion rate between carbon and CO_2 is 1 tC = 3.67 tCO_2.

Economic valuation of carbon storage

The annual value of carbon sequestration can be estimated by multiplying the annual (net) quantity of sequestered carbon by the value per tonne of carbon, as represented by equation:

$$Value\ Carbon\ Sequestration_t = \sum(r_{s,t} - q_{s,t}) * Value\ per\ tonne\ carbon$$

The economic valuation of carbon storage examines two aspects of carbon value:

1. Potential value of marketed carbon credits from enhanced sequestration and avoided emissions. This is potentially useful information for resource management, which may be interested in examining financing mechanisms to pay for ecosystem conservation. The observed price of marketed carbon credits provides an indication of the potential revenue from crediting and selling stored carbon. One limitation of this approach is that prices in carbon markets are largely artefacts of the set up and regulation of the market and do not reflect the full benefits of carbon storage.
2. Social cost of carbon (SCC). The SCC is the estimated damage caused by climate change resulting from additional units of carbon emitted to the atmosphere. It therefore represents the global benefit of reducing carbon concentrations in the atmosphere (e.g. through sequestration in forests). The SCC is intended to be a comprehensive estimate of climate change damages but due to current limitations in the integrated assessment models and data used to estimate SCC, it does not include all important damages and is likely to under-estimate the full damages from carbon emissions.

The data used to estimate the value of carbon sequestration and storage are:

- The change in carbon stocks under alternative land use scenarios (tonnes of carbon) is obtained from InVEST modelled output. Quantities of carbon are converted to tonnes of CO_2-equivalent using the conversion factor 1 tC = 3.67 t CO_2. The additional quantity of carbon released or stored under each scenario is computed as the total carbon stored under the scenario minus the total carbon stored under the baseline scenario.
- The saleable proportion of additional stored carbon is estimated from existing initiatives. Existing projects to certify and market carbon credits are observed to only be able to sell a limited proportion of the potential total volume due to the challenges of establishing a credible baseline, obtaining and marketing credits. The saleable proportion is assumed to be 20% of the physical potential.
- The price of carbon credits is 4.9 US$ per tonne CO_2-equivalent, which is obtained from Forest Trends (2015).
- The costs of setting up, monitoring, enforcing, crediting and marketing carbon credits is obtained from existing initiatives. The total costs are divided by the quantity of carbon

credits generated to obtain an estimate of cost in terms of US$ per tonne CO_2-equivalent. The cost per credit is estimated to be 0.73 US$/t$CO_2$-equivalent.

- The potential producer surplus obtained from crediting and selling avoided carbon emissions is computed by multiplying the total quantity of avoided carbon emissions (tonnes CO_2-eq) by the market price[4], minus the costs of managing and crediting emissions reductions.
- The estimated social cost of carbon is 59 US$ per tonne CO_2-equivalent (US Interagency Working Group, 2013).
- The global societal benefit or cost from changes in stock of stored carbon is computed by multiplying the change in the quantity of stored carbon by the SCC.

The estimated quantities and values of carbon storage are presented in Table 15. The annual potential net revenues from selling carbon credits under each scenario are represented in Figure 30. Under the reforestation scenario, the potential annual net revenue (revenue minus costs) in 2020 is estimated to be US$ 347,000. The annual net revenue rises to US$ 381,000 in 2035, reflecting the increasing area of forest sequestering carbon, resulting in an increasing number of carbon credits that can be sold. These potential annual net revenues could be used to fund the additional forest management activities under the reforestation scenario. Under the degradation scenario the quantity of stored carbon decreases relative to the baseline and there is no scope for selling carbon credits. In this case, the estimated negative net revenues represent the loss in value of the carbon stock under this scenario.

The annual global benefits from changes in the quantity of carbon stored in Adjaran forests, measured using the social cost of carbon, is represented in Figure 31. Under the restoration scenario, the annual global value of avoided climate change damages due to increased storage of carbon is estimated to be US$ 24.5 million in 2020, rising to US$ 27 million in 2035. This reflects the high avoided damage costs associated with climate change but it is important to note that these are global benefits that do not accrue exclusively or directly to the Adjaran population. Under the degradation scenario the increase in annual global climate change damages due to the release of carbon is estimated to be US$ 18.5 million in 2020 rising to US$ 22 million in 2030.

[4] This calculation is made with the assumption that avoided emissions that will occur in the future (i.e. as biomass and soil carbon is released over time) can be credited and sold in the current year. If this is not the case, it would be necessary to estimate the quantity of carbon released in each year following the land use change and then compute a present value of the stream of credits.

Table 15. Annual changes in carbon storage (all quantities and values in thousands)

	Degrade 2020	Degrade 2035	Restore 2020	Restore 2035
Change in stored carbon (tCO2-eq/year)	-313	-376	416	457
Saleable carbon credits (tCO2/year)	-63	-75	83	91
Revenue carbon credits (US$/year)	-307	-369	408	448
Costs carbon credits (US$/year)	-46	-55	61	67
Net Revenue carbon credits (US$/year)	-261	-314	347	381
Social cost of carbon (US$/year)	-18,493	-22,191	24,539	26,987

[1] Change in carbon stored relative to the baseline stock of carbon
[2] Using the assumption that 20% of 'additional' carbon storage can be sold. Additional carbon is assessed relative to the BAU scenario.

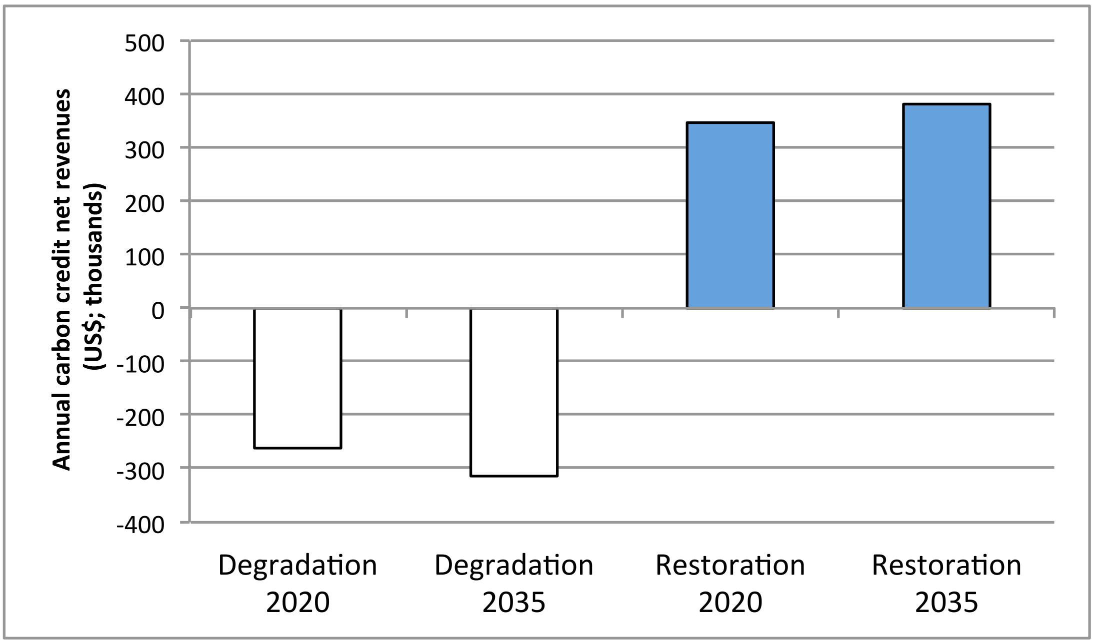

Figure 30. Annual potential net revenue from sale of carbon credits

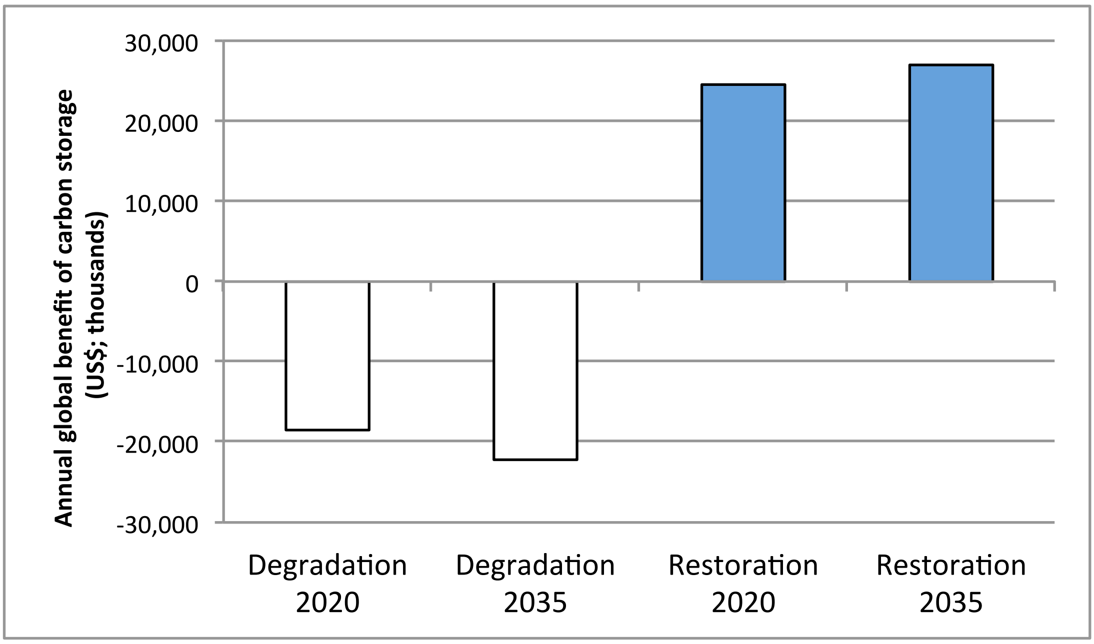

Figure 31. Annual global benefits of carbon storage measured using the social cost of carbon

Natural hazard regulation

Forests play an important role in stabilizing steep mountain slopes and regulating rates of erosion and natural hazards such as floods and landslides. Here the economic value of Adjaran forests for their role in regulating the occurrence of landslides is estimated. Risk from natural hazards is generally modelled as a combination of the hazard itself (e.g. frequency of landslides) and exposure (e.g. assets that may be damaged) (de Moel and Aerts, 2015). The methodology for the assessment and valuation of landslide regulation by forests in Adjara is represented in Figure 32. The approach combines spatial data on land cover under each scenario with a bio-physical model (InVEST) of sediment retention and export to estimate spatially variable rates of sediment export for each scenario. The baseline data on sediment export is combined with data on the frequency of landslide damage to houses in Adjaran villages and used to estimate a predictive function for landslide damage. Village level data on sediment export under each scenario is then fed into this function to predict changes in landslide damage frequency in each village under each scenario. The costs of predicted damages are estimated using data on average compensation payments. The steps, assumptions and data used in this analysis are described in detail in the sections below.

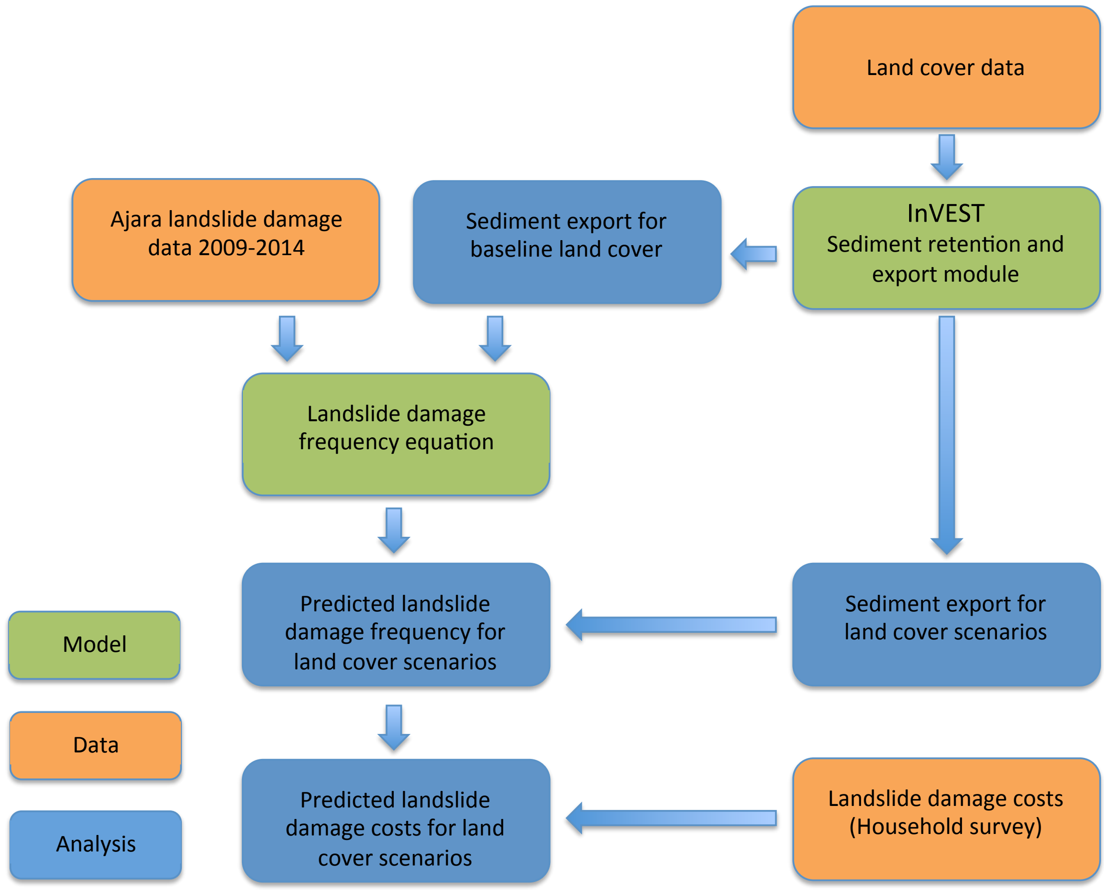

Figure 32. Methodology for assessment of landslide regulation

Sediment export model

Soil erosion is a natural process that occurs when rain detaches soil particles and washes them overland and eventually into streams and rivers. Soil erosion is prevented, or at least reduced, through forest or plant cover. The root structure of trees holds topsoil in place preventing erosion. Soil erosion can be damaging to the environment by affecting water quality, causing landslides, sedimentation of reservoirs and damaging dams downstream. The InVEST model is used here to quantify the changes in sediment export due to changes in land cover (Sharp *et al.*, 2016).

Annual sediment delivery/export model on each pixel *i* $(ton.ha^{-1}yr^{-1})$ is based on the revised universal soil loss equation which is given as:

$$usle_i = R_i \; x \; K_i \; x \; LS_i \; x \; C_i \; x \; P_i$$

Where:
R_i is the rainfall erosivity (MJ.mm $(ha.hr)^{-1}$)
K_i is the soil erodibility (ton.ha.hr $(Mj.ha.mm)^{-1}$)
LS_i is the slope length-gradient factor
C_i is the crop management factor
P_i is the support practice factor

To quantify the flow of sediment from upstream to downstream, the estimation requires input from a digital elevation model. The above formula is applied to each grid cell to estimate the annual soil loss from each cell within a catchment area. Since many factors affect the soil loss, including land management, slope gradient, vegetation, soil property, etc., the model also assesses the sediment delivery ratio (SDRi), which is the proportion of actual soil loss from each pixel. These two parameters are then used to find the total amount of soil loss from each pixel as can be seen in the Figure 33.

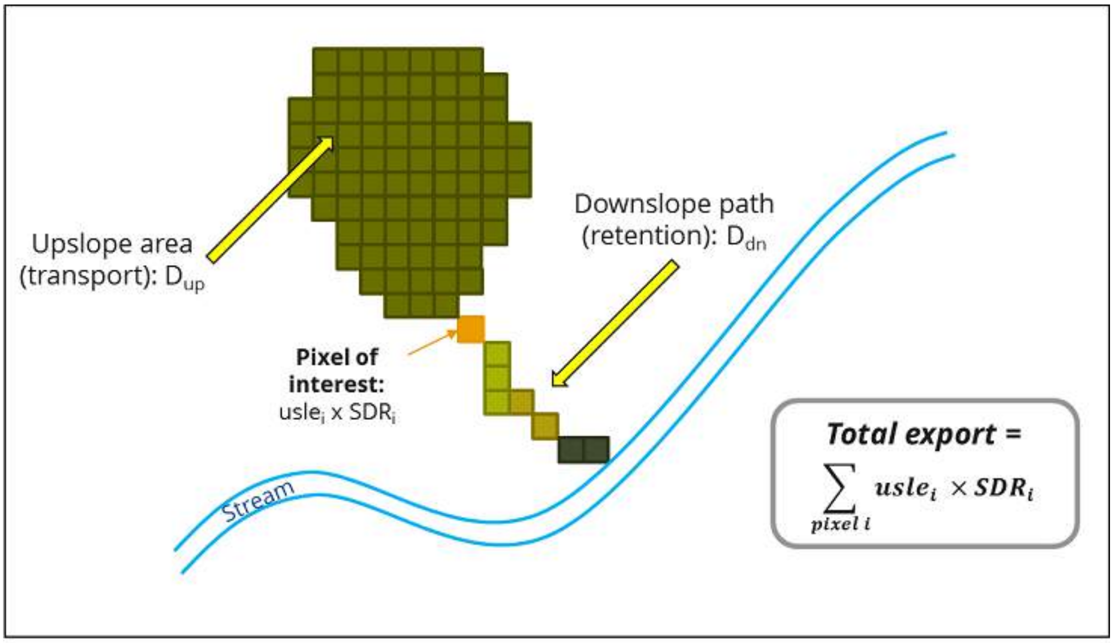

Figure 33: Conceptual representation of sediment export quantification in InVEST.

The sediment loss from a given pixel is calculated by the following formula:

$$E_i = usle_i \times SDR_i$$

And, the total soil loss within a catchment area is computed by the formula:

$$E = \sum_i E_i$$

Given the simplicity of the model, there are several recognised limitations. The model is suitable for estimating overland erosion but other types of erosion such as gully erosion, bank erosion, and mass erosion (such as landslides) are not incorporated into the model. The model to predict landslides directly was not used; instead, the estimated changes in sediment export as a predictor of landslide damage were used.

The steps to extract data on sediment export within 5 km radius of each village are similar to the steps used to extract data regarding forest area. Buffer zones for each village were processed using the ArcGIS application and then the resultant information was fed to QGIS to obtain the sediment export for each buffer zone.

Spatially explicit changes in sediment export under each scenario are represented in Figure 34. For the purposes of presentation, these maps show the quantity of sediment export aggregated at the level of water sub-catchments. The level of analysis, however, is for individual pixels and subsequently 5 km buffers around each village location. The maps indicate where sediment export increases under the degradation scenario and decreases under the restoration scenario.

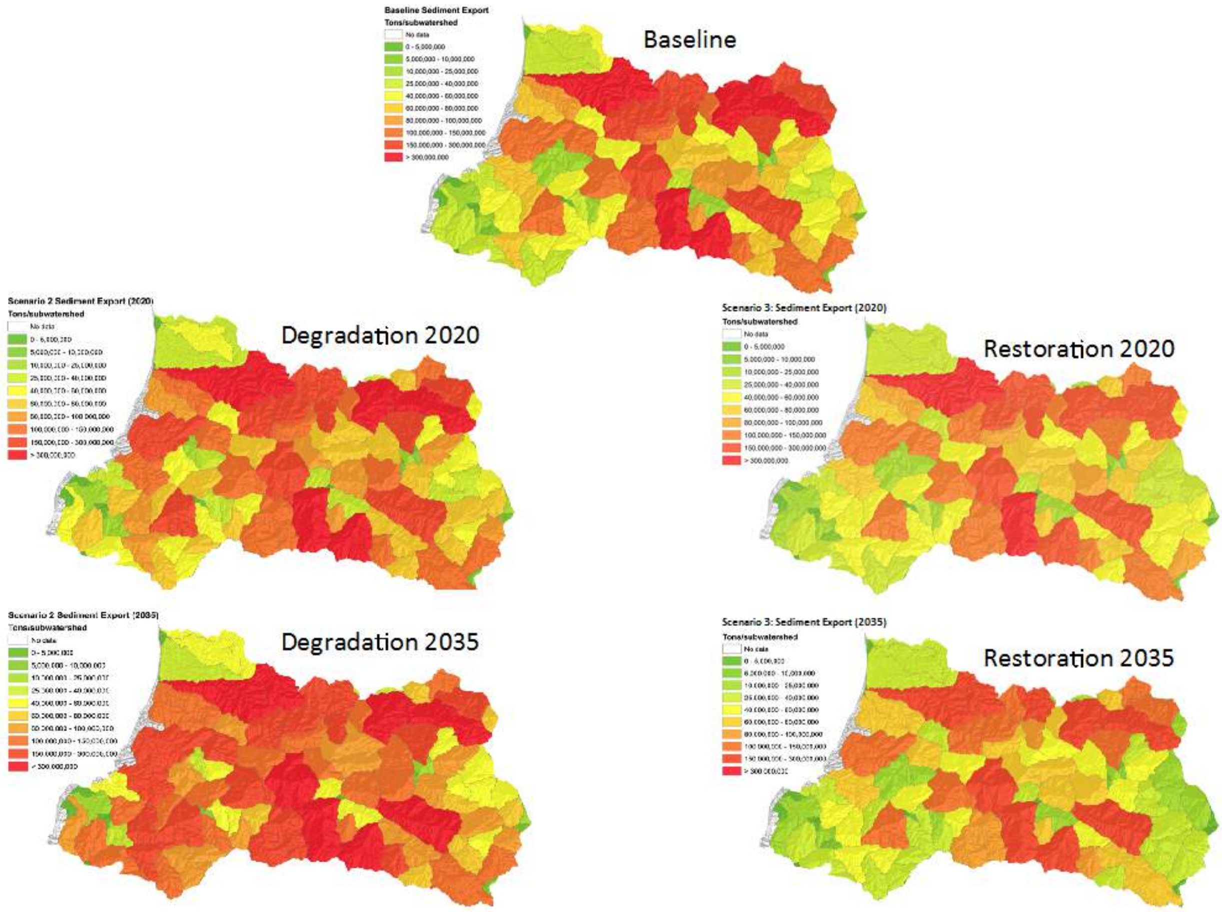

Figure 34. Sediment export per water sub-catchment

Landslide damage frequency function

Historic data on landslide damages in Adjara (2009-2014) was obtained from DEPNR of Adjara (2016). This data has been reorganized into count data indicating the number of houses that are damaged by landslides in each village in each year. The data cover 383 villages and 6 years, giving 2,298 data points.

This data on landslide damage frequency was combined with data on sediment export for baseline land cover estimated using InVEST. Using information on the geographic coordinates of each village, the annual quantity of sediment exported within a 5 km radius of each village was extracted. Geographic coordinates are only available for 237 out of 383 villages so the remaining 146 were omitted from the analysis.

Data was also added on the number of households in each village (DEPNR, 2016), which was used as a measure of exposure to landslide hazard. Data on the number of households is available for only 41 villages so the sample is further restricted leaving a total of 246 data points (41 village*6 years = 246). Table 16 provides a description of the variables used in the landslide damage frequency function.

Table 16. Descriptive statistics for village level data used to estimate landslide damage frequency function

	Mean	S.E. Mean	Median	Min.	Max.
Number of houses damaged by landslides	3.22	0.41	1.00	0.00	67
Sediment export (tonnes; 5 km radius)	1,814	33.49	1,879	584	3,068
Households	246	18.87	105	23	1,000

This data was then used to estimate a function for predicting changes in the frequency of landslide damage to houses following changes in land cover. The function was estimated using a generalised Poisson loglinear model since the dependent variable is count data.[5]

The estimated landslide damage frequency function is reported in Table 16. The dependent variable is the number of damaged houses per village per year. All estimated coefficients on the explanatory variables are statistically significant at the 5% level or better. The positive estimated coefficient on the sediment export variable indicates that landslide damages are higher in areas with higher sediment export. Similarly, landslide damage also increases with the number of houses in a village (i.e. there is a higher likelihood of damage in villages with more houses that may be damaged). The dummy variables for each year 2010-2014 are used to control for year specific variation in the number of houses damaged by landslides, possibly related to the occurrence of extreme weather events in each year. The omitted category year to which other years are compared is 2009. Relative to the number of houses damaged by landslides in 2009, there were significantly more houses damaged in 2013.

The validity of using the estimated function was checked to predict landslide damage by performing an in-sample test to predict the number of damaged houses in the respective data. The mean number of houses damaged by landslides per village per year in the data is 3.22 and the mean predicted number is 2.79, indicating that the landslide damage function tends to slightly (13%) under predict the scale of landslide damage. In particular, the function does not predict well extreme events in which multiple (>10) houses are damaged in a single village. Since this analysis is focused on estimating average levels of landslide damage across Adjara

[5] Poisson regression assumes the response variable (in this case the number of houses in a village damaged by landslides) has a Poisson distribution, and assumes the logarithm of its expected value can be modelled by a linear combination of unknown parameters. A Poisson distribution is a discrete probability distribution that expresses the probability of a given number of events occurring in a fixed interval of time if these events occur with a known average rate and independently of the time since the last event. Poisson regression is appropriate when the dependent variable is a count, for instance the number of houses damaged by landslides in a year. The events must be independent in the sense that one house damaged by a landslide does not make another more or less likely, but the probability of events per unit time is related to covariates such as the quantity of sediment export in the vicinity of a village and the number of households in the village.

rather than specific events, the function is considered to be sufficiently accurate and slightly conservative.

Table 17. Landslide damage frequency function. Dependent variable is the number of houses damaged by landslides per village per year.

Parameter	Coefficient	Std. Error	95% Wald Confidence Interval	
			Lower	Upper
Constant	-11.225***	1.2998	-13.773	-8.678
Sediment export (tonnes; ln)	0.995***	0.1447	0.711	1.279
Households (ln)	0.847***	0.0513	0.747	0.948
2010 dummy variable	0.346**	0.1509	0.05	0.642
2011 dummy variable	-0.68***	0.1991	-1.07	-0.29
2012 dummy variable	0.617***	0.1433	0.336	0.898
2013 dummy variable	1.476***	0.128	1.225	1.726
2014 dummy variable	0.346**	0.1509	0.05	0.642
N	246			
Likelihood ratio	706.131			

***, ** indicates statistical significance at the 1% and 5% levels respectively

Predicted landslide damage

To predict how the frequency of landslide damage to houses changes with changes in land cover, a separate database was prepared for all villages in Adjara that includes information on the explanatory variables used in the damage function (i.e. sediment export within a 5 km radius of each village; and the number of households). Estimated sediment export under each scenario was obtained from the InVEST model output and extracted for a 5 km radius buffer around each village using a GIS. Data on the number of households in each village was obtained from DEPNR (2016) and the 2014 population census (GEOSTAT, 2016). In cases for which village specific information on sediment export and number of households was not available (due to missing coordinates for some villages), the municipality averages were assigned.

This data was then combined with the estimated damage function to predict the number of houses damaged by landslides in each village per year. The results are presented in Table 18 and Figure 35. The total number of houses predicted to be damaged by landslides per year under the business-as-usual land cover is 549, which is slightly lower than the annual average (632 houses) for the period 2009-2014. The number of houses damaged by landslides increases substantially under the degradation scenario, rising to an additional 326 houses damaged in 2035 relative to the business-as-usual scenario. Under the restoration scenario, the number of houses damaged by landslides is predicted to decrease by 58 houses per year in 2035.

Table 18. Number of houses damaged by landslides

	BAU	Degradation 2020	Degradation 2035	Restoration 2020	Restoration 2035
Mean per village	1.43	1.65	2.29	1.38	1.28
Total	549	632	876	528	492
Dif. From BAU	0	83	326	-21	-58

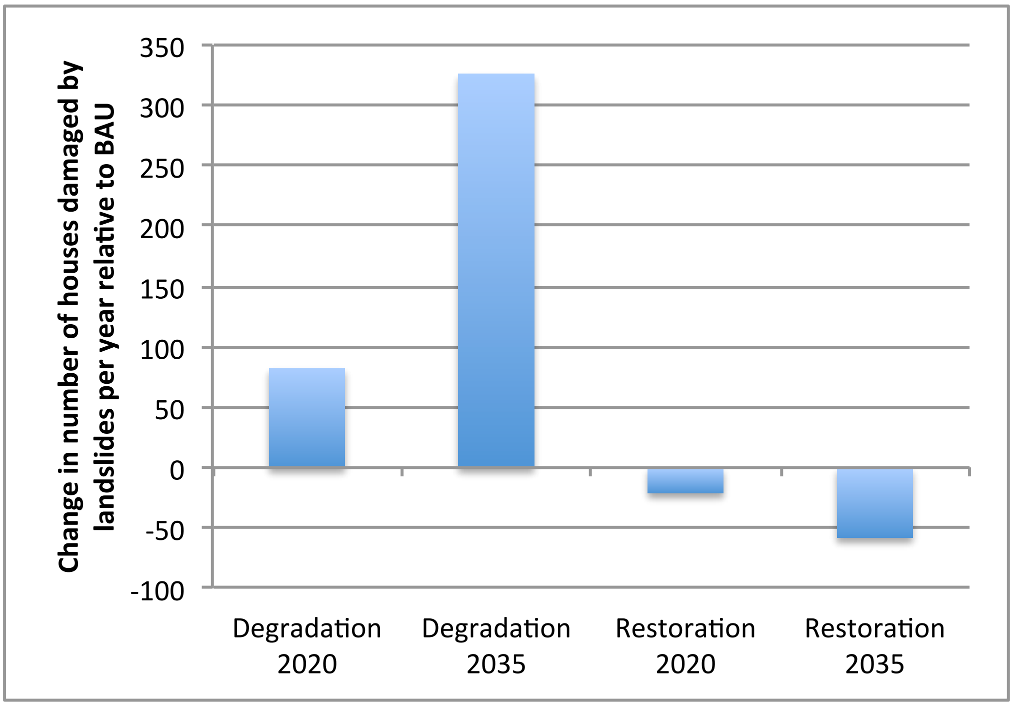

Figure 35. Change in the number of houses damaged by landslides per year relative to the business-as-usual scenario

Avoided landslide damage costs

The economic value of the role forests play in regulating the occurrence of landslides is estimated as the damage costs that are avoided due to forest cover. More specifically, the change in damage costs due to changes in land cover under each scenario is estimated. Damage costs were computed by multiplying the number of houses damaged by the average government compensation payment to households that had suffered natural hazard damage during the period 2013-2015. This is US$ 2,010 per household (DEPNR, 2016).[6]

The results of this valuation are represented in Figure 36. Avoided damage costs decrease substantially under the degradation scenario relative to the business-as-usual case. Damages increase by US$ 166,000 in 2020, rising to US$ 656,000 in 2035. To put this in perspective, current annual compensation payments to households for damage caused by natural hazards is US$ 196,000. Under the restoration scenario there is a moderate decrease in damages from landslides of US$ 42,000 in 2020 rising to US$ 116,000 in 2035, relative to the business-as-

[6] Total compensation payments due to natural disasters were US$ 590,000 to 293 household for the period 2013-2015. This is equivalent to US$ 196,000 per year or US$ 2,010 per household.

usual case. Figure 37 represents the spatial distribution of changes in avoided damage costs. The increases in landslide damages under the degradation scenario are fairly evenly distributed across villages in all five municipalities. The benefits of reducing landslide damages under the restoration scenario are largely received in Khulo and Shuakhevi municipalities, where most forest restoration takes place.

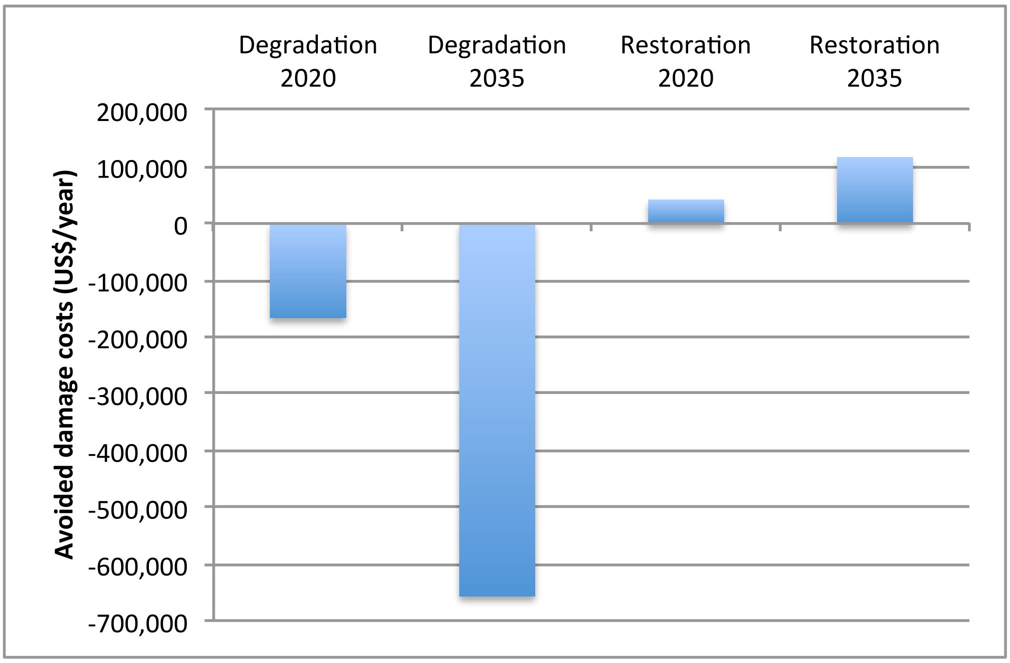

Figure 36. Annual avoided landslide damages (US$/year)

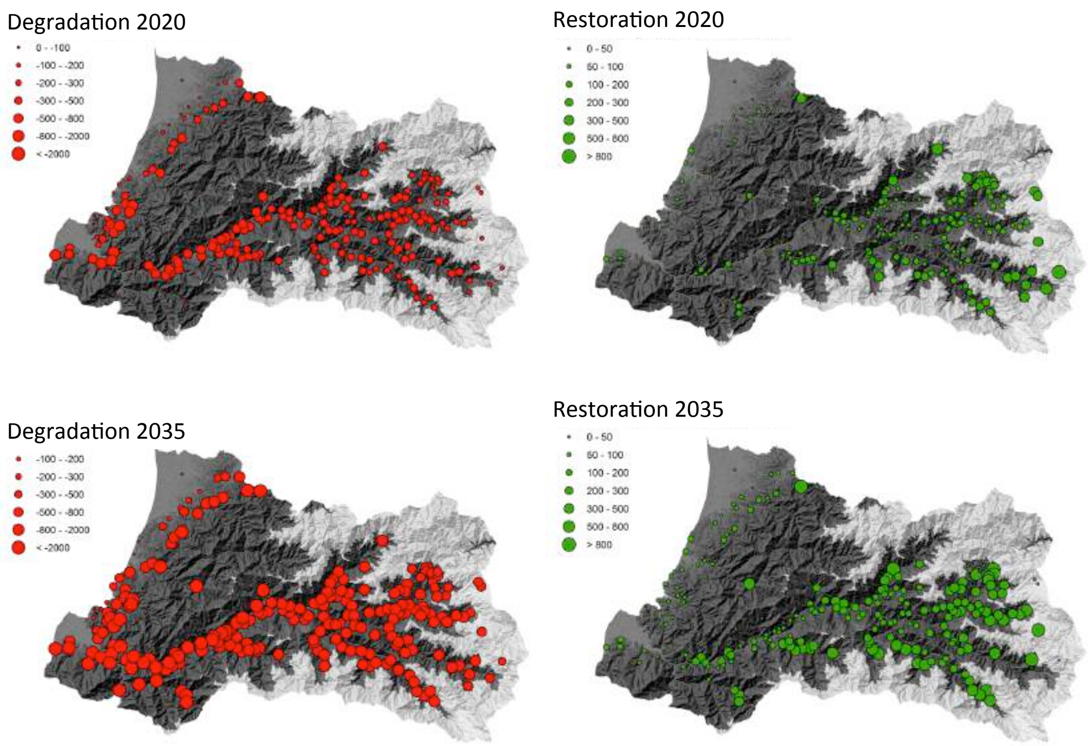

Figure 37. Spatial distribution of annual change in landslide damages (US$/year)

Summary of ecosystem service values

Changes in the values of ecosystem services provided by Adjaran forests under each scenario are summarised in Table 19 and Figure 38. To focus on services that directly benefit the people of Adjara, the estimated value of carbon storage measured as the avoided damage costs of climate change (social cost of carbon) is left out. The provision of fuel wood, NTFPs and the regulation of landslides are all services that directly and currently benefit the population of Adjara. The values of these services decrease substantially if forests are allowed to degrade. Under the degradation scenario, an 18% decline in forest cover by 2035 leads to an annual loss in welfare equivalent to almost US$ 1.3 million. Over 50% of this loss is due to increased landslide damages. Under the restoration scenario on the other hand, converting 34.5% of pasture and 27.3% of scrub and sparsely vegetated land to forest by 2035 (an increase of total forest area to 185,359 ha or 15.7%) results in an annual welfare gain equivalent to just over US$ 300,000. In this case the gains due to increased provision of fuel wood and reduced landslide damages are approximately equal in value.

Although the regulation of the global climate through the storage of carbon is a global benefit, it may be possible to capture part of this benefit for Adjarians through the marketing and sale of carbon credits. This, however, is currently only a *potential* source of revenue for Adjara. This revenue stream would add substantially to the benefits received under the restoration scenario.

Table 19. Summary of annual ecosystem service values in Adjara (US$)

Ecosystem Service	Degradation 2020	Degradation 2035	Restoration 2020	Restoration 2035
Fuel wood	-102,042	-412,548	41,559	120,582
NTFPs	-58,453	-203,021	20,080	68,553
Landslide regulation	-166,127	-655,758	42,051	116,301
Carbon (potential credits)	-261,353	-313,621	346,805	381,402
Total	-587,976	-1,584,948	450,495	686,839

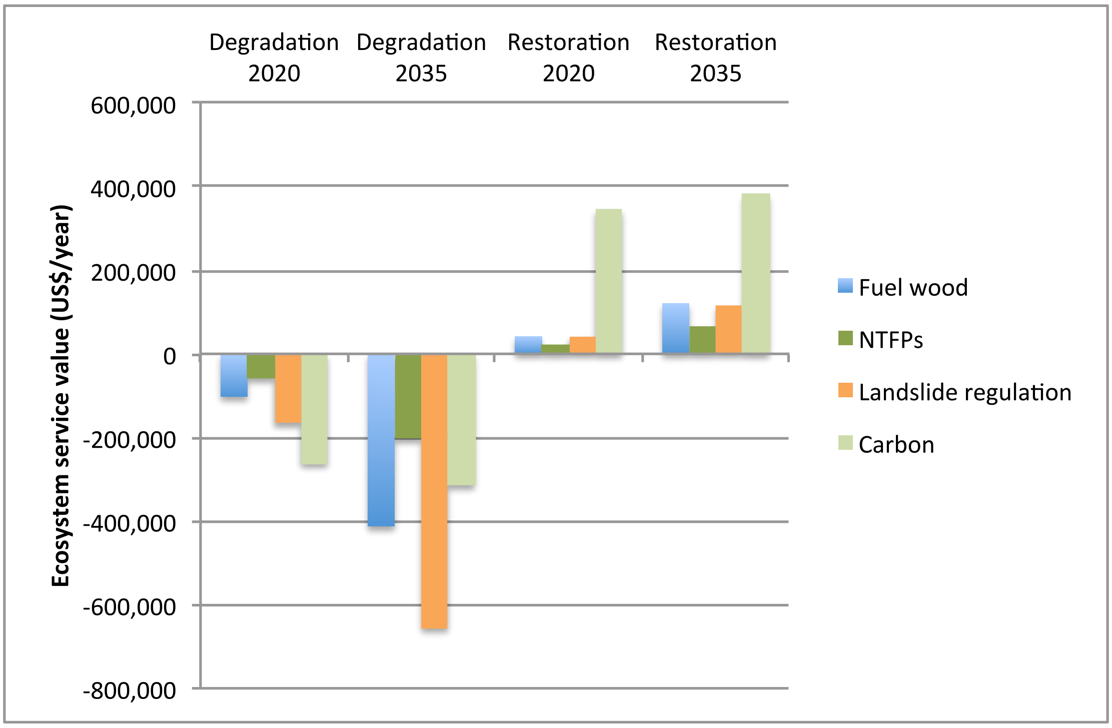

Figure 38. Annual ecosystem service values (US$/year)

The results presented above are in terms of changes in annual values, i.e. the value of ecosystem services received in specific years (2020 and 20135) relative to the baseline. In order to provide a measure of the differences in value of ecosystem services over the entire time horizon of the analysis, Table 20 and Figure 39 report the total changes in ecosystem service values for the period 2016-2035 under each scenario. These values represent the sum of losses or gains due to alternative policy directions over the period 2016-2035. The total value of lost ecosystem services under the degradation scenario approaches US$ 19 million; whereas the gains from restoration are approximately US$ 10 million.

Table 20. Total value of changes in ecosystem service provision in Adjara under alternative forest management scenario (2016-2035; US$)

	Degradation	Restoration
Fuel wood	-4,320,805	1,380,249
NTFPs	-2,208,692	749,227
Landslide regulation	-6,907,341	1,350,911
Carbon (potential credits)	-5,122,499	6,519,273
Total	-18,559,337	9,999,660

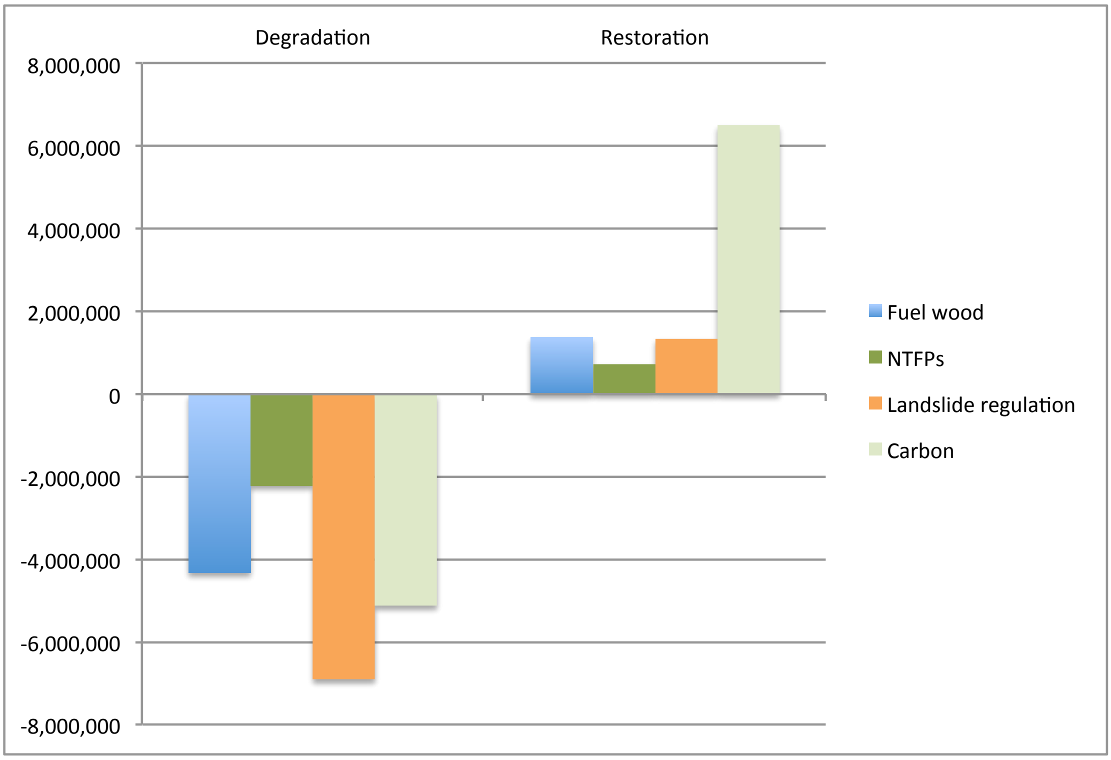

Figure 39. Total value of changes in ecosystem service provision in Adjara under alternative forest management scenario (2016-2035; US$)

6. Conclusions and Policy Recommendations

Based on the outcomes of the forest ecosystem service valuation, this chapter discusses which management challenges arise, identifies relevant policy and regulatory structures and how to address the challenges through appropriate interventions.

This analysis suggests that there is a potential for increasing social and economic benefits through well-conceived policy interventions that can improve forest conditions and increase forest cover in Adjara. The analysis compares two alternative scenarios for the future condition of forests in Adjara (degradation and restoration) in the years 2020 and 2035 to a business-as-usual scenario. Under the business-as-usual scenario present conditions continue into the future and there is no appreciable change in forest quality or quantity. It is assumed that the Adjara government's budget for forest related activities remains at the present level, international donors continue their current support, and the Ministry of Social Welfare continues to pay out approximately US$ 200,000 in compensation for damage to private assets in the case of landslides and other related disasters.

However, with climate change and the possibility of significantly increased precipitation, incidence of landslides may increase even without any change in the underlying condition of forests. Hence, in this respect, the estimates are conservative (i.e. the value of forests in regulating landslides will be higher with climate change). The Degradation Scenario indicates that if forest cover were to be reduced by 1% per year to an 18% total decline by 2035, this would result in a potential annual loss in value from ecosystems services exceeding US$ 1 million per year by 2035. The Managed Use and Restoration Scenario describes an improvement in forest cover as pasture, scrub and sparse vegetation is restored to forest at a rate of 2% (of pasture, scrub and sparce vegetation) per year, leading to a total increase of 16% by 2035. Under this scenario, proactive measures in improving forest quality will create additional value from ecosystems services estimated to reach almost US$ 700,000 per year.

The additional value created by increased forestation derives from four main sources. First, the availability of more fuel wood and the ability to harvest it at less expense would create additional use value of US$ 40,000 in 2020, rising to US$ 120,000 per year in 2035. Additional potential harvests of NTFPs (blackberries, blueberries and mushrooms) would yield US$ 70,000 per year by 2035. Savings from avoided landslide damages add up to US$ 42,000 in 2020 and US$ 116,000 in 2035. These values have been estimated under conservative assumptions and thus considered to represent lower bound estimates. Furthermore, an additional potential benefit of US$ 347,000 per year in 2020 rising to US$ 381,000 per year in 2035 could be obtained if the additional carbon captured by increased forest cover could be certified and carbon credits sold. This figure is a conservative estimate based on the assumption that only 20% of the physical potential for carbon credits are saleable. Even if it proves difficult to sell carbon credits, the global benefits accruing from increased carbon storage would still be realized, just not appropriated by Adjara, and that these would total up to US$ 27 million per year in 2035. There are likely to be several other smaller and less significant benefits obtained from the restoration scenario, such as from positive impacts on tourism, which are not included in this study so as to focus attention on the most economically important ecosystem services.

From these findings, the central policy challenge that emerges is how to enable these additional economic benefits to be generated and captured locally. At a minimum, this analysis suggests that a conservative figure of US$ 100,000 per year in 2020, rising to US$ 200,000 by 2035, could be spent additionally on forest regeneration activities to increase forest cover by 16% by 2035. In other words, the benefits in terms of locally received ecosystem services would justify these additional costs of forest management.

Implementation of policies that would achieve this requires attention to be paid to contextual institutional and organizational interests and capacities. The review of stakeholders in Chapter 3 of this report indicated that a holistic approach to this issue in Adjara involves multiple actors and levels of governance. In such contexts where policy decisions have to consider the costs and benefits related to ecosystem management across multiple levels of governance, although there is a growing awareness of the importance of biodiversity and ecosystems services, incorporating them fully in policy making is subject to various challenges, ranging from the ecological to the economic and the political (Ring et.al. 2010). To address these issues, forest management in Adjara faces five institutional and organizational factors that may limit its response.

First, there is a knowledge deficit. Decision makers and AFA personnel may be inadequately aware of the benefits provided by forests and the value that the forests create. This point was made in the National Forest Policy Concept, which noted that foresters "do not take into account the consequences which may case degradation of forest ecosystems and eventually lead to human induced natural disasters."

Second, there are gaps in the framework of laws and regulations around forest management in Adjara, which many reviews have found to be unclear and inconsistent. The foundation of forest law in Georgia is the Forest Code of 1999. Clarity of the code and consistency of the subsequent legislations have both proved to be problematic. Terminology such as "forest fund" for example, is a legacy from the Soviet era referring to forests or forest lands, but is internationally defined and understood as the financial resources for forest management. Closely linked is the issue of inadequate legal framework for protecting biodiversity and forests. This is most apparent in the absence of clear categorization or zoning of forests (UNEP and WWF 2013). For instance, the category of Area with Special functions is defined by "Forest use rules" (Government Resolution No. 242, 20.08.2010) with certain provisions such as the prohibition of commercial logging (final cuts) in these areas. However, the location of this category of forest areas is not demarcated under any statutory act (Green Alternative 2016). The underlying issue is that forest management in Georgia is geared towards a perception of forests as having primarily commercial functions, with environmental management being secondary and not linked to economic value. In Adjara, the strategic plan of the AFA notes the problem of an "inadequate, insufficient legislative base", stating that as a result of imprecise boundaries of forest lands, it is not able to enforce laws when other organizations or individuals take over the land.

Third, there are capacity constraints in the AFA, both in terms of finance and staffing. As a result, existing regulatory and legal frameworks are weakly enforced. This is particularly evident when it comes to logging of timber or fuel wood. The problem is two-fold, with often illegal activities going undetected, and when detected going unpunished (Machavariani 2014). As locals are legally allowed to use certain areas of the forests and with set limits, there is often plenty of activity in the forests and hence high risk of illegal activity as well. However, the systems for monitoring and enforcing laws on forest activity are inadequate, and there is only limited staff of regulating authorities overseeing these activities. Further, the high levels of rural poverty in Adjara not only exacerbate the risk of illegal activity but also imply a low ability to enforce penalties on vulnerable populations. Indeed, fines imposed by enforcement authorities on poor violators of the forestry law are routinely rescinded in the courts. Moreover, forest management organizations lack resources to carry out their statutory functions effectively. Funding is a major constraint, and remains so for several forestry operations including restoration, thinning, pest and disease control and controlling forest fires. Further, even as funding is increasing, there are impediments to using the funds efficiently including inadequate competency of staff, lack of updated forest management plans, and an absence of modern information technology systems (Machavariani 2014).

Fourth, local governments have not been empowered to manage their forest areas despite the 1999 Forest Code's emphasis in this area. Decision-making power remains centralized and currently located in the MENRP and the National Forest Agency. Decentralization is complicated by the fact that there are still no clear boundaries of the local forest fund (Macharashvili 2009) and, further by the fact that, as noted in the earlier TEEB scoping study for Georgia, "local self-governing bodies are not ready to take over the responsibility for forest management… because they lack funding, capacity and experience".

Finally, data management on forests suffers from the lack of reliable sources and updated information. For instance, assessments of the status of non-timber resources in Georgia are incomplete (UNEP & WWF 2013). This greatly impedes efforts to evaluate the state of affairs and thereby hinders the process of policy learning.

Each of these areas requires attention from the authorities as they are essential to facilitating other policy initiatives aimed at improving the management of forest ecosystem services.

Policy Alternatives

Keeping these contextual issues in mind, several alternatives can be developed with an aim to improving forest cover, including both demand side (where the demand for forest services is reduced thereby allowing natural regenerative forces to improve forest condition) and supply side (where the supply of forest services is increased through targeted interventions in regeneration and reforestation) approaches:

1. Promoting and subsidizing the use of alternative fuels and energy sources for heating and cooking, such as through gasification and solar.
2. Strengthening the enforcement of the permit system for fuel wood collection so that only designated trees and prescribed amounts are collected.
3. Creating a system whereby the AFA undertakes the harvesting and marketing of fuel wood combined with strict controls on social forestry.

A choice among these alternatives implies trade-offs among competing desirable impacts. Evaluating the potential alternatives can be aided by the use of decision support tools such as multi-criteria analysis (MCA).[7] The evaluative criteria should include economic, social, political

[7] Multi-criteria analysis (MCA) is a well-established tool for decision-making that involves conflicting or multiple objectives. MCA can be used to establish preferences between alternative options by reference to a set of measurable criteria that the decision making body has defined. The basic idea behind MCA is to allow the integration of different objectives (or criteria) without assigning monetary values to all of them (unlike a cost-benefit analysis). In short, MCA provides a systematic method for

and environmental factors, including the required budgetary commitments, public acceptance, ease of implementation and the value of enhanced ecosystem services. The weighting for each criteria would need to be decided by the people of Adjara through a multi-stakeholder process that aims to reflect the needs and desires of the population.

OPTION 1

Facilitating a shift towards other fuels, such as gas, has distinct advantages and disadvantages. This would create a permanently suppressed demand for fuel wood for heating and cooking, which would reduce future pressures on forest resources. While these fuels would be cleaner and more convenient, they are also more expensive than fuel wood, and may require subsidies for a number of low-income citizens. Administratively, the burden of managing fuel wood supply and forest regulation would be reduced while that of managing a subsidy program for lower income citizens would increase. The standard challenges of administering subsidy programs such as errors of inclusion and exclusion and leakages would also apply.

Private sector involvement in terms of creating supply lines for gas and other fuels would also be required.

OPTION 2

A strengthened permit system for fuel wood collection would require little additional planning. The AFA would need to be strengthened with more equipment and personnel. The AFA personnel would also need more training in identifying the correct places to mark for tree harvest and plan forestation activities so that the supply of fuel wood is maintained and able to meet demand. In the absence of compensatory policies, users' time and expense in harvesting fuel wood would increase, and social welfare for the lower income groups might decrease to an undesirable extent.

OPTION 3

Creating a new system whereby the AFA harvests and markets fuel wood would address the problem of unauthorized felling as the forest agency would be able to avoid felling in sensitive areas and also in the longer term be able to create harvest lots which sustainably supply fuel wood to the communities. This initiative would require that AFA have adequately qualified personnel to identify ideal areas for harvesting, and also the initial investments in equipment and personnel required to harvest and supply fuel wood. In case the AFA were to outsource this to private contractors, then AFA would need to ensure adequate oversight and monitoring. In addition, the policy environment would need to ensure that the price charged by the AFA is not too low as otherwise the supply of fuel wood will require subsidies. Since any operation that is not self-financing may be vulnerable to budget restrictions and eventually to a deterioration of the service.

Table 21 provides an outline template that could to be used to apply a MCA framework to determine the attractiveness of each option.

---

comparing these criteria, some of which may be expressed in monetary terms and some of which are expressed in other units (Brander and van Beukering, 2015).

Table 21 Multi-Criteria Analysis scoring

	Budgetary commitment	Ecosystem service values	Public acceptance	Ease of administration	Total weighted score
Option 1	Score X Weight	Score X Weight	Score X Weight		
Option 2	Score X Weight	Score X Weight			
Option 3	Score X Weight				

For the implementation of any of these policies, the following organizational issues will need to be addressed:

First, it is generally difficult to get approval for policy initiatives that require significant and recurring financial outlays in budget constrained environments, even if such initiatives are eventually financially advantageous. In the context of disaster prevention, it has been repeatedly verified that in spite of the fact that expenditures on disaster prevention routinely are more economical that in disaster response, there is a policy bias towards response and relief over prevention. A common hurdle is that financial allocations are hotly contested and while prevention, given its non-immediate nature often loses in budgetary allocations, disaster responses, given their urgent nature, generally succeed in obtaining funds. In the Adjara forest management context, the challenge is to explore mechanisms for how budgetary resources can be transferred from a reactive disbursement allocation for landslide and natural disaster compensations to proactive afforestation and forest regeneration purposes.

Second, mechanisms would need to be developed so that revenues from the supply of fuel wood to communities would pay not only for the immediate costs of supply but also for improving the conditions of the supply such that in the longer term fuel wood is made available in larger quantities and also made more easily and cheaply accessible.

Finally, mechanisms need to be developed for crediting and marketing carbon credits through existing and potential channels so that the people of Adjara can internalize some of the global benefits created by preserving and expanding forest carbon stocks in their region. This would require a designated agency that would conduct the necessary inventory tasks and liaise with the international bodies that commercialize carbon credits. In the absence of direct sales of carbon credits, proposals for donor funding of afforestation and regeneration measures can also be made in light of the significant global positive environmental externalities that such initiatives would entail.

Acknowledgments

The development and implementation of this study has benefited from indispensable inputs from numerous sources. In particular the authors are sincerely grateful to Dr. Giorgi Sanadiradze, the Director of WWF-Caucasus Programme Office for the promotion of TEEB initiative in Georgia and Dr. Nugzar Zazanashvili, the Conservation Director of WWF-Caucasus Programme Office for the constant support to the study. Our thanks also go to Mr. Vakhtang Tsuladze, Head of Directorate for Environment Protection and Natural Resources of Adjara Autonomous Republic (at present, Member of the Supreme Council of Adjara Autonomous Republic and the Chairman of Agrarian and Environmental Issues Committee of the Supreme Council) for his great support in data collection; to Mr. Ilia Osepashvili, WWF-Caucasus, for his guidance, knowledge and detailed reviews; to Mr. Giorgi Beruchashvili, WWF-Caucasus, for providing GIS support and maps; to all participants of the stakeholder workshop held on 26-27 November 2015 in Batumi for advice and insights into the bio-physical and institutional context of the Adjara forestry sector; to Tariel Tuskia (Directorate for Environment Protection and Natural Resources of Adjara), Ramaz Jincharadze (Ministry of Health and Social Affairs of Adjara) and Zurab Manvelidze (forestry expert) for advice, data and expert knowledge. The photographs used in the cover page are credited to WWF-CauPO (upper, left and lower images) and Zurab Manvelidze (righthand image).

References

Aalde, H., Gonzalez, P., Gytarsky, M., Thelma Krug, Kurz, W. A., Ogle, S., Raison, J., Schoene, D., Ravindranath, N. H., Elhassan, N. G., Heath, L. S., Higuchi, N., Kainja, S., Matsumoto, M., Sánchez, M. J. S. and Somogyi, Z. (2006) 'Forestland', in 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Japan: IGES.

Adjara Forest Agency (Legal Entity of Public Law, LEPL) (2015). Strategic Plan, Batumi 2015.

Balmford, A., Fisher, B., Green, R. E., Naidoo, R., Strassburg, B., Turner, R. K., & Rodrigues, A. S. (2011). Bringing ecosystem services into the real world: an operational framework for assessing the economic consequences of losing wild nature. Environmental and Resource Economics, 48 (2), 161-175.

Bateman, I.J., Mace, G.M., Fezzi, C., Atkinson, G., and Turner, K. (2011). Economic analysis for ecosystem service assessments. Environmental and Resource Economics, 48(2), 177-218.

Bhagabati, N., Barano, T., Conte, M., Ennaanay, D., Hadian, O., McKenzie, E., Olwero, N., Rosenthal, A., Suparmoko, S. A. and Tallis, H. (2012) 'A Green Vision for Sumatra: Using ecosystem services information to make recommendations for sustainable land use planning at the province and district level', Natural Capital Project, WWF-US and WWF-Indonesia, Washington DC.

Bishop, J. ed. (2013). The Economics of Ecosystems and Biodiversity in Business and Enterprise. Routledge.

Brander, L.M., Brauer, I., Gerdes, H., Ghermandi, A., Kuik, O., Markandya, A., Navrud, S., Nunes, P.A.L.D., Schaafsma, M., Vos, H. and Wagtendonk, A. (2012b). Using meta-analysis and GIS for value transfer and scaling up: Valuing climate change induced losses of European wetlands. Environmental and Resource Economics, 52: 395-413.

Brander, L.M. and van Beukering, P.J.H. (2015). Trade-offs and decision support tools. In Bouma, J.A. and van Beukering, P.J.H. (Eds.), Ecosystem Services: From Concept to Practice. Cambridge University Press.

Costanza, R., d'Arge, R., De Groot, R., Faber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'neill, R.V., Paruelo, J. and Raskin, R.G. (1997). The value of the world's ecosystem services and natural capital.

Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Farber, S. and Turner, R.K. (2014). Changes in the global value of ecosystem services. Global Environmental Change, 26, pp.152-158.

Daily, G. (1997). Nature's services: societal dependence on natural ecosystems. Island Press.

De Groot, R.S., Alkemade, R., Braat, L., Hein, L. and Willemen, L. (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological complexity, 7(3), pp.260-272.

de Moel, H., & Aerts, J. C. J. H. (2011). Effect of uncertainty in land use, damage models and inundation depth on flood damage estimates. Natural Hazards, 58: 407-425.

Defra (2007). An Introductory Guide to Valuing Ecosystem services. Department for Environment, Food, and Rural Affairs, London, United Kingdom.

Delaney, M., Brown, S., Lugo, A. E., Torres-Lezama, A. and Quintero, N. B. (1998) 'The Quantity and Turnover of Dead Wood in Permanent Forest Plots in Six Life Zones of Venezuela1', Biotropica, 30(1), pp. 2–11.

Department for Environment, Food, and Rural Affairs in the United Kingdom. 2007. An Introductory Guide to Valuing Ecosystem services. London.

Dilley, M. and Heyman, B.N. (1995). ENSO and Disaster: Droughts, Floods and El Niño/Southern Oscillation Warm Events. Disasters 19 (3): 181-193.

Directorate of Environment Protection and Natural Resources of Adjara (2016). Information on wood harvest, landslides and floods occurring in Adjara in 2009-2014 and respective compensations paid to affected households. Sent to WWF-Caucasus Programme Office in the forms of postal letters and electronic files.

FAO (2010) Global forest resources assessment 2010: Country report Georgia. Report. Forestry Department Food and Agriculture Organization of the United Nations.

FAO (2016). Georgia Case Study, Prepared for FAO as part of the State of the World's Forests 2016 (SOFO). Food and Agricultural Organization of the United Nations.

GEOSTAT (2016). General Population Census 2014. National Statistics Office of Georgia.

Gogichaishvili, G. P. and Urushadze, T. T. (2006) 'Estimation of erosion danger lands of the reclamation fund in Georgia', Journal of Agriculture and Rural Development in the Tropics and Subtropics, 107(1), pp. 85–94. Available at: https://www.scopus.com/inward/record.uri?eid=2-s2.0-33745439199& partnerID=40&md5=1d5bcfe79152f8 79bbf668940205ae0c.

Green Alternative (2016). Forestland Governance in Georgia: Assessment of Legislation and Practice. Tbilisi 2016.

http://earthexplorer.usgs.gov/ (no date). United States Geological Survey. [Accessed on May 10th, 2016]

http://www.naturalcapitalproject.org/invest/#resources.

http://www.omafra.gov.on.ca/english/engineer/facts/12-051.htm#t2.

IPCC (2014) 'Chapter 3: LUCF Sector Good Practice Guidance', in Good Practice Guidance for Land Use, Land-Use Change and Forestry. Kanagawa, Japan: Institute for Global Environmental Strategie.

MA (2005). Millennium Ecosystem Assessment: Ecosystems and human well-being. Washington, DC.

Macharashvili, I. (2009). Forestry Sector Reform in Georgia. Caucasus Institute for Peace, Democracy, and Development. Policy Brief. March 2009.

Macharashvili, I. (2012). Problems and Challenges of Forest Governance in Georgia. Association Green Alternative. Tbilisi 2012.

Machavariani M. (2010). Standards and practice of forest management in Georgia. ENPI FLEG Program, 2010.

Machavariani M., (2014). Analysis of Voluntary Forest Certification Potential within Forestry Sector of Georgia. ENPI-FLEG Program, 2014.

Ministerial Conference on the Protection of Forests in Europe (MCPFE) (1993) Resolution H1: General Guidelines for the Sustainable Management of Forests in Europe. Second MCPFE 16–17 June 1993, Helsinki, Finland.

Ministry of Environment and Natural Resources Protection of Georgia (2015), Vulnerability and Adaptation, Forestry Sector. Third National Communication to the UNFCCC, Tbilisi 2015.

Mitsch, W. J., Bernal, B., Nahlik, A. M., Mander, Ü., Zhang, L., Anderson, C. J., Jørgensen, S. E. and Brix, H. (2013) 'Wetlands, carbon, and climate change', Landscape Ecology, 28(4), pp. 583–597. doi: 10.1007/s10980-012-9758-8.

Nachtergaele, F. and Batjes, N. (2012) Harmonized world soil database. FAO.

National Forest Policy Document for Georgia

Osepashvili I. (2016). The current state of the forestry sector in Georgia and future perspectives. Woodland Heritage 2016.

Regional Development Strategy of the Autonomous republic of Adjara, Batumi 2011.

Ring, I., Hansjürgens, B., Elmqvist, T., Wittmer, H. and Sukhdev, P. (2010). Challenges in framing the economics of ecosystems and biodiversity: the TEEB initiative. Current Opinion in Environmental Sustainability, 2(1), pp.15-26.

Sharp, R., Tallis, H. T., Ricketts, T., Guerry, A. D., Wood, S. A., Chaplin-Kramer, R., Nelson, E., Ennaanay, D., Wolny, S., Olwero, N., Vigerstol, K., Pennington, D., Mendoza, G., Aukema, J., Foster, J., Forrest, J., Cameron, D., Arkema, K., Lonsdorf, E., K., Kennedy, C., Verutes, G., Kim, C. K., Guannel, G., Papenfus, M., Toft, J., Marsik, M., Bernhardt, J., Griffin, R., Glowinski, K., Chaumont, N., Perelman, A., Lacayo, M., Mandle, L., Hamel, P., Vogl, A. L., Rogers, L. and Bierbower, W. (2016) InVEST User Guide, The Natural Capital Project, Stanford University, University of Minnesota, The Nature Conservancy, and World Wildlife Fund. doi: 10.1007/s13398-014-0173-7.2.

Sukhdev, P.W., Schröter-Schlaack, H., Nesshöver, C., Bishop, C. and Brink, J., (2010). The economics of ecosystems and biodiversity: mainstreaming the economics of nature: a synthesis of the approach, conclusions and recommendations of TEEB (No. 333.95 E19). UNEP, Ginebra (Suiza).

TEEB (2009): The Economics of Ecosystems and Biodiversity for National and International Policy Makers. Available at: www.teebweb.org

TEEB (2010). The economics of ecosystems and biodiversity: ecological and economic foundations. Edited by Pushpam Kumar. Earthscan. London.

UNDP in Georgia (2013) Climate Change Strategy of Adjara.

UNEP and WWF (2013). TEEB Scoping Study for Georgia. United Nations Environment Programme (UNEP), Geneva, Switzerland

Vigiak, O., Borselli, L., Newham, L. T. H., McInnes, J. and Roberts, A. M. (2012) 'Comparison of conceptual landscape metrics to define hillslope-scale sediment delivery ratio', Geomorphology, 138(1), pp. 74–88. doi: 10.1016/j.geomorph. 2011.08.026.

Wittmer, H. and Gundimeda, H. eds. (2012). The economics of ecosystems and biodiversity in local and regional policy and management. Routledge.

World Bank (2015) Georgia Country Environmental Analysis, Institutional, Economic, and Poverty Aspects of Georgia's Road to Environmental Sustainability, Washington D.C.

Appendix 1. Abbreviations

AFA	Adjara Forest Agency
APA	Agency for Protected Areas of Georgia
CICES	Common International Classification of Ecosystem Services
DEPNR	Directorate of Environment Protection and Natural Resources of Adjara Autonomous Republic
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GNI	Gross National Income
InVEST	Integrated Valuation of Ecosystem Services and Trade-offs
MA	Millennium Ecosystem Assessment
MENRP	Ministry of Environment and Natural Resources Protection of Georgia
MEPNR	Ministry of Environment Protection and Natural Resources of Georgia
NFA	National Forest Agency of Georgia
NTFP	Non-timber forest products
PES	Payments for Ecosystem Services
SEEA	System of Environmental Economic Accounting
SCC	Social cost of carbon
TEEB	The Economics of Ecosystems and Biodiversity
TEV	Total Economic Value
UNDP	United Nations Development Program
UKNEA	UK National Ecosystem Assessment
WTP	Willingness to Pay

Appendix 2. Forest user questionnaire

LOCATION __________ DATE _______ INTERVIEWER _______

1. Do you use wood for:
   (a) Cooking YES/NO
   (b) Heating YES/NO
   (c) Preparing animal fodder YES/NO
2. In a year, how much wood do you use? QUANTITY____ UNITS_______
3. Where do you obtain the wood?
   (a) Market QUANTITY__________ UNITS_\
   ___
   (b) Forest QUANTITY__________ UNITS_\
   ___
   (c) Other QUANTITY__________ UNITS_\
   ___
4. What is the amount of time, money and effort you spend collecting wood?
   (a) Time (own labour) DAYS________
   (b) Hired Labour DAYS________ LARI_________
   (c) Cost of renting equipment LARI_________
   (d) Cost of transporting wood LARI_________
5. Do some people cut trees that are not marked by the Forest Agency? YES/NO

   If YES, do they cut trees that are not marked by the Forest Agency because:
   (a) The trees marked by the Forest Agency are too far away\
   YES/NO
   (b) The trees marked by the Forest Agency are not of the right quality\
   YES/NO
   (c) The trees marked by the Forest Agency are insufficient to meet their needs\
   YES/NO
   (d) Other reason(s): ____
6. If the Forest Agency were to prohibit you from cutting trees and instead provide you with your fuel wood needs, would you be in favour?\
   YES/NO

   Please give your reasons: ____

7. What is the maximum amount you are willing to pay the Forest Agency for the amount of wood that you use in one year?   LARI PER YEAR ______

8. What other products do you obtain from the forest? For each product, how much is for your own use and how much is sold?

   (a) PRODUCT _______ QUANTITY __________OWN USE (%) _____________

   (b) PRODUCT _______ QUANTITY __________OWN USE (%) _____________

   (c) PRODUCT _______ QUANTITY __________OWN USE (%) _____________

Appendix 3. Household survey on natural hazard damage

LOCATION ______ DATE _______ INTERVIEWER _______

1. Have you ever experienced damages caused by natural hazards (e.g. landslides, flooding)? YES/NO
2. If YES, what was the cause of the damage you suffered? ______________
3. When did the incident occur? DATE ______________
4. What was the damage you suffered (as much detail as possible)? Describe and, if possible, give the approximate money value of the damage.
   (a) House ___________________________________ LARI _________
   (b) Other fixed assets ____________________________ LARI _________
   (c) Animals ___________________________________ LARI _________
   (d) Loss of income ____________________________ LARI _________
   (e) Any injuries/human loss ____
5. After the incident, did you change your place of residence? YES/NO
   a. If YES, where did you move to? ________________________________
   b. How much did the new residence cost? LARI _________
6. Did you receive compensation from the Government? YES/NO
   a. If YES, how much compensation did you receive? LARI _________
   b. How long after the incident did you receive the compensation? _______ ______________
   c. How satisfied are you with the process of obtaining compensation? ______ ______________

Appendix 4: Carbon Storage

Input data preparation and processing

1. **Current land use/land cover:** *A GIS raster dataset, with a LULC code for each cell. The dataset was projected in meters and the projection to be used was defined.*

The dataset was produced by WWF-CauPO by relying on Landsat 8 OLI satellite image 2016 (see Figure 1).

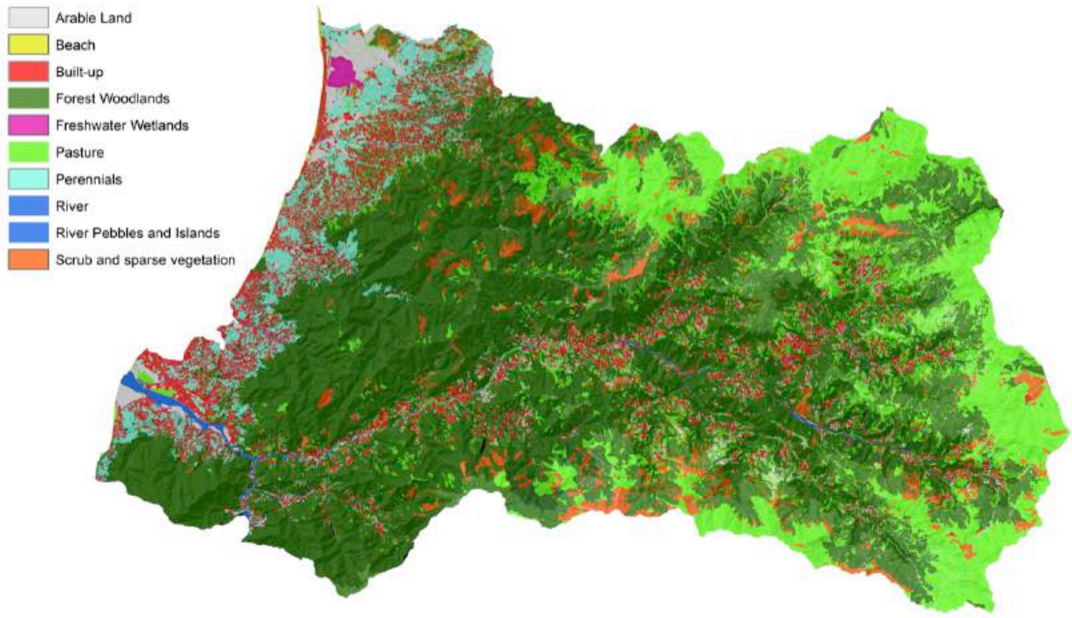

Figure 1. Current land cover 2016 produced by WWF-CauPO

2. **Carbon pools table:** *A table of LULC classes, containing data on carbon stored in each of the four fundamental pools for each LULC class. Carbon storage data can be collected from field estimates from local plot studies, extracted from meta-analyses on specific habitat types or regions, or found in general published tables (e.g., IPCC, see Appendix). If information on some carbon pools is not available, pools can be estimated from other pools, or omitted by leaving all values for the pool equal to 0. The table should be stored in *.CSV file formate and each row of the table in the file is a LULC class.*

   The carbon pool table is table consisting of [1] carbon above ground, [2] carbon below ground, [3] carbon in soil, and [4] carbon in organic dead wood and leaf for each land use class (See Table 1).

   2.1 Carbon above ground: The values of biomass above ground of each land use types are shown in Table 1.

Table 1. Estimated values of above-ground biomass for each land use class[8]

LU Code	LULC_Name	C_above (Mg/ha)	Adopted source for carbon above ground
1	Built-up	0.0	Value of "Town" used by Bhagabati *et al.* (2012)
2	Perennials	25.8	Khan et al. (2015)
3	Pasture	2.1	IPCC (2014)
4	Roads	0.0	
5	Scrub and sparse vegetation	25.8	Khan et al. (2015)
6	River	0.0	
7	River Pebbles and Islands	0.0	
8	Wind Breaking Lines	0.0	
9	Bridge	0.0	
10	Canal	0.0	
11	Artificial Lakes	0.0	
12	Gullies	0.0	
13	Freshwater Wetlands	20.0	Mitsch *et al.*, (2013)
14	Lake	0.0	
15	Railways	0.0	
16	Reservoir	0.0	
17	Beach	0.0	
18	Rocks	0.0	
19	Forest Woodlands	59.9	FAO (2010)
20	Arable Land	2.7	IPCC (2014)

2.2 Carbon below ground: Most values of carbon belowground of vegetation covered land use classes were retrieved by multiplying the carbon above ground with ratio of below-ground biomass to above-ground biomass (R). The R value was taken from IPCC (2006).

Table 2. Estimated values of carbon below ground for each land use class

LU Code	LULC_Name	C_above (Mg/ha)	C_below (Mg/ha)	R	Adopted source for R
1	Built-up	0.0	0	0	
2	Perennials	25.8	5.16	0.2	Subtropical humid forest (Mokany et al., (2006) cited by Aalde et al., 2006)
3	Pasture	2.1	3.36	1.6	Subtropical grassland (Aalde et al., 2006)
4	Roads	0.0	0	0	
5	Scrub and sparse vegetation	25.8	5.16	0.2	Subtropical humid forest (Mokany et al., (2006) cited by Aalde et al., 2006)
6	River	0.0	0	0	
7	River Pebbles and Islands	0.0	0	0	

[8] The table was prepared to simulate with InVEST V.3.3.1

LU Code	LULC_Name	C_above (Mg/ha)	C_below (Mg/ha)	R	Adopted source for R
8	Wind Breaking Lines	0.0	0	0	
9	Bridge	0.0	0	0	
10	Canal	0.0	0	0	
11	Artificial Lakes	0.0	0	0	
12	Gullies	0.0	0	0	
13	Freshwater Wetlands	20.0	32	1.6	Subtropical grassland (Aalde et al., 2006)
14	Lake	0.0	0	0	
15	Railways	0.0	0	0	
16	Reservoir	0.0	0	0	
17	Beach	0.0	0	0	
18	Rocks	0.0	0	0	
19	Forest Woodlands	59.9	11.98	0.2	Subtropical humid forest (Mokany et al., (2006) cited by Aalde et al., 2006)
20	Arable Land	2.7	0.54	0.2	Subtropical humid forest (Mokany et al., (2006) cited by Aalde et al., 2006)

2.3 Carbon stored in dead organic matter: Based on IPCC report (Aalde *et al.*, 2006), carbon stored in organic matter can be computed by the following formula:

Carbon stored in dead organic matter = Carbon in leaf litter + Carbon in deadwood.

Where:

Carbon in leaf litter for each land use class can be derived from Table 2.2 (p. 2.27) of Aalde *et al.* (2006) (which entitled "Default carbon stocks for leaf litter in forested by LULC types."). The values of carbon in leaf litter of the remaining land use classes are assumed to be zero.

Carbon in deadwood for each land use class except water body, non-forest, and human-modified land use classes is calculated based on Delaney *et al.*, (1998) who estimates carbon stored in standing and down dead wood in 6 tropical forests of Venezuela. Deadwood is typically 1/10 the amount of carbon aboveground.

2.4 Carbon stored in soil: Carbon stored in soil (sometimes known as soil organic carbon,) for this study, 1 meters depth soil is considered by employing the database from Nachtergaele and Batjes (2012). The carbon stored in soil for each soil type can be calculated by:

Soil organic carbon in 1 meter depth per soil type = Soil organic carbon of topsoil (0-30cm in depth) per soil type + Soil organic carbon of subsoil (30-100cm in depth) per soil type

Where:

Soil organic carbon is given by *Bulk density x % organic C x Soil depth*

Bulk density and % organic carbon were derived from Nachtergaele and Batjes (2012)

After the soil organic carbon in 1 meter depth map was produced, then the average of soil organic carbon in 1 meter depth for each land use class was computed by using land use classes from land use/cover to extract statistic from the produced carbon soil map. It is also highlighted that for water body and manmade environment such as "Build-up", "Road" and so on were assigned zero value for their soil organic carbon.

Table 2. Carbon pools table for carbon model in Adjara, Georgia

N	C_above	C_below	C_soil	C_dead	lucode	LULC_Name
1	0	0	0	0	1	Built-up
2	25.8	5.16	73.7	2.58	2	Perennials
3	2.1	3.36	77.7	0	3	Pasture
4	0	0	0	0	4	Roads
5	25.8	5.16	74.7	2.58	5	Scrub and sparse vegetation
6	0	0	0	0	6	River
7	0	0	0	0	7	River Pebbles and Islands
8	0	0	0	0	8	Wind Breaking Lines
9	0	0	0	0	9	Bridge
10	0	0	0	0	10	Canal
11	0	0	0	0	11	Artificial Lakes
12	0	0	0	0	12	Gullies
13	20	32	71.2	2	13	Freshwater Wetlands
14	0	0	0	0	14	Lake
15	0	0	0	0	15	Railways
16	0	0	0	0	16	Reservoir
17	0	0	0	0	17	Beach
18	0	0	0	0	18	Rocks
19	59.9	11.98	79.6	10.09	19	Forest Woodlands
20	2.7	0.54	73.6	0.27	20	Arable Land

Appendix 5: Sediment Export

Input data preparation and processing

1. **DEM Raster:** *A raster dataset of elevation value.*

Example: The DEM used for the model is ASTER DEM V.2 with the resolution of 30 meters and downloaded from http://earthexplorer.usgs.gov/ accessed on May 18th, 2016. Before inputting to the model, the DEM was checked for the missing value and then the sinks were filled in raster. There was no single missing value in the target area, and therefore only the fill processing was done for the DEM using the Fill tool of ArcGIS's Hydrology model. After the sinks were filled, the DEM was fed to the model for the analysis (See Figure 1).

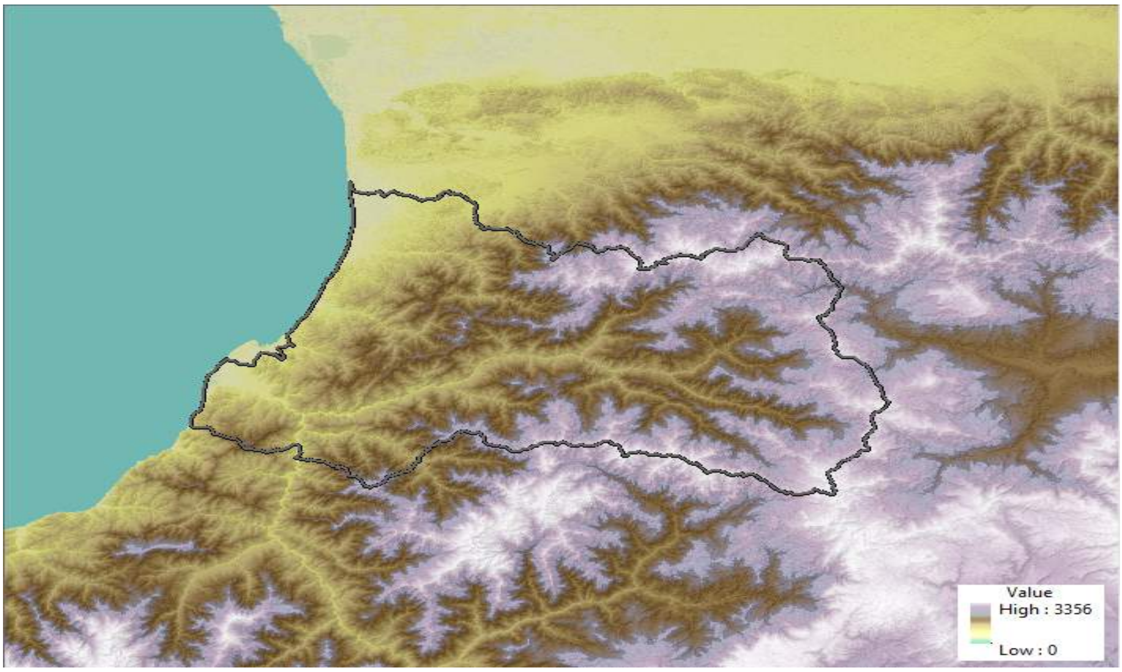

Figure 1. Prepared filled Digital Elevation Model (DEM)

2. **Rainfall Erosivity Index Raster**: *A GIS raster dataset containing erosivity index for each cell. This value depends on the intensity and duration of rainfall and it is*

$$MJ*mm*(ha*h*yr)^{-1}.$$

Based on Zaslavski et al. (1981) cited by Gogichaishvili and Urushadze (2006), rainfall erosivity index (R) is based on the following formula:

$$R_{30} = 0.25841 * H * I_{30} - 0.14921$$

Where:

H is annual precipitation (mm)
I_{30} is the maximum intensity of rain (mm/hr). I_{30} was assumed equal to 96 mm/hr.

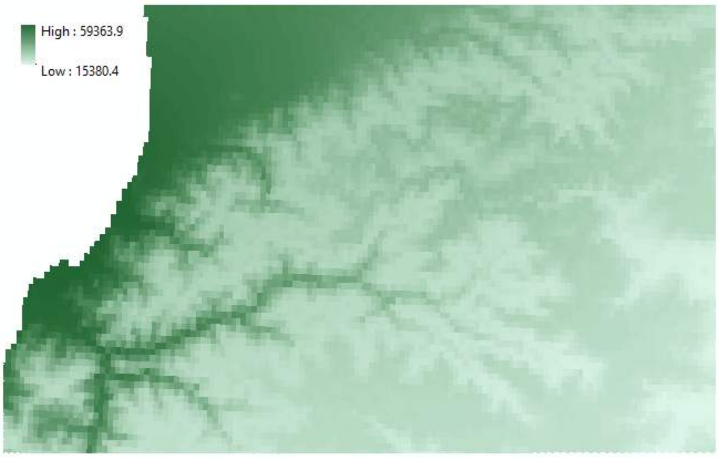

Figure 2. Prepared rainfall erosivity index raster

3. **Erodibility Raster**: *A raster dataset of soil erodibility; it is a measure of the susceptibility of soil particles to detachment and transport by rainfall and runoff. It value is in T.ha.h.(ha.MJ.mm)$^{-1}$.*

In this study, the data is based on OMAFRA Fact Sheet (see Table 1).

Table 1. OMAFRA Factsheet for estimating soil erodibility based on soil texture and organic matter content

Textural Class	K Factor		
	tonnes/hectare (tons/acre)		
	Average OMC	Less than 2% OMC	More than 2% OMC
Clay	0.49 (0.22)	0.54 (0.24)	0.47 (0.21)
Clay loam	0.67 (0.30)	0.74 (0.33)	0.63 (0.28)
Coarse sandy loam	0.16 (0.07)	–	0.16 (0.07)
Fine sand	0.18 (0.08)	0.20 (0.09)	0.13 (0.06)
Fine sandy loam	0.40 (0.18)	0.49 (0.22)	0.38 (0.17)
Heavy clay	0.38 (0.17)	0.43 (0.19)	0.34 (0.15)
Loam	0.67 (0.30)	0.76 (0.34)	0.58 (0.26)
Loamy fine sand	0.25 (0.11)	0.34 (0.15)	0.20 (0.09)
Loamy sand	0.09 (0.04)	0.11 (0.05)	0.09 (0.04)
Loamy very fine sand	0.87 (0.39)	0.99 (0.44)	0.56 (0.25)
Sand	0.04 (0.02)	0.07 (0.03)	0.02 (0.01)
Sandy clay loam	0.45 (0.20)	–	0.45 (0.20)
Sandy loam	0.29 (0.13)	0.31 (0.14)	0.27 (0.12)
Silt loam	0.85 (0.38)	0.92 (0.41)	0.83 (0.37)
Silty clay	0.58 (0.26)	0.61 (0.27)	0.58 (0.26)
Silty clay loam	0.72 (0.32)	0.79 (0.35)	0.67 (0.30)
Very fine sand	0.96 (0.43)	1.03 (0.46)	0.83 (0.37)
Very fine sandy loam	0.79 (0.35)	0.92 (0.41)	0.74 (0.33)

(Source: http://www.omafra.gov.on.ca/english/engineer/facts/12-051.htm#t2 accessed on June 01, 2016). The information of soil texture and organic matter of the dominant soil obtained from FAO's harmonized world soil database (2012).

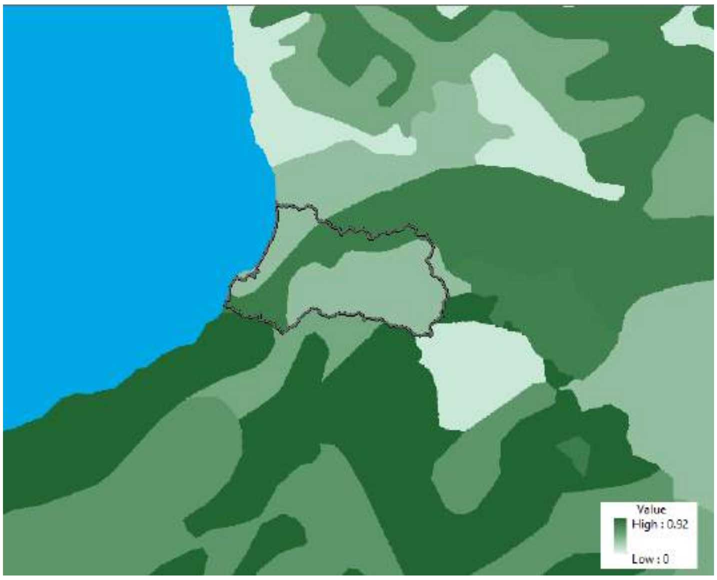

Figure 3. Prepared soil erodibility raster.

4. **Watersheds:** A shapefile, with one polygon per watershed; this is a layer of watersheds such that each watershed contributes to a point of interest where hydropower production is to be analysed.

The watersheds/basins used in this study were automatically simulated by applying Basin Tool in ArcGIS V. 10 on Aster DEM V.2 (http://earthexplorer.usgs.gov/ accessed on May 10th, 2016). The boundary of basins can be seen in Figure 4.

Due to the limitations in wider watershed data, the watershed was just assumed the same as the boundary of the study area.

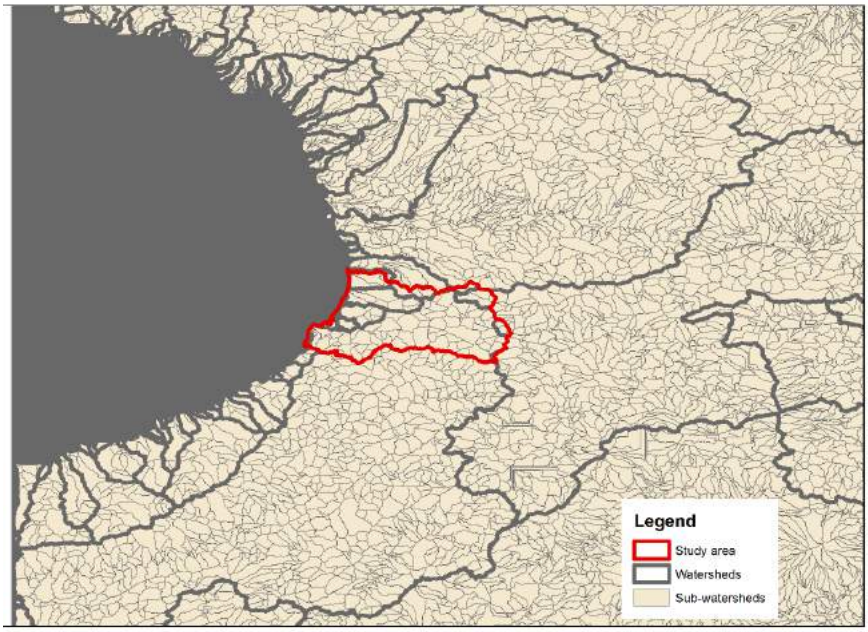

Figure 4. Watershed for the study area.

5. **Sub-watersheds:** *A shapefile, with one polygon per sub-watershed within the main watersheds specified in the Watersheds shapefile.*

The polygon shapefile of the sub-watersheds was automatically generated from Aster DEM V.2 with the stream threshold pixel value of 20,000.

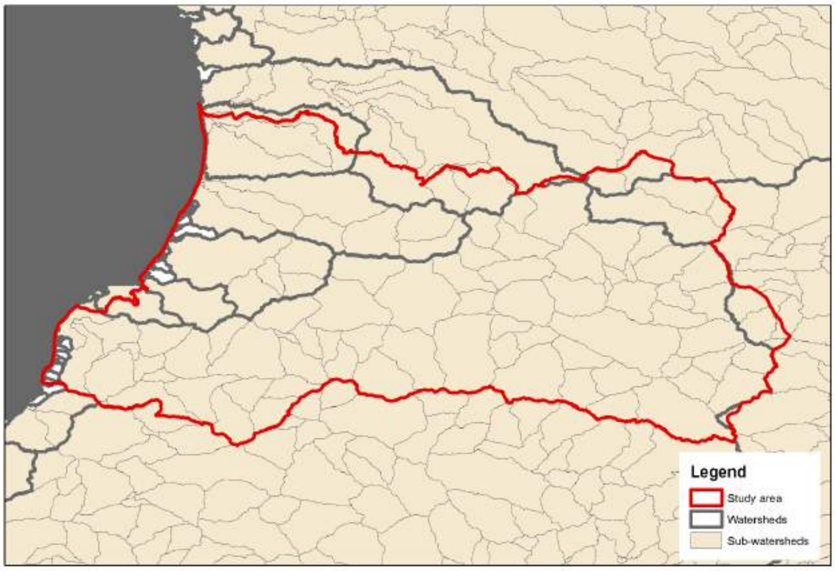

Figure 5. Sub-watersheds for the study area.

6. **Biophysical Table** – *A table containing model information corresponding to each of the land use types; the file is stored in *.CSV. The table has the following field:*

   6.1 Lucode (Land use code) – *unique integer to identifier for each LULC class.*

   6.2 LULC_desc – *nominal name for each LULC class.*

   6.3 usle_c – *It refers to cover management factor for the Universal Soil Loss Equation (USLE). Its value is stored in a float value ranging from 0 to 1*

   6.4 usle_p – *It refers to management practice for the USLE. Its value is stored in a float value ranging from 0 to 1.*

   6.5 sedret_eff – *the sediment retention factor for each LULC class. The column contains information in a float value ranging from 0 to 1. It refers to capacity of each LULC class retain sediment. This value is a percent per pixel area. The value of 1 for LULC class means that the class contains most natural vegetation (forest, natural pastures wetlands, and prairie) in that class. The value of 0 means otherwise. The LULC class with value of 0 should be pavement, roads, or urban areas.*

Table 2. Assumed biophysical table for simulating sediment delivery/export model.

LULC_desc	LU Code	Kc	root_depth	usle_c	usle_p	LULC_veg
Built-up	1	0	0	0.27	0.95	0
Perennials	2	0.5	2100	0.39	0.87	1

LULC_desc	LU Code	Kc	root_depth	usle_c	usle_p	LULC_veg
Pasture	3	0.4	2700	0.56	0.83	1
Roads	4	0	0	0	0	0
Scrub and sparse vegetation	5	0.4	2000	0.85	0.92	1
River	6	0	0	0.03	0.9	0
River Pebbles and Islands	7	0	0	0	0	0
Wind Breaking Lines	8	0	0	0	0	0
Bridge	9	0	0	0	0	0
Canal	10	0	0	0	0	0
Artificial Lakes	11	0	0	0	0	0
Gullies	12	0	0	0	0	0
Freshwater Wetlands	13	0.9	5100	0	0.75	0
Lake	14	0	0	0.03	0.9	0
Railways	15	0	0	0	0	0
Reservoir	16	0	0	0	0	0
Beach	17	0	0	0	0	0
Rocks	18	0	0	0	0	0
Forest Woodlands	19	0.8	3000	0.06	0.81	1
Arable Land	20	0.3	2100	0.39	0.87	1

Note: the value in the table is derived from Natural Capital Project Sediment database (http://www.naturalcapitalproject.org/invest/#resources *download on June 1st, 2016.)*

7. **Threshold flow accumulation:** *the number of upstream cells that must flow into a cell before it is considered as part of a stream; the default value of 1000 is used.*

8. **k_b and IC_0:** *two calibration parameters that determine the shape of the relationship between hydrologic connectivity (the degree of connection from patches of land to the stream) and the sediment delivery ratio (percentage of soil loss that actually reaches the stream); the default values are* k_b*=2 and* IC_0*=0.5.*

9. **SDR_{max}**: *the maximum SDR that a pixel can reach, which is a function of the soil texture; more specifically, it is defined as the fraction of topsoil particles finer than coarse sand 1000 µm* (Vigiak *et al.*, 2012). *This parameter can be used for calibration in advanced studies. Its default value is 0.8.*