Project Paper

Drivers of Forest Cover Developments in Armenia: A Potential Afforestation Scenario of the Getik River Basin

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January 2020

AUA ACOPIAN CENTER for the ENVIRONMENT

UNIVERSITY OF HOHENHEIM

This project is a part of the DAAD-funded collaboration, GAtES (German-Armenian Network on the Advancement of Public Participation GIS for Ecosystem Services as a Means for Biodiversity Conservation and Sustainable Development), between the University of Hohenheim (UHOH) and the American University of Armenia's (AUA) Acopian Center for the Environment.

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List of Acronyms

a.s.l.	above sea level
CO_2	carbon dioxide
eq	equivalent
ESS	Ecosystem Service
GHG	Greenhouse Gas
ha	Hectare
LUC	land use change
LULC	land use and land cover
m	meter
m^3	cubic meter
NDC	Nationally Determined Contribution
NTFP	Non-Timber Forest Product
PA	protected area
RA	Republic of Armenia
SFM	Sustainable Forest Management
SNCO	State Non-Commercial Organization
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change

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1. Introduction

With the Agenda 2030, a first global sustainable development directive was set in 2015 aiming to mitigate consequences of different climate change scenarios which are heralded by the IPCC (2014). These consequences, such as desertification processes, land erosion or biodiversity losses, can be summarized as the deterioration of ecosystem services (ESS). Forests play a pivotal role in mitigating the consequences of climate change (FAO 2018). In this context, they are included into national legislation to meet declared conventions such as the 1.5°C Paris Agreement for which nationally determined contributions (NDC) are set by countries all over the world (UNFCCC 2015).

In Armenia, the committed NDC indicates for the land use and land cover (LULC) sector an increased forest area from 11.1 % of today (UNECE and FAO 2019) to 20.1 % in 2050 (Government of the Republic of Armenia 2015). For this endeavor, a key role plays a knowledge-based and holistic approach of ESS-conservation in line with economic development, especially focusing on agriculture, including forestry, since the sector employs about 35% and contributes to 20.8% of Armenia's GDP in 2015 (Government of Armenia and FAO 2016). However, the country's forests and their provision of ESS like carbon sequestration are under serious threat, e.g. by uncontrolled logging and subsequent use of wood as a primary energy source (Ministry of Nature Protection of the Republic of Armenia 2018). Especially in rural parts of Armenia, which are marked by smallholder farming, poverty remains a considerable issue to face and deforestation-related problems are most urgent (Government of Armenia and FAO 2016). Thus, the NDC-commitment to nearly double its forest area until 2050 is under serious pressure.

Therefore, efforts from multiple entities are underway to alleviate poverty, stop illegal logging and find alternatives to wood as the primary rural energy source (Gevorgyan 2017). In this context, the bilateral project GAtES (German-Armenian Network on the Advancement of Public Participation GIS for Ecosystem Services as a Means for Biodiversity Conservation and Sustainable Development) between University of Hohenheim and the Acopian Center for the Environment of the American University of Armenia aims on broadening awareness of aforementioned issues within the local population and decision-makers of Armenia. Until today, basic data on e.g. rural energy use patterns or LULC which focuses on the Getik River Basin in the northeast of Armenia are published (Harutyunyan et al. 2019a; Harutyunyan et al. 2019b; Harutyunyan et al. 2019c).

The present study proceeds on this work and takes on the question where potential afforestation in the area could be realized and how it could develop. With regard to the NDC of the country of nearly doubling its forest area, the objective of the present paper is to provide a possible future scenario for afforestation within the Getik River Basin in Armenia and show its potential greenhouse gas (GHG) mitigation.

To approach this objective, the applied methodology comprised scenario technique in combination with carbon balancing via the ex-ante carbon balance tool "EX-ACT" (Grewer et al. 2017). For this, first, potential afforestation areas were identified within the Getik River Basin via ArcGIS 10.1 software. Second, a literature review was performed to identify key drivers which influence forest cover developments in Armenia. Third, expert interviews were conducted to receive plausible key driver relations for a plausible afforestation scenario. Finally, the scenario was created in the form of a narrative and its respective carbon mitigation was calculated in tons of CO_2 equivalents (t CO_2 eq).

2. Materials & Methods

2.1 Scenario Technique

The applied method in this working paper is scenario technique, or scenario planning whose basic idea is represented by the scenario funnel in Figure 1. The border lines of the funnel represent all possibilities how the present situation could develop. By reaching further into the future, the range of possibilities increases. Each yellow spot represents one possible future scenario while the blue spot illustrates the situation of today. The dotted lines symbolize the developments that could lead to the yellow spots which are most likely not linear but characterized by disruptions.

Scenario technique is based in strategic business planning and is characterized by the creation of distinguishable scenarios which can result in the form of narratives. Following Kosow and Gassner (2007), they describe possible future scenarios based on significant events and underlying processes like changes, decisions and other developments that could occur, and which bring an alternative future to life. Thus, scenarios can also be defined as descriptions of possible future situations including paths of development which may lead to that future situation. Therewith, scenarios aim to "generate orientation regarding future developments through an observation of certain key factors" (Kosow and Gassner 2007). For this, several points are important to consider. First, scenarios are not a comprehensive picture of the future but direct the focus on one or more segments of reality. Key factors are deliberately included, and others are excluded, and they are brought into constellation in which they relate to and influence each other. Second, it needs to be considered that the constellation of the key factors creating a future horizon is a construct. This construct is knowledge-based on the one hand for which literature and other sources of information are used, and on the other hand it is formed by assumptions which underly subjective bias. The assumptions therefore highlight that scenarios do not have the claim to represent reality and thus merely represent a hypothetical construct of potential futures which are based on present and past knowledge (Kosow and Gassner 2007). In this context, van der Heijden (2005) states that scenario projects cannot be generalized but that each project is specific and thus requires for a customized approach and work design for optimal results. Thus, for scenario technique various typologies exist as for example normative or exploratory scenarios (Börjeson et al. 2006). Regarding its objectives, Schoemaker (1995) describes scenario technique as a tool which "attempts to capture the richness and range of possibilities, stimulating decision

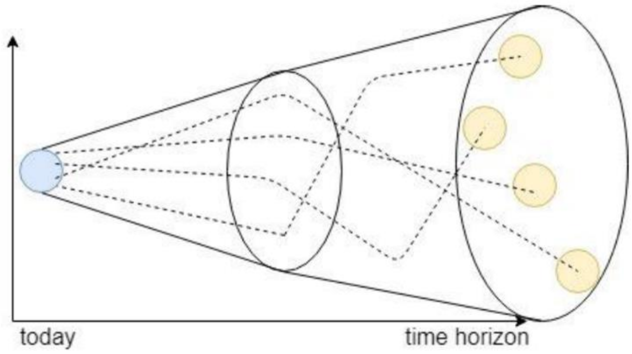


Figure 1: Scenario funnel, own design, based on Mahmoud et al. (2009)

makers to consider changes they would otherwise ignore."

In this study, an explorative scenario approach is applied to unfold a possible future development which aims at increasing the awareness of LULC changes in the Getik River Basin and shows its consequences regarding potential GHG mitigation.

The methodological steps of scenario technique are not determined to a fixed set of process steps. However, authors like Schoemaker (1995), Kosow and Gassner (2007), Mahmoud et al. (2009) or Parkinson et al. (2012) developed a comparable set of steps. For this study, the following sequence was drawn from them:

1. *Scope:* Defining the boundary of the study including its geography and time limits

2. *Key Driver Identification:* Identifying major factors that drive the development and thus shape the scenario

3. *Scenario Logic:* Examining the influences and relationship among the identified key drivers

4. *Scenario Creation:* Writing the scenario as a narrative, based on a previously defined framework

2.2 Scope

The present study investigates the Getik River Basin (Figure 2) in the northeast of Armenia, and its potential future forest cover development from 2020-2030. Recently, LULC in the Getik River Basin is distributed into the following sections with the corresponding areas given in ha (Harutyunyan et al. 2019c): 69% grassland and pastures, equaling 39,900 ha, 25% forests which are predominant in the northern part and equal 14,700 ha, 3% bare area which is mainly located on slopes in the central part of the river basin and is represented by rocks and roads equaling 1,600 ha, 2% shrublands which majorly cover slopes of the northern part of the river basin and

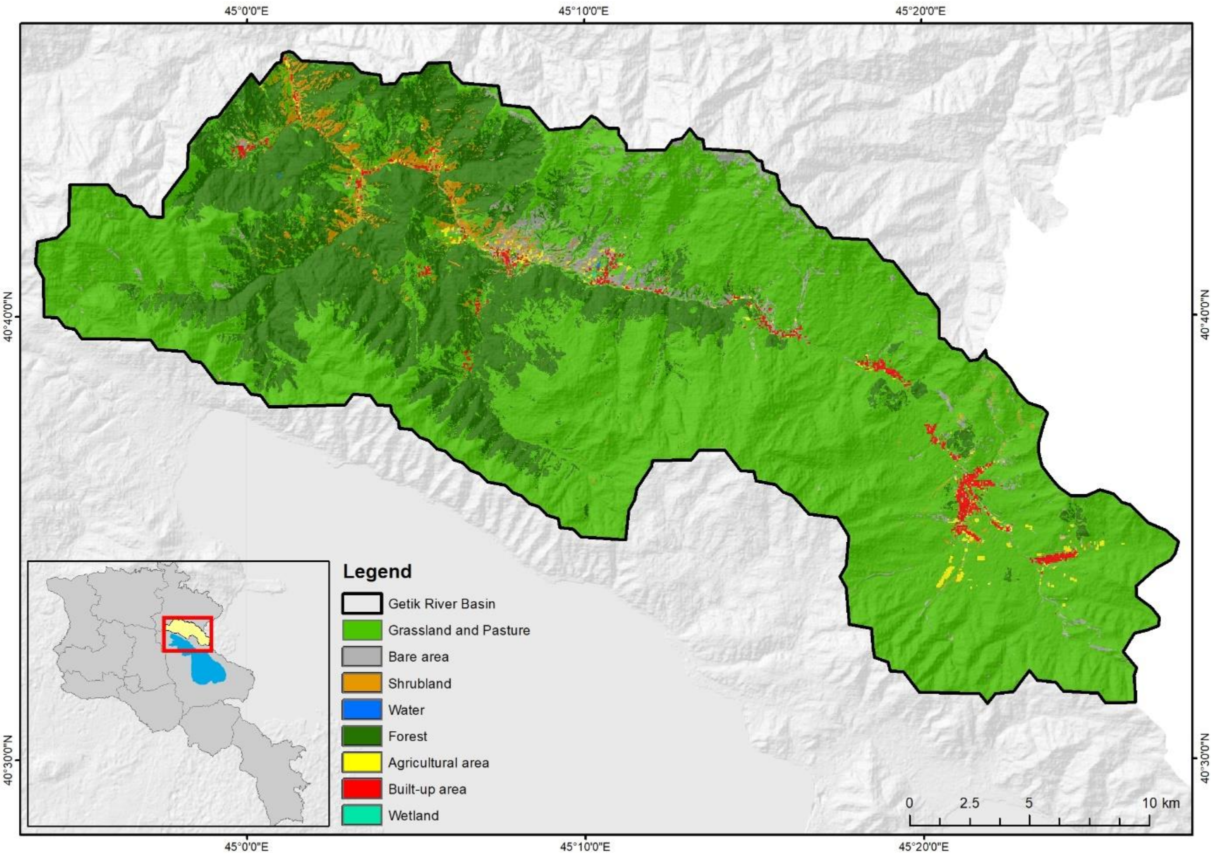


Figure 2: Land use and land cover map of the Getik River Basin

equal 1,100 ha, built-up areas which make 1% and equal 600 ha, and agricultural areas which comprise less than 1% and equal 300 ha. Finally, open water and wetlands represent also less than 1% and equal 7 ha.

The potential afforestation areas of the study area were identified using ArcGIS 10.1 software and applying a set of physical, and anthropogenic limitations. The physical limitations (Figure 3) comprise, first, land elevation above 2,000 m, which represents approximately 75% altitude of the regional timberline (Troll 1973). Second, a minimum annual precipitation regime of at least 600 mm which is based on Subbiah et al. (2013). Third, a suitable LULC class, i.e. grassland, and fourth, a maximum slope angle of 25° which represents 50% of the maximal angle on which vegetation cover was found according to Nadal-Romero et al. (2014). Anthropogenic limitations represent the ownership distribution of the land. Only publicly owned areas that are officially designated as "forest land" were chosen for potential afforestation. Further, all identified areas of "forest land" that were larger than 1 ha in extension were segregated. These areas thus show an increased eligibility regarding the tradeoff between work input and output of afforestation. In summary the physical and the anthropogenic constrains mean that the target areas for potential afforestation were official forest land, which however, following satellite imagery do not show forest cover (as they represent grassland) and which are marked by convenient physical forest growth conditions (altitude, precipitation, slope angle).

At this point it remains important to mention, that the denotation of forest cover in this study represents land that is covered with forests and not land that is officially designated as "forest land". In the case of Armenia, no definite data is given about actual forest cover extension. Yet, numbers are given for the area that is designated as forest land which however is not always entirely covered with forests. Contrastingly, there is land that is covered with forest but that is not designated as forest land. In this study, the LULC classification of the Getik River Basin represents remote sensing imagery based on Harutyunyan et al. (2019c). All area designated as forests on the maps also represents forest cover.

2.3 Key Driver Identification and Scenario Logic

The identification of key drivers which influence forest cover developments in Armenia was carried out by a literature review. As a detailed data basis for the region of the Getik River Basis was not given, a generalization was made at this stage, i.e. key drivers of forest cover development which are influential on a national level were identified.

Based on the identified key drivers, the scenario logic was elaborated. The scenario logic consists out of the influences of the key drivers among each other and was investigated by interviewing experts from the Armenian forest sector. For this, a key driver matrix was used as a visualization of the key driver influences. The interviewees were asked to identify the most influential relations between the key drivers and to briefly argue why this is the case. Possible influences were "low" influence, which was represented by green color, "moderate" influence, given in yellow, and "high" influence, which was represented by red. By this, the most influential relations among the key drivers were identified. Finally, all filled key driver matrices were compared with each other and the most frequently stated influences were used for creating the scenario narratives.

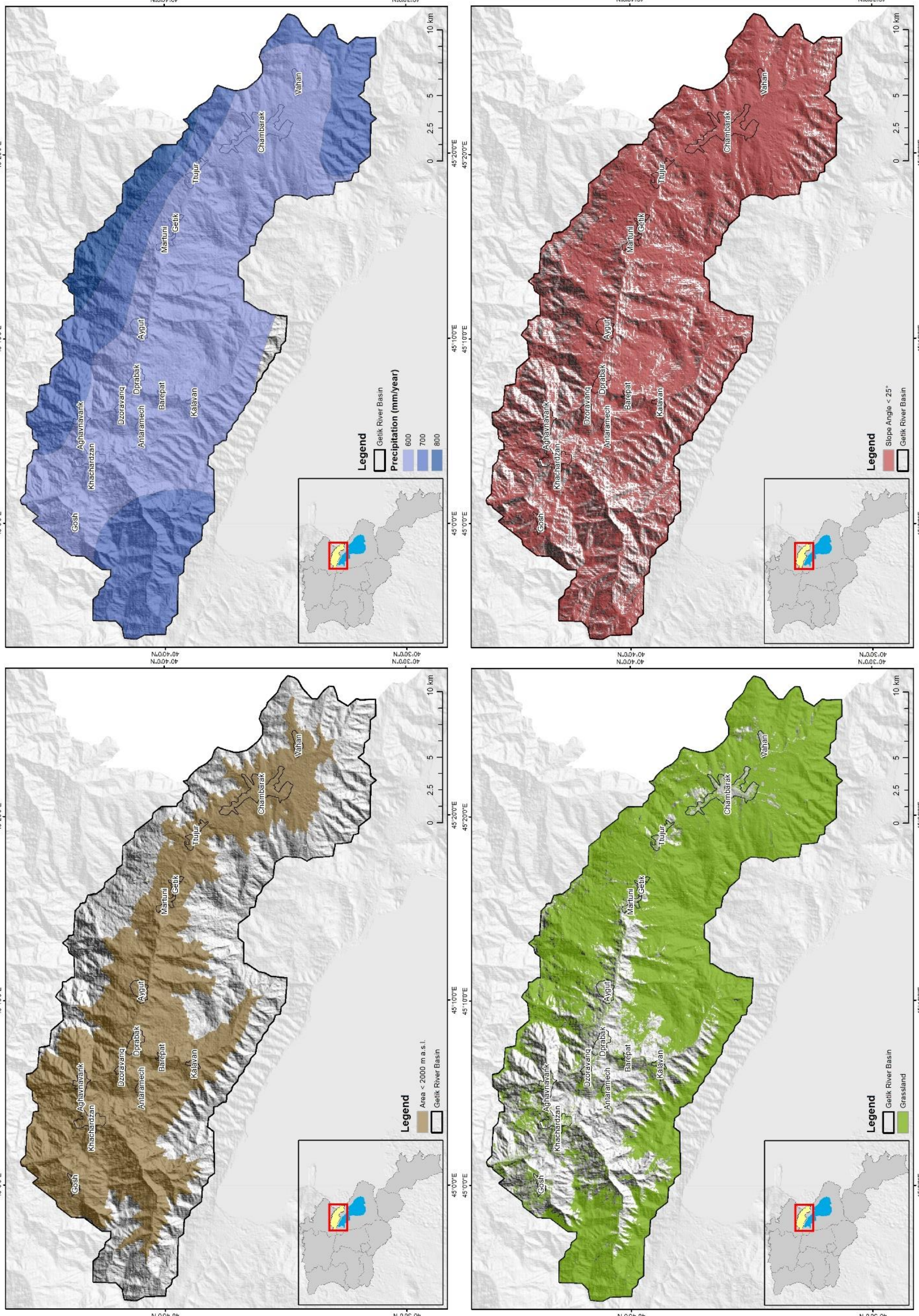


Figure 3: Maps of the physical limitations applied for potential afforestation areas in the Getik River Basin. Blue depicts the minimal precipitation regime (600 mm). Red illustrates the suitable slope angle (< 25°). Brown shows the appropriate altitude (< 2,000 m a.s.l.), and green the suitable LULC class (grassland)

2.4 Scenario Creation and Calculation of Potential GHG Abatement

The creation of the scenario narrative was based on the identified key drivers, their influences that were determined via the experts' estimation, and the methodology described in chapter 2.1. The scenario narrative was then coupled with its corresponding GHG abatement to show its potential contribution to the NDC of Armenia. For calculation, the ex-ante carbon balance tool EX-ACT was used which was developed by the FAO (Grewer et al. 2017). The software, which is based on interlinked Excel sheets, enables to create different LULC scenarios of e.g. agriculture and forestry for any size of area, and provides corresponding GHG emissions and sequestrations of a chosen future time frame. By this, EX-ACT offers to compare a baseline scenario of LULC (e.g. business-as-usual) with a "project-based" scenario (e.g. afforestation).

Figure 4 depicts the functioning and outcome of EX-ACT (Grewer et al. 2017). The time frame is divided into an implementation phase (e.g. the realization of the project) and a capitalization phase (e.g. the period of the

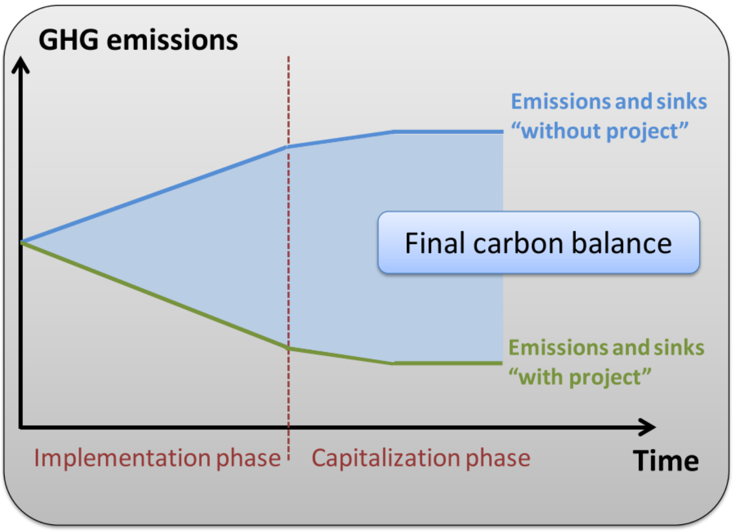


Figure 4: Functioning and output of EX-ACT (Grewer et al. 2017)

project). During this time frame, the carbon balance is calculated which is based on the different LULC scenarios. In blue, the baseline scenario ("without project") is depicted which, after the determined timeframe, represents a higher GHG emission as does the project-based scenario ("with project"), shown in green. The final output of EX-ACT is thus the GHG balance between the two different future scenarios.

In a preliminary step, input data on the status quo is needed (i.e. time and geographical scope) similar to the first step of the methodology of scenario technique (see chapter 2.1). However, here also climate and soil conditions are used. For the purpose of the present study only land use change (LUC) was considered, which represents one of the input categories of EX-ACT. Within LUC, the actual identified potential afforestation area was inserted. That means that the former LULC class "grassland" was substituted by the forest cover native to the geographical region of Armenia. Other criteria which also have an important influence on the overall GHG balance such as livestock farming, or degradation processes of the land were neglected in this study. Reasons for this were insufficient data and information on the corresponding current situation in the Getik River Basin and their unknown potential future developments.

In this study, the implementation phase of the afforestation projects was assumed to be 5 years (i.e. 2020-2025) while the remaining 5 years represented the capitalization phase (i.e. 2025-2030). Other key input variables were the following: the geographical scope was set “Eastern Europe”, with a “cool temperate” climate and a “moist” moisture regime, and the dominant soil type in the region was “LAC soil”.

3. Results & Discussion

In the following, first the identified areas which are appropriate for afforestation projects are presented. Second, the identified key drivers of forest cover development in Armenia are given and explained. Third, the results from the expert interviews are synthesized in the form of one key driver matrix which contains the most influential relations among the identified key drivers. Finally, the scenario narrative of the potential afforestation scenario is given which at its end gives the corresponding potential GHG mitigation for the period from 2020 until 2030.

3.1 Potential Afforestation Areas in the Getik River Basin

Figure 5 shows all identified areas within the Getik River Basin which are appropriate for possible afforestation projects. Out of these areas, Figure 6 shows the potential afforestation plots which have a minimum extension of 1 ha each. In both maps, the areas represent grassland as the current LULC. They are located below 2,000 m a.s.l., hold an annual precipitation regime >600 mm and a maximum slope angle of 25°, and are situated on officially designated forest land, according to the constraints given in chapter 2.2 and in Figure 3. Table 1 provides detailed information on the entire areas identified and the plots with a minimum extension of 1 ha with regard to their actual size, and their affiliation to the respective administrative community of the Getik River Basin.

In total, the identified potential afforestation areas amount 1,705 ha (± 78 ha) and thus represents 11.6% of the current forest cover of the Getik River Basin. Within the entire areas identified, the three communities of Aygut, Khachardzan, and Dprabak hold the largest potential afforestation areas with 486 ha, 270 ha, and 224 ha, respectively.

Out of the entire areas identified, the potential afforestation plots which are coherent areas of a minimum size of 1 ha each represent 1,005 ha (± 46 ha) in total. Within these, the three municipalities with the greatest potential afforestation area are Aygut, Dprabak, and Martuni, with 420 ha, 146 ha, and 86 ha, respectively.

Table 1: Identified potential afforestation areas, divided into the communities of the Getik River Basin

Community	Total afforestation area [ha]	Area of afforestation plots > 1 ha [ha]
Aghavnavank	140	60
Antaramej	61	20
Aygut	486	420
Chambarak	45	41
Dprabak	224	146
Dzoravank	108	49
Getik	3	3
Gosh	150	47
Kalavan	95	32
Khachardzan	270	81
Martuni	99	86
Ttujur	21	17
Vahan	3	3
Total	1705	1005

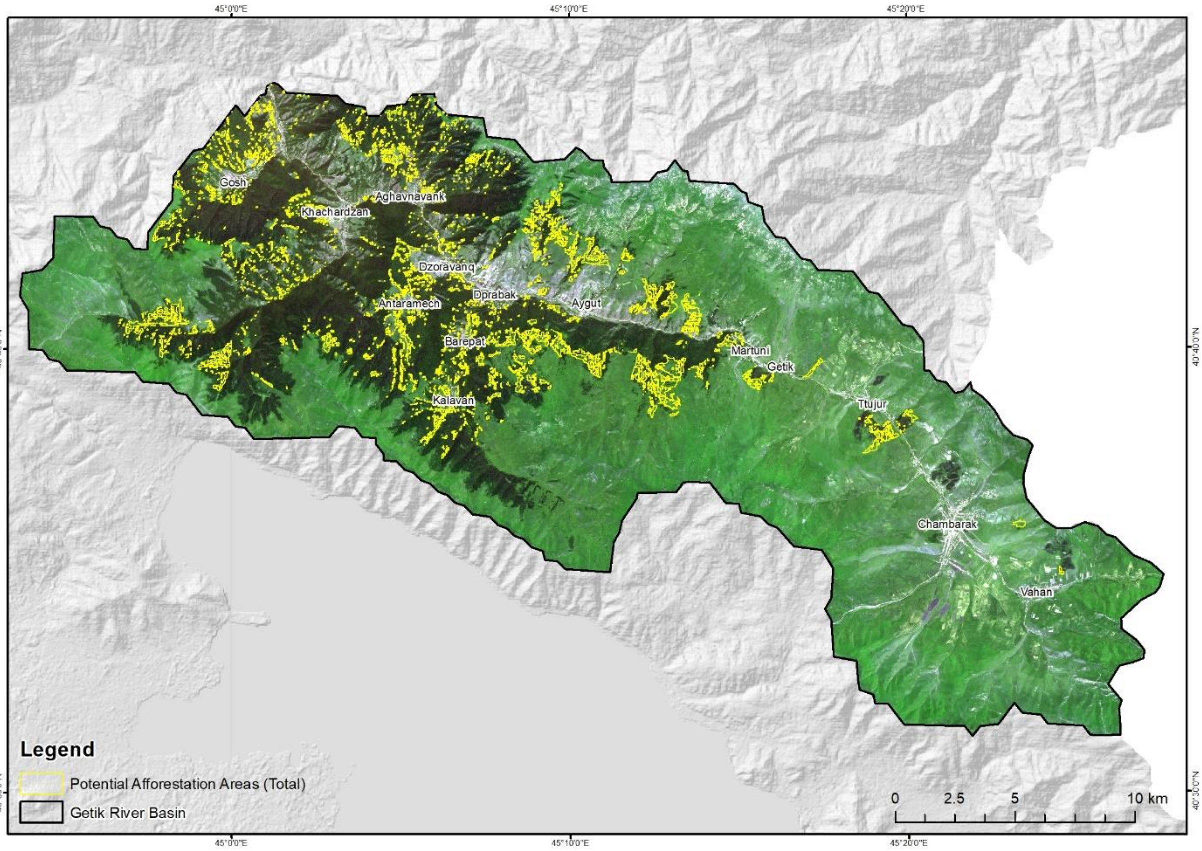


Figure 5: Entire potential afforestation areas of the Getik River Basin

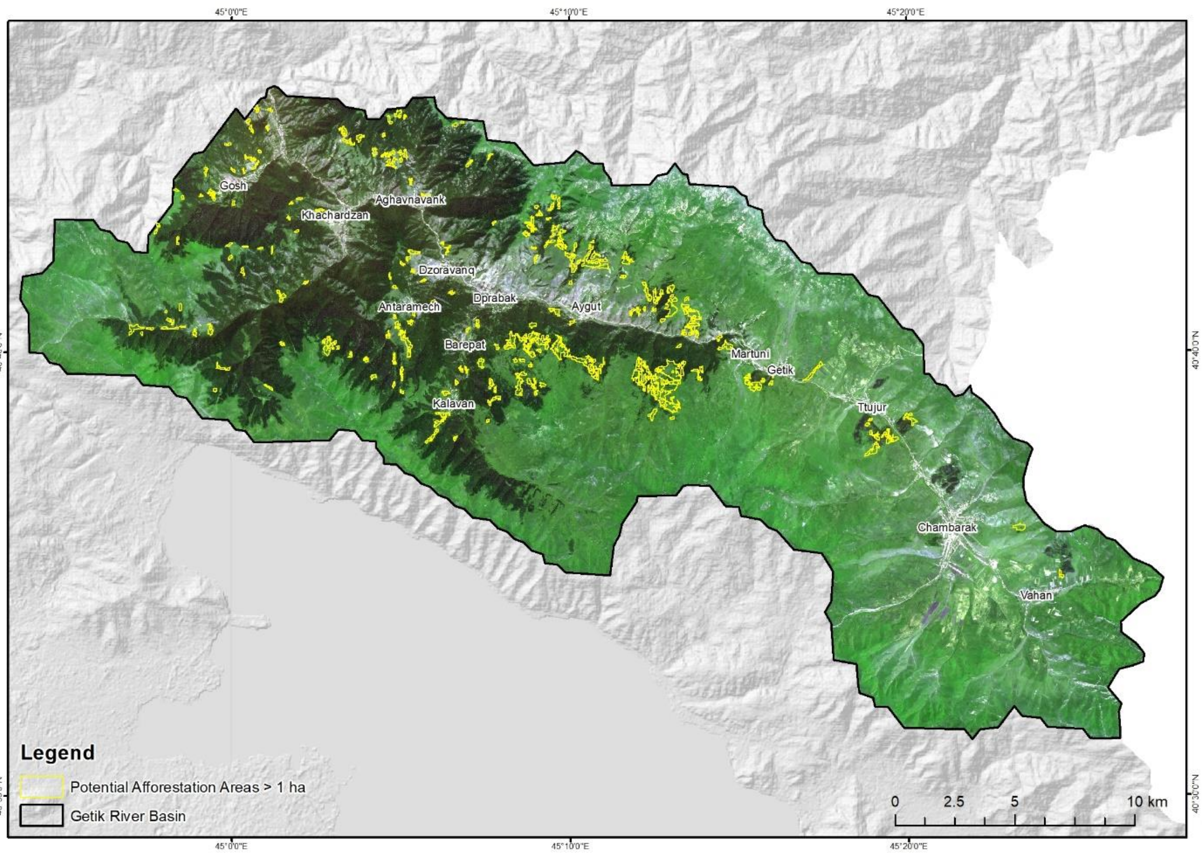


Figure 6: Potential afforestation areas in the Getik River Basin with a minimum plot size > 1ha

3.2 Key Driver of Forest Cover Developments

In the following, the key drivers are given which were found to influence forest cover developments in Armenia.

Wood harvest

In Armenia, wood harvest or logging, especially illegally performed, appears to be one of the main drivers of deforestation and thus of forest cover development (Urutyan and Zohrabyan 2011) (Galstyan 2016) (UNECE and FAO 2019). Due to high demand, logging rates still exceed the rate of natural regeneration of forests whereas the logging primarily occurs next to villages and cities adjacent to forests (Moreno-Sanchez and Sayadyan 2005) (Galstyan 2016). However, making estimates about the actual volumes of wood harvest remains difficult. FAO (2014) states that of the 847,000 m^3 of harvested wood in 2003 there were only 63,000 m^3 legally documented. Junge and Fripp (2011) indicate that for 2010 recorded wood harvest was approximately 75,000 m^3 and estimated household consumption 457,000 m^3. Similarly, this harvest trend is mentioned by UNECE and FAO (2019). Reasons behind underly a complex interplay of socioeconomic factors, which simplified can be partly summarized by ever ongoing poverty of rural population.

Wood harvest is performed out of subsistence reasons for energy supply on the one side. Although natural gas, which is more expensive than fuelwood, is available in most rural communities in the country (Mkrtchyan 2016), wood still represents the main source of fuel for the communities that live nearby to forests (Gevorgyan 2017). Contrastingly, the Republic of Armenia (RA) (2014) states that between 2008-2012 there was a “significant reduction in the volumes of illegal loggings” which was “mainly conditioned by development of the natural gas supply system”. In the Getik River Basin however aforementioned trend persists. Harutyunyan et al. (2019a) found that wood still has a considerable share of energy supply, which is in harmony with the statements from Gevorgyan (2017). Wood shares 62% of the energy sources in the area while manure, with 17%, and gas, with 16%, represent the second and third mostly used energy source (Harutyunyan et al. 2019a).

On the other side, wood harvest is done due to commercialization. Mkrtchyan (2016) state that 61% of the income that is generated from forest resources originate from firewood selling. In this regard the author mentions that the RA introduced a decree allowing forest-adjacent communities a legal access of up to 8.5 m^3 firewood per annum and per household. However, there are official cases where demand for firewood exceeds this limit, for instance in Syunik region with 13 m^3 (Mkrtchyan 2016). Consequently, the author concludes that the illegally commercialized firewood is considerably higher as it is presented in her study. Further, wood harvest is influenced by the trade of high value wood products (e.g. furniture or brandy barrels) which developed from the 1990s on when rural communities were even more dependent on wood as an energy resource and consequentially a business established out of their activities (Moreno-Sanchez and Sayadyan 2005). In this context, it was recommended e.g. to prohibit any exportation of wood by law (Gevorgyan 2017).

Moreover do weak institutions contribute to the continuing deforestation and forest degradation induced by forest harvest (Junge and Fripp 2011). Here, a major role plays “Hayantar”, the state non-commercial forest organization that manages a major share of the forest land in the country (Galstyan 2016). Thus, “Hayantar SNCO” represents a key stakeholder in the regard of forest cover developments in Armenia. Especially areas that are designated as forest land have the imperative to be also covered with forests, which however is not always the case as also in the Getik River Basin. In the context of public institutions, executive authorities can also play an important role for forest cover developments. Following information from CNF (2019) on the case of Dilijan National Park executive authority shows a significant impact. First the local community’s awareness rose about the illegal logging, and second “incidents of illegal loggings have decreased by 70% since the start of regular patrolling”, due to a “Public Monitoring Group” (CNF 2019). “Their progress has been reflected in a rise in prosecutions” states Nerssessian (2019) who emphasizes that the rise in crimes accounted to illegal logging is not due to an increase of the logging itself, but instead due to a “stronger focus on investigations of the criminal behavior”.

Livestock Grazing

For the rural population in Armenia, livestock represents a crucial asset which is also the case for those communities living near to forests. Due to the presence of high mountainous fodder-producing areas, livestock breeding represents one of the most important fields of agriculture in the country (RA 2019). However, with regard to forest cover developments, grazing practices of livestock can mitigate regrowth of deforested land and may induce a permanent degradation of the land and its ecosystem services (Junge and Fripp 2011) (Piana and Marsden 2014). In this context does especially overgrazing represent a form of grazing which next to illegal wood harvest and a lack of infrastructural projects, is interpreted as one of the most important drivers of deforestation processes in Armenia (KFW 2017). After the fall of the soviet union, many smallholders became dependent on livestock farming for their subsistence due to privatization of the large collective farms (Moreno-Sanchez and Sayadyan 2005). However, within the last 20-25 years, the number of livestock fell considerably while, contrastingly, degradation processes increased significantly. This was mainly because the pasturelands were used irregularly in some regions in the country and improved measures of vegetation cover were lacking (RA 2019). These uncontrolled grazing practices are emphasized by Ulander and Ter-Zakaryan (2012) who also highlight that overgrazing prevents degraded forest land from recovery. The RA (2019) furthermore states that overgrazing is indirectly responsible for a biodiversity loss in the ecosystems because it led to erosion processes that resulted in reduced plant diversity. By this, the species composition altered, i.e. the share of valuable plant populations decreased, “while aggressive weeds and toxic species […] have become widespread”. As a result, also due to an uneven distribution of the overgrazing practices, alpine carpets (i.e. *juniperus communis*) got replaced by alpine meadows which are marked by sub-alpine weeds. One measure to decrease aforementioned consequences for forest cover development from livestock grazing was implemented in the project by KFW (2017). Here, fencing the forest area prevented livestock from entering. However, it is emphasized that for a successful protection there is a need for maintenance and management of the fences since rotting processes can easily end the fence’s function which is the case in many regions. Furthermore, the authors conclude that local residents who were interviewed, accepted the agreed areas for forest land and pastures. In the Getik River Basin, Harutyunyan et al. (2019b) state that all area that is indicated as grassland and pasture is also used for livestock grazing. The respondents (98 in total) who were interviewed about grazing practices mentioned that “they are free to graze animals in areas that are not privately owned” which matches to aforementioned uncontrolled grazing situation.

Tree Pests

In this study, the term tree pest is used for summarizing the occurrence of invasive species (e.g. insects or plants) which influence forest cover developments. Hertel and Snyder (2004) point out that within the context of Armenian forest degradation, the ongoing problems with diseases and insects that harm forests were usually not mentioned. They highlight the need for improved documentation and monitoring of insect and disease conditions in Armenian forests and state the requirement for technical specialists who would provide leadership and technical expertise in dealing with the problems. The study described in UNDP (2008) provides a starting point for the comprehension of the forest pest situation in Armenia. Out of the 15,000 insect species in the country, approximately 1,300 species are considered to be tree-shrub pests. Among these, especially leaf eating species are harmful to forest development which are characterized by butterfly, beetle, or phylloxera varieties (Sayadyan and Moreno-Sanchez 2006) (UNDP 2008). However, only a little fraction from them can spread considerably and can harm the forest in extensive dimensions over thousands of hectares. In particular, this number of species is constrained to a few dozen (UNDP 2008). Because of leaf eating pests, trees lose the ability to regenerate and thus to establish wood mass or their root system. Consequently, they are more prone towards other degradation processes like erosion or other diseases. Evermore increasing this effect is climate change which in its witnessed form "unambiguously concurs with forecasted climate change" (UNDP 2008). Following the UNDP study, temperature increases, precipitation decreases, and the increases of droughts and forest fires all coincided with an increase of "forest pestholes and diseases" for which a "quantitative increase per unit area has also been detected". So does, as in the case of the Syunik region, pest infestation affect an area of 20,000 ha while it is expected that in the southeastern forests of Armenia, forest pests in the form of leaf-eating insects "will significantly grow due to climate change conditions if no actions are undertaken". The growth rate of trees affected by pests decreased by 80% whereas it is expected that the "areas of prevalence of these pests will grow to reach 50,000 ha and more by 2100 (UNDP 2008). It is further estimated, that if no means against the tree pests are taken, "the loss in the annual wood growth will significantly increase and total around 54,100 m^3". This emphasizes the need of e.g. aerial pest control measures which are save for the environment for which the government is committed. However, as is was observable during a project during pest outbreaks in 1999-2001, biodiversity suffered from aerial pest control measures and in times of climate change, alternative options are to be preferred (UNDP 2008). Nevertheless, during 2003-2013 chemical pest control measures took place on 76,786 ha, out of which approximately 23,243 ha during 2009-2013 among which 22,828 ha via aviation (RA 2014). Alternative methods represent early warning systems for pest outbreaks on the one hand (UNDP 2008), and monitoring on the other, as it is also stated by Hertel and Snyder (2004) (Aghababyan et al. 2010). Monitoring guidelines exist and consist out of e.g. training of foresters in species identification, and data collection (Aghababyan et al. 2010). Yet, the corresponding stakeholder "Hayantar" is not considered to have the resources to deal with the threats imposed by tree pests (Sayadyan and Moreno-Sanchez 2006).

Forest Fires

The Armenian forests are under considerable threat with regard to fires (Ulander and Ter-Zakaryan 2012). RA (2014) states that the extent of forest fires has increased in 2003 from registered 3.92 ha to 91.58 ha in 2013 while during this decade the most forest fires occurred in 2006, 2010 and 2011. The number of forest fires made up 198 during the period from 2009-2013 influencing an area of 1616.72 ha. In opposition to this, forest fires totaled 25 during 2001-2004, and 26 between 2005-2008. Consequently, approximately 7 forest fires occurred during this time while in the two years 2010 and 2011 alone, over 50 forest fires were observed (Ulander and Ter-Zakaryan 2012). The FAO (2015) states that the total forest area burned during 2003-2012 made 400 ha in 2003, 300 ha in 2006, 800 ha in 2010, 400 ha in 2011, and 200 ha in 2012. Moreover, following information from R. Petrosyan, a national forest expert, there was more wood burned in the year 2017 as in the previous ten years together (Gevorgyan 2017). Thus, different numbers on the actual extent of forest fires exist. However, it can be concluded that on the one hand an increase of affected area is evident and on the other hand, an increase in the number of forest fires prevails. This general trend is confirmed by Ulander and Ter-Zakaryan (2012) who relate the increased occurrence and extension of forest fires also to climate change induced drought conditions and persisting hot temperatures. But also other factors influence spread and acceleration of forest fires. So do the authors state that, for instance, volatile substances like oils, resins and wax in the wood strongly affect the rate of ignition and combustion. Therefore do different levels of affection prevail among the forests since the composition of tree species contributes to a considerably to the extension and number of forest fires. RA (2014) mentions the burning of adjacent agricultural sites as "the main cause of the majority of forest fires". Further, it lists "the complex relief, poor condition of forest roads, [and] absence of respective technical equipment for fire control" as current problems and thus as barriers for an efficient fire control. The geographical conditions within forests are also highlighted, as also by Ulander and Ter-Zakaryan (2012). They indicate that the angle of slopes has a significant impact on fire spread. The steeper the slope angle, the more intense the heat convection induced by the fire and thus the faster the fire spreads uphill. To defy these developments, working approaches towards an implementation of, e.g. early warning systems for forest fires or online access forest information systems including the fire dynamics, exist (Gevorgyan 2017).

Tourism

Armenian forests play an important role for touristic activity of the country. In general, they represent the "natural capital and raw material" of tourism on the one side, but on the other side forests can deteriorate from tourism induced activities e.g. in the form of increased pollution and energy use or related infrastructure developments (Kuvan 2010). These deteriorating factors also can occur especially in mountainous regions where energy lacking supplying infrastructure can lead to increased logging and thus increase the pressure on forests. However, also individual tourists can affect forest ecosystems especially by trampling of plant cover, collecting plants, or via pollution of picnic sites with domestic waste (Galstyan 2016). This can, among other implications, lead to a hampered vegetation cover development and change in species distribution. Within Armenia, the Getik River Basin became one of the developing centers for rural tourism (Harutyunyan et al. 2019b). Out of 119 local persons interviewed in 2018, a share of 18.8% indicated to be employed in the service sector, including tourism, while the dominating field of occupation with 29.2% is the agricultural sector. In nearly every community of the Getik valley, there are sightseeing locations while the villages of Gosh and Kalavan are the major tourist sites in the region. So does e.g. the monastery of Gosh represent one of the main tourists taking places where corresponding infrastructure was established in the surroundings and locals sell non timber forest products (NTFP) (Harutyunyan et al. 2019b). Moreover, agriculture related activities also result in touristic attraction as beekeeping in Martuni village. However, infrastructure for touristic developments in Armenia is often lacking as is highlighted by Sayadyan et al. (2017). For instance, there is missing information on the conditions and locations of natural monuments. No information signs are installed which impedes tourists to find and recognize the monuments.

In the regard of Getik valley's amenity for touristic activity, ecotourism can play an important role. Its roots date back to the 1980s and it is considered to pose an alternative "to channel tourism revenues into conservation and development" (Stronza et al. 2019). Ecotourism is recognized by the RA as a promising, and increasingly important niche for tourism development, while factors which influence foreign tourists' choice for the country are under study by Armenakyan and Brown (2019). Results of their study highlight the potential for Armenia to improve its positioning as an ecotourism location among foreign tourists and that this potential can be found in providing "more targeted service policies and practices" as the local ecotourism industry "misses out the opportunity to capitalize on service tour satisfaction" while "positive destination satisfaction" is given (Armenakyan and Brown 2019). I.e. lacking infrastructure for touristic developments mentioned by Sayadyan et al. (2017) was identified to carry key importance to improve Armenia's position as an ecotourism destination.

Protected Areas

Representing sites of biodiversity conservation, protected areas (PAs) can be a key driver for forest cover developments. In Armenia, the area that is protected covers 393,065 ha and by this 13.2 % of the country which is divided into four different types (Galstyan 2016): Firstly, three state reserves, which cover 1.19 % of national territory, secondly four national parks, which take up 7.96 % of the country's area, thirdly 27 state sanctuaries extending to 3.95 %, and finally 232 natural monuments. Moreover, there is one protected landscape which is a community managed area and makes 6,010 ha (Galstyan 2016).

Forests of the country are protected in different types, e.g. in National Parks, or state sanctuaries in which forests cover 110,269 ha and thus represent 28.5 % of the total area of PAs (Galstyan 2016). Within the Getik River Basin, PAs are Getik Sanctuary and Dilijan National Park, which are both located within the administrative region of Gegharkunik (Gevorgyan 2017).

Although PAs aim at conserving the natural areas, they are no guarantee for absence of deforestation and forest degradation which is also highlighted by Ulander and Ter-Zakaryan (2012). So does e.g. illegal logging still occur and there is evidently no border for forest fires which in PAs can have even larger impacts due to an increased spatial density of biomass, e.g. by great amounts of leaf litter, and an increased biodiversity. In this context, the study of van Butsic et al. (2017) which was conducted within an eastern European setting, shows that no definite pattern regarding deforestation developments within PAs was found. The study's results show that in Czech Republic, Slovakia, and the Ukraine, significantly less deforestation was observed inside PAs in comparison to external areas as the probability of disturbances declined by 1-5 %. Further, within Romania and Hungary older PAs were more effective, which yet was not the case for Czech Republic and Poland where newer PAs showed a larger conservation effect (van Butsic et al. 2017). Irrespective of the PA's age did the degree of protection, i.e. International Union for Conservation of Nature [IUCN] protection category Ia-II not guarantee more effect as a "landscape level-protection" (IUCN III-VI) (van Butsic et al. 2017). The authors therefore emphasize the different effects PAs can have on their objective, i.e. to preserve ecosystems, and indicate that the "effectiveness of protected areas […] [being] transitory over time and space" can be misleading (van Butsic et al. 2017). One measure suggested to improve the situation of PAs and their insufficient conservation of forests is the concept of High Conservation Value Forests which is related to Principle 9 of the Forest Stewardship Council (FSC) under which in Armenia no forest land is managed (FAO 2014) (Galstyan 2016). In this regard, for Tavush region whose territory partly also lies in the Getik River Basin, Sayadyan et al. (2017) found two flaws related to forest landscape management. First, the need for an adjustment and demarcation of forest enterprises, PAs and forest borders, and second, the absence of clearly separated functional and buffering areas within PAs.

Erosion

The prevention of erosion processes is considered to be an essential regulating ESS. This regulation is supported by forests which on the one hand have important anti-erosion and soil protective functions (Gevorgyan 2017), but on the other hand heavily depend on non-eroded land availability. Thus, erosion processes act as a key driver on forest cover development, especially in Armenia. Erosion adversely affects “the natural resources base which is the main source of income for rural populations” (UNDP 2008). It is estimated that about 66 % of Armenia is suffering from “heavy to medium erosion processes” (Sayadyan and Moreno-Sanchez 2006). In the country, various factors exist which are responsible for the erosion of soils. Tree loggings play a prominent role which have accelerated erosion processes and thus created conditions for mudflows which occur during short and heavy rainfall events in summer (Moreno-Sanchez and Sayadyan 2005). Within the Getik River Basin, loggings on steep slopes led to landslides as a dominant erosion process which is present in the alpine area of Chambarak (Mkrtchyan 2016). Today, these slopes are exposed to wind and water erosion which together with cattle grazing and haymaking further deteriorate the issue (Mkrtchyan 2016). Next to the increased occurrence, also the intensity of erosion processes augmented (Gevorgyan 2017). Climate change is fueling these trends as increasing temperatures and extreme weather events in the form of intense rainfalls will provoke a larger vulnerability of soils towards erosion (Ulander and Ter-Zakaryan 2012). One measure to decrease these trends is put by Moreno-Sanchez and Sayadyan (2005) highlighting that “the mitigation of some of the most critical environmental problems the country is facing today (erosion and water supplies depletion) is directly linked to the conservation and recuperation of the forest cover”. This is also emphasized by Basher (2013) who names afforestation as one key strategy for erosion control. So does e.g. a tall, closed-canopy vegetation reduce land sliding in large storms by 70-90 % while afforested stands can have a similar effect as long as the establishment and survival is adequate (Basher 2013). Moreover, he points out that the slope angle has a significant influence on overall erosion probability (Figure 6). Starting with an angle of 27° the erosion rate [mm y^{-1}] of pasturelands skyrockets exponentially while for native forests, the rate increases linearly with a less pronounced rise starting from an angle of 30° (Basher 2013).

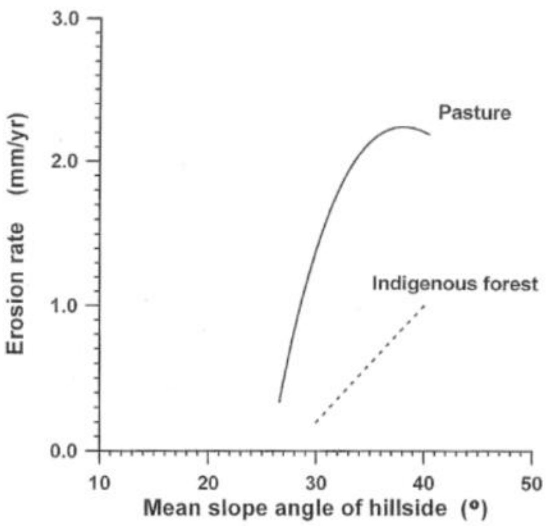


Figure 7: Effect of slope angle on erosion with different vegetation cover (Basher 2013)

Other influential factors

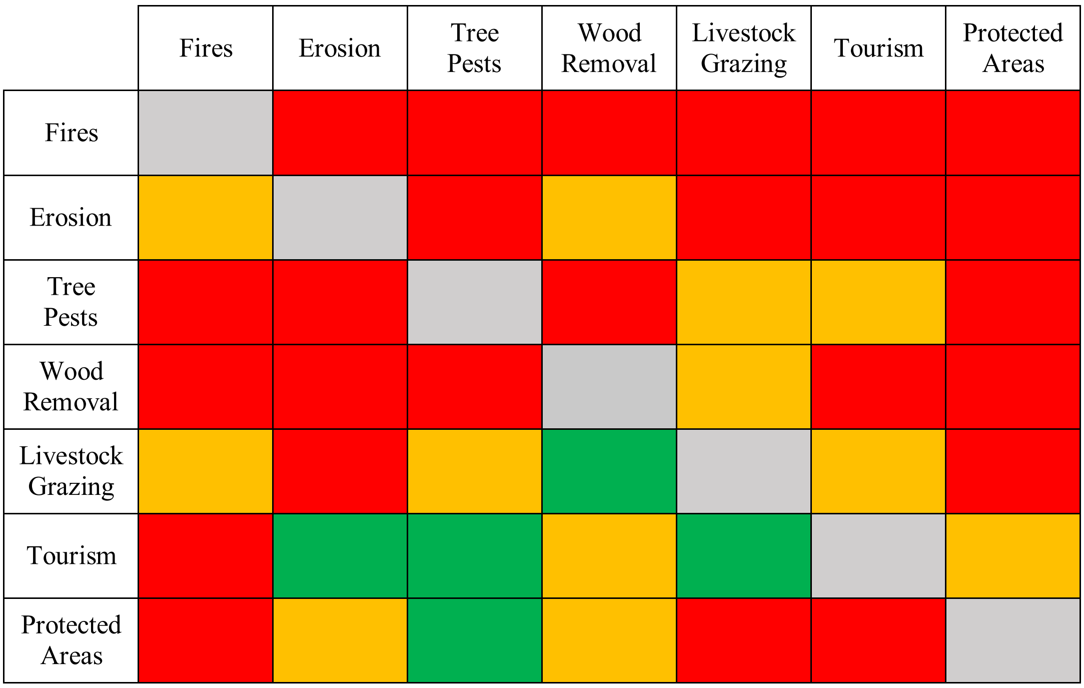
Next to the aforementioned key drivers of forest cover developments in Armenia, the are other influential factors strongly connected to the subject. First, policy on a sustainable forest management (SFM) is a very influential point which in Armenia is given nationally, however not on regional or local level while on the national level a measure and reporting activity is missing (FAO 2014). Second, gas prices play a crucial role as they influence the logging rate drastically (Galstyan 2016). Third and indirectly do institutional structures, political incapacities, failures in management, corruption and shadow markets also influence forest cover developments whose actual contribution however is very difficult to identify (Sayadyan and Moreno-Sanchez 2006). Fourth, mining activities and the establishments of hydropower plants pose a further threat to an expansion of Armenia's forest cover (Galstyan 2016). And finally, alien tree species and wind throw represent present threats to forest cover developments whose future dimensions are heavily dependent on climate change.

3.3 Scenario Logic

Table 2 shows the summarized results from the key driver matrices which were elaborated by the interviewed forest sector experts.

Evidently, fires and wood removal represent the greatest influence on all other key driver as they share a high influence on the other key drivers 6 and 5 times, respectively. Subsequently, both erosion and tree pests are considered 4 times to have a high influence on the other key drivers. Protected areas represent 3 times a high influence on the other key drivers and a low influence on tree pests. Finally, livestock grazing, and tourism are considered to be the least influential key drivers of forest cover developments as they have a high influence on only 2 and 1 other key drivers, respectively. For livestock grazing there is a low influence given regarding wood removal and for tourism there are low influences considered concerning erosion, tree pests, and livestock grazing.

Table 2: Summarizes key driver influences from the expert interviews



3.4 A Potential Afforestation Scenario for the Getik River Basin

Today, in the year 2030, the RA successfully incorporates the region of the Getik River Basin, being a part of Gegharkunik and Tavush region, into its NDC report to submit it to the UNFCCC. From the former 14,700 ha of forest cover back in 2020, an increase of 1,705 ha was finally achieved. This was primarily made possible by setting a political priority on the topic at the first national Forest Summit in October 2019 where, next to the proposal of a realignment of the country's forest land borders, a map of potential afforestation areas of the Getik River Basin was presented.

Back in the early 2020s, during the development phase of the afforestation projects, all communities of the Getik River Basin were informed about and included into the decision making of developing and managing the afforestation projects. As one of the conclusions of the Forest Summit back in 2019, this multi-stakeholder approach was one major agreement for the project implementation. As a result, nearly all involved communities welcomed the proposed plans and added local knowledge to the project development, which revealed itself as pivotal regarding the actual project implementation, e.g. in the form of indicating the most proper soil conditions on the mapped potential afforestation areas.

The identified potential afforestation areas where divided - with agreement of the communities - into different "forest types" to also economically benefit the local population. One form was the "orchard forest", which, next to the local forest tree species, also included apple, plum, pear, and walnut trees, which held economic and ecological advantages at the same time. The other, and spatially dominant form of afforestation however was implemented by representing the natural, Caucasian mountainous forest ecosystem. In doing so, the tree species which already revealed themselves to be the most vulnerable to climate change got mostly replaced by more drought and heat resistant tree species.

Yet, climate change induced increase of forest fires posed an ongoing and urgent threat to the forests of the Getik River Basin. As it represented one of the most influential drivers of forest cover developments in Armenia, a special focus was put to tackle this increasingly urgent issue. Thanks to early and extensive investments, particularly into existing early warning systems of fire outbreaks, the extension of forest fires could be minimized by the majority of incidents.

Also, the number of tree pests increased due to climate change induced heat and drought increases, which also was found to be an influential factor on forest cover developments. However, since the local population was involved in close cooperation with the management of the afforestation areas, most of the tree pest outbreaks could be detected and ceased via targeted logging of the affected trees within short time periods and without wide spreading.

Next to this, the nationally promoted ecotourism represented a key avenue to foster an economically and environmentally sustainable development in the Getik River Basin. Former touristic hot-spots such as Gosh community, with its monastery, or Kalavan community, including Timeline Foundation, maintained its village-based character, as mass tourism was prevented. Kalavan furthermore became a sort of rural science center, as in the early 2020s, several scientists, including archeologists, found the place to hold promising research assets. The ecotourism was achieved, among other restrictions, by limiting international visitors to enter the region via the obligation of buying tickets for overnight stays beforehand online. Overall, ecotourism activities such as beekeeping, wild plant harvest, or hiking evolved to be top-sellers to open minded, wealthy, young to middle-agers from foreign countries who visited Armenia to experience an active and sustainable tourism, and see the country's pristine ecosystems and landscapes.

The activities aligned with the ecotourism thus represented a prosperous income source for the local population who during the 2020s became less and less economically dependent, e.g. on increasing its livestock farming activities. Therewith, and in combination with the establishment of fenced grazing plots, the intensity of uncontrolled erosion processes in the Getik River Basin lost one crucial driver. Nevertheless, climate change induced heavy and intense rainfall events today still represent a serious threat to the communities e.g. in the form of landslides.

The remaining livestock was more and more used for cheese production, which became another magnet for ecotourism next to the trade with other NTFP. The cheese became one high value product, which is now delivered to, e.g. Dilijan, where former pioneer-restaurants from the late 2010s such as "Food Lab" multiplied and whose principles now represent a role model case for other restaurants in the city.

In total, Dilijan national park increased its size, while the local population of the communities is also engaged in management activities of the park, e.g. by monitoring the reintroduction of deer species into the natural Caucasian ecosystem which was initiated in the early 2020s.

Since global public movements concerning ecosystem conservation and environmental sustainability became also increasingly prominent and influential in Armenia during the 2020s, the societal pressure on illegal logging rose significantly. Back in 2019, it still represented one of the most urging threats to forest cover developments in the country while only several activists fought the ongoing criminal activities. However, via the approximation, on the one side, of public institutions and their proposals about the afforestation projects plans, and one the other side, the inclusion of the local population, the communities of the Getik River Basin formed local vigilance teams which were financially supported by the RA. Therewith, a form of a transdisciplinary executive authority established itself out of a collaboration of public institutions from the state, and the local population. Thus, the former key threat of illegal logging became more insignificant year by year although until today it could not be eliminated entirely. However, the motivation for illegal logging in the Getik River Basin today in 2030 is, with very rare excuses, not induced by energy needs anymore.

Consequently, the conversion from grassland to afforested area of an overall extent of 1,705 ha over a time period of 10 years already contributed to an abatement of 186,525 t CO_2 *eq in comparison to a baseline scenario in which the grassland and forest cover extensions would have stayed the same as back in 2019. Therewith, the Getik River Basin today represents one major example of a holistically successful afforestation project in Armenia, which ensures an economically decent, societally sound and ecologically sustainable region.*

4. Conclusion

To fulfill Armenia's NDC, forest cover expansion is key and includes economic and ecological importance for the country as it bears manifold ESS, and represents a crucial income source, e.g. by NTFP. However, forest cover developments and thus afforestation projects in Armenia heavily depend on various key drivers. In this study, these key drivers were found to be particularly forest fires, (illegal) wood removal and erosion processes, followed by tree pests and protected areas, as well as livestock farming, and tourism. Within this study, an area of 1,705 ha in the Getik River Basin, a region in the north eastern part of the country, was identified which, regarding its natural conditions and the legal situation, theoretically is directly ready to be afforested. The identified key drivers of forest cover developments were interlinked to generate a potential afforestation scenario. The scenario tries to explore a positive future pathway of the Getik River Basin to contribute to a holistically sustainable development of the region and show its role of contributing to the national NDC.

However, it is concluded that a real afforestation project implementation depends on further aspects as the identified key drivers. Among other points plays the respect and the implementation of the local population's needs and expectations in the afforestation process a pivotal role. Therefore, the present project paper recommends to include societal aspects, e.g. desires whether and how to afforest, into the implementation of detecting potential afforestation areas into future works in this field.

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