Spread of Forest Ecosystems in Azerbaijan, Structure, Usage Changes and Learning

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Abstract:

This article provides an analysis of the distribution and structure of forest ecosystems, changes in use, and the work carried out in the last 10-15 years in the direction of their study. For this, the report materials of the Forest Development Service of the MENR for the relevant years were used. Here, the dynamics of changes in the spread of trees and forest covers in the Republic, their distribution by area and species, are given. Here, at the same time, a distribution scheme for land use categories was developed. Hansen's global changes in forest lands during 2000-2018 are presented. The article shows the biodiversity characteristics of the forest ecosystems of the Republic, the distribution directions of the main forest-forming species in the altitudinal zones of mountainous areas, which were analyzed. The work also highlights the main functions of forest ecosystems and their role. Finally, issues such as the protection of forest ecosystems and their sustainable development and expansion of their areas are analyzed, and promising directions are identified.

Keywords: Forest ecosystems, Land use change, Biodiversity in Azerbaijan, Sustainable Forest management,

1. Introduction

1.1. Forest ecosystems and their distribution and structure.

In 2021-2023, forest-related land use and land use change, fire, etc., were studied using Collect Earth at the country level with the Remote Sensing method in Azerbaijan. The report was prepared by collecting and analyzing national data. This report assesses both current forest cover and land-use change from 2000 to 2024. As a result of the evaluation, it was found that the area covered by forest in Azerbaijan is 1.301, 088 thousand have, or of the general area 15.1% constitutes. Comparing the land uses of 2000 and 2016, the results show that relatively small land use changes occurred in all types of land use in Azerbaijan. Very slight increases were observed in forests (annual increase of 0,007%) and grasslands (annual increase of 0,018%). However, an increase of 37,962 ha or 7,9% was observed in settlements over sixteen years. The results of the Global Forest Survey also confirm very little land use change between forest and non-forest land use classes (Forest Code of the Azerbaijan Republic, 1997. art.8).

Forest management on 1.213,7 thousand hectares of the republic's forests is carried out by the Ministry of Ecology and Natural Resources according to the Forest Code of the Republic of Azerbaijan and the Law on Environmental Protection. Other forest areas are located on lands owned by other owners (FAO Collect Earth, 2019).

1.213,7 thousand belonging to the Ministry of Ecology and Natural Resources. Hectare of forest land of the forest fund – 1.035 thousand hectares, and areas covered with forest 1.021 thousand hectares, which is unevenly distributed throughout the territory of the Republic. Thus, 49 % of the total forest areas belong to the Greater Caucasus, 34 % to the Lesser Caucasus, 15% to the Southern zone, and 2 % to the lowland zone (Fig. 1).

Of the total area in Azerbaijan, 31,8 percent has tree cover, which is 2.751,2 thousand hectare. The tree cover is approximately 52,7%-i is available in other types of land use. All types of land use in Azerbaijan have different levels of fire risk (Ahrends A., et al., 2010).

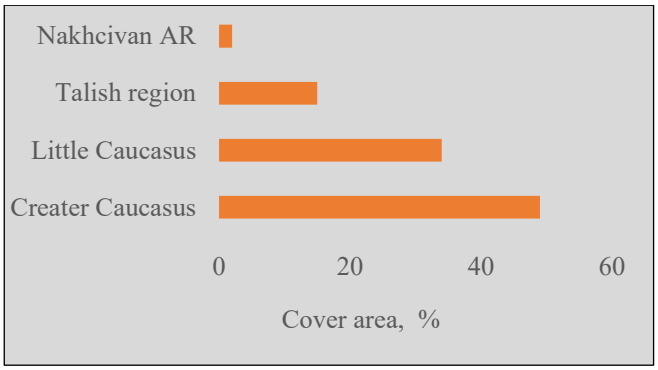


Figure 1. Tree cover of the regions

During the last inventory, it was determined that the total area of the state forest fund is 1.213,7 thousand hectares, and 1.043,8 thousand hectares of this area are covered with forest. During the inventory conducted in 2018-2021, it was calculated that there is a total of 1.301,2 thousand ha of forested area in the temporary forest fund and in the territories belonging to other owners. In the 2015 Forest Resources Assessment (FRA), it was determined that the forest area in Azerbaijan is 1.139,4 thousand ha (Fig. 2).

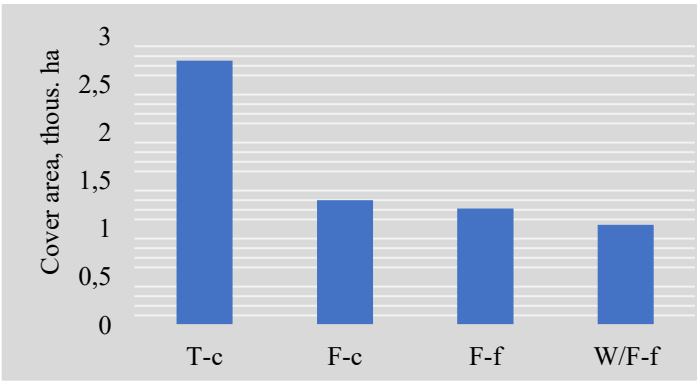


Figure 2. *Comparison of forest area statistics by assessment/survey: T-c - Tree-coveredarea AzR; F-c – Area covered with forest; F-f – Including the forest fund; W/F-f – Woded area in the forest fund*

Among the six types of land use in Azerbaijan (forests, arable lands, other lands, pastures, wetlands, and residential areas), land use change and area growth were mainly observed in residential areas. This is followed by grasslands and woodlands. On the other hand, the area of farmland, other lands and wetlands has decreased (Tab. 1).

Table 1. *Land use change trends in forest ecosystems*

Soil use categories	Primary areas (ha)	Current areas (ha)	Change in area (ha)	Change in areas (%)
Forest	1 299 729, 29	1 301 188,32	1 459,03	0,11
Sown areas	3 305 138,59	3 270 192,26	-34 946,33	-1,06
Othes areas	1 019 834,86	1 011 951,91	-7 882,95	-0,80

Pasture areas	2 298 562,71	2 305 186,62	6 623,91	0,29
Swamps	256 429,12	253 213,71	-3 215,41	-1,25
Residential areas	480 305,43	518 267,18	37 961,75	7,90
Total	8 860 000,00	8 860 000,00	0,00	0,00

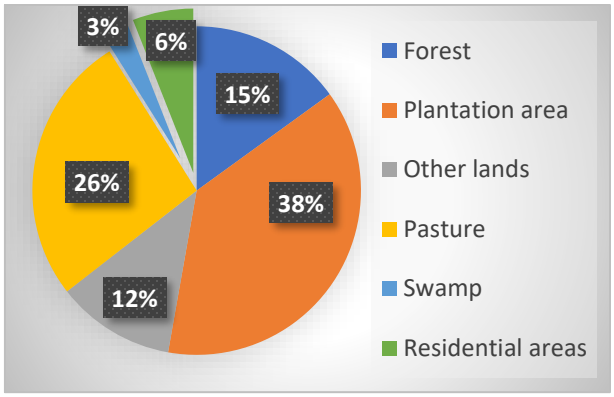
Cropland, other land, and wetlands decreased by 1.06%, 0.80%, and 1.25%, respectively, while forests, grasslands, and settlements increased by about 0.11%, 0.29%, and 7.90%, respectively. The Collect Earth estimate shows a total net forest increase of 1,459 ha (0.11%) over the sixteen years of interest. In contrast, Hansen et al. (2013) report a forest loss of 8,611 hectares between 2000 and 2017 (FAO Forest Resources Assessment, 2015).

It should be noted that between 2000 and 2016, no forest area was converted to agricultural land or other land use categories. It is considered a good thing that the forest areas are not turned into farmland for agricultural purposes. The figures show that very little forest loss has occurred in the country over the past period. The reason for this is natural regeneration in the forests destroyed during the occupation (more than 54,000 hectares), abandoned settlements and farmlands, afforestation related to forest protection, and reforestation works are carried out rapidly.

On the other hand, due to the increase in infrastructure needs of the population in the country, some of the land use categories, such as farmland, other lands and pastures, have been transformed into the residential use category (Fig.3).

The land use change matrix shows that the areas of land use categories have not changed much over time, except for settlements. Hansen's global forest change shows a similar trend (Fig. 4).

Figure 3. *Soil use categories, ha*



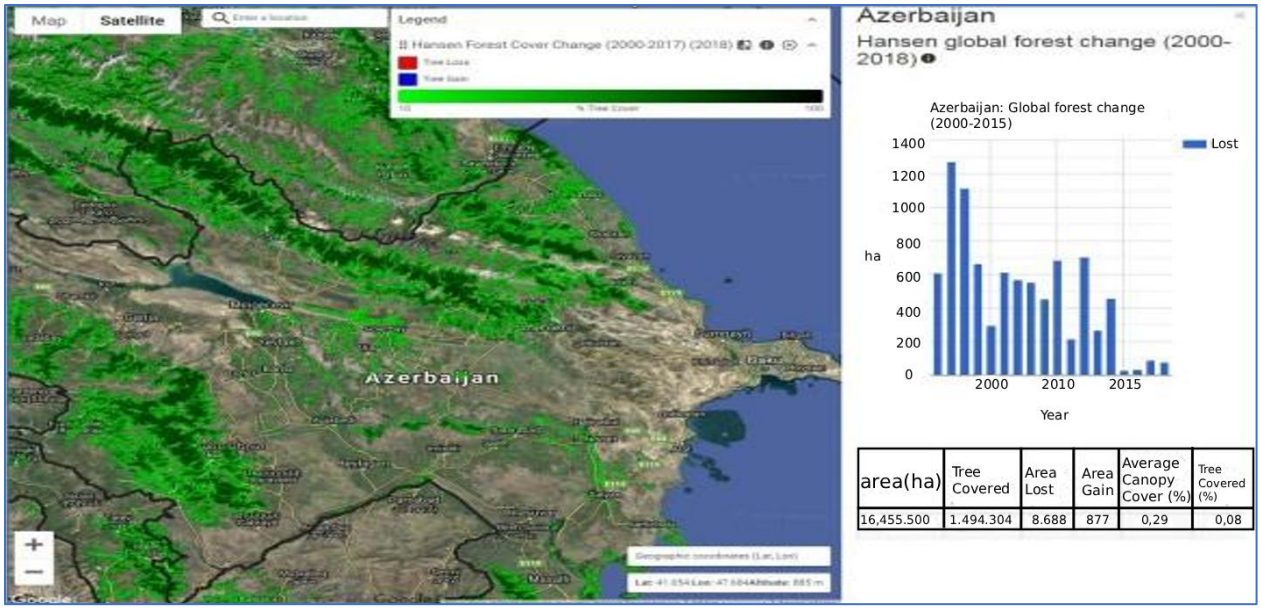


Figure 4. *Hansen global forest change (2000-2018)*

Based on satellite images of tree-covered areas, land use changes caused by various natural events such as cutting of trees, fire and flood, etc. have been determined with high accuracy. In addition, the changes caused by the fire were determined graphically based on the NDVI program. According to the results of the analysis, during the research period, fires occurred at different levels in all categories of land use in Azerbaijan. Based on the same program, there are also changes in the category of pasture use areas that have been discovered (IPCC, 2003: Good Practice Guidance for Land Use, Land-Use Change and Forestry).

Table 2. *Change directions of land use categories, ha*

Compared to other land use categories, most of the changes in use occurred in croplands (50.8%),

Land resignation category.	Opening	Fire	Pasture	Flood	Fishing	Other	None of them	Total
Forest	99,5	120 776,4				1 628,8	1 178 683,7	122 504,6
Plantation area	100,0	554 893,1	99,5			1 665,3	2 714 998,5	556 757,8
Other lands		35 354,3		1 623,1		1 683,8	981 173,7	38 661,2
Pasture	2 030,5	278 618,6	698,5				2 023 839,0	281 347,6
Swamp	1,614.6	23,988.9		1 723,2	1 580,9		222 741,9	28 907,7
Residential areas		64 881,5				3,399.9	449,985.8	68,281.4
Total	3 844,5	1 078 512,8	797,9	3 346,3	1 580,9	8 377,8	7 571 422,6	1 096 460,3

pastures (25.7%) and forests (11.2%). As it turns out, fire is a major threat in all land use categories, and sustainable measures must be taken on farms to prevent it (IPCC, 2006. Guidelines for National Greenhouse Gas Inventories).

The conducted analyses are the total for the Republic for all land use categories. 1.078.512,85 ha area was determined to be burnt. According to the data of the Hansen global organization, between 2000 and 2018, a total of 3,090,864 hectares of land were burned in the country. Changes in logging, fire and other use categories in the country 122.504,65 ha affected the forest area, which is 9.4% of the total forest area.

One of the factors that significantly affects the change of land use categories is the erosion processes occurring in forested and other land use areas. In wooded areas in the country total area prone to erosion is 161,073.48 hectares (Table 3).

Table 3. Erosion trends of land use categories, ha

Soil heat-fade category.	Type of erosion	Very low	Down	Medium	High	Very high	Total
Forests	Sliding			99,45	1 636,89		1 736,34
	Precipitation Surface flows	1 768,28	100,03	100,03	99,45	1 738,72	3 806,51
	River erosion	1 594,74	1 631,67	99,45			3 325,86
Cultivated fields	River erosion	1 673,66		100,03			1 773.69
Other lands	Sliding		7 965,94			1 585,34	9 551,28
	Precipitation Surface flows		8 036,96	14 503,67	1 575,95	6 764,67	30 881,24
	River erosion		1 545,66				1 545,66
	Coastal erosion		1 594,74			1 580,94	3 175,68
	Wind erosion	11 183,75	14 797,02	3 304,23		1 672,56	30 957,56
Grasslands	Sliding	1 575,95	3 101,54	198,90	1 919,12		6 795,50
	Precipitation Surface flows	5 493,98	5 110,80	11 323,97	3 497,55	1 729,20	27 155,51
	River erosion	198,90		1 549,08	1 599,58		3 347,56
	Wind erosion	1 705,91	3 321,45				5 027,37
Swamps	Precipitation Surface flows			1 606,55			1 606,55
	River erosion	1 527,81	199,48	4 717,79	6 401,76	1 714,64	14 561,49
	Coastal erosion	1 557,22	3 201,63	4 715,65	4 744,73	1 606,47	15 825,69
Total		28 280,19	50 606,9	42 318,8	21 475,03	18 392,53	161 073,48

As can be seen from the obtained figures, small and medium-sized planting areas are the least prone to erosion (1773.69 ha - 1.1%), and forested areas (8868.69 ha - 5.5%) are attributed. In other categories of use, it was determined that the tendency to erosion is higher (IPCC, 2019. Intergovernmental Panel on Climate Change Web Page). \

According to the analysis, the tree cover is 31.77% of the total area, which is 2,751,167 thousand. ha constitutes. As can be seen from the table, the existing forest areas make up 47.29% of the area covered with trees, of which 1830.87 hectares are sparse. 52.7% of the tree cover belongs to other land types outside the forest stock. Most of this area is cultivated land (638,190 thousand ha - 23.2%) and pastures (430,413.77

thousand ha - 15.65%). Residential areas also have groves, and the tree cover is more than 12.67%. In comparison to cropland, settlements and pastures, tree stands are relatively less common in other lands and wetlands and are found in 13,013.85 ha and 19,941.95 ha, respectively (NFP, 2013. National Forest Program 2015- 2030 (Final Draft), Republic of Azerbaijan, Baku).

Tree stands are mostly distributed in forested areas. Since the trees in residential areas cover an area of 348,519.53 ha, this area constitutes 67.3 percent of the total residential area (FAO. (2010. Global forest resources assessment and baseline report).

2. Biodiversity characteristics of forest ecosystems.

As a whole, the forests of the Republic of Azerbaijan are classified as group I and are of great importance in the prevention of climate change, the expansion of desertification processes, the reduction of biological diversity, and the disruption of the gas balance in the atmosphere, which are considered global environmental problems. Plays an important role in the development of the fields. The changeable and complex topography of the areas, as well as the growth of forest trees and shrubs up to 2000-2200 meters above sea level, also led to the formation of a rich and colorful species diversity. From this point of view, 435 types of trees and shrubs, including 107 trees and 328 shrubs, are spread over wide areas in the forests of our Republic. The Republic of Azerbaijan is among the countries with the least forest cover. The country's forest fund, belonging to the state, performs irrigation, soil protection and climate regulation functions. The forests of Azerbaijan belong to the first group and are given to forest enterprises for the purposeful development of forestry. Since the forests belong to group I, there is no industrially significant scraping. Forests in our country are unevenly distributed; 85% of them are located in mountainous areas, and 15% are located in plains (Burgi M. and Hersberger A., 2009).

Azerbaijan forests have unique forest formations. These formations are:

Coniferous forest formations consisting of hook pine;

Juniper sparse forest formations;

Beech forest formations consisting of eastern beech;

Oak forest formations

Chestnut oak forest formations;

Forest formations consisting of Caucasian oak;

Forest formations consisting of eastern oak;

Forest formations consisting of long-stemmed oak;

Forest formations consisting of Araz oak;

Velas forest formations;

Relic forest formations consisting of ironwood;

Birch forest formation

Forest formations of velvet birch;

Forest formations consisting of Tranttoveter birch;

Palm forest formations;

Elm forest formations;

Forest formations consisting of common walnut;

Forest formations consisting of common chestnut;

Forest formations consisting of azad wood;

Forest formations consisting of silk acacia;

Forest formations consisting of sedge;

Pollen forest formations;

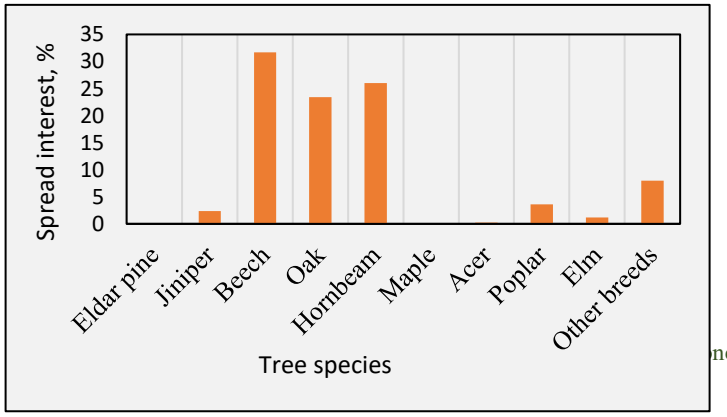
Tugay forest formations formed along the Kura-Araz coasts;

Poplar forest formations.

There are 435 types of trees and shrubs in the forests and green areas of Azerbaijan, 70 of which belong to endemic species. Broad-leaved forests are typical of the entire Republic. 95% of the forests are in the highlands, and the remaining 5% are mainly located around watercourses and in the plains. Most of the forests are located on steep mountain slopes, and they have irreplaceable soil protection, water purification and climate purification importance. This type of forest is more common in the low and medium mountainous areas of the Greater Caucasus, the Lesser Caucasus, Talysh Mountains (especially at 600-1600 m absolute altitudes).

Forests consist of three main tree species - beech, hickory and oak. They make up 81.09 percent of the entire forest cover. Besides these, birch, elm, linden, alder, poplar, linden, willow, etc., broad-leaved trees are also common throughout the area. 7 out of 107 tree species growing naturally in Azerbaijan are conifers. They include European sycamore, Eldar pine, hook pine, multi-fruited, heavy-smelling, red and long-stemmed junipers.

The Republic of Azerbaijan is considered the homeland of many rare species of shrubs. As a relic plant of the Tertiary period, blackthorn is a rare gem of forests. This tree is distributed in the South (Ismayilli, Gabala regions), Southeast (Pirgulu, Shamakhi regions) of the Greater Caucasus. Late-growing but long-lived blackthorn has never covered large areas. The homeland of the Eldar pine is Azerbaijan, and its distribution area is the Eldar hollow area of the Jeyranchol mountain range. Among the relict and rare trees of the third period growing in the Talysh mountains are ironwood, Lankaran acacia, chestnut-leaved oak, azat, Caucasian palm, boxwood, walnut, Hirkan maple, etc. are rare pearls of (Fig.5).



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Belts	The main plant formations	of the Greater Caucasus	
		south slope	North, East part
Semi-desert and desert	Yovshanli-shorangali semi-desert	100-200m	up to 150 m
Semi-desert and semi-steppe	Semi-desert with wormwood, Steppe, frigana groups and complex of arid forests	120-200 m	400-600m
Semi-steppes, arid forests and scrubs	Fragments of stony semi-steppe and arid forests, thickets	200-700m	-
Arid forests	Saqqizli - juniper forests, stone-standing, semi-steppe, frigana groups, sables	200-600m	-
Plain forests	Mixed broadleaf ivy forest, marshy meadows	200-800 m	0-600 m
Low mountain forest	Iberian oak, holm oak, oak-black forests	350-900m	-
Middle mountain forest	Beech, beech-beech forests	1600-2300m	600-2300m
Upper mountain forest	Subalpine forests, thickets and meadows	1600-3000 m	1500-3000m
Alp		3000 (3300) m	3000m and above

3. Forest ecosystems and their functions.

Forest ecosystems represent complex natural-historical systems spread throughout the forest stock and covering the fauna and flora of the area. The benefits of ecosystems to human society are called "ecosystem services". In other words, ecosystem services are a set of products and services that ecosystems provide in accordance with the needs and demands of people. In turn, these services have an important role in ensuring the continuity of life on Earth. The following are the main directions of "ecosystem services":

- Conservation of biodiversity; - Regulation of the atmosphere; - Watershed services;
- Soil protection services; - Recreational services (Dudley N., et al, 2005).

Conservation of biodiversity. There are various relationships between forest formations and biodiversity. Forests are areas where many types of trees and plants are spread. In addition, forests provide habitat for numerous species, some of which are endemic to the area and of special economic importance. The use of these types of endemic trees and shrubs for various purposes leads to their destruction. Therefore, the protection of this type of tree and shrub plants by the farm is considered one of the important measures in the protection of biodiversity. Biodiversity is essential to the sustainability of ecosystems and supports all other ecosystem services (Millennium Ecosystem Assessment, 2005). Forest ecosystems with high biodiversity are considered more attractive for recreational activities, as well as providing more carbon sequestration. However, in addition to wood, forest ecosystems contain various non-wood products, including wild fruits, vegetables, nuts, mushrooms, medicinal plants, etc. can provide forest products supply services (Gibson L. et al, 2011).

It is considered important to take the following measures to protect biodiversity in forest ecosystems: - restoration of natural forest cover; - protection of intact forest landscapes; - main-taining a

network of ecologically protected areas; - preservation or restoration of natural forest features; - conservation or restoration of species diversity.

Recreational services. In Azerbaijan, the use of forests for recreational and tourism activities (sports excursions, watching wildlife) continues to spread widely. When people use these services in the forest, they restore their health, including reducing stress, providing psychological and physiological recovery. In this direction, the infrastructure created in the forest ecosystems of the Republic and their quality (for example, roads, camps), and the intensity of management of these networks increase their attractiveness for recreation (Gurevitch J. and Padilla D., 2004).

Invasive plant species. At the same time, ***a***n analysis of the results of the inventory of the invasive flora of the Azerbaijani part of the Greater Caucasus (BC) was carried out. Researches were carried out in the natural (desert, psammophyte-littoral, desert, bush, forest, meadow) ecosystems of the Azerbaijan part of the BK, as well as ecosystems disturbed by anthropogenic activity. Here, 39 plant species of foreign origin (60.9% of the total flora of Azerbaijan, including 64 species) are mentioned, of which 12 (30.7% of the region's foreign flora) are invasive species. *Asteraceae Dumort* (11 types, 28%), *Poaceae Barnhurt* (13 species; 33.3%), *Amaranthaceae Juss* (5 species, 12.8%) are the main groups of invasive flora of the region. The results obtained analysis showed that annual plants are dominated by 25 species (64.1%), and perennials by 12 species (30.8%). The participation of tree forms is 2 types (5.1%). According to the system of life forms, therophytes with 27 species (69.23%) are dominant, the rest are hemicryptophytes with 10 species (25.64%), chamephytes - 2 species (5.13%). The distribution of invasive plants is subject to vertical zonation. It was determined that the most optimal height level of invasive plants is spread at heights of 100-600 (700) m.

It should be noted that in the middle of the 20th century, the highest point of vertical distribution of species was 600 (700) m above sea level. Currently, the spread of invasive plants from sea level up to 1100 m is observed; that is, the distribution range of these plants is also observed in the middle and upper mountain belts of the mountains, which can be associated with global warming (Larsen F. et al, 2012).

In the Azerbaijani part of the Greater Caucasus, most of the invasive species are distributed in the regions bordering Russia and Georgia. In particular, 12 species enter the local flora more rapidly and have a high reproductive potential, and these include: Australia akalifi (*Acaliph of the south*), Refolding Blackbird (*Amaranthus retroflexus*), Wormwood ragweed (*Ambrosia artemisiifolia*), high rotation (*Ailanthus altissima*), Canadian bluebell (*Erygeron canadensis*), curly crumb (*Erigeron Bonariensis*), small-flowered onion (*Galinsoga parviflora*), Amerika çiçəbaharı (*American Phytolacca*), annual creeper (*Phalacroloma annual*), False white acacia (*Robinia pseudoacacia*), common plover (*Xanthium strumarium*), Thorny xanthium (*Xanthium spinosum*). The analysis of the situation of invasive plants in the areas where invasive plants are spread has shown that the representatives of foreign flora species are starting to intensify in the region, and regular monitoring should be considered as the first measure to control them (Mason N. et al, 2005).

4. Protection of forest ecosystems and increase of forested areas.

In 2003, the "National Program for the restoration and increase of Azerbaijan's forests" was adopted. The national program covered the years 2003-2008 and reduced the problems of the forest sector to some extent. Thus, during these years, reforestation measures were carried out in 71634 hectares, out of which 28030.0 hectares were planted in open areas.

In the last decade, there has been a trend of decreasing forest areas around the world. According to the information provided by the UN FAO organization, 5 million ha of forest areas are lost (destroyed) on our planet every year. This manifests itself mostly in the Amazon and African forests. This intensifies the process of desertification, leading to land degradation, food shortages and, ultimately, population starvation. The most forested regions in the world are Russia, Brazil, Canada, and Finland. Forestry and the forest industry make up 15% of the economy in Russia, 18% in Brazil, 12% in Canada, 22% in Finland. It is the development of the forest industry that increases the export potential of these countries' forest products. In recent years, the reduction of forest areas has increased the attention of international organizations to this issue. Taking into account the reduction of forest areas, the "Bonn Call" document was prepared, and the restoration of the forest landscape in 130 million ha by 2030 was envisaged by the countries. Since this challenge is voluntary, each country, taking into account its potential, informed about the contribution it will make and joined that challenge. Currently, 96 countries have joined the call. Since the main priority direction of our country is the increase and restoration of forest areas, as well as the increase of the percentage of forests, the Republic of Azerbaijan joined this call in 2018 and undertook to carry out forest restoration measures in 170 thousand ha by 2030. Targeted measures are being implemented in this direction (McCarthy J. and Prudham S., 2004).

In 2011-2020, reforestation measures were carried out on 106,299.0 ha in the territory of the republic, of which 25,634 ha were planted and seeded. During these years, 27,876.0 thousand pieces of planting material were grown, 35,878.94 thousand trees were planted, and the forested areas increased by 30,739 ha.

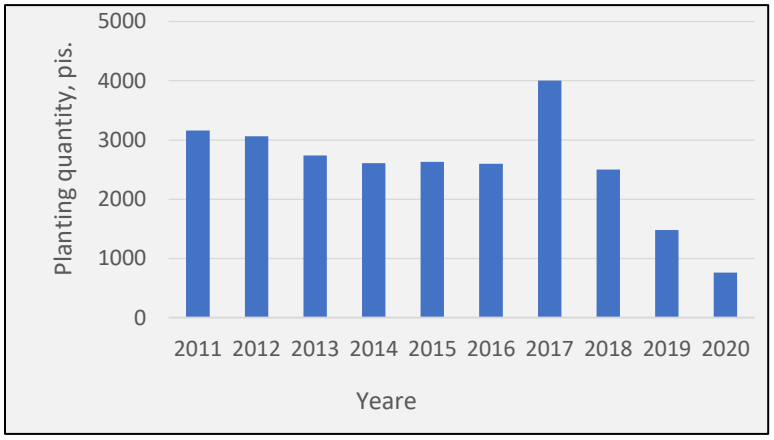

Figure 6. Cultivated areas by year

On the other hand, as a result of continuous and decisive measures taken in the field of forest protection, the cases of illegal logging have decreased by 2.5 times in the last ten years. At the same time, during these years, the volume of wood materials and products imported to the Republic increased 10 times and reached 180 million US dollars. 12.1 thousand tons of grass, 1.3 thousand tons of grain, 792 tons of garden fruits, 1.4 thousand tons of garden pomegranates, 1.2 thousand tons of nuts, 214 tons of citrus fruits and 32,065 tons of honey were supplied in connection with the implementation of the "State Program on the reliable provision of food products to the population in the Republic of Azerbaijan" (2003-2008 and 2008-2015) done (Tab. 6).

5. Effects on forest ecosystems.

As in many parts of the world, there is strong pressure on biodiversity in Azerbaijan on three levels. The main threats are the conversion of natural ecosystems to productive systems (agriculture or livestock), pollution, climate change, overexploitation of populations and the introduction of exotic species.

Threats affecting the forests of Azerbaijan affect not only trees, but also fungi, microorganisms, fauna, etc., which are the main components of the forest disappear with them. Threats to forests are mainly divided into two groups: direct and indirect. Direct threats include deforestation, which has the following causes: Use of firewood - fuel and scraps for industrial purposes; Urbanization - destruction of forest areas due to urban development; Cutting down trees for the purpose of creating pasture for livestock or burning; Forests for the creation or expansion of additional use areas such as roads; Deforestation to build infrastructure (Mittermeier R., et. al, 2004).

One of the problems that hinders the natural regeneration of forest resources is the existence of nomadic livestock, which is the overloading of pastures and the overgrazing of livestock by farmers. This situation causes the retreat of the upper border of the forests and the destruction of subalpine plant formations. All this makes it even more necessary to review the management of forest resources of the Republic of Azerbaijan. For centuries, forests have been considered the main source of human economic activity. As in other countries, forests in Azerbaijan, especially those spreading near settlements, performed two main economic and cultural-spiritual functions. Even now, there are forest areas that are considered sacred and no economic activities are carried out there. Below is the dynamics of illegal cutting in the forests of the Republic in 2010-2020 (Tab. 5).

Table 5. Defined in the Republic in 2010-2020

dynamics of illegal scraps

Years	Number of trees cut (number)	Volume, m^3	Value (manats)
2010	61637	34483	245813
2011	38587	24300	172922
2012	52563	24066	157437
2013	56958	32623	222348
2014	47389	22051	152032
2015	42152	21362	147687
2016	43365	22253	154619
2017	81420	55437	470138
2018	49816	26355	289941
2019	38956	19107	337290
2020	21583	11041	453836
Total	**534426**	**293078**	**2804063**

During the 9 months of 2021, 12,834 trees were cut down illegally. Illegally cut trees were valued at 277,495 manats, with a volume of 6,050 m^3.

At the same time, preliminary calculations conducted in the Karabakh region show that the forest areas were intensively changed during the occupation. Deforestation of these forests from 1992-2020 was initially determined to be more than 54 thousand hectares.

6. Degradation of forests.

Deforestation and degradation are global problems. Thus, according to the forecasts of leading international organizations, by 2030, approximately 47% of the world's forests will face the risk of intensive fragmentation or degradation. Both cases have a negative impact on the sustainable development of forests.

There is an approach to the degradation of forests as a change in the diagnostic indicators of the land under the forest by cutting down trees. In this direction, there is a high risk of forest destruction in the area of about 6.5 million km² in the next 10 years. Another major driver of forest degradation is climate change: higher temperatures and unpredictable weather patterns increase the risk and severity of wildfires, pests and diseases. However, the main cause of forest degradation is unsustainable and illegal logging (Pereira H., et. al, 2010).

7. Tugai forests can be cited as an example.

In the last 20-30 years, the lack of fuel and the resettlement of refugee families in the surrounding regions of Kura increased the pressure on the trees of Tugai forests, which led to the thinning of the existing forests, the deterioration of their condition, and the reduction of their area. Another factor affecting forest degradation is the presence of settlements nearby. This has gradually enabled the spread of cases such as the occupation of forest areas by local residents and the carrying out of various purposeful activities. Also, cattle damage to forests has completely stopped the development of natural regeneration in forests. The thinning of forest massifs and problems arising from the normal development of forest plantations planted in open areas create serious obstacles to the development of forests, which increases the negative effects on the environment.

8. Problems arising in forest ecosystems and directions for their solution.

The role of the forest sector in the national economy is underestimated, and the paradigm of sustainable forest management is poorly applied in practical forest management. The most important forest management issues were identified in several scientific discussions held in 2018-2020. During the discussions, it was shown that the main problem of forestry in the country is the replacement of the extensive operational nature of forest management with a continuous intensive forest management model. This, in turn, will allow for achieving a higher economic efficiency of the forest sector by increasing the productivity of forests and the volume of firewood supply in areas with developed social and transport infrastructure by protecting protective forests, especially protected and untouched natural areas.

The need to address important issues, such as replacing primary data-based and comprehensive forestry projects with a sound methodological base, adequately funded forestry activities, and forest management regulations that provide quality control tools for forest management, is justified. Forecast indicators for the development of the Forest Sector until 2030 require the importance of a new forest policy and significant investments in the forest sector.

The forested area of the country is 11.8%, 85% of which is spread in the mountainous part and has great potential in terms of ecological services. In these areas, erosion and degradation problems are very serious.

To ensure the implementation of the "Strategic Action Plan prepared for the effective solution of socio-economic, humanitarian, organizational and other urgent issues in the liberated territories" of the Coordination Headquarters established by the Order of the President of the Republic of Azerbaijan No. 2303 dated November 24, 2020, the "State Program for the Restoration and Sustainable Development of the Liberated Territories of the Republic of Azerbaijan for 2022-2026" was prepared. According to the mentioned State Program, the Ministry of Ecology and Natural Resources prepared the "Forest Fund Restoration Program" covering the years 2022-2026 in the occupied territories of the Republic of Azerbaijan. These lands intended for reforestation will open up great social, economic and ecological opportunities for the country.

9. Study of forest ecosystems.

Within the framework of the "Assessment and Monitoring of Forest Resources" - GCP/AZE/007/GFF project in the Republic, the issues of determining the borders of forest fund lands, carrying out geodesy-topographic works, drawing up plan-cartographic materials, inventorying forests by determining the distribution of forests, their species composition, age groups, firewfood stock, afforestation, reclamation, conservation, protection and other economic measures were studied. Forest structure works were carried out for the purpose of determining the rules and methods of conducting these measures, determining the functions of forests, determining the directions and volumes of forest use, studying recreation, tourism and logistics issues, conducting forest-biological, forest-pathological observations, evaluating the activities of forestry, and forming and developing the optimal organization of the farm.

The rules, research and studies applied in forest management are carried out in accordance with the principles of the Forest Legislation of the Republic of Azerbaijan, the FAO (Food and Agriculture Organization) guidelines of the United Nations, and the "Methods and Principles" of the Republic of Turkey for the preparation of Ecosystem-Based Functional Forest Structure Planning.

Ecosystem-based Functional Forestry works enable the identification of "Ecosystem Services" (water and soil conservation and carbon sequestration), digitization and integration of the landscape planning process.

Assessed forest "Ecosystem services" are mapped according to mathematical models, terrain, data and developed methods. The distribution area of trees and shrubs and the analysis of forest functions are carried out on the maps. The purpose of these analyses includes the services provided by the forest ecosystem.

Within the framework of the "Assessment and Monitoring of Forest Resources to Strengthen the Forestry Knowledge Framework in Azerbaijan" - GCP/AZE/007/GFF project, research was conducted in the service areas of Barda, Zagatala, Sheki, Gabala, Shamakhi, Lankaran and Masalli Regional Forestry Centers in 2018-2021.

Research on forest ecosystems was carried out in Lankaran and Masalli Regional Forestry Centers. The research was carried out by the Forestry Development Service under the Ministry of Ecology and Natural Resources. At this time, forest ecosystem services have been evaluated economically, ecologically, and socio-culturally.

With this approach, which was applied for the first time in Azerbaijan, it played an important role in the development of effective decisions, taking into account the impact of plans and projects in the forest ecosystem on all services provided by the forest ecosystem.

In addition, between 2018 and 2021, forest-related land use and land use change, fire, etc., were carried out based on the "Collect Earth" method at the country level by the Remote Sensing method in Azerbaijan within the framework of the "Assessment and Monitoring of Forest Resources to Strengthen the Forest Knowledge Framework in Azerbaijan" - GCP/AZE/007/GFF project. A comprehensive report was prepared through the collection and analysis of national data. This report assesses both the current forest area and land-use change from 2000 to 2016 and provides appropriate recommendations.

The results of the assessment show that the total forest area in Azerbaijan is approximately 1,301,188 ha or 15.1% of the total area. Comparing the land uses of 2000 and 2016, the results show that relatively small land use changes occurred in all land use categories in Azerbaijan. Very slight increases were observed in forests (annual increase of 0.007%) and grasslands (annual increase of 0.018%). However, residential areas accounted for the largest change with an increase of 37,962 ha or 7.9% over 16 years. The results of the Global Forest Survey also confirm that very little land-use change occurs between forest and non-forest land use categories.

1,213.7 thousand of the total forest area belongs to the forest fund. ha (Ref: NFP, 2013; ProDoc) and previous studies show that this land area is 1,021 thousand. ha (NFP, 2013) or 1,036.27 thousand. ha (Ref: ProDoc), i.e., 11.8%. And 12% of the total country area is covered with forests. According to the FAO Forest Resources Assessment Report (FRA-2015), the total forest area of Azerbaijan is 1,139.4 thousand. ha or 13% of the country's territory.

10. Conclusion

As a result of the work carried out, the following conclusions can be drawn:

1. There have been no significant changes in the area of trees and forest cover in the territory of the Republic over the past 20 years, but a further 7.9% increase in the use of forest lands as a place of residence has been recorded.
2. The trends in biodiversity change in forest ecosystems in recent years and the shifts of the main forest formations against the background of climate change have been analyzed, and the migration of the main forest-forming species to relatively humid (to the upper mountain belts) afforestation conditions has been identified.
3. It has been established that the forest ecosystems of the Republic mainly carry out functions such as biodiversity protection, atmospheric regulation, protection of water and soil resources, and recreational activities.

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