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ECONOMIC VALUATION OF FOREST SERVICES: CASE STUDY OF ZAWITA FOREST, KURDISTAN REGION OF IRAQ

MOSA ASAAD IBRAHIM[*] and MOHAMMAD K. HASSAN[**]
[*]Dept. of Forestry, College of Agricultural Engineering Sciences, University of Duhok, Kurdistan Region-Iraq
[**]Dept. of Recreation and Ecotourism, College of Agricultural Engineering Sciences, University of Duhok, Kurdistan Region-Iraq

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ABSTRACT

Forest is a kind of natural reserve that provides many goods and services. This work intended to value a group of environmental services (water and soil conservation, carbon sequestration, oxygen generation, nutrient cycling, and air purification) provided by two forest types that exist in Zawita area, namely pine forest and oak forest. This study depended on data collected from forest inventory, key informant interviews, secondary data, and state institutions and from published and unpublished sources. The economic value of only the environmental services that were evaluated for each of pine forest and oak forest in 2022 were 705,000 ID (479.28 US$) and 213,000 ID (144.61 US$)/ha/year respectively. These results present valuable information which could be considered by decision maker to develop policies that enhance the sustainability of Zawita forest.

KEYWORDS: *Economic Valuation, Forest Services, Kurdistan Region, Oak Forest, Pine Forest, Zawita Forest.*

1. INTRODUCTION

Forests cover around 25 percent of the world's land mass and provide a group of goods and services that is vital to the wellbeing of humankind. The intangible benefits consist of a wide variety of services that help preservation of biodiversity, watershed protection, and soil and water conservation. If these values could be considered in decision making it could contribute to better preservation consequences (Landell-Mills and Porras, 2002). Yet, globally there is an extraordinary rise in deforestation. According to the Agriculture and Food Organization (FAO, 2006), each year, almost thirteen million hectares of international forests are cut down and changed to other land uses.

This raises a serious concern about the sustainability of the numerous services provided by the forest ecosystems. This is one of the main factors that has caused climate change which have brought disastrous events in many parts of the world, such as droughts, floods, global warming, and forest fires.The rising significance of the forest ecosystem in global policy may be seen in different worldwide initiatives such as reduce emissions from forest degradation and deforestation (REDD) by supporting sustainable forest management, and the Paris Contract in 2015 to fight climate change and adapt to its influence (Masiero et al., 2019).These initiatives are activated by the fact that mismanagement and overexploitation of ecosystems joined with population progress, climate change, economic development and growing demand for food, water, materials and energy have triggered steady degradation and/or damage of habitat structure over the years according to the Millennium Ecosystem Assessment (MEA, 2005). The degradation and damage of valuable ecosystems also weakens the welfare that flows from environment to people and the economy, subsequently resulting in a permanent loss of ES and ecosystem functions, threatening the sustainability of human well-being (Masiero et al., 2019). Over the past three decades, a variety of economic valuation approaches have been developed to estimate the value of ecosystem services by using people's preferences as expressed by willingness to pay (Akrawee, Z. M, 2020). Valuation methods have discovered the importance of forest assets and provided a good understanding of various methods in which forest capitals benefit mankind (de Groot et al. 2002; Amirnejad et al. 2006).

Most of Iraq's natural forests are limited to the northeastern part of the nation, in foothills occupied by Kurdish communities (Mosa, W. L,2016). According to the FAO (2014), approximately 825,000 ha of Iraq land are covered by forest or 1.9 percent of the land area and the planted forests are around 15,000 ha.

The Kurdistan region forests have witnessed degradation caused by many natural and man-made factors such as fires, military operations, natural disaster and conversion to other land uses that impacted its ecological services (Nasser 1984; Şefik 1981; Chapman 1948). Therefore, there is an urgent need to value the goods and services that forest provides in order to be considered in forest policy formulation and decision making regarding forest management and planning which will contribute in better forest conservation. The indigenous pine forest exists only in Zawita and Atrush. Its stands are lightly stocked and composed mainly of pine species (Pinus brutia Ten.) which is grown naturally and distributed over a vast area of Zawita district (Mosa, 2016). The height of pine trees reaches up to 20 m with irregular branches and open crown (Shahbas, 2007). It has a moderate growth and the annual ring width is about 0.59 cm (Shahbaz et al., 2002). It is frequently used for reforestation. Dense forest and stands can be found in some sites while in other sites open stands and forest are found.Oak is a native tree species and covers about 70 % of the total oak area which constitutes about 90% of the region's forest (Shahbaz S. E. 2010). It tends to develop a decurrent growth pattern, therefore, and objectivesits wood is distributed over tree branches and tree trunk, and is used for various purposes (Younis, A. J.,2019). Valonia oak lives up to 200 years, and its attributes, height, diameter and crown width may reach 20 m, 100 cm and 7m respectively (Shahbaz,2005).

Oak forest has many environmental and socioeconomic benefits.

The environmental services provided by forests are not fully considered by decision makers because their values were not evaluated economically. The hypothesis tested in this work is 'Zawita forest provides magnificent environmental services that must be valued in order to be appreciated in forest management plan' This work is a descriptive study design aims at estimating the values of a given group of environmental services provided by two forest types in Zawita area, namely pine forest and oak forest.

2. MATERIALS AND METHODS

2.1. Study area:

This work was conducted in Zawita forest, which is one of the most important forest ecosystems in Duhok Governorate, Kurdistan Region-Iraq (Fig.1). It is located 16 Km away from Duhok city at 36°54′59″ N and 43°04′46″E at an elevation range of 720 and 1440 m above sea level (Mustafa.Y. T.,2014). The entire forest area is about 41591ha, with nearly 30129 ha of it consisting of natural forests (Mosa, W. L, 2016). Since the 1960 of the last century, The Zawita sub-district has been cited by several visitor's guides as one of the main tourist attractions in Kurdistan Region-Iraq and Iraq (Tourist Guide for Kurdistan Region, 2012). It is well-known for its famed pine forests; its wide shady spots make it mainly good-looking in the summer (Mosa, W. L,2016). The study area is characterized by beautiful scenery with high mountains at different points, cultivated grasslands, deep valleys and mountain chains. The soils under pine forest are clay, clay loam, and loam texture and it is clay under oak forest (Fayyadh, M. A., 2019). From a climatic standpoint, the study area is comparable to the Mediterranean climate circumstances, dry summer and a modest amount of rainfall through winter (Koeppe and De Long, 1958). Under the Köppen-Geiger system, the temperature inZawita forest reaches as high as 43°C in the summer season while the low temperature reaches under freezing point in the winter season. From a vegetation and biodiversity community structure standpoint, the Zawitapine trees are the main species linked with the oak trees and the massive shape of the Zawita foothill chain has traditionally maintained a rich biodiversity range of animals and plants, (Guleur and Kettenah, 1972). Therefore, this natural ecosystem was selected to evaluate the economic value of its environmental services. The valued services included water and soil conservation, carbon sequestration, oxygen generation, nutrient cycling, and air purification.

The total area covered during this work is 6596 ha divided into two forest types, pine forest (2908 ha) and oak forest (3688ha). The ground-based forest inventory revealed that pine forest had almost only one tree species (Pinus brutia Ten.) with very poor biodiversity. The average number of trees, diameter and basal area were 240/ha, 22.25 cm and 13.62 m^2 /ha respectively. In the oak forest, valonia oak was the dominant species, other species could also be found such as Quercus aegliops, Quercus infectoria, Pistacia khinjuk, P. mutica, Acer cinerascens, Crataegus azarolus, Pyrus syrica, and Celtis). Oak forest consisted of copies grown from the stump of the trees. The copies were small in size and the forest inventory revealed that the average number of trees, diameter and basal area were 360/ha, 7 cm and 1.72 m^2 /ha respectively. Oak forest was richer than pine forest with respect of biodiversity.

2.2. Data collection

Three methods were used in data collection. The first one was interviewing key informants which included the local chief (Mukhtar), government employees and the Zawita forest technicians in order to obtain information about the study area that cannot be obtained from other sources. In the second method, secondary data were collected from reports, government institutions, research organizations, internet sources, journal articles, and local factories in Duhok governorate. In the third method, data was obtained directly from the study area through conducting forest inventory to obtain data which could be used to estimate growth and yield of the two forest types. Systematic sampling with equal radios of 17.8 m was conducted (Husch et. al., 2002). Mines field cover considerable area in both forest types, especially in oak forest. For security reason, samples from such area were not taken. Accordingly, more plots were taken from pine forest (75 plots), while only 35 plots were taken from oak forest. The forest inventory operation was carried out from December, 2021 to May, 2022.

To forecast future growth, multiple Regression analysis was used to establish a relationship between past diameter growth of trees as independent variables and expected future diameter growth as dependent variables for each of pine trees and oak trees. Past diameter growth was obtained using increment borer, and from cross sections at breast height for very small trees. Sample of 43 pine trees and 44 oak trees were taken. The pine sample included sapling trees with small diameter as low as 4 cm and the biggest one was 75 cm. While oak sample included copies as small as 2 cm and the biggest tree had a diameter of 30 cm.

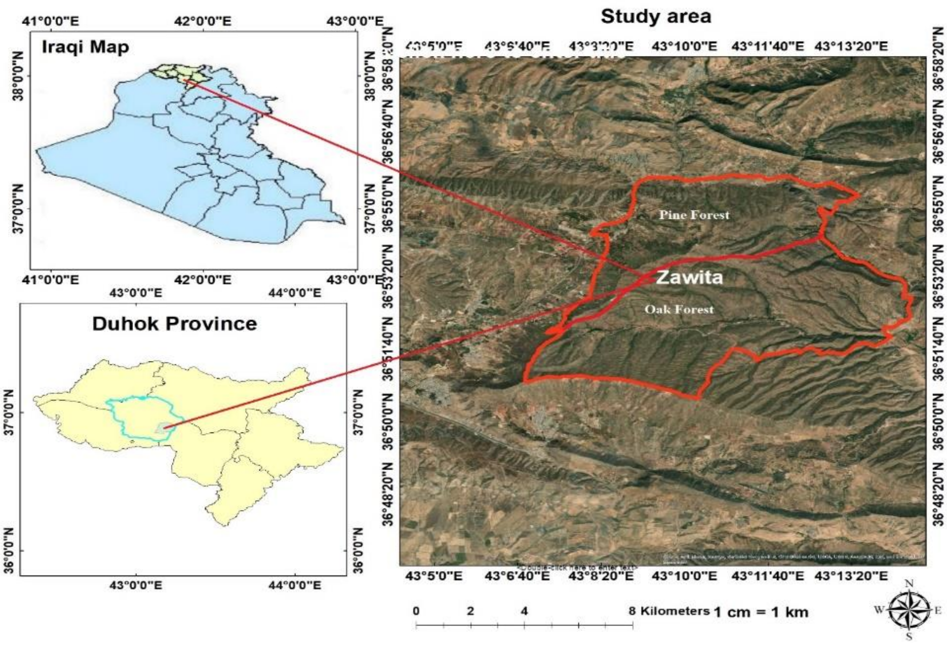

Fig (1): The Location of the study area.

2.3Valuation Methods

Many goods and services that are produced by forests are not traded in the market, therefore, it is hard to attach economic values to them, yet, these goods and services are essential for human wellbeing. As such, it is very important to develop methods to value them in order to reveal the true value of forest which could be implemented in forest policy formulation and forest management and planning. Over the past three decades several effective economic methods have been developed to estimate the value of such forest services. In general, these methods can be grouped into three approaches; stated preferences, revealed preferences, and direct market valuation methods. Benefit transfer approach can also be used when it's difficult to develop a value for a particular service (P. Riera, 2012). In this work, different direct market approaches were employed as listed in table 1. These methods have also been adopted by J. Boyd and S. Banzhaf (2007), B. Fisher (2009) and R. Godoy (2007).

Table (1): Valuation approaches adopted for different services of Zawita forest.

Ecosystem service	Valuation method(s)	Benefits
Water conservation	alternative cost	storing rainfall water
Soil protection	opportunity cost approach	controlling erosion in a dam
Carbon sequestration	market price	absorbing CO_2
Oxygen generation	replacement cost	releasing oxygen
Air purification	alternate cost	absorbing air pollutants (SO_2& NO_2)
Soil nutrient cycling	replacement cost	accumulating nutrients

2.4.1 Water Conservation

This service is accomplished by the process of filtration of precipitation into the groundwater that is facilitated by the forests. To calculate the amount of conserved water in forest, the average evaporation and water run-off rates is subtracted from the average annual rainfall received in the study area. Same procedure is followed to calculate the amount of water conserved in medium vegetation cover, the difference between the above two calculated quantities is the conserved water attributed to the forest. The rainfall storage method was adopted to estimate the value of conserved water (Xue and Tisdalle, 2001: Xi, 2009). Dawod and Julien (1987) developed a model (equation 1) that estimate runoff depth in Zawita forest under different situations related to conservation practice, vegetation cover, and soil texture. The developed model was utilized to calculate water conserved in each of bare land and pine forest. Such model has not been developed for oak forest; therefore, the model developed for pine forest was used as a proxy for oak forest;

$$Vr = 0.23\ Pr\ Cr\ Kr\ S^{0.357}r;\ (R^2 = 0.82) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where V_r is the runoff depth (in mm), r is the average rainfall depth which is 762 mm (Directorate of Meteorological station), Pr is the conservation practice which is 1 for no practice, C_r is the vegetation cover which is 0.77 and 0.54 for medium cover and forest land respectively, $K_r$is the soil texture parameter which is considered 1for medium soil texture in study area, S is the surface slope of Study which was assumed to be 0.1 (10%) as an average value. The obtained value in addition to the evaporation

value was deducted from the amount of annual precipitation to obtain water that is filtered into the ground water. Value of conserved water is calculated by multiplying it with cost of storing one cubic meter of water in Duhok dam which was estimated to be 0.007US$/m^3.

2.4.2 Soil Conservation

Forest protects soil from the direct rainfall impact and it reduces speed and amount of runoff. Hence, forests greatly contribute in reducing soil erosion and its sedimentation in rivers, reservoirs and extended dams' life (Junhua, 1999; Xue and Tisdell, 2001). To estimate amount of soil erosion in bare land and pine forest land the following model developed by Dawod and Julien (1987) using data taken from Zawita forest. Same model was used as a proxy for oak forest;

$$V_s = 0.743\ S^{0.72}\ V_r^{1.44} P_s C_s K_s;\ (R^2 = 0.95) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where V_s is the annual erosion losses in m^3/ha, S is the surface slope of the study area which is assumed to be on average 0.1, V_r is runoff depth which will be calculated from equation (1), P_s is conservation practice parameter which is 1 for no practice, C_s is the vegetation parameter which is 0.52 and 0.23for medium cover land and forest land respectively,

K_s is the soil texture parameter which considered equal to 1 for clay soil.

The difference between the magnitude of the eroded soil of bare land and forest land represents the contribution of forest in soil conservation. The percentage of sediments that cause damage by entering reservoirs or rivers to entire soil loss was assumed to be 50% (Okelo, 2008). Soil conservation value was measured based on avoided cost of sediment removal from dredging rivers and reservoirs (Xue and Tisdalle, 2001). This cost was estimated to be on average around 1.59US$/m^{3}in Kenya (Ikobe, 2014) and 1.592US$/m^{3}in Vietnam (Nguyen, M. D., 2016). In Kurdistan Region, this cost was assumed to be 1.592US$/m^3 because of unavailability of such figure at local level.

2.4.3 Carbon Sequestration

Forests regulate the air by storing carbon and releasing oxygen (Ninan, 2013). Main stem volume of pine trees was obtained using a model developed by Kalkhan (1980) (equation 3), while the total volume of oak trees was calculated using the model developed by Younis (2019) (equation 4). Diameter growth of each type of tree was modeled using past diameter growth as an independent variable. For pine species 43 trees were taken with diameter ranging 4 - 75 cm and for oak species 44 trees were taken with diameter ranged 2-30 cm. Equations 5 and 6 were obtained.

$$\text{Log } V = -4.17608 + 2.57749 (\log D) \quad \text{for Pine} \quad \ldots\ldots(3)$$
$$VT = -9.84006 + 2.59526 \ln D \quad \text{for Oak} \quad (R^2 = 0.985) \ldots\ldots(4)$$
$$Dg = 4.95072 - 0.0643509 * D \quad \text{for pine} \quad (R^2 = 0.86) \ldots\ldots(5)$$
$$Dg = 0.677784 + 0.0651737 * D \quad \text{for Oak} \quad (R^2 = 0.90) \ldots\ldots(6)$$

Dg is diameter growth (cm); D is diameter at breast height (cm). The developed diameter growth equations were then used to estimate current yield and future growth of the stands of each species using the forest inventory data.

Results of the growth of each forest type along with the latest informed parameters used by IPCC (2006) for converting wood to dry biomass and to carbon were used to calculate amount of carbon sequestered each year using the following procedure adopted by Başkent, E. Z. (2021) and Ninan, K. N. and Kontoleon (2016);

1- Aboveground Biomass (ABG)= V*WD*BEF*CF ……………………………………… (7)
2- Belowground Biomass (BGB) = V*WD*BEF*CF*R ………………………………… (8)
3- Carbon in Deadwood (Organic matter) = V*WD*BEF*CF*0.01 ……………………… (9)
4- Total carbon sequestration = (ABG + BBG+ Carbon in Deadwood)……………………… (10)

Where V is the annual growth (m^3/ha/year) which estimated to be 6.5093 for pine and 0.7076 for oak, WD is wood density which is 0.7363ton/m^3 for oak (AA, A., Suliman, 2021) and 0.4676 ton/m^{3}for pine (Al-Muhaisin, 1979), BEF is biomass expansion factor which is 1.5for pine (IPCC, 2006), CF is Carbon fraction which is 50% of the biomass density (IPCC, 2003), R is root-to-shoot density which is 0.40 for pine and 0.46 for oak as recommended by the (IPCC, 2006). The proportion of carbon in deadwood was assumed 1% as stated by Başkent, E. Z. (2021).

The World Bank report (2021) presented the carbon prices across emissions crediting and trading schemes in several countries, it ranged from under 1US$/t$CO_2$ in the Mexican carbon tax to 137US$/t$CO_2$ in the Swedish carbon tax. Langat, D. K. (2016) estimated the carbon price in Kenya to be 10US$/t$CO_2$. In India, Ninan, K. N., & Kontoleon, A. (2016) applied the marginal social damage to estimate CO_2pricewhich was found to be 20US$/t$CO_2$. In Iran, Komeil, J. (2017) also used marginal social damage costs for this purpose which was found to be 20US$/t$CO_2$. Başkent, E. Z. (2021) used a price of 20US$/t$CO_2$.Due to the drastic changes in world climate that has been witnessed in the past few years CO_2 prices have been considerably increased, the current trend in carbon prices is 50US$/t$CO_2$ which was used in this work (World Bank, 2021).

2.4.4 Oxygen Generation

The oxygen generation capacity of forests depends on carbon storage capacity, by implementing the photosynthesis reaction formula (Xue and Tisdalle, 2001; Xi, 2009).

$$6CO_2\ (264g) + 6H_2O\ (180g) \dashrightarrow C_6H_{12}O_6\ (180g) + 6O_2\ (192g)$$

$$\downarrow$$

Polysaccharide（162g cellulose or starch）

Based on the above formula, 1 ton of absorbed CO_2 releases 0.73 ton of O_2 (192/264). The economic value of Oxygen is estimated using the average cost of industrial oxygen production which is 150US$/ton in Duhok governorate.

2.4.5 Nutrient Cycling

Annual biomass growth is required to estimate the amount of nutrients generated by forest each year. The obtained value for annual biomass growth for each species which was calculated in the section related to carbon sequestration is used for this purpose. To estimate the quantity of nutrients generated by the forest, these figures are multiplied with concentrations of NPK in the biomass. A study in Beijing (China) found that NPK concentrations are 0.01186 and 0.01644 t/ha/year for pine and oak forest respectfully (Xue et al., 2001). Because of unavailability of better estimates of NPK concentration to count on, the figures from Beijing, which has precipitation similar to that in Zawita area, were used in this research. The soil nutrient cycling value was estimated using a replacement cost approach. In Kurdistan Region of Iraq, the average whole price of mixed fertilizers is 1400US$/ton.

2.4.6 Air purification

The vegetation cover has an imperative role in regulating atmosphere quality by eliminating pollutants gaseous from the air such as SO_2, NO_2 (Nowak, 2000). Bahzad (2020) found that Zawita district is contaminated with these two gases. The pollution absorption ability of trees differs depending on tree, forest and site features, location, periods and weather circumstances, pollution levels, etc. A study by Yoshida (2001) in Japan, found that the annual absorption rates of NO_2 and SO_2 at 15.6 and 10.8 kg/ha respectively. These figures were used in this research. To estimate the economic value of air purification, the engineering cost or abatement cost of controlling NO_2 and SO_2 is used. The study by Ning, et. al. (2016) noted that the abatement cost for NO_2 and SO_2 was 287US$ and 96US$ per ton respectively. These figures are used to value air purification service in the two forest types.

3. RESULTS

3.1 Water conservation

The average percentage of annual precipitation that is intercepted and conserved in the pine forest was calculated to be 86% and only 14% flows away as surface runoff/evaporation. Because of unavailability of a model that estimates the percentage rainfall that is stored in oak forest, the figure obtained in pine forest was used as a proxy for oak forest. The price of water conservation was estimated using water storage methods based on the average cost of storing 1 m^3 of water in Duhok dam. The annual economic value of water conservation in the study area, on hectare bases, for both of pine forest and oak forest was found to be 67,500 ID/ha/year (45.95US$). The annual value for the entire study areawas196,435,000ID/year (133,628.99US$) and 249,123,000 ID/year (169,471.71US$) for pine and oak forest respectively.

(Table 2): The Value of water conservation by forest type in the study area

Description	Pine Forest	Oak Forest
Area	2908	3688
Water conserved (m^3/ha/year)	6,564.6	6,564.6
Water conserved per forest (m^3/year)	19,089,856.8	24,210,244.8
Value of water per hectare ($/year)	45.95	45.95
Value of water for the forest ($/year)	133,628.99	169,471.71

3.2 Soil conservation

The value of this service was measured using an avoided cost approach for soil protection based on the cost of sediment removal from a dam or water course. The annual economic value of reducing soil erosion in the study area for both pine forest and oak forest was estimated to be 23,000 ID/ha/year (15.39 US$). These values are equivalent to 65,808,000 ID/year (44,767.61US$) and 83,430,000 ID/year (56,755.43US$) for pine forest and oak forest respectively.

Table (3): The value of soil conservation by forest type in the study area

Description	Pine Forest	Oak Forest
Area	2908	3688
Soil eroded in bare land (m^3/ha/year)	26.32	26.32
Soil eroded in forest land (m^3/ha/year)	6.98	6.98
Soil conserved by forest (m^3/ha/year)	19.34	19.34
Soil conserved by forest (m^3/year)	56,240.72	71,325.92
Cost of removing eroded soil (US$/$m^3$)	1.592	1.592
Cost of removing eroded soil (US$/ha)	15.39	15.39
Total cost of removing eroded soil (US$)	44,767.61	56,755.43

3.3 Carbon sequestration

This service was valued based on the market price of CO_2 in the international carbon market. The annual economic value of carbon fixed in pine forest and oak forest was found to be 158,000 ID/ha/year (107.28US$) and 28,000 ID/ha/year (19.14US$) respectively. These values translate to a total value of 458,613,000 ID/year (311,982 US$) and 103,791,000 ID (70,606 US$) per year for pine forest and oak forest respectively.

Table (4):- The Annual Value of Carbon sequestration by forest type

Forest type	Forest pool	Area (ha)	Total annual growth (ton/ha/ year)	Carbon stock (ton/ha/ year)	Total carbon stock(ton/year)	Value of carbon stock (US$/ha/year)	Total value of carbon stock (US$/ year)
Pine Forest	Aboveground	2908	3.0437	1.5218	4425.39	76.09	221,267.5
	Belowground	2908	1.2174	0.6087	1,770.09	30.43	88,504.5
	Deadwood	2908	0.0304	0.0152	44.20	0.76	2,210
The annual value of carbon sequestration						**107.28**	**311,982**
Oak Forest	Aboveground	3688	0.5210	0.2605	960.72	13.02	48,036
	Belowground	3688	0.2396	0.1198	441.82	5.99	22,091
	Deadwood	3688	0.0052	0.0026	9.58	0.13	479
The annual value of carbon sequestration						**19.14**	**70,606**

3.4 Oxygen generation

The value of this service was estimated based on the carbon storage in each forest type and the price of local industrial oxygen manufacturers in Duhok Governorate. The annual economic value of the oxygen generation for pine forest and for oak forest was estimated to be about 345,000 ID/ha/year (234.92 US$) and 62,000 ID/ha/year (41.89 US$) respectively. The total annual value turned out to be 1,004,269,000 ID/year (683,176 US$) and 227,126,000 ID/year (154,507 US$) for pine forest and oak forest s respectively.

Table (5): The Value of Oxygen generation by forest type

Forest type	Forest pool	Area (ha)	Carbon stock (ton/ha/year)	Oxygen generated (tons/ha/ year)	Total oxygen generated (tons/year)	Oxygen value (US$/ha/year)	Total oxygen value of (US$/year)
Pine Forest	Aboveground	2908	1.5218	1.1109	3,230.53	166.63	484,574.58
	Belowground	2908	0.6087	0.4443	1,292.17	66.64	193,803.66
	Deadwood	2908	0.0152	0.0110	32.26	1.65	4,798.2
The annual value of Oxygen generation						**234.92**	**683,176.44**
Oak Forest	Aboveground	3688	0.2605	0.1901	701.08	28.51	105,163.32
	Belowground	3688	0.1198	0.0874	322.33	13.11	48,349.68
	Deadwood	3688	0.0026	0.0018	6.63	0.27	994.5
The annual value of Oxygen generation						**41.89**	**154,507.5**

3.5 Nutrient cycling

This service was valued using replacement cost methods based on the average price of mixed fertilizers in the Kurdistan region. Its economic value for pine forest and oak forest was estimated to be 104,000 ID/ha/year (71US$) and 26,000 ID/ha/year (17.5US$) respectively. The total values for this service were 302,226,000 ID/year (205,596 US$) and 94,874,000 ID/year (64,540 US$) per year for pine forest and oak forest respectively.

Table (6): The Value of nutrient cycling by forest type

Forest type	Forest pool	Area (ha)	Biomass growth (t/ha/yea)	Total biomass (ton/year)	Quantity of NPK (t/ha/year)	Quantity of NPK per forest	Value of nutrient (US$/ha/year)	Value of nutrient (US$/ year)
Pine Forest	Aboveground	2908	3.0437	8,851.07	0.036	104.97	50.53	146,963.3
	Belowground	2908	1.2174	3,540.19	0.014	41.98	20.21	58,781.4
The annual value of nutrient cycling							**70.74**	**205,744.7**
Oak Forest	Aboveground	3688	0.5210	1,921.44	0.0085	31.58	11.99	44,224.04
	Belowground	3688	0.2396	883.64	0.0039	14.52	5.51	20,337.96
The annual value of nutrient cycling							**17.5**	**64,562**

3.6 Air purification

This service was valued based on the abatement cost of controlling SO_2 and NO_2. Its value for pine forest and oak forest was estimated to be about 7,000 ID/ha/year (4.74 US$). These values on forest level are equivalent to 20,292,000 ID/year (13,804.62 US$) and 25,740,000 ID/year (17,510.02 US$) respectively.

Table (7): The value of air purification by forest type in study area

Forest type	Type of gases	Area (ha)	Absorption amount (Kg/ha)	Total absorbed quantity (t/year)	The abatement cost (US$/ton)	The annual value US$
Pine Forest	SO_2	2908	8.8	25.59	96	2,456.64
	NO_2	2908	13.6	39.54	287	11,347.98
The annual value of air purification						**13,804.62**
Oak Forest	SO_2	3688	8.8	32.45	96	3,115.2
	NO_2	3688	13.6	50.15	287	14,395
The annual value of air purification						**17,510.02**

3.7 The total annual economic value: A summary of the estimates of the annual economic value of the valued environmental services provided by each pine forest and oak forest and evaluated in this work is presented in Table 8. The annual economic value for pine forest and oak forest was found to be705,000ID/ha/year (479.28US$) and 213,000 ID/ha/year (144.61US$) respectively. On forest level, these values are equivalent to 2,047,645,000 ID/year (1,392,955.66US$) and 784,084,000 ID/year (533,390.66US$) per year respectively.

Table (8): Summery of annual economic value by forest type in the study area.

Ecosystem services	Value (US$ /ha/year)	Total value (US$ /year)	Contribution to total value (%)
Pine Forest			
Water conservation	45.95	133,628.99	9.58
Soil conservation	15.39	44,767.61	3.21
Carbon sequestration	107.28	311,982	22.38
Oxygen generation	234.92	683,176.44	49.01
Nutrient cycling	71	205,596	14.81
Air purification	4.74	13,804.62	0.988
Total	**479.28**	**1,392,955.66**	**100**
Oak Forest			
Water conservation	45.95	169,471.71	31.77
Soil conservation	15.39	56,755.43	10.64
Carbon sequestration	19.14	70,606	13.23
Oxygen generation	41.89	154,507.5	28.96
Nutrient cycling	17.5	64,540	12.10
Air purification	4.74	17,510.02	3.27
Total	**144.61**	**533,390.66**	**100**

Note: The exchange rate of 1 US$ = 1470 IQD the average annual for 2022.

4. DISCUSSION

The value of water conservation for each of pine forest and oak forest was 45.95US$/ha/year. This value is lower than that of 64.12 and 146.79 US$/ha/year in Iran and China respectively as reported by (Komeil, J., 2017) and (Xue and Tisdell, 2001) respectively. This could be attributed to amount of precipitation which is greater in the study area of these two nations which facilitate obtaining denser forest. The value of soil conservation is varied depending on the method applied in valuation and nature of the forest ecosystem under consideration (Langat, D. K, 2016). The value of this service was found to be 15.39 US$/ha/year which lies within the range of values obtained in other countries. This service was valued at 4.9, 15, 46,101.1, and 205.4 US$/ha/year in United Kingdom, USA, Kenya, Indian and Iran respectively as reported by (Pearce, 2001), (De Groot et al., 2012), (Langat, D. K., 2016), (Ninan, K. N., 2016), and (Komeil, J., 2017) respectively. The value of soil nutrient cycling for pine forest and oak forest was estimated to be 71 US$/ha/year and 17.5 US$/ha/year respectively. Oak forest was severely understocked compared to pine forest, therefore its value for nutrient cycling came low. Identical results were also witnessed in carbon sequestration and oxygen generation services because their values also, in part, depend on stocking level. The value of nutrient cycling obtained in other countries were 3, 6.19, 13.3, 40.27, and 96.23 US$/ha/year in China, USA, Indian, Kenya and Iran respectively as reported by (Xue and Tisdell, 2001), (De Groot et al., 2012), (Ninan, K. N., 2016), (Langat, D. K, 2016) and (Komeil, J., 2017) respectively. The variation in value is mostly attributed to how vigor is the forest with respect to annual growth and on the price of NPK fertilizer in these nations. This indicates that the economic value obtained for both pine and oak forests do not deviate from values obtained in other countries.

Forests play an important role in climate regulation by balancing the levels of CO_2 and oxygen cycle in the air. The contribution of the study area in climate regulation was estimated based on market price of CO_2 in the international carbon market and cost of producing oxygen at local level. The value of carbon sequestration for pine forest and oak forest were about 107.28 US$/ha/year and 19.14 US$/ha/year respectively. Poor stocking of oak forest made pine forest has much more value than that of oak forest. The carbon sequestration value for pine forest is much higher than the values reported in other parts of the world which were 11.80, 31.63 and 4.46 US$/ha/year in Indian, Iran and Turkey respectively as presented by (Ninan, K. N.,2016), (Komeil, J., 2017) and (Başkent, E. Z., 2021) respectively. This is attributed to the increase in the prices of CO2 by two and half folds as a result of the climate change issues. The value of oxygen generation for pine forest and oak forest was about 234.92and 41.89US$/ha/year respectively. The oxygen generation value for pine forest is lower than values presented in Kenya which was 1,365 US$/ha/year as reported by (Langat, D. K., 2016) and slightly higher than value presented in China which was 52.09 US$/ha/year by (Guo, Z., 2001). The value of latter two services for oak forest cannot be compared to forest in other parts of the world because of its poor stocking.

The air purification service of pine forest and oak forest was estimated to be about4.7US$/ha/year for both forest types which is lower than figures obtained in China, Indian and Turkey which were 9, 29.65 and 7.5 US$/ha/year respectively as reported by (Xue and Tisdell, 2001), (Ninan, K. N.,2016) and (Başkent, E. Z., 2021) respectively. This could be attributed to variation in forest type, forest cover and the different prices(costs)of abatement cost for air pollution removal.

This study has revealed that the annual economic value of the assessed environmental services for pine forest and oak forest was about 479.28 and 144.61 US$/ha/year. With regard to the value of Oxygen generation both Pine forest and Oak forest had the highest share of total value which was 49% and 29% respectively. This could be attributed to the high price of oxygen production obtained from the local factory. The value of carbon sequestration service for pine forest had the second-high share which was 22%. This could be attributed to the sharp increase in the price of this service globally from US$20/t CO_2 to US$50/t CO_2 over the past few years because of increased cost of disasters caused by climate change. The value of water conservation service for oak forest had a high share which was 32%. This could be attributed to forest canopy and vegetation under trees can slow down runoff of rainfall, and forest soil, because of its good permeability, can foster infiltration of precipitation to groundwater and normal rainfall rate in the study area. While the values of the other services were pretty normal compared to the value from the studies. The discrepancy between the results of this work compared to results obtained from other parts of the world could be caused by variation in forest factors such as (stocking, forest type, growth, and yield) and environmental factors (soil category, topography, climatic factors, precipitation, agro-ecological and demographic factors).

5. CONCLUSION

The annual value of the considered environmental services for pine forest was about 705,000 ID ID/ha/year (479.28 US$), and for oak forest about 213,000 ID/ha/year (144.61 US$). The economic value of oak forest came very low compared to pine forest because it was a degraded forest their trees are mostly shoots grown from stumps. Oak forest surpasses pine forest in value if they have similar stocking that is because of its high socioeconomic values. This work reveals that both pine forest and oak forest provide substantial value despite that only few services were considered. Valuing other services, both direct and indirect use values, in addition to nonuse values will greatly upgrade the importance of these forests. Considering the results obtained in this research in forest policy formulation and decision making regarding forest management and planning will greatly contribute to the sustainability of local forests. As a result, steps have to be taken to enhance the current efforts to protect the forest from both natural and manmade factors that adversely affect the status of Kurdistan Region forest. It is also very necessary to raise the society's awareness of the importance of forests and the right of future generations to enjoy their services.

REFERENCES:

AA, A., Suliman, H. H., Saeed, H. S., & Dawod, N. A. (2021). Some of phenotypic, physical and anatomical wood properties of valonia oak trees in Kurdistan-Iraq. Iraqi Journal of Agricultural Sciences –2021:52(3):589-600.

Akrawee, Z. M., & Hamad, E. M. (2016). Economic evaluation of eco-tourism for zawita forest location in duhok province/iraqikurdistan region. In the 2nd scientific agricultural conference (p. 250).

Amirnejad H., Khalilian S., Assareh M.H., Ahmadian M. (2006): Estimating the existence value of north forests of Iran by using a contingent valuation method. Ecological Economics, 58: 665–675.

Al-Muhaisen, Azzam Ahmed Musa. (1979). A study of some technological properties of protea pine wood Naturally growing in a corner, unpublished master's thesis, University of Mosul, College of Agriculture and forests.

B. Fisher, R. K. Turner, and P. Morlin, (2009). "Defining and classifying ecosystem services for decision-making," Ecological Economics, vol. 68, pp. 643–653, 2009.Available at: https://doi.org/10.1016/j.ecolecon.2008.09.014 .

Başkent, E. Z. (2021). Assessment and valuation of key ecosystem services provided by two forest ecosystems in Turkey. Journal of Environmental Management, 285, 112135.

Chapman, G. W. (1948). Forestry in Iraq. Unasylva, 2(5), 251–253.

De Groot R.S., Wilson M.A., Boumans R.M.J. (2002): A typology for the classification, description and valuation of ecosystem function, goods and services. Ecological Economics, 41: 393–408

De Groot, R.S., Brander, L., Ploeg, S.V., Costanza, R., Bernard, F., Braat, L., Christie, M., Crossman, N., Ghermandi, A., Hein, L., Hussain, S., Kumar, P., McVittie, A. Portela, R., Rodriguez, L.C., Brink, P., Beukering , P. (2012). Global estimates of the value of ecosystems and their services in monetary units. Ecosystem Services, 1 (2012), 50–61.

European Commission, 2011. Our Life Insurance, Our Natural Capital: an EU Biodiversity Strategy to 2020. European Commission, Brussels.

FAO (2006). Global Forest Resources Assessment 2005 –Progress towards sustainable forest management. FAO Forestry Paper 147: Rome, FAO.

FAO (2014). State of the World's forests: Enhancing the socioeconomic benefits from forests.

Fattah, S. A., &Fayyadh, M. A. (2019). Comparison of Some Soil Quality Indicators of Forest Soils Under Two Different Tree Species. Journal of Duhok University, 22(2), 133-146.

Husch, B., Beers, T. W., & Kershaw Jr, J. A. (2002). Forest mensuration. John Wiley & Sons

Gulcur, M., &Kettenah, M. S. (1972). Forestry research, demonstration and training, Iraq. Development plan: Zawita-Swaratoka watershed

Guo, Z., Xie, Y., Hong, I., & Kim, J. (2001). Catalytic oxidation of NO to NO2 on activated carbon. *Energy conversion and management*, *42*(15-17), 2005-2018.

Ikobe, G. A. (2014). Assessment of small dams and pans in TANATHI water services board (Doctoral dissertation, University of Nairobi).

IPCC. (2003). IPCC good practice guidance for LULUCF. The Institute for Global Environmental Strategies.

IPCC. 2006. IPCC Guidelines for National Greenhouse Gas Inventories. Chapter 4. Forest Land.

J. Boyd and S. Banzhaf, "What are ecosystem services? The need for standardized environmental accounting units," Ecological Economics, vol. 63, pp. 616–626, 2007.Available at: https://doi.org/10.1016/j.ecolecon.2007.01.002.

Julien, P. Y., & Dawod, A. M. (1987). On predicting upland erosion losses from rainfall depth. Stochastic Hydrology and Hydraulics, 1(2), 127-134

Junhua, Run (1999). A Review of forest hydrology studies. Journal of Tropical and Subtropical Botany, 2 (2), 347-356.

Kalkhan. M. A. (1980). Studies on Tree Biometry Tables and Relationships For Pinus brutia Ten. Growing Naturally in Atroosh-Belkaif and Zawita Localities. M. S. C. Thesis. College of Agriculture and Forestry, Mosul University

Koeppe, C. E., & De Long, G. (1958). Weather and climate.

Komeil, J., Hamid, A., Zahra, A., & Alireza, V. (2017). Estimation of the value of forest ecosystem services to develop conservational strategy management (strengths, weaknesses, opportunities and threats). Journal of Forest Science, 63(7), 300-312.

Landell-Mills, N.and Porras, I.T. (2002). Silver bullet or fools' gold? A global review of markets for forest environmental services and their impact on the poor. London, UK: IIED. 236-250.

Langat, D. K. (2016). Economic valuation of forest ecosystem services and its implications on conservation strategies in East Mau forest, Kenya (Doctoral dissertation, Egerton University).

Masiero, M., Pettenella, D., Boscolo, M., Barua, S.K., Animon, I., Matta, J.R., 2019. Valuing forest ecosystem services: a training manual for planners and project developers. In: Forestry Working Paper No. 11. FAO, Rome, p. 216. License: CC BYNC-SA 3.0 IGO

MEA (Millennium Ecosystem Assessment), (2005). Ecosystems and Human Well-Being: A Framework for Assessment, Washington, D.C.

Mosa, W. L. (2016). Forest cover change and migration in Iraqi Kurdistan: a case study from Zawita Sub-district. Michigan State University.

Mustafa, Y. T., & Habeeb, H. N. (2014). Object based technique for delineating and mapping 15 tree species using VHR WorldView-2 imagery. In SPIE Remote Sensing (p. 92390G–92390G). International Society for Optics and Photonics.

Nasser, M. H. (1984). Forests and forestry in Iraq: prospects and limitations. The Commonwealth Forestry Review, 299–304.

Nguyen, M. D. (2016). Forest governance and economic values of forest ecosystem services in the northwest region of Vietnam (Doctoral dissertation).

Ninan, K. N., &Kontoleon, A. (2016). Valuing forest ecosystem services and disservices–Case study of a protected area in India. Ecosystem services, 20, 1-14.

Ninan, K.N., Inoue, M. 2013a. Valuing forest ecosystem services- what we know and what we don't. Ecological Economics. 93. 137-149.

Nowak, D.J., K.L. Civerolo, S. Trivikrama Rao, G. Sistla, C.J. Luley, and D.E. Crane. 2000. A modeling study of the impact of urban trees on ozone. Atmospheric Environment 34: 1601–1613.

Ning, Z. H., Chambers, R., & Abdollahi, K. (2016). Modeling air pollutant removal, carbon storage, and CO2 sequestration potential of urban forests in Scotlandville, Louisiana, USA. iForest-Biogeosciences and Forestry, 9(6), 860.

Okelo, M. O., Onyando, J. O., Shivoga, W., & Miller, S. N. (2008). Assessment of Infiltration Using a Mini Rainfall Simulator in the River Njoro Watershed.

P. Riera, G. Signorello, M. Thiene, P. A. Mahieu, S. Navrud, P. Kaval, and P. Elsasser, (2012) ."Non-market valuation of forest goods and services: Good practice guidelines," Journal of Forest Economics, vol. 18, pp. 259–270, 2012.Available at: https://doi.org/10.1016/j.jfe.2012.07.001.

Pearce, D.W. and Pearce, C.T. (2001). The Value of forest ecosystems. A Report to the Secretariat Convention on Biological Diversity, Montreal, Canada: Secretariat of the Convention on Biological Diversity.

R. Godoy, "Some organizing principles in the valuation of tropical forests," Forest Ecology and Management, vol. 50, p. 171−180, 2007.Available at: https://doi.org/10.1016/0378-1127(92)90322-z.

Şefik, Y. (1981). Forests of Iraq. Journal of the Faculty of Forestry Istanbul University (JFFIU), 31(1).

Shahbaz S.E. (2007). Pinales with a field guide to the trees and shrubs of Kurdistan Region of Iraq. Spirez Press and PublisherDuhok. P175.

Shahbaz S.E., (2010). Trees and Shrubs, afield guide to the trees and shrubs of Kurdistan region of Iraq, Duhok University.

Shahbaz, S. E., Balo A. H., and J.MT. Hameed (2005). Phenotypic variation in natural stands of Quercus aegilops (Fagaceae) in Duhok province. Journal of Duhok University, Vol. 8, 1-9

Shahbaz, S.E., Pasha, A.A and Balo, A.H. (2002). The Altitudinal variation of Pinus bruitia Ten (Pinaceae) in Atrush Natural forest. J. Duhok Univ. 5: 23-32

World Bank, (2021). State and Trends of Carbon Pricing 2021. Washington, DC: The World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/35620 License: CC BY 3.0 IGO."

Xi, J. (2009). Valuation of ecosystem services in Xishuangbanna Biodiversity Conservation Corridors Initiative Pilot Site, China, Greater Mekong Sub-Region Core Environment Program-: ADB TA 6289.

Xue, D., Tisdell, C., 2001. Valuing ecological functions of biodiversity in Changbaishan mountain biosphere reserve in northeast China. Biodiversity and Conservation 10, 467–481

Yoshida, K., 2001. An economic evaluation of multifunctional roles of agriculture and rural areas in Japan. Food and Fertiliser Technology Center-Technical Bulletin 154, 1–9, August. Tokyo.

Younis, A. J. 2019. Stand volume equations for Quercus argilops L. and Quercus infectoriaOlic. In Duhok Governorate. M.Sc. thesis. University of Duhok.

هەلسەنگاندنا نرخێ ئابووریێ خزمەتگوزارییێن ژینگەها دارستانێ زاویتە ل پلرێزگەها دهوك, هەرێما کوردستانێ – عێراق

پوختە

خزمەتێن ئیکۆسیستەمێ دارستانێ جۆرەکە ژ ژێدەرێن سروشتی کو چەندین مفایێن گرنگ بخۆڤەدگریت و دابیندکەت. ئەڤ ڤەکۆلینە هاتەئەنجامدان ژبۆ هندەك خزمەتگوزارییێن ژینگەها دارستانا زاویتەی بۆ دوو جۆرێن دارستانا کو پێك دهێن ژ دارستانا کاژێ و بەریا سروشتی. ئەنجامێن ئەڤێ ڤەکولینێ دێ بنە ئەگەرێ دروستکرنا بنەمایەکی گرنگ و بهێز و دابینکرنا پزانینێن پاش دەربارەی ئەڤان دارستانیێن سروشتی کو دێ هلریکاربن ژبۆ بڕیاردانێ و پاراستن و برێڤەبرن و بەردوامبوونا دارستانا ل دەڤەرێ. ئەڤ ڤەکۆلینێ هاتە ئەنجامدان ب پشتبەستن ب داتایێن هاتینە کۆمکرن برێکا ئەنجامدانا جەردا دارستانێ و چاڤپێکەفتنان و داتایێن هاتینە وەرگرتن ژ ژ فەرمانگەهێن حکوومی، ژێدەرێن بەلاڤکری. ئەنجامێن ئەڤێ ڤەکۆلینێ دیاردکەن کو سەرجەمێ بەهایێ ئابووریێ ژینگەها دارستانا زاویتەی بۆ دارستانا کاژێ کو نێزیکی **705000** دینارێن عیراقی بوون (**479.28 $US**) و دارستانا بەرییێنێزیکی **21000** دینارێن عیراقی بوون (**144.61 $US**) بۆ هەر هکتارەکێ سالانە لدیف ئێك. ئەنجامێن ئەڤێ ڤەکولینێ زانیارییێن گرنگ دیارکرن لسەر گرنگییا ئەڤان خزمەتێن ئیکۆسیستەمێ دارستانا زاویتەی کو گرێداینە ب بڕیاردان و سیاسەتا تایبەت ب پاراستن و برێڤەبرنا ژینگەها دارستانا زاویتەی ژبۆ باشترکرنا خزمەتگوزارییێن ژینگەهێ و بەردەوام بوونا وان.

دراسة التقييم الاقتصادي للخدمات البيئيه التي تقدمها غابة زاويته، محافظة دهوك- إقليم كردستان –العراق

الخلاصة

الغابات هي نوع من المحميات الطبيعية التي توفر العديد من السلع والخدمات. يهدف هذا العمل إلى تقييم مجموعة من الخدمات البيئية (صيانة التربة و المياه و تثبيت الكاربون و أنتاج الاوكسجين و و تدوير العناصر الغذائية و تنقية الهواء) التي يقدمها نوعان من الغابات الموجودة في غابة زاويته، غابة الصنوبر وغابة البلوط.. واعتمدت هذه الدراسة على البيانات المجمعة من قوائم جرد الغابات، من ذوى الاطلاع على غابة زاويته، والبيانات الثانوية، ومؤسسات الدولة، ومن المصادر المنشورة وغير المنشورة. بلغت القيمة الاقتصادية للخدمات البيئية التي تم تقييمها لكل من غابات الصنوبر وغابات البلوط 705000 دينار عراقي (479.28 دولار أمريكي) و 213000 دينار عراقي (144.61 دولار أمريكي) / هكتار / سنة على التوالي. وتقدم هذه النتائج معلومات قيمة يمكن