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Economic evaluation of the reforestation; emphasizing on the ecological functions (Case study: Northeast of Tehran, Iran)

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ABSTRACT

Nowadays, it is of interest of forestry experts to quantify different values of urban forests nowadays since systematic planning and management require appropriate qualitative and quantitative information. In this paper, the benefits and costs of forestation in a5104-hectare area at the Northeast and East of Tehran is investigated. The results indicate that by creation of a 5104-hectares forest in Tehran, 112 thousand USD annual profits will be obtained from producing compost. In addition, 131 million USD profit from the absorption of pollutants and also 221 thousand USD profits for preventing soil erosion will be gained. In addition, the ecological benefits of soil erosion per hectare, is estimated 181 kg whose total approximate value is 43.36 USD. Although from the private view, the Net Present Value of the project is negative; yet, by considering ecological functions, the project will have a very high Internal Rate of return and Net Present Value. Two scenarios were assumed for age of trees, 30 years and 50 years; in both cases, the project is ecologically at economic profitability.
KEYWORDS: Economic Analysis, private income, ecologic function, reforestation, North-East of Tehran.

1. INTRODUCTION

The forests play an important role in maintaining essential ecological processes; such as, climate mitigation, carbon storage, ecological services, and economic growth support (FAO, 2009).Besides the economic values, forests have social and cultural values in human's life. Forested areas – through natural products, various environmental services, and employment- create significant economic value. Plant species, especially trees and shrubs, are the most precipitants that act by absorption gases, air pollutants, and dust particles in the air, so they improve the quality of urban life (Rai, and Mishra, 2013).

As element of the Green Open Space, trees play their roles as reducer of air pollution, oxygen producer, and shade, reducer of air temperature, atmospheric refiner, and improving quality of urban environment. Vegetation have better effect in controlling the increased air temperature due to the existence of artificial elements made by human. Trees are able to provide coolness to the hot city (heat island) due to the reflection of solar heat from buildings, asphalt and steel. Urban temperature heat has 30-100C higher air temperatures than rural. The trees plantation at the specific area will reduce the atmospheric temperature in the related area (Sitawati *et al*, 2011).

Tree cover in cities could reduce energy consumption in cold seasons through the reduction of carbon dioxide and also work to provide shade and cooling air and improve the air quality in warm seasons (Escobedo, et al, 2008; Heisler, 1986; Nowak and Rowntree, 1994). Through the rain absorption by their leaves and branches, trees reduce runoff caused by heavy rains (Villarreal-Gonzalez and Bengtsson, 2005). Urban tree cover can absorb carbon dioxide and sequestrate carbon through the process of photosynthesis (Birdsey, 1992; Jo, and McPherson, 1995; McPherson, and Simpson, 1999).

Thus, providing advantages such as aid to treatment of diseases, urban parks are considered ideal environments for children growth, social unity, etc. and play significant social, economic, and ecological roles in human wealth improvement (Balram and Dragicevic, 2005). Moreover, such environments are considered as an instrument to enhance the quality of life, and community development. To construct urban parks on one hand has a major impact on the quality of urban life and on the other hand is widely valuable because of their financial contributions to the municipalities (Manlun, 2003).

Obviously, ecological values of the forest are very important in any creature's life. Some of these values are diminishing the dust winds and storms, restricting climate temperature increase, preventing avalanche, maintaining plant and animal genetic resources, reducing soil erosion, preventing of landslides, and reducing air pollution (Dochinger, 1980; McPherson, and Simpson, 1999). Yet, unfortunately nowadays, population growth and urbanization have changed the urban green landscapes into rough and impermeable concrete surfaces. This

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process, especially in developing and third world countries is more apparent (Shi, 2002). Therefore the restoration and expansion of forest lands seem to be necessary.

Iran is located in an area with negligible forest lands. Area of forests in Iran is estimated about 14.3 million hectares; 56 percent of which, is consisted of sparse forest, 24 percent semi-lush forests, and12 percent lush forests. However, in the past few decades, forest area has experienced a serious decline due to many reasons, such as uncontrolled exploitation, urban development, urban and industrial installations, degradation and encroachment. Volume of northern forests is about 400 million cubic meters and of forests out of the northern zone of Iran are about 200 million cubic meters (Forests Range & Watershed Management Organization of Iran, 1991). Iran has 17 hectares of forest per capita, while the global forest capitation is 62 hectares (FAO, 2014). Comparing these figures implies the requirement to preserve, restore and develop the forests in Iran. Meanwhile, the valuation of these resources can help the general public to understand real value of the forests. An issue which is currently accounted by urban forestry experts is to quantify the different values of urban forests; including, diminishing air pollution, reducing atmospheric carbon, and the intrinsic value of each tree, etc. Regarding the important roles of reforestation in various aspects, it is vital to work on reforestation plans in Iran. Considering a reforestation project in the north-east of Tehran, the present paper tends to estimate private and ecological benefits of the project.

2. MATERIALS AND METHODS

In the present paper, a reforestation plan in 5104 hectares area in Northeastern Tehran is considered and its private and ecological costs and revenues are estimated. The private costs of the project were adopted from Forest and Watershed Organization of Iran. The costs have updated given to the addressed year. The region, with an area of 5104 hectares, is located in the northeastern and eastern part of Tehran between 35˚ 41´and 35˚ 52´ longitudes and between 51˚ 32´ and 51˚ 41´latitudes. Besides, it is bordered to Latyan Lake and Jajrood River from north and to Damavand road and Khojeir dirt-road from south and to Jajrood road from east and to Tehranpars Road of Quchak Notch and Hilson Mount from west. Overall, the project zone is mountainous and full of peaks and valleys with a very variable slope- from 5 to 100 percent. The average altitude of the area is between 1400 to 2500 m. a. s. l.

The economic software applied to analyze the project is Comfar III. For cost-benefit analysis of reforestation, the construction phase is considered 4 years and operation phase is considered in two scenarios of trees life: 30 and 50 years. Additionally, inflation rate, in three scenarios, is considered 10, 15, and 20 percent. All costs of Reforestation Project according to the zone of plan and the start point of construction phase in 2015 calculated. The products in the private analysis are the foliage that is shed annually, and considered equivalent to the price of the compost fertilizer which is assumed mulch. In addition, at the ecological analyses, reduced costs of soil erosion and pollutants absorbance are considered as ecological revenues.

This paper considers the reforestation in two ways: Reforestation with seeds and reforestation with saplings. The latter is forested in 3500 hectares with 1920 seedlings. Various types of conifer and broad-leaf trees are suggested to plant in the studied zone. Given the ecological conditions of the area, 30% of species are conifers such as Larix, Eldarica Pine, Pinusnigra. Arnold, Norway spruce, Cedrus, oleaster. In addition, 70% of species that are broad-leaf trees such as oleaster, acacia, juniper, judas tree, pistachio, *pistacia atlantica*, hackberry, bitter almonds will be planted. In Table 1 the required varieties in reforestation project is considered.

Table 1: species required for forestation plan

species	Appropriate altitude for forestation (m. a .s. l)
Pinusnigra Sp.	more than 1500
Juniferusexcelsa Sp.	more than 1800
Picea excels	more than 1800
Larix Europa	more than 1800
Cedruslibani	more than 2400
Pinussylverstris	more than 1400
Cupressusarizonica	more than 1800
Thuyaorientalis Sp.	more than 1800
Pinuseldarica	1400-1600
Celtiscaueasica	1400-1800
Eleaynusanyustifolica	1400-2200
Cercissiliquastrum	1400-1800
Robinia Sp.	1400-1600
Alilanthus Sp.	1400

Reference: Forests Range & Watershed Management Organization of Iran, (1991) Project costs include personnel costs, equipment costs, seeds cost and seedlings, and operation and maintenance cost. The labor required for the project concludes an expert and an expert-assistance for every 500 hectares, two car drivers and a truck driver for every 500 hectares, a preserver for every 500 hectares, and an unskilled worker for every 10 hectares. All personnel's salaries have been considered for 13 months activity in a year (including New Year bonus –which is the money paid to workers coincided at Iranian Neurosis as a gift- and rewards).Water required to 5104 hectares of reforestation projects, can be provided from two sources. A portion of the river Jajrood, and Latyan Dam downstream located at the affiliated nursery unit at a rate of 315.5 cubic meters per hour for reforestation of 1972 hectares will be put under irrigation. Another portion with the water resources provided in the first place from the downstream of Latyan Dam using drilled wells will be transmitted to the highest point of the level of 2132-hectare area. Meanwhile if water supply from the above method is not feasible; water supplication will be conducted by tanks and hoses. The amount of water needed for 1972 hectares is approximately 315.5 cubic meters per hour, considering 6 x 4 rows of trees and irrigation period of every 10 days. Moreover, 15 hours irrigation duration a day has been considered for the months of July and August that are the warmest seasons of the year. In order to analyze the cost - private benefit, water price per unit is 0.24 USD which is equivalent to approved tariffs of Tehran Province Water and Wastewater Company of Iran announced by the Ministry of Energy. Thus, during operation years, the irrigation cost will be 31000 USD per year. One of the indicators of a successful reforestation can be low losses in the early years. Usually losses between 10 to 25 percent are acceptable (Fitz Patrix, 1960); therefore, the cost analysis for reforestation under review is accordingly intended. In the years after conducting the project, post-planting cares include maintaining the roads and buildings and repairing the vehicles and fuel. Financing related to the maintenance in the years after the project is estimated at 562 thousand USD.

On the evaluation of environmental values of natural resources, there are some new valuable researches such as Mahmoodi and Fadaei Nezhad (2015), Nasirian and Hossein Zadeh (2015), Vafakish, et al (2014), and Setiono, et al (2014); each of these studies works on socioeconomic aspects of evaluation, especially on environmental and natural resources.

Financing related to post-maintenance years, is estimated at 562 thousand USD. This reforestation project assumes that credits are required from the state funds. The inflation is assumed to be 15 percent analyses (average inflation over the past 10 years of Iran). The low and high inflation bounds, i.e. 10 and 25%, have also been considered and using the two rates the project has been re-analyzed. Table 2 identifies the annual cost of reforestation projects approximately 12 million USD.

Table 2: annual costs of forestation plan

operation	Cost (Thousand USD)
Irrigation and infrastructure installations	4126.63
Producing seeds and saplings	36.11
Mechanical and watershed operations	0.429
forestation	5579
Pasture-management and stooling	74.30
Operation and Maintenance (O & M)	2851.04
total	12667.509

Reference: research findings

3. DISCUSSION

3.1 The cost-benefit private analysis

Wastes of urban green landscapes are consisted of branches and twigs, cut grasses and similar materials other than rock, gravel and sand can be converted to compost. Applying compost will lead to the development and evolution of urban greeneries and also prevents infestations of disease-producing organisms. The product of this project from the perspective of the private sector is the compost fertilizer with the considered price per kilogram as much as 0.01 USD (This price is obtained of the average market price in Iran). The biomass and produced compost depends on the soil fertility and the growth of the trees (Arias, Calvo-Alvarado, and Dohrenbusch, 2007) in order to obtain a realistic estimate of the amount of compost produced the previous similar studies were used. The results of a study dealing with the measurement of leaf biomass in oak and *Pistacia Atlanticain* Yasooj forest shows that the average amount of leaf biomass for oak is 2498 kg and for *Pistacia atlanticais* 76 kg per hectare (Adl, 1994). Another study conducted in eucalyptus and acacia forestry in the Fars province shows that the amount of biomass stored in *Eucalyptus Camaldulensis* in Fasa town in relatively fertile sites is 3.62, and in poor sites 2.27 tons per hectare in year (Bordbar, and Mortzavi Jahromi, 2006). This value for *Acacia Salisina* species in poor habitats was calculated 1.5 tons per hectare per year. In addition, the storage of biomass in the 19-year oak reforestation is estimated equal to 2000 kg per hectare (Vesterdal, 2002). Moreover, the biomass value stored in China's forests is estimated 118 million tons annually

(Zhang and Xu, 2003). Additionally, oak forests (conifer) produce1.67 tons biomass annually per hectare of which only 5.6 percent is related to litter leaves and the rest is related to aerial and underground organs (Khademi, Babayi Kafaki, and Metaji, 2010). Thus, according to previous researches, oak leaf biomass (conifer) and *Pistacia Atlantica* (board-leaf) biomass will be considered 2498 kg per hectare and 76 kg of compost per hectare will be addressed equivalent to reforestation compost obtained annually that is shed from the trees and converted into mulch. Given to the 30% to 70% composition of the board-leaf to conifer reforestation per hectare annual economic benefit of 21.85 USD is obtained for oak and 0.28 USD for *Pistacia Atlantica*.It means that per hectare annual private economic benefit about 22 USD can be obtained resulted from reforestation biomass, which is the same as mulch. With respect to the plantation area at the total forest area, the annual private revenue is estimated equivalent to 112 million USD.

3.2-Ecological analysis

Today, due to environmental concerns and sustainable development of economy, the valuation of goods and intangible services resulting from natural environments and forests is increasing drastically today. In this paper, the ecological functions of reforestation projects have been identified in two portions of the absorption of pollutants and reducing soil erosion.

3.2.1 Absorbing pollutants

One of the intangible services, of interest of the researchers, is the ecological services by natural resources that will reduce losses from air pollution. The problem of air pollution is one of the biggest environmental problems of developed and developing cities and while the plants can be effective in reducing air pollution to some extent, will be affected by pollutants and damaged. Millions of trees in the City of Sacramento absorb 1607 tons of pollutants. These trees absorb 665 tons of O_3, 748 tons of PM_{10}, 164 tons of NO_2, and 30 tons of SO_2. The total annual value of these pollutants is amounted by 28.7 million USD (USDA Forest Service, 2005). Trees in the city of Los Angeles absorb around 77,000 tons of carbon and about 1,976 tons of air pollution annually (Nowak, et al, 2011). Additionally, the trees and shrubs in Philadelphia absorb 971 tons of air pollution annually and are worth 4.8million annually (Nowak, et al, 2007). Urban forests of Montegry absorb 1603 tons of air pollutants and are worth 7.9 million USD annually (American Forests, 2004). Trees in metro Atlanta absorb 18,618 tons of air pollutants and are worth about 47 million USD annually (American Forests, 2001). Besides, trees clean the air and absorb carbon dioxide, sulfur dioxide, nitrogen oxides and other pollutants and will provide shade and reduce greenhouse gas emissions (McPherson, et al, 2006). Trees in the cities of United States absorb 711000 tons of pollutants including O_3, PM_{10}, NO_2, SO_2, and CO2 that are worth 3.8 billion USD (Nowak, 2006). However, the value of urban forests in Chicago is 2.3 billion USD (Foster, et al, 2011). Since each tree in the annual profits arising from the absorption of pollutants has not been measured, according to the studies conducted in other countries, the average annual profit for Iran trees is calculated. In Table 3, the annual profits of a tree in different countries are compared.

Table 3: annual profit per a tree

Species	research	annual profit (USD)
Glendale	(McPherson, et al, 2005)	31
Berkley	(McPherson, et al, 2005)	89
Minneapolis	(McPherson, et al, 2005)	79
Large tree in the yard	(McPherson, et al, 2007)	85
Large tree in public locations	(McPherson, et al, 2007)	113
Large tree in public locations	McPherson, et al, 2006	97
Average tree in public locations	McPherson, et al, 2006	19
small tree in public locations	McPherson, et al, 2006	1
Conifer tree in public locations	McPherson, et al, 2006	41
Large tree in the yard	McPherson, et al, 2006	100
Average tree in the yard	McPherson, et al, 2006	25
small tree in the yard	McPherson, et al, 2006	7
Conifer tree in the yard	McPherson, et al, 2006	51
Trees of Washington Street	Foster, et al, 2011	10.7

Since the surface of conifer is greater than of board-leafs so they are more advantageous to absorb pollutants and aerosols in the air and therefore more spices of them is proposed in the project. Thus, according to Table 2, the average annual income for board-leafs is 41 USD and the maximum profit is 51 USD for the board-leafs. The annual average cost of conifers is considered 97 USD. Table 4 summarizes the minimum, average, and maximum benefit of a tree considered annually.

Table 4: minimum, average, and maximum annual benefit of each tree (USD)

Type of tree	minimum annual benefit	average annual benefit	maximum annual benefit
Conifer	31	41	51
Broad-leaf	81	97	113

Reference: research findings

Benefit analysis for each of the three trees in three scenarios have been considered. The average number of trees per hectare is 410 trees per hectare in this reforestation project and since 30 percent of trees are board-leafs, and 70% of them are conifers. So annuity of 27,839and 5043 USD per hectare is the profit of board-leafs and conifers. Thus, in Table 5, the average total benefit of a tree plantation projects have been identified.

Table 5: average annual benefit of forestation plan (Thousand USD)

Type of tree	minimum annual benefit	average annual benefit	maximum annual benefit
Conifer	15252	20172	25092
Broad-leaf	92988	111356	129724
Total	108240	131528	154816

Reference: research findings

3.2.2 Soil Erosion

Soil is a renewable resource whose production rate is much less than of its degradation. Creation of each centimeter of soil in different weather conditions takes 100 to 1,000 years. The loss of vegetation, especially trees, will cause erosion and loss of soil. Erosion generally refers to the process by which soil particles are separated from their original context and with the help of a transporter agent will be carried to another location. Soil erosion aside from being the main limiting factor in assessing the ability and determining the proper soil application will lead to the loss of water resources, because by destruction of soil, water will find no room to be stored and penetrate into the soil (Barbier and Bishop, 1995). Retaining cost of the nutrient values of forests in the north of Iran is estimated equal to 2893 USD per hectare (Panahi, 2005). However, the annual rate of soil erosion in the country is estimated at 2.5-3billion tons (Agheli Kohneh Shahri and Sadeghi, 2005). In addition, the amount of wasted NPK based on nutrients measured 452.19 kg and at the value of 31.125 USD (Bakhtiari, et al, 2009). In order to estimate the cost of soil erosion in desired reforestation project intended method of Nutrient Replacement Cost (NRC) Method has been used. This method is also known as the cost of nutrient depletion, follows the restoration of eroded soil to the level before erosion. In this method, the cost of fertilizer needed to maintain and restore the crude productivity, and to maintain and restore soil productivity is calculated. In this method, Nutrient Replacement Costs estimated directly based on NPK depletion by considering the balance of nutrients and retail price of fertilizer. Moreover, the soil per hectare will be eroded between 15-20 tons annually. To conclude, the least nutrients are reviewed according to the main elements of (the soil) and the minimum amount of soil erosion i.e. 15 tons per hectare per year, is considered. Table 6, represents the percentage of the required elements of plants. For the calculation, the minimum percentage of the available elements required in soil is considered. Therefore, the minimal elements in the soil for nitrogen, potassium, phosphate and magnesium are 0.0, 1.2, 0.03, and 1.2 respectively.

Table 6: percentage of soil elements needed for plant

N	K	P	Mg
0.03-0.3	0.2-3	0.01-1	0.1-1

Reference: (Agheli Kohneh Shahri and Sadeghi, 2005)

Thus, according to Table 7, the amount of soil materials lost per hectare, is estimated by taking into account the least erosion per hectare (15 tons).In addition, the amount of chemicals lost, is compared now with fertilizers content. Urea fertilizer contains 46% nitrogen, superphosphate fertilizer contains 24% pure oxygen-free phosphorous fertilizer, potassium sulfate fertilizer contains 24% potassium, and magnesium sulphate fertilizer contains 16% magnesium.

Table 7: calculation of lost materials of soil per hectare

Type of lost material	calculation of lost material	Amount of lost material (kg)
N	0.03*% 15	4.5
K	0.01*% 15	1.5
P	0.2*%15	30
Mg	0.01*% 15	15

Reference: research findings

Accordingly, in Table 8, the minimum amount of lost fertilizers is obtained. Thus, according to Table 8, the estimated amount of erosion per hectare in the country is estimated about 43.36 USD. This amount, according to the reforestation area, is equal to 221 thousand USD per year.

Table 8: minimum amount of lost chemical fertilizer per hectare soil

Type of fertilizer	Minimum amount of fertilizer	Price (USD)	Cost (USD)
urea	9.78	0.2187	2.13
Simple super phosphate	6.25	0.0937	0.58
Potassium sulfate	71.4	0.3437	24.54
Magnesium sulfate	93.75	0.1718	16.11
Total fertilizer needed for soil survive	181.18	-	43.36

Reference: Forests Range & Watershed Management Organization of Iran, 1991 and research findings

4. RESULTS

Economic evaluation of the reforestation projects from both private and ecologic viewpoints is intended. From the perspective of the private sector income includes branches and leaves shed from the trees. Yet, income from the viewpoint of ecological functions is defined differently and includes absorbing the pollutants and reducing soil erosion. Cost-benefit analysis of project from the viewpoint of private and ecological functions, in an area of 5104 hectares, has been performed in various scenarios and the results output from Comfar III software is shown in Table 9 indicating that if the operation phase of the project, the trees life, is considered either the minimum age, 30 years, or the maximum age, 50 years, from the viewpoint of ecological analysis, the project would be economic in both scenarios. However, the private analysis of the project results the negative net present value. Reforestation project internal rate of return is more than 150 percent in the nine applied scenarios, and the project is economically beneficent accordingly.

Table 9: results of private and ecologic analysis of forestation plan in 5104 hectare area

Scenario of pollutant absorption	Scenario of operation phase (year)	20			50		
	Scenario of inflation (percent)	10	15	20	10	15	20
108240	NPV (million USD)	539	893	1525	59	1085	2385
	IRR (percent)	186	199	212	186	199	212
131528	NPV (million USD)	657	1087	1856	711	1321	2901
	IRR (percent)	201	214	228	201	214	228
154816	NPV (million USD)	7752	12822	21880	897	15580	34180
	IRR (percent)	213	228	242	213	228	242

Reference: research findings

5. CONCLUSION

In the present paper, reforestation project in an area of 5104 hectares, locating in Northeastern Tehran, is considered and analyzed from the private and ecological functions views by utilizing Comfar III software. In the Cost - Benefit Analysis of the project, the construction phase is four years and operation phase –considered equal to trees life- is 50 years. Inflation is considered 10%, 15%, and 20% in three different scenarios. The beginning of the construction phase is considered on April 2015.The results indicate that with the establishment of 5104 hectares of forest in Tehran, 112 thousand compost fertilizers annually, and 131 million USD profit from the absorption of pollutants and 221 thousand USD profit resulting from soil erosion are obtained. The ecological cost of the considered reforestation is 181 kg per hectare, worth approximately 43.36 USD which is consistent to the results of previous studies that estimate the erosion value to be 31USD per hectare in Iran (Bakhtiari, et al, 2009); nevertheless, the difference between the calculated price of mentioned study and of the present one corresponds to the difference between the prices per kg of fertilizer at the addressed years. The results also are consistent to the results of previous studies that estimated the amount of nutrients lost as much as 188 kg per hectare (Agheli Kohneh Shahri and Sadeghi, 2005). For conducting the project, three scenarios of high, average and little inflation rates are intended; yet, the final results of project in the three inflation scenarios are the same. If reforestation project is considered just from the perspective of the private sector, NPV of the project will become negative, that is not economically justifiable. However, the reforestation project is not considered to produce compost and wood for private sector; but, its main objective is to create the ecological functions. It is not far-fetched that the project is not economic from the private perspective; while, considering the ecological benefits of the project results a positive NPV and a more-than-100-percent IRR evincing high profitability of the intended Reforestation Project. Since the development of reforestation projects follows positive externality objectives, such as creating green space in order to clean the environment, preventing undesirable extension of

Tehran City, preserving areas of natural resources, preventing the destruction of national resources, establishing a favorable environmental balance, contributing in the beauty of the city and creating a public promenade, and also preventing the penetration of sediment into the lakes of dam, environmental protection and employment generation. Therefore, the ecological benefits of the project will be much higher than the estimated value. However, the profitability of the reforestation is not verified from the perspective of private sector but according to the macro-economic aspects and its effects on the national economy, it is suggested to execute the reforestation project in order to make positive effects on Iranian economy.

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