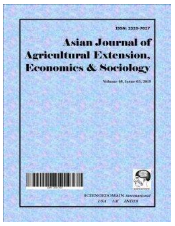

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Evaluating the Most Suitable Tree Species Using Land Expectation Value: A Case Study from Plantation in North of Iran

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Plantation in north of Iran is rapidly increasing by local farmers and state but it is not clear which species is most suitable for perpetual timber production. Thus, this study is carried out to evaluate the most suitable timber species among ash (*Fraxinus excelsior*), elm (*Alnus glutinosa*), maple (*Acer velutinum*), oak (*Quercus castanifolia*), bald cypress (*Taxodium distichumin*) in north of Iran for evaluation of most suitability using Land Expectation Value (LEV). Data such as wood price at forest road side and variable harvesting cost was collected from secondary souce especially General Office of Natural Resources in Guilan province for a period of 20 years. Average annual increment of different species derived from previous researches. Consumer Price Index (CPI) was used for deflation of stumpage price. Regression analysis was used to predict the stumpage price of different species. Then, the mean price process was determined for different species. Faustmann's formula was used to determine the LEV or Net Present Value (NPV) for a perpetual timber production of different species. The results showed that the LEV of ash, elm, maple, oak and bald cypress were 2623.883, 4653.042, 4319.9644, 2206.8788, 8064.667 (0.33 US dollar/ m3), respectively. The LEV of bald cypress was the highest, so it can be concluded that this species is the most suitable for timber production.

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Keywords: Land Expectation Value (LEV); timber price; timber production; plantation.

1. INTRODUCTION

Plantation forests can be defined as forest or other wooded land of introduced species and in some cases native species, established through planting or seeding. Planted forests are ever more significant element shaping our present landscapes. These forests are potential source of income generation. In addition, they provide direct and indirect socio-economic and environmental benefits too. Specifically, the direct benefit is supply of timber for construction and furniture while the indirect benefits are promotion of forest ecosystems services such as carbon sequestration, clean water production, regulation of the hydrological cycle, improvement of biodiversity conservation and the ease of desertification. It is expected that the relative importance of such services will be increased more in the future [1].

The global new planting rate is estimated at 4.5 million ha/year. Half of the forest is suitable for commercial functions in the world. They are 25% for non-industrial usage and 25% is for other purposes. Although forest plantation consists 5% of the forests worldwide, the rest are natural. Infact, the plantation can supply about 35% timber and it is expected to increase up to 44% by 2020 [2]. Here is about 1% planted forest in Iran [3].

Martin Faustmann [4] presented the Faustmann's Formula or Land Expectation Value (LEV) formula for land taxation to evaluate the land. The Faustmann's Formula was the earliest known as application of the discounted cash flow concept in a management context [4]. Mainly costs, revenues and timings are prime variables used in Faustmann's Formula to compute the LEV [5].

Harrison et al. [6] stated that cultivation of *Acacia mangium* and *Gmelina arborea* was economically fruitful with a NPV of 12641 and 30782 PhP per hectare, respectively. LEV and IRR were found to be 14602 and 35556 PhP per hectare and 17 and 31% for Acacia and Gmelina, respectively.

Nienow et al. [7] investigated the economic appraisal of plantation of *Salix tetrasperma*. He reported that maximum expenditure 44.64% was incurred as land rent and minimum 0.41% as protection for the establishment of *Salix tetrasperma* plantation. Besides, Mahapatra & Tewari [8] also economically evaluated the NPV of dry deciduous forests of eastern India. He found that the NPV of non-timber forest products was US$ 1016 at coastal areas and US$1348 per hectare at the interior areas. Remarkably these values are significantly greater than revenue from other farm uses. Other study done by Peichen [9] showed that the proper choice of decision model for determining the optimal planting density and LEV for a Scotis pine *(Pinus sylvestris L.)* plantation in northern Sweden. First, a general adaptive decision model for determining the regeneration alternative that maximizes the LEV is presented. This model recognizes future stand state and timber price uncertainties by including multiple stand state and timber price scenarios, and assumes that the harvest decision in each future period will be made conditional on the observed stand state and timber prices. Alternative assumptions about future stand states, timber prices, and harvest decisions can be incorporated into this general decision model, resulting in several different decision models that can be used to analyze a specific regeneration problem.

Many forest species have been planted for perpetual timber production by the farmers in Shafaroud forest, north of Iran namely ash (*Fraxinus excelsior),* elm *(Alnus glutinosa),* maple *(Acer velutinum)*, oak (*Quercus castanifolia*), bald cypress *(Taxodium distichumin)* but which one is the most suitable is not evaluated properly. If this is evaluated clearly, the country farmers will obviously be benefitted. Though, there are many tecgbiques and tools to evaluate the suitable species but one of the important tools is land expectation value of the species. This tool is more useful to motivate the farmers so this is applied here for this research work. Therefore, it is essential to determine the LEV of these species. For, specific objectives of this research set like: i. to find the Stumpage price and Expected mean price and ii. to evaluate the LEV of different plantation species and their Sensitivity analysis.

2. MATERIALS AND METHODS

The materials and method includes the description of study area, data collection, data analysis process.

2.1 Study Area

This research was conducted in Shafaroud forest, north of Iran. Its altitude is -24 m to 40 m.

Latitude is 36°54′ and longitude 45°25′ (Fig. 1). The total area of forest management plan is 1524 ha, of this about 922.17 ha is planted. There were two kinds of soil at this area. One was forest brown soil with alluvium origin moderate texture, deep soil, the structure of soil is granular to prismatic and in another part, type of Pascagoula soil and texture of heavy and clay soil [10].

2.2 Data Collection

Could you please mention about the data collection step wise process clearly so that the readers can easily understand. The article will be qualitative.

Mainly growth data and Stumpage price were collected for this research. In addition, the Numerical price data was deflated or adjusted. Step wise process is given below.

Step 1: Growth data collection

Data regarding the growth was collected from previous research (Table 1).

Step 2: Similarly, the data related to Stumpage price was collected from secondary sources. Specifically, timber price and variable harvesting cost were collected from Shafaroud Forest Company and General Office of Natural Resources in Guilan province, north of Iran for period 1993-2013. Moreover, the average stumpage price was derived from actual timber, round wood, fire and pulpwood prices at road side minus the variable harvesting costs.

Step 3: The numerical price data was deflated or adjusted according to the Consumer Price Index (CPI) of Iran for the base year of 2011 [11] (Table 2).

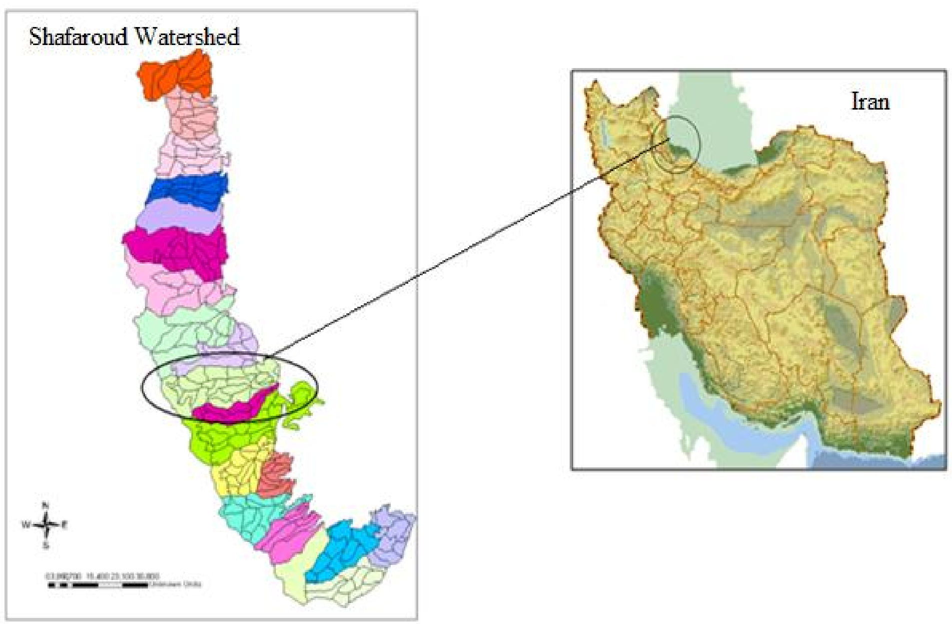

Fig. 1. The study area, Shafaroud watershed management, district No. 9

Table 1. Growth data of different species

Species	Annual average volum growth (m^3/ha)	References
Fraxinus excelsior	6.75	[12]
Acer velutinum	10.8	[12]
Quercus castanifolia	8.09	[12]
Alnus glutinosa	12.9	(Khanjani Shiraz et al. 2005)
Taxodium distichumin	8.96	(Mostafa Nejad and Sadati, 2008)

2.3 Data Analysis

This has mainly focus on finding of Mean price process of stumpage,

2.3.1 Mean price process of stumpage value

Mean price process is the long term expecting price based on historical data. In this research, the possible assumption was the price as stationary autoregressive (AR) process. Its literal meaning is price changes in one period is generally not affect to expected prices to other periods. The best forecast of the future price is given by the mean of the process (when the time distance to the future period of interest approaches infinity). The price in this assumption can be estimated as $P_{t+1} = \alpha + \beta P_{t,}\ \ 0 < \beta < 1$ [13].

First of all the regression analysis was done to estimate the stumpage price in order to determine the expected mean price process of stumpage. For this, following regression analysis was used to estimate the stumpage price process:

$$P\ = \alpha\ + \beta P\ + \varepsilon \tag{1}$$

$P_{t+1}$is price at year $t+1$. $P_t$is price at year t. α and β are estimated parameters.

It was assumed that ε is a series of normally distributed errors with mean zero and autocorrelation zero, and $0 < \beta < 1$.

The expected mean of the price process (P_{eq}) was calculated applying the following function [13]:

$$P_{eq} = \frac{\propto}{1-\beta} \tag{2}$$

2.3.2 LEV

LEV is the net present value (NPV) for bare land assuming perpetual land management regime to measure the economic efficiency. The Faustmann's LEV maximization model was used.

The LEV of different species for plantation can be calculated by the following function:

$$\pi = \frac{P_{eq} \times G \times t}{(1+i)^t - 1} \tag{3}$$

Where, P_{eq} is the mean of the net price process, G is the annual growth (m3/ha) (Table 1). t is the harvest time interval (it changes for different species) and $\mathbf{i}$ is the rate of interest in the capital market. In calculation at this paper, $\mathbf{i}$ is considered to be 5%.

Table 2. Real stumpage price of different species during 1993 to 2013

Year	Stumpage price (0.33 US dollar/ m^3)				
	Ash	**Maple**	**Oak**	**Elm**	**Bald cypress**
1993	120.1	118.3	61.20	102.40	55.08
1994	100.93	99.4	58.77	85.90	46.11
1995	178.45	176.00	134.29	154.59	92.26
1996	221.11	218.17	156.01	192.34	116.83
1997	246.21	242.90	143.34	214.01	129.47
1998	260.36	256.92	195.05	226.80	138.45
1999	290.31	286.40	191.35	252.24	152.12
2000	347.44	342.81	260.63	302.30	183.52
2001	317.46	313.12	223.55	275.17	164.56
2002	274.55	270.81	183.72	238.18	142.29
2003	283.42	279.60	191.38	246.19	146.58
2004	266.31	262.71	180.16	231.19	137.57
2005	245.91	242.55	168.59	213.20	126.93
2006	258.14	230.63	165.04	196.14	124.06
2007	229.65	212	158.24	180.41	116.43
2008	208.37	198.28	156.9	191.56	111.04
2009	185.42	176.31	139.62	170.25	97.54
2010	179.58	174.72	133.05	166.62	96.55
2011	232.75	226.09	162.28	220.32	127.42
2012	139.57	139.57	95.96	139.57	100.85
2013	151.55	243.01	144.93	243.01	151.55

3. RESULT

The results are categorized under two main parts according to the specific objectives of the research. They are: a. Stumpage price process and Expected mean price process of stumpage and b. LEV and Sensitivity analysis.

3.1 Stumpage Price Process Expected Mean Price Process of Stumpage

3.1.1 Stumpage price process

Results of regression analysis showed that there is a significant relation between $P_{t+1}$and P_t at significant level of 0.05. The estimated parameters of different species stumpage price based on equation 1 are shown in Table 3.

3.1.2 Expected mean price process of stumpage

Equation 2 was used in order to determine the expected mean price based on the estimated parameters in Table 3. The expected mean price is shown in Table 4.

3.2 LEV and Sensitivity Analysis

The results showed that the LEV of ash, elm, maple, oak and bald cypress are 2623.883, 4653.042, 4319.9644, 2206.8788, 8064.667 (0.33 US dollar/ m^3), respectively.

Sensitivity analysis was conducted to examine the impacts on land expectation value by shifting the interest rate. For this the Faustmann's formula was applied particularly using the interests rates like 2% and 10%. The sensitivity analysis showed that when the interest rate increased the LEV of plantation decreased (Table 5). So, there was reverse relationship between interest rate and LEV.

4. DISCUSSION

Financial returns from planted and native forests are one of the most important factors driving forest management, conservation, and investments throughout the world. Periodic studies examine these returns for individual species or countries, especially for plantation species [14].

Table 3. Estimated parameters of different species stumpage price

Species	α	β	P-Value		Standard deviation (ε)
			α	β	
Ash	54.745	0.768	0/010	0/000	38/075
Maple	77/940	0/679	0/034	0/000	40/590
Oak	65/063	0/615	0/017	0/001	31/790
Elm	82/108	0/625	0/022	0/001	37/502
Bald Cypress	42/132	0/690	0/025	0/000	20/151

Table 4. Expected mean price process of different species

Species	Expected mean of price (P_{eq})(0.33 US dollar/ m^3)
Ash	235.96
Maple	242.803
Oak	168.994
Elm	218.95
Bald Cypress	135.909

Table 5. Results of sensitivity analysis

Species	Interest rate	LEV (0.33 US dollar/ m^3)		
		2%	5%	10%
Ash		32878.773	2623.883	62.234
Maple		54131.648z	4319.964	102.462
Oak		28222.355	2206.878	53.420
Elm		58305.310	4653.042	110.362
Bald cypress		40322.607	8064.667	1100.557

The aim of this research was to evaluate the most suitable species species among ash *(Fraxinus excelsior),* elm *(Alnus glutinosa),* maple *(Acer velutinum),* oak *(Quercus castanifolia),* bald cypress *(Taxodium distichumin)* using the LEV in north of Iran. The results showed that the LEV of ash, elm, maple oak, bald cypress are 2623.883, 4653.042, 4319.9644, 2206.8788, 8064.667 (0.33 US dollar/ m^3), respectively. Therefore, the LEV of bald cypress was the highest among others. Appraisers often use discounted cash flow (DCF) techniques to value timber and timberland. However, the LEV is considered as a standard DCF technique. The LEV is used to calculate the value of bare land in perpetual timber production and it is often used to evaluate the value of even-aged pine plantations. Besides, it is also useful to check the value of immature timber stands and uneven-aged timber stands periodically. These models have wide applicability in timberland appraisal situations [15].

Mohammadi limaei et al. [16] determined the optimal felling cycle in an uneven-aged beech forest in the North of Iran. He applied the logistic growth model for an uneven aged forest. Based on this, the stumpage price was predicted by employing an autoregressive model. The average stumpage price of beech was derived from actual timber, round wood, fire and pulpwood prices at road side minus the variable harvesting costs. Price and growth models were used in order to determine the optimal felling cycle under different interest rates and setup costs. The Faustmann's model was used for optimal felling cycle. The results indicated that the optimal felling cycle will decrease if the interest rate is increased. Additionally, if the establishment costs increases, the optimal felling cycle will also increase.

Lohmander & Mohammadi limaei [17] determined the optimal harvest policy via stochastic dynamic programming. The result showed that you may increase the expected present value by 26% or even more based on optimal adaptive decisions.

Guo et al. [18] Used LEV as a criterion for economic analyses of natural rubber and tea monoculture, and rubber–tea intercropping in China. They found that rubber-tea intercropping generated higher LEV than rubber and tea monoculture under current socio–economic circumstances. Sensitivity analysis was also done to show the impacts based on the interest rate, price of natural rubber and tea, and labor costs.

Furthermore, Niskanen [19] assessed the financial and economic profitability of industrial, community and agroforestry-based reforestation of *Eucalyptus camaldulensis Denhn* and *Tectona grandis L.,* in northeast Thailand. It was found that the plantation was more profitable to invest by the society, than from private investor. The LEV was recorded 12–52% higher than the financial LEV. Planting teak was more profitable than planting eucalypt. Cropping of cassava between tree rows decreased the financial and economic profitability of reforestation. The decrease in the LEV in intercropping was mainly due to a poor—although rather common in northeast Thailand-selection of agricultural species for cultivation. As expected, the LEV was highly sensitive to the changes in the growth and yield and stumpage prices, which may vary in real circumstances. Their study was somehow similar to our study to consider LEV of different species in plantation.

Alavalapati et al. [20] develop a model that determines the profitability of broadleaf and slash pine for timber production and carbon sequestration, habitat for the endangered red-cockaded woodpecker, and other amenity benefits. Additional payments of $16 to 33 per ha per year, reflecting extra amenity benefits associated with longleaf pine relative to slash pine, make longleaf production financially competitive. Incentives that reflect carbon, biodiversity, and amenity benefits associated with longleaf production may be the optimal way of restoring longleaf pine ecosystems on rural private lands in the US South.

Diaz-Balteri & Rodriguez [21] investigated LEV in *Eucalypts* plantation in Spain. The results showed that the seedling rotation in the following coppice rotations usually is not the best option. Besides, the optimal cycle and the land expectation value vary when carbon sequestration is evaluated for the two plantations c. Finally, the results are exceptionally showed very sensitive to changes in parameters like the carbon price and discount rate. Meanwhile, Friday et al. [22] described NPV of a 50 acres teak (*Tectona grandis*) plantation was US$ 2719 per acre for 35 years rotation. The discount rate was 4%. Internal Rate of Return (IRR) was found to be 6 to 8.01% for different stumpage values. The estimated LEV was $ 3634 per acre. Similarly, Pitigala & Gunatilake [23] found LEV of mahogany and pine plantations as LKR1 4,267.98 and 21,999.85, respectively with negative sign. The discount rate used for calculations was 15%. The results of their study were somehow similar to the results of this study to explain importance of plantation by softwoods.

5. CONCLUSION AND RECOMMENDATION

This research provides information on plantations for Commercial timber production in the Shafaroud forest, north of Iran. Bald cypress as a softwoods species is the first priority for plantation according to the results of LEV. This species is a fast growing tree, therefore it has short rotation period. Due to the expansion of wet lands in the north of Iran in coastal and flat areas as well as the industrial importance of this species such as producing suitable pole and tunnel wood. It is suggested to plant this species on a large scale at this area. Demand of wood is higher than it supply in Iran. Hence, the plantation of fast growing species can reduce the shortage of domestic wood in Iran. The methods like SEV, IRR. BC ration and NPV of this species should be employed to evaluate the best timber production species based on perpetuity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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