Socioeconomic evaluation of agroforestry systems (Case study: Northern Iran)

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ABSTRACT: The aim of this research was to investigate the socioeconomic values of different land use in the agroforestry system. Questionnaires were used to collect social and economic data in two villages at Guilan province, northern Iran. Internal Rate of Return (IRR) and Profitability Index (PI) were used for cost-benefit analysis. Net Present Value (NPV) of different farming systems was determined. ANOVA test was used to compare the outcomes of different land use. The results indicated that there is a significant relationship between literacy and variety of land use in two villages. Results of IRR and PI indices show that these indices were higher in poplar plantation than in the other land use (paddy and tea field, horticulture and vegetable). Results of ANOVA test showed that there is a significant difference between net incomes from different farming systems in Tamchal village. Furthermore, the ANOVA test showed that there is no significant difference between net incomes from different farming systems in Narenj Bon Paeen village. The results showed that farmers tend to participate in training and promoting classes associated with the maximum use of land. Chi-squared test was used in order to determine the effect of participation in training and promoting classes on multiple uses of land, land use change, sericulture, and apiculture. The results of Chi-squared test showed that there is a significant and positive relationship between people's participation rates and the multiple use of land. In overall, results showed that traditional agroforestry systems provide a higher income than monoculture in the study area.

Keywords: internal rate of return (IRR); profitability index (PI)

Agroforestry is the set of land-use practices including the combination of trees, agricultural crops and/or animals on the same land management unit in some form of spatial arrangement or temporal sequence (Lundgren, Raintree 1982). Agroforestry systems consist of cultivation activities that combine arboreal species with either annual or perennial crops in a way which is looking for the optimal use of land together with the maximum income per unit area. Agroforestry is a land management program that intersperses agricultural crops with trees (Krstansky et al. 1997). Agroforestry practices provide multiple benefits including high productivity and additional income while maintaining the soil health (Kang et al. 1984). Agroforestry can gain a greater range of environmental benefits than traditional kinds of annual crop cultivation. Agroforestry has several advantages such as improvement in soil fertility which increases vegetable yields, extends the harvesting season and improves the quality of produce as well as increased the income of rural communities. In the economic development process, the capital is an important key factor. It is also a limited production source in agriculture. The capital is important because it increases the productivity of other production factors including land and labour. Most agricultural activities in Iran like in the other parts of the world are done in rural areas. Investment in the agricultural sector can create job opportunities in rural areas and prevent the migration to urban areas. Despite the importance and role of the capital in the agricultural sector, the investment process in Iran shows that the share of the capital in agriculture has been lower than in the other sectors (Soltani 2003).

Net Present Value (NPV) at mixed and pure cultivation in the south of India was determined and results indicated that the mixed cultivation of poplars with wheat, soybeans and other crops has high-

er NPV than the single crop cultivation (Ranas-inghe, Mayhead 1990). Satyasai (2009) used the modified Internal Rate of Return (IRR) method for watershed evaluation. Results showed that the rate of return from watershed investment is less lucra-tive when modified IRR is used with necessary ad-justments for scale and time span and the ranking based on IRR and NPV is consistent. The ranking of the projects has been found to change using the adjusted modified IRR methodology.

Molua (2005) studied the economics of tropical agroforestry system: the case of agroforestry farms in Cameroon. The analysis indicated the importance of market prices, farm operating costs and contacts with the extension service personnel as positive covariates of agroforestry production in the study region. Bar-bieri and Valdivia (2010) investigated the recre-ation and agroforestry, examining new dimensions of multifunctionality in family farms in Missouri (USA). Results showed that family farms provide several recreational services for their household members and others, and the existence of synergies between the recreational function of the farmland and agro-forestry practices is consistent with the transition to strong multifunctionality. Results also show that the higher the perception of intrinsic (i.e. planting of trees for wind protection and carbon sequestration) and economic (i.e. perceived economic benefits and flood protection) values of agroforestry, the higher the rec-reational use of the land. (Keča 2010) studied the cost efficiency for wood production in poplar plantations

in Ravan Srem, in Serbia, based on IRR. The research showed that the IRR for 12 sample plots varied in the interval of 4.32–6.94% with an average rate of 5.63%. The internal rates are higher for plantations on good quality soil types, regarding the poplar plantation (al-luvial semigleyic soil), and for shorter rotations and vice versa. Sherafatmand et al. (2008) studied the IRR in different sectors in Iran. The results showed that IRR in the subdivision of farm and horticultural, live-stock, forestry, and fishery sector are 1.7, 3.8, 0.42 and 0.21 percent, respectively. (Mohammadi Limaei et al. 2010) compared the profitability of paddy field and poplar plantation in Guilan province, Iran. The results showed that the net income from poplar plantation is almost twice higher than that from paddy field.

Paddy field and tea cultivation have been the main crops in many rural areas in northern Iran for al-most one century. Afterwards citrus trees and mul-berry trees were planted between the rows of tea plants. Furthermore, popular trees were planted in the margins of fields and houses. Therefore, the aim of this research is to investigate the socioeconomic aspects of agroforestry systems in two villages at Guilan province, in the north of Iran.

MATERIAL AND METHODS

Study area. The required data was collected from two villages of Guilan province in Iran. One village is called Tamchal and it is located in Astaneh-Ashra-
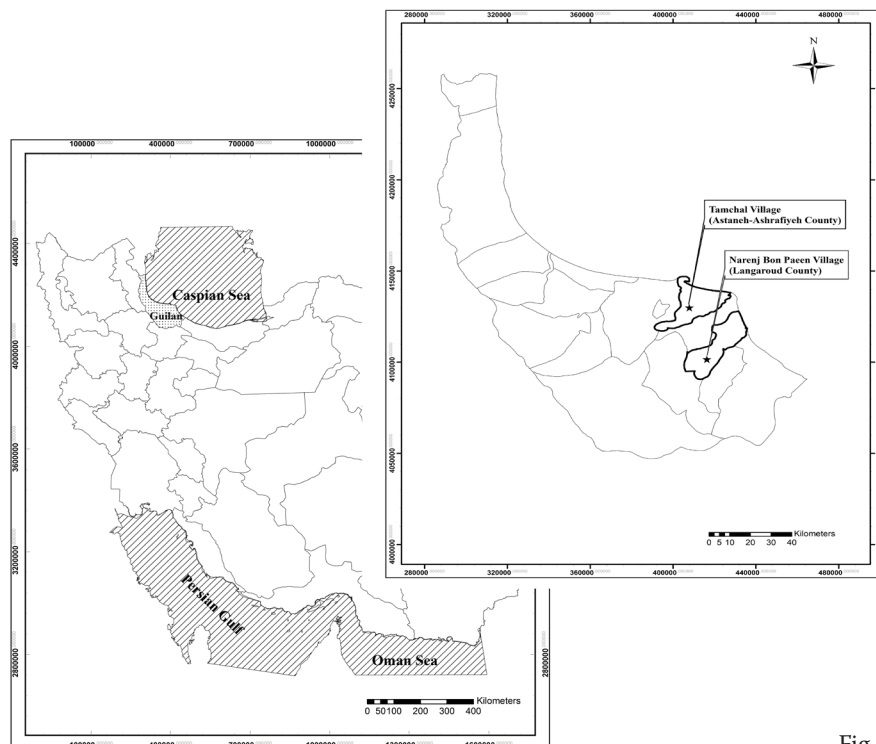

Fig. 1. The study areas

fiyeh county. This village is located within 49°57'39"E longitude and 37°18'38"N latitude (Fig. 1). The main agricultural activities in this village are paddy field, poplar plantation, sericulture, peanuts and other cultures (horticulture and vegetables). The other village that is called Narenj Bon Paeen is located in Langaroud county and its geographic position is 50°03'15"E longitude and 37°03'34"N latitude (Fig. 1). The main agricultural activities in this village are paddy field, tea field, poplar plantation, horticulture and olericulture.

Methods. In order to collect the data, questionnaires were used. A questionnaire based on the Likert scale was designed for data collection. Questionnaires were distributed between 58 rural households (41 questionnaires for Tamchal village and 17 questionnaires for Narenj Bon Paeen village). Collected data was classified into social and economic categories. The social factors included: age, gender, education and occupation of the household head, employment status, family size and location, rate of participation in training and promoting classes, rate of acquaintance with agroforestry systems, agricultural techniques and migration. Economic questions included (1) the total area of farmer's farm, (2) the area of the farm under cultivation, (3) the resources of providing seed, fertilizer and pesticide consumption, (4) the farm costs including the costs of planting (i.e. ploughing, costs of providing seed and fertilizer), costs of labour, pesticides and herbicides, harvesting and so on, (5) the amount of production per unit area and (6) the price of produced crop in the market. To compare the profitability of different land uses, the annual profit was calculated. The ANOVA was used for data analysis using SPSS software, version 16 (SPSS, Tulsa, USA). The ANOVA is used here in order to compare the mean values of different agroforestry systems.

For calculating the cost-benefit of poplar plantation, the income per hectare of harvested poplar at harvesting age (8 yr) was discounted from plantation cost and variable costs such as fertilizing, irrigation etc. Then, by dividing the net income or profit by the project period (8 yr), the annual net income was calculated. It should be mentioned that in this research it was assumed that harvesting age is 8 years because it is more common among the farmers to cut the poplar trees at this age in the study areas. For the cost-benefit calculation of paddy and tea fields, the total annual costs were discounted from the total income and profit per hectare was calculated. Similarly, for the other land uses, profit per hectare was calculated and the cost-benefit calculation of vegetation was also determined in the same manner. The following func-

tions were used in order to determine NPV, IRR and PI indices (Amacher et al. 2009).

The Internal rate of return (IRR) or economic rate of return is a rate of return used in capital budgeting to measure and compare the profitability of investments (Eq. 1):

$$NPV = \sum_{t=0}^{n} \frac{R_t - C_t}{(1+i)^t} = 0 \qquad (1)$$

where:
NPV – net present value,
R_t – income in year t,
C_t – cost in year t,
i – internal rate of return,
t – time (year).

Profitability index (*PI*) was determined using Equation 2:

$$PI = \frac{\sum \frac{R_t}{(1+i)^t}}{\sum \frac{C_t}{(1+i)^t}} \qquad (2)$$

where:
R_t – income in year t,
C_t – cost in year t,
i – internal rate of return,
t – time (year).

RESULTS

Education status of household

According to the results of data analysis, farmer's education status was classified into 6 groups including illiterate, elementary school, middle

Table 1. Resultant rate of education in villages

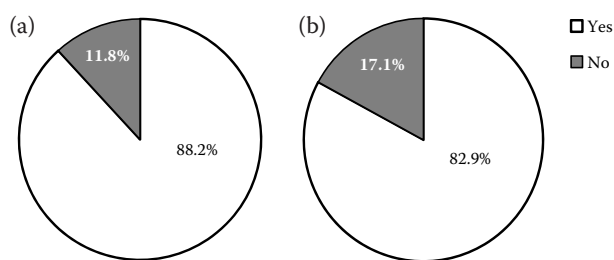| Education level	Frequency		
	absolute	relative	cumulative
Narenj Bon Paeen			
Illiterate	8	47.1	47.1
Elementary school	4	23.5	70.6
Middle school	2	11.8	82.4
High school	–	–	–
Diploma	3	17.6	100
Higher school	–	–	–
Total	17	100	–
Tamchal			
Illiterate	12	29.3	29.4
Elementary school	16	39	68.3
Middle school	5	12.2	80.5
High school	1	2.4	82.9
Diploma	6	14.6	97.5
Higher school	1	2.4	100
Total	41	100	–

Fig. 2. Willingness rate of farmers to participate in promoting and training classes: Narenj Bon Paeen (a), Tamchal (b)

school, high school, diploma and higher education. The results related to education status are shown in Table 1. According to Table 1, 47.1% and 29.3% of the household head population is illiterate in Narenj Bon Paeen and Tamchal villages, respectively.

Furthermore, farmer's participation in training and promoting classes was investigated. The results showed that farmers tend to participate in training and promoting classes associated with the maximum use of land (Fig. 2).

The employment status of farmer's children was investigated (Fig. 3). The results of questionnaires also showed that the farmer's children are usually engaged in agroforestry activities when they do not have a better job such as employment opportunity in governmental sectors.

Effect of participation in training and promoting classes on the qualitative variables

Chi-squared test was used in order to determine the effect of participation in training and promoting classes on multiple uses of land, land use change, sericulture, and apiculture. The results of Chi-squared test showed that there is a significant and positive relationship of people' participation rates with the multiple use of land. The results also

showed that there is no significant relationship between participation in classes and sericulture and apiculture activities (Table 2).

NPV of different farming systems

Results of this study showed that there are 4 types of farming systems in Tamchal village including of (1) paddy-poplar plantation-other products, (2) paddy-other products, (3) paddy-poplar plantation, (4) paddy. Furthermore, there are 4 types of farming system in Narenj Bon Paeen village including (1) tea-horticulture-olericulture, (2) tea-horticulture, (3) paddy-poplar plantation, (4) horticulture.

NPV of different farming systems are shown in Fig 4. The results showed that the "paddy-poplar plantation-other products system" has the highest income in Tamchal village (Fig. 4a) and "tea-horticulture" has the highest net income in Narenj Bon Paeen village (Fig. 4b).

The ANOVA test was used to compare the NPV of different farming systems. The results showed that at a significance level of 0.05, there are significant differences between the NPV derived from

Table 2. Results of Chi-squared test in villages

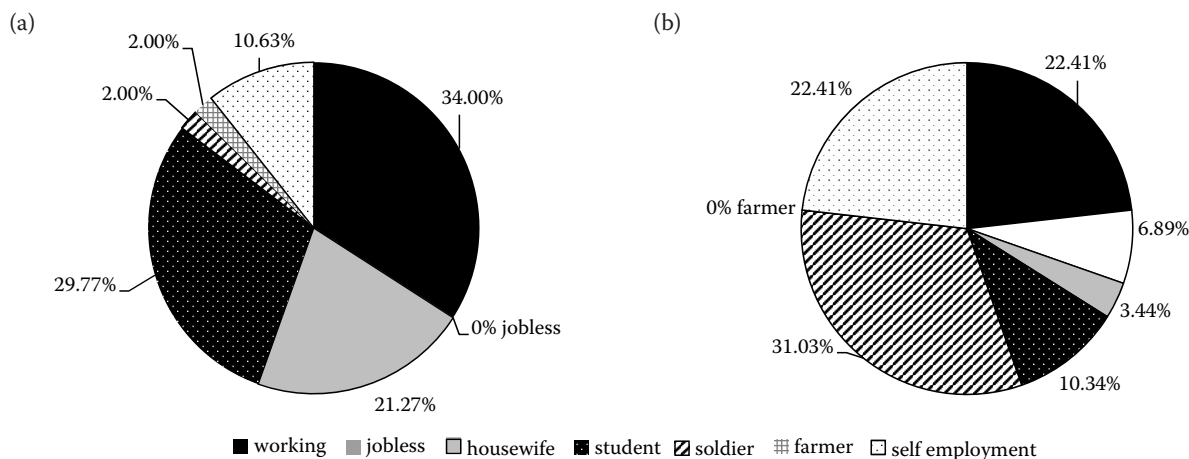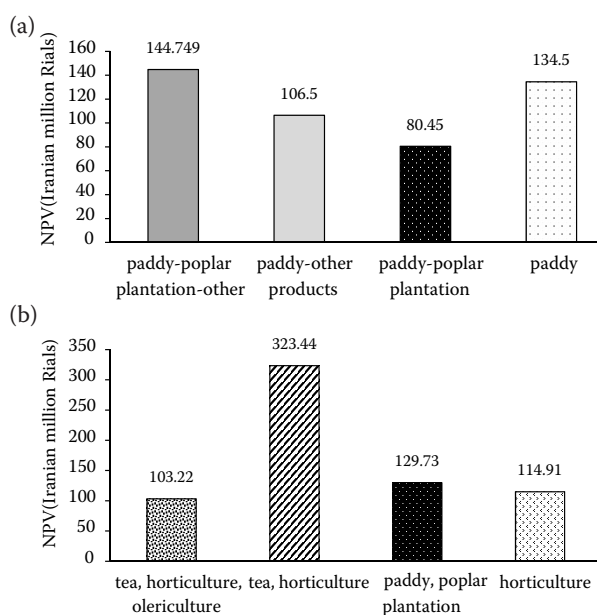| Variable	Significant level
Narenj Bon Paeen	
Multiple use of land	0.007
Land use change	0.044
Sericulture	0.061
Apiculture	0.279
Tamchal	
Multiple use of land	0.000
Land use change	0.04
Sericulture	0.096
Apiculture	0.308

Fig. 3. Employment status of farmers' children

Fig. 4. NPV derived from different farming systems in villages: Tamchal (a), Narenj Bon Paeen (b)

different farming systems in Tamchal village (Table 3). The results also showed that in Narenj Bon Paeen village there is not any significant difference between the NPV derived from different farming systems (Table 3).

IRR of different farming systems

The results of IRR for each land use are shown in Fig. 5. The results showed that the poplar plantation and paddy field have the highest and the lowest IRR in Tamchal village, respectively (Fig. 5a). It should be mentioned that the other products in Fig. 5a include peanuts and vegetables. Also, the results of IRR for each land use are 12.7, 9.9, 6.7 and 4.4% for poplar plantation, citrus, tea and paddy in Narenj Bon Paeen village, respectively (Fig. 5b). The results showed that the poplar plantation and paddy field have the highest and the lowest IRR, respectively.

PI of different farming systems

The results of PI for each land use are shown in Fig. 6. The results showed that in Tamchal village the poplar plantation and paddy field have the highest and the lowest PI, respectively (Fig. 6a). Furthermore, the results indicated that in Narenj Bon Paeen village, PI for each land use are 1.65, 0.69, 0.47 and 0.31 for poplar, citrus, tea and paddy, respectively. Poplar plantation and paddy have the highest and the lowest PI, respectively (Fig. 6b).

DISCUSSION

There are various types of agroforestry systems worldwide. Agroforestry systems have traditionally been popular among farmers. In this study different agroforestry systems as well as the potential of Guilan villages for acceptance of agroforestry have been evaluated. The socioeconomic aspects of the study were investigated. The results
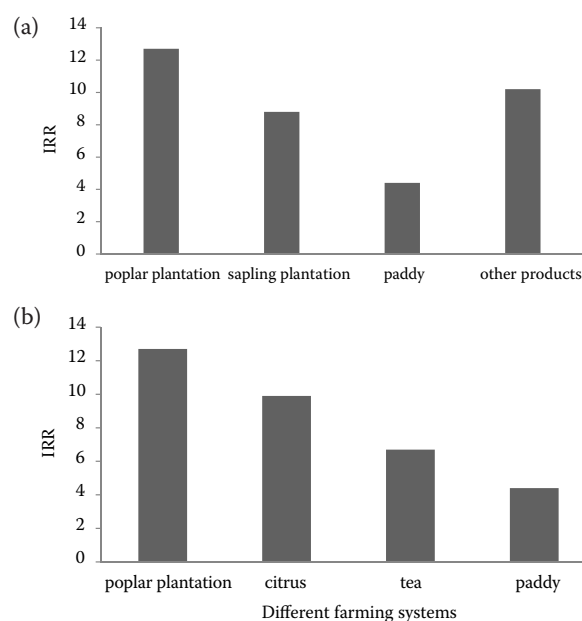

Fig. 5. IRR for different land use in villages: Tamchal (a), Narenj Bon Paeen (b)

Table 3. Results of ANOVA test for comparison of NPV in villages

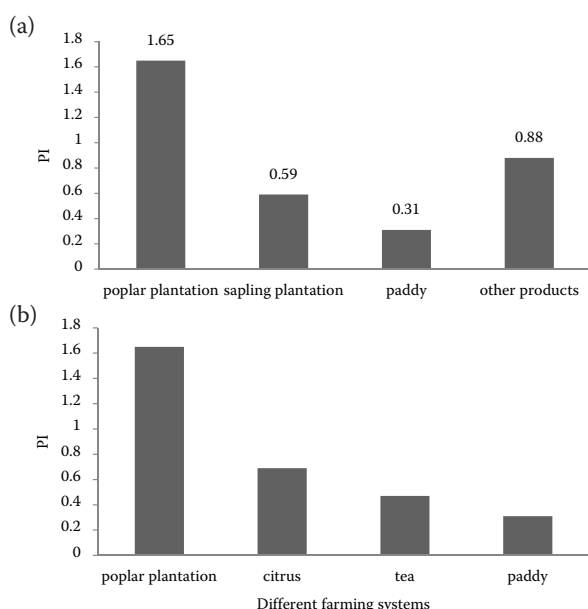|	Sum of squares	df	Mean square	F	Sig.
Tamchal					
Between groups	47675.226	3	15891.742	4.869	0.008
Within groups	91384.542	28	3263.734		
Total	139059.768	31			
Narenj Bon Paeen					
Between groups	1111.31	3	370.437	0.559	0.651
Within groups	8615.546	13	662.427		
Total	9722.855	16			

Fig. 6. Rate of PI for different land use in villages: Tamchal (a), Narenj Bon Paeen (b)

showed that the educational level of the village is low (Table 1). Farmers' participation in training and promoting classes was investigated. The results showed that farmers tend to participate in training and promoting classes associated with the maximum use of land. The willingness rate of farmers to participate in promoting and training classes in Narenj Bon Paeen and Tamchal villages was 88.2% and 82.9%, respectively (Fig. 2). Furthermore, the results showed a significant and positive relationship between participation in training and promoting classes and the multiple use of land and change of land use variables (Table 2). Results of this study are similar to the results of Rafi (1993), Barasa (2001), Taganta and Alavalapafi (2003). Agroforestry systems affected the job creation in the study area, especially for the children of farmers. In addition, the implementation of these systems causes the job creation in related industries such as chain management, logistics that increase household incomes (Fig. 3). The results concerning the job creation in agroforestry systems are in accordance with results of Robins et al. (1996), Tonts et al. (2001), Yakhkeshi (2007) and Mohandesi Namin et al. (2009).

Results indicated that in Tamchal village the cultivation of integrated crops including rice, poplar and other products (peanuts and vegetables) has the highest NPV (Fig. 4a) and in Narenj Bon Paeen village "tea-horticulture" has the highest net income (Fig. 4b). Integrated cultivation of multi-crops and multiple use of land (rice, poplar and other products) have higher economic gain

than the monoculture system such as paddy field. Furthermore, the ANOVA test showed that there is a significant difference between NPV derived from agroforestry and agricultural systems at the 0.05 probability level (Table 3). The results of our research are similar to the results of Tonts et al. (2001); Gruenewald (2006); Yakhkeshi (2007). Furthermore, the ANOVA test showed that there is not any significant difference between the profits of different agroforestry systems in Narenj Bon Paeen village (Table 3). It was also indicated that the combination of tea and horticulture has the highest incomes compared with the other agroforestry systems (Fig 4b).

Jianbo (2006) believed that the energy efficiency and economic benefits of agroforestry systems are key issues with respect to their actual sustainability as sound agricultural practices as well as to their potential for further development. The results showed that in the two villages the poplar plantation and paddy field have the highest and the lowest IRR, respectively (Fig. 5). The results also showed that the poplar plantation and paddy have the highest and the lowest PI, respectively (Fig. 6).

Therefore, it should be mentioned that investment in the poplar plantation section is more efficient. Mohammadi Limaei et al. (2012) showed that the net income of poplar plantation is almost twice higher than that of paddy field in Guilan province, north of Iran. NPV at mixed and pure cultivation in the south of India was determined and results indicated that the mixed cultivation of poplars with wheat, soybeans and other crops had higher NPV compared to single crop cultivation Ranasinghe and Mayhead (1990). The results of that study are similar to the results of this study that mixed cultivation has the highest NPV.

The results of research carried out at 95 ha of afforestation in Shafaroud area (northern Iran) showed that the net income of afforestation is 700 million Iranian Rials in every 5-year period (Anonymous 2000). They mentioned that this amount of income is higher than the income of the other cultivation sectors in the area.

CONCLUSIONS

As it was mentioned, the results of this research show that there is a significant difference between NPV gained from monoculture system and different agroforestry systems. It means that the NPV of mixed crops is higher than that of single crop in the study area. There are many advantages to

cultivate mixed crops in an agroforestry system such as environmental, social and economic ones. Therefore, we have proved that the agroforestry system has a higher economic gain. In addition, agroforestry increased the rural economic development in the study area.

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