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## A socio-economic problem regarding poplar plantation and a problem solving model by AHP

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**Abstract:** The current research presents the best solution for socio-economic problem regarding poplar plantation in Eastern and Western Azerbaijan, Iran. Planting fast growing species such as poplar is highly profitable in wood farming in Eastern and Western Azerbaijan, hence identification of socio-economic qualifications of poplar plantation would solve the problems of wood and paper industries regarding wood supply in the coming decade. Assuming previous researches and visiting poplar plantation surfaces in the so-called provinces, 51 sub-criteria were identified. These sub-criteria were categorized in five major groups: application, economic and financial, social and cultural, technical, and infrastructure. The priority and weight of the criteria and sub-criteria were determined through survey the experts and poplar farmers in wood and paper industries and poplar plantation. The findings revealed that economic and financial aspects are the most important criteria, and the sub-criteria of pre-purchase contract, water sources, and improved species have the highest priorities, respectively. For selecting the best optimized solution in the provinces, three groups of alternatives were selected: poplar farmer promotion and education using national and foreign experts, offering multiple facilities, and increasing the participation of wood and paper industries and investors with respect to poplar farmers' problems. To select the best solution, a questionnaire was designed and administered among the experts, and then evaluated considering the sub-criteria. The results of synthesizing by AHP and Expert Choice software indicated that poplar farmer promotion and education through national and foreign experts' contribution is the best solution for providing proper situation of poplar plantation in the area and consumption of wood and paper industries. The result of sensitivity analysis indicated that economic & financial, technical and structural criteria are more sensitive when affect the solutions.

**Keywords:** poplar plantation, AHP, Azerbaijan, socio-economic, alternatives, criteria, solution.



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## 1. Introduction

Researches of executive organizations show that the current areas of poplar plantation in Iran are only 23%, and 77% of the capable areas have not been applied. In the future, the areas of poplar plantation and wood production can be increased 520000 hectare – 14438000m<sup>3</sup> annually.

Among provinces of Iran Western and Eastern Azerbaijan have the second and third priority in poplar plantation area, respectively. Overall, proper areas of poplar plantation and production capacity of Eastern Azerbaijan are 42000 hectare and 1134000 m<sup>3</sup>, respectively. Proper areas of poplar plantation and production capacity of Western Azerbaijan are 39000 hectare and 1053000m<sup>3</sup> respectively. In Western Azerbaijan, new varieties of poplar have been used. Poplar as a native fast growth species with low ecological requirement has been distributed in the provinces. Western and Eastern Azerbaijan are very capable areas to develop poplar plantation, and the people are familiar with poplar farming. The lands near the rivers' fertilized soil are preferences of the areas which give rise to concentrate various woods and paper factories in the region. In recent years, the provinces have had a major development in poplar farming. At the present time, the poplar trees (*Populus alba. and populous nigra.*) are the most traditionally planted species in Iran. If favorable financial support of industrialists is available in the form of providing improved seedlings, granting appropriate land with long-term payment, etc. and the implementation of poplar plantations will ease the problem of raw material supply significantly. As the cost of raw material supply such as wood decreases, paper products' prices correspond and become more competitive in the marketplace, making Iranian production of these products possible.

## Literature review

In the 23rd Session of the International Poplar Commission, Carle et al. (2008) reported that using poplar trees to produce pulp for producing paper, particleboard, wooden boxes, veneer, matches, furniture, and bioenergy consumption has grown significantly in recent years. In China, poplar plantation areas have been extended from 3.9 to 4.3 million hectares during the years 2004 to 2007 while 2.7 million hectares of these areas are under traditional poplar plantation.

Togawa et al. (2007) studied economic development in the east of China. They also showed the increasing price of planted poplar trees and the growing number of poplar-based wood products based on poplar such as plywood, veneer, particleboard. Kishwan and Kumar (2003), in their studies, have concluded that poplar was an important species for silviculture in India. Native poplars can be found mainly in the mountains. They play an important role in programs of silviculture, reforestation, and forests protection. Anderson and Luckert (2007) determined that from a total of 67.8 million hectares agricultural lands in Canada, genetically-modified poplars were planted on 21 million marginal hectares. These plantings were the result of provincial government policy in western Canada and were based on silvicultural principles and demand for wood cultivation. Spinelli et al. (2005) stated that poplar plantation is an important wood resource in France and Italy. Poplar plantation in France is 240,000 hectares with an approximate annual production of 1.5 million cubic meters. In Italy, poplar plantation totals 120,000 hectares with an annual production of 1.8 million cubic meters. Fast growing poplars were touted to be more similar to agricultural products than most other plantation species, in that investment returns might be realized over shorter terms due to growth rates. For this reason, poplar plantations were favored by paper companies as a potential source of low-cost and reliable pulp supply. However, over longer term periods, lower-than-expected return on investment of many of these ventures has resulted in these plantations being grown for longer rotations and harvested for solid wood and engineered wood products (Davison and Riggs, 2004). New applications of modified poplar wood has been expanded since the devaluation of its commercial pulps, such as frames of furniture, pallets, plywood, *oriented strand boards*, laminated timbers, etc. The global competition in wood products industry requires companies to be innovative and aggressive in the development of new products and implementation of new manufacturing strategies. Scientific work on hybrid poplar development and alternative wood species in support of the development of alternative fiber sources for our paper mills and oriented strand board plants have resulted in continued viability of this industry. For example, the Natural Resources Research Institute at the University of Minnesota-Duluth has been used by industrial and public agencies to make decisions regarding the use of hybrid poplar plantations for building products and energy from forest biomass (Natural Resources Research Institute, 2003).

## Problem

Many economic and social problems such as long-term investment return, profitability, liquidity shortage, lack of financial support for poplar plantation, lack of uniform farming lands, insurance problem, traditional or unindustrialized use of poplar wood, and lack of competitiveness with other agricultural products give rise to poplar plantation community face undesirable development.

## Goal

Familiarity with effective criteria of poplar plantation development in Western and Eastern Azerbaijan as two capable provinces of poplar plantation and presentation of proper solutions to help poplar plantation development in the regions are of crucial importance.

## 2. Effective criteria of poplar plantation

Criteria are divided into five groups: Application group, Economic and financial group, Social and cultural group, Technical group, Structural group.

Decision tree of the criteria and sub criteria has been shown in fig. 1 (attachment 1).

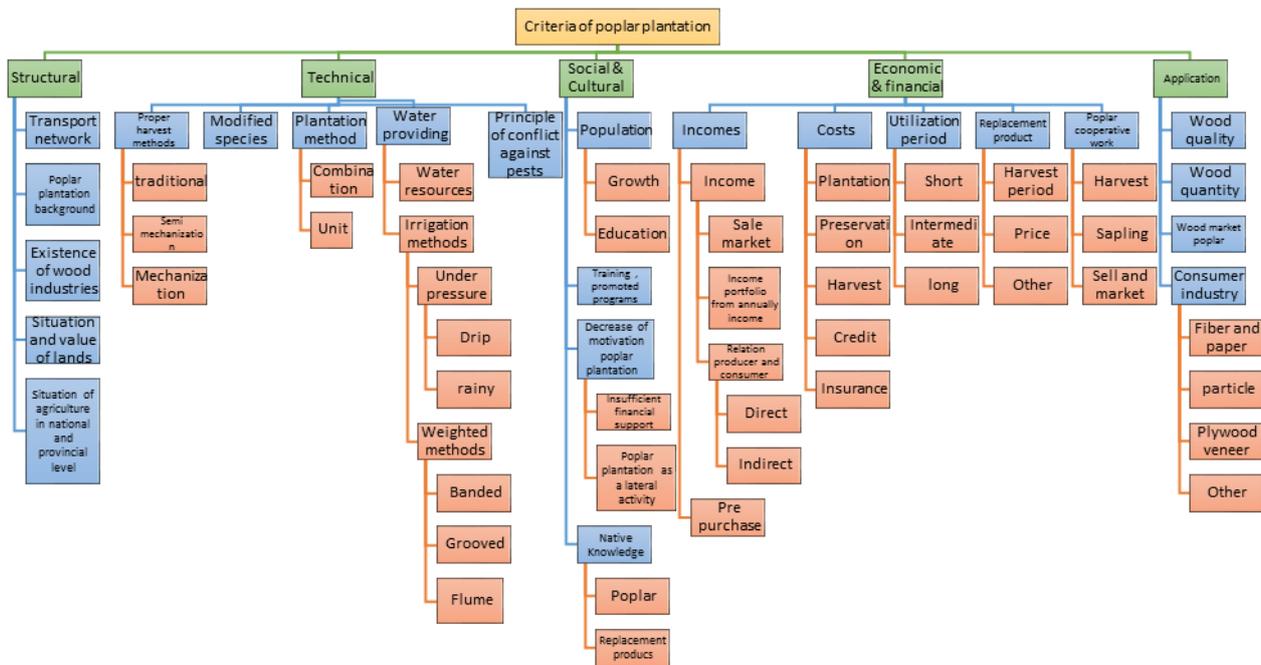


Figure 1. Decision tree of criteria and sub criteria of development of poplar plantation

## 3. Alternatives

Alternatives or solutions of poplar plantation development are three; here, one of them is selected in the model: 1. Training and promotion of poplar farmers using internal and foreign experts' experiences. 2. Increasing cooperation between manufacturers of wood and paper industries and investors with poplar farmers in poplar plantation. 3. Granting various facilities.

## 4. Method

### Preparing questionnaire for the first and second stage

Two questionnaires were provided to gather experts and poplar farmers opinions:

First questionnaire: After visiting poplar plantation regions of Western and Eastern Azerbaijan and interviewing poplar farmers and experts, the effective criteria of poplar plantation development were recognized, and then the decided trees were planted. Questionnaires were provided and distributed among 30 people: six academic members, eight participants from natural resources organization, six researchers, and 10 experienced poplar farmers.

The individual judgments were checked for consistency, and the aggregated opinion was derived using TEAM- EC 2000. Second questionnaire: The questionnaires were provided and distributed to prioritize alternatives or solutions related to poplar plantation development in the regions. The people who responded to the questionnaire were as follow: six academic members, eight participants from natural resources organization, six researchers, and 10 experienced poplar farmers. The questionnaires were gathered and synthesized by Expert Choice 2000.

### Analytical Hierarchy Process

The AHP developed by Saaty (2000) determines the relative importance of a set of activities in a multi-criteria decision problem. The process makes it possible to concurrently incorporate judgments on intangible qualitative criteria with tangible quantitative criteria into an analysis of alternatives. The AHP method is based on three steps: model structure; comparative judgment of the alternatives and criteria; and synthesis of the priorities. In the literature, the main developments in AHP have been widely used to solve many complicated decision-making problems (Ishizaka, Labib, 2011). In the first step, a complex decision problem is structured as a hierarchy. AHP initially breaks down a complex multi-criteria decision-making problem into a hierarchy of interrelated decision elements (criteria, decision alternatives). The objectives, criteria and alternatives are then arranged in a hierarchical structure similar to a family tree. This hierarchy has at least three levels, with the overall goal of the problem at the top, multiple criteria that define the solution alternatives in the middle and decision alternatives at the bottom (Albayrak, Erensal, 2004). The second step is the comparison of the alternatives and criteria. Once the problem has been decomposed and the hierarchy is constructed, a prioritization procedure is conducted to determine the relative importance of the criteria within each level. The pair-wise judgment starts at the second level and finishes with the lowest level alternatives. In each level, the criteria are compared pair-wise according to their levels of influence and based on the specified criteria in the higher level. In AHP, multiple pair-wise comparisons are based on a standardized comparison scale of nine levels (Table 1).

**Table 1. Standardized nine-level comparison scale used in AHP**

Definition	Importance ranking
Equally important	1
Moderately more important	3
Strongly more important	5
Very strong more important	7
Extremely more important	9
Intermediate values	2, 4, 6, 8

Let  $C = \{C_j \mid j=1, 2, \dots, n\}$  be the set of criteria. The result of the pair-wise comparison on  $n$  criteria can be summarized in an  $(n \times n)$  evaluation matrix  $A$  in which every element  $a_{ij}$  ( $i, j=1, 2, \dots, n$ ) is the quotient of weights of the criteria, as shown in Eq. (A.1):

$$\begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} a_{ii} = 1, a_{ij} = \frac{1}{a_{ji}} \quad (\text{A.1})$$

where  $a_{11}$  represents the comparison between element  $i$  and element  $j$ .

At the final step, the mathematical process commences to normalize and identify the relative weights for each matrix. The relative weights are given as the eigenvector ( $W$ ) corresponding to the largest eigenvalue ( $\lambda_{max}$ ), as

$$A.W = \lambda_{max} W, \quad (A.2)$$

where  $\lambda_{max}$  = the maximum eigenvalue and  $W$  = eigenvector corresponding to  $\lambda_{max}$ .

If the pair-wise comparisons are consistent, the matrix  $A$  has rank  $n$  and  $\lambda_{max} = n$ . In this case, weights can be obtained by normalizing any of the rows or columns of  $A$ .

An important advantage of AHP over other algorithmic methods is that it takes into account inconsistencies in the preferences. Inconsistencies exist because of the redundant information relating to the priorities in each decision matrix. If the inconsistency exceeds 0.10, some revisions of judgments may be required. When the inconsistency ratios are below 10%, the decision matrices that are prepared for the criteria are consistent. The quality of the output of the AHP is strictly related to this consistency of the pair-wise comparison judgments. The consistency is defined by the relationship between the entries of  $A$ :  $a_{ij} \cdot a_{jk} = a_{ik}$ . The consistency index (CI) is

$$CI = (\lambda_{max} - n) / (n - 1), \quad (A.3)$$

where  $\lambda_{max}$  is the largest eigenvalue of the judgment matrix  $A$ , and  $n$  is the rank.

**Table 2. Random consistency index (RI) (Saaty 1988)**

Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

The final consistency ratio ( $CR$ ), which allows one to conclude whether the evaluations are sufficiently consistent, is calculated as the ratio of the CI and the random index (RI), as indicated in Eq. (A.4)

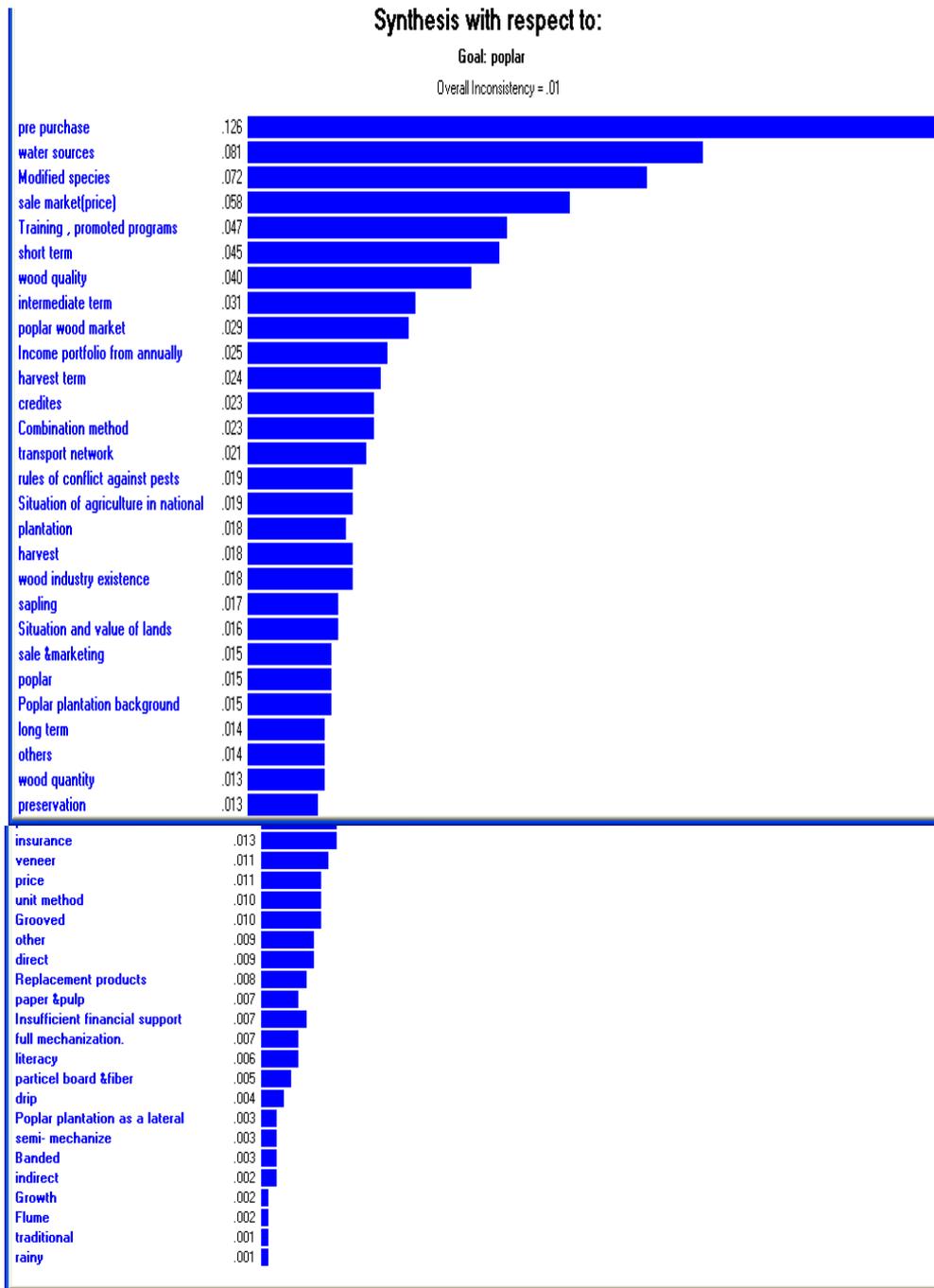
$$CR = CI / RI, \quad (A.4)$$

where the random index ( $RI$ ) is given in Table 2.

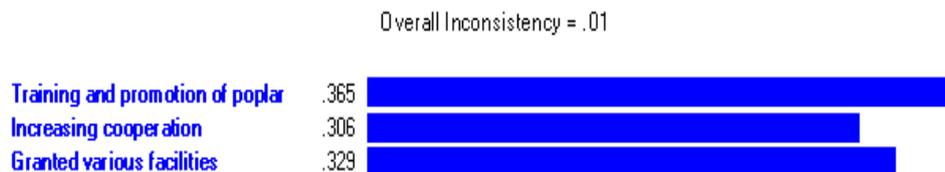
The consistency ratio ( $CR$ ) provides a measure of the probability that matrix ratings were randomly generated. A value of 0.1 is the accepted upper limit for  $CR$ . If the final consistency ratio exceeds this value, the evaluation procedure has to be repeated to improve the consistency of the respondent answers. In addition to its use in measuring the consistency of decision-making, the  $CR$  measure can also be used to evaluate the consistency of all the hierarchy (Wang, Yang, 2007). After the calculation of the priorities of each criterion with respect to the goal, the alternatives are re-evaluated against each criterion for all stages of the hierarchy.

## 5. Results

In this part results of priorities of criteria, alternatives and sensitivity analysis figures have been presented.



**Figure 2. Result of overall synthesize of criteria and sub criteria**



**Figure 3. Result of overall synthesize of alternatives**

## 6. Discussion

Synthesis of criteria and sub criteria priority: There are 51 sub-criteria in the fifth group. Some of them have high priority in poplar plantation development of Western and Eastern Azerbaijan. We describe their importance (figure 2). Pre-purchase of poplar wood (0.126): Pre-purchase is a period before making a purchase and is a guaranty for seller which the purchaser accepts to pay for a product before its completion. Pre-purchase is a kind of financial assistance to the producer which encourages producers and develops the product. Water resources (0.081): Water is a life material. Every country, to achieve sustainable development, needs programming for water resources to obtain maximum utilization. In Iran, water resource is a main limiter factor of agriculture development. Modified species (0.072): In Iran, poplar is planted in traditional form which has not useful output; some varieties or the utilization period are long term that cause discouragement of farmers toward poplar plantation. At present, varieties and species have been supplied which are utilized in short term and produce high quantity product in one hectare. Sell market (0.058): Although there is a shortage regarding wood resources in Iran, poplar has high applications in many fields. Poplar has good quality and provides many requirements of the factories. Therefore, poplar market is favored, and with an appropriate price, it has good purchasers. Training and promoted programs (0.047): Training and promoted programs have high effect on development of the industry. Compatibility of the programs with culture of community will have high efficiency on the industry. Short term utilization period (0.045): Poplar is cultivated in small distances about 1-2m for each tree, and after 4-6 years, it is harvested. This system is scientific and technical. Wood is produced in mass volume. The size of the produced wood is less than long term produced wood and is used in special consumptions including pulp and paper, packaging, paperboard, and so on. Among special regions with proper capability with respect to soil and water, this system has been concerned.

### Synthesis of alternatives priority

Result showing alternative (fig. 3): Training and promotion of poplar farmers using experiences of internal and foreign experts have highest priority (0.365). This alternative includes four sub-sections which are as follow:

1. Increase of scientific and technical knowledge of poplar farmers
2. Familiarity of poplar farmers with different applications of poplar wood in various ages and diameters
3. Introduction of limitative factors to poplar farmers by experts and familiarity of poplar farmers with problem solving methods regarding poplar plantation
4. Relation between propagator and poplar farmers

Granting various facilities (0.329) and increasing cooperation between manufacturers of wood and paper industries and investors with poplar farmers in poplar plantation (0.306) have the second and third priorities.

### Highest priority alternative discussion

Training and promotion of poplar farmers using experiences of internal and foreign experts' is the best solution for developing poplar plantation in Western and Eastern Azerbaijan provinces. As regards, the produced wood from poplar plantation can be used in several industries such as match factories, veneer, box making, particleboard, fiberboard, and paper making, some of these factories need high diameter wood, but some use low diameter wood. For this purpose, using short term utilization of poplar and application of the varieties that are proper for this kind of utilization (low diameter) can generate an impressive change in the industries. Generally, poplar farmers are not familiar with scientific methods of poplar plantation; the experts can familiarize farmers with new methods and new varieties of poplar which give rise to increase in production in unit area or one hectare. Poplar is a species that needs abundant water. Traditional irrigation decreases production in unit area, and the production needs enough water resources, so the farmers are concerned about this problem. Lack of training and promoted facilities regarding irrigation methods intensifies this situation. Regarding water supply, training and promotion of poplar farmers is a preferable solution. Training and promotion of poplar farmers using experiences of internal and foreign experts' alternative is an important solution for developing modified species of poplar. Poplar species has several varieties that poplar farmers are not well familiar with them, and required expertise regarding seedling and cultivated location have not been provided. Farmers have to know how modified species are compatible with agricultural activities and how market capacity will be in the region. Farmers have to consult with the experts of modified species to recognize proper and compatible poplars and estimate the proceeding and management practices, expected product, production costs, and market value for products.

Training and promotion of poplar farmers using experiences of internal and foreign experts' can be the best alternative for training and promoting programs. As regards most poplar farmers' familiarity with plant and

harvest of poplar, experiences of the experts will help them regarding increasing income and profitability. Training and promotion of poplar farmers using experiences of internal and foreign experts' is a preferable solution for familiarity of poplar farmers with qualities of poplar wood with respect to kind of consumption. Granted facilities help poplar farmers to protect poplar until the utilization age and exploitation of favorite logs. Most poplar trees which are planted in traditional form are developed to respond local needs and sometimes are opposite to industrial needs. As regards the advances which have been done in this field, the experts can direct poplar farmers to improve quality of these woods.

## 7. Sensitivity analysis

It can be shown that by increasing or decreasing the weight of one criterion the ratios of the weights of other three criteria (with respect to each other) remain unchanged, although the sum of their weights changes accordingly [Eq. (A.5)]. For example, if the weight of Social and Cultural criterion increases from 0.087 to 0.5, then the new weights of other groups of criteria will be as follows:

Application: 0.063, Economic and financial: 0.259, Technical: 0.129, Structural: 0.049. Although the sum of these weights is decreased to 0.5, they are proportional to the previous ones, that is, 0.114, 0.474, 0.235 and 0.090.

$$E + T + ST + A = 0.913 \quad \text{Total weight of criteria} \quad (\text{A.5})$$

E: Economic and financial, T: Technical, ST: Structural, A: Application

$$\frac{E}{0.913} = 0.519$$

$$0.519 = \frac{e}{(1-0.5)}$$

$$e = 0.259$$

e: New weight of Economic and financial.

Since there may be different judgments about the comparison of priority rates of main group of criteria or their sub-criteria, to achieve stability and compatibility of the analysis, we apply sensitivity analysis (Saaty, 2001). To perform sensitivity analysis, we apply Expert Choice software. The results are presented in Table 3. From Figure 4, the priorities are P>A>I. After changing the weights of one criterion, the priority of alternatives also change, as shown in Table 3. With respect to this table 3 economic and financial group is more sensitive than four other groups.

**Table 3. The results of sensitivity analysis. (Basic priority: P>A>I)**

Criterion	Basic Weight	New Weight	Number of changes	New Priorities
Application	0.114	0.538	1	P-I-A
Economic and financial	0.474	0.655 0.658 0.67	3	A-P-I A-I-P I-A-P
Social and cultural	0.087	-	0	P-A-I
Technical	0.235	0.101 0.052	2	P-I-A I-P-A
Structural	0.09	0.273 0.475	2	A-P-I A-I-P

P: Training and promotion of poplar farmers using experiences of internal and foreign experts

A: Granted various facilities

I: Increasing cooperation between manufacturers of wood and paper industries and investors with poplar farmers in poplar plantation

## Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at <http://dx.doi.org/10.14254/2223-3822.2016.14-1.6>

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## Attachment A

Description of criteria and sub criteria:

### A.1. Application group

#### Quality of poplar wood:

Poplar is a fast growing tree, and working on the wood is easy. Poplar can be used in several industries like paper making, matches, particle board, and so on.

**Quantity of poplar wood**

Poplar is a high capable species in a short-term. Annual average production of Northern forests in one hectare is 2.5m<sup>3</sup>. Production of poplar plantation can be developed more than 15-20m<sup>3</sup> in one hectare.

**Marketing of poplar wood**

Poplar is a main raw material to produce wooden products and an important factor in wood market share. Changes of demand and poplar supply, influence price and trade of poplar and replacement products.

**Consumer industries of poplar wood**

Consumers are divided into four industries: *paper making, fiber board industry, particleboard industry, plywood and veneer industry.*

**A.2. Economic and financial group**

This group is divided into four sub-criteria: Income, costs, utilization period, and replacement products and cooperative company of poplar plantation

**Income** is divided in two sub sections: *pre purchases* and *selling income*.

*Selling income* is divided into three sub sections which are as follows:

- *Selling market*
- *Income portfolio* of poplar plantation from annual income
- *Relation between producer and consumer*, the relation can be direct or indirect:

**Direct relation:** Farmers produce poplar with respect to industry requirements and obtain more income.

**Indirect relation:** Farmers have not any idea regarding consumer's needs and sell the product with unreal price and do not obtain real income.

**Costs:** Farmers have not financial ability and cannot pay costs of plantation; on the other hand, they cannot wait for a long time to obtain high income from poplar utilization. There are some costs of poplar plantation: costs of harvest, costs of preservation, costs of plantation, costs of credit, and costs of insurance.

**Utilization period:** the period is various and has been determined with respect to goal and consumption of produced wood. If distance of planting is less, then the volume of produced wood will be smaller and the utilization period gets shorter. The period is divided into three periods: short term, intermediate term and long term.

In *short term* period, the trees are 1-2 meters, and the harvest is after 4-6 years.

In *intermediate term*, the trees' harvest is after 6-10 years, and uses are for several purposes.

In *long term*, the farmers plant poplar in regular intervals and they harvest after 8-12 years. This utilization period is normal in different capable regions of Iran.

Replacement products: due to harvest period of poplar and agriculture part situation, motivation for poplar plantation decreases.

The return rate of wood farming profit and the poplar harvest rate are longer than agricultural products, so the farmers prefer other replacement products. There are three sub criteria: harvest period, price, and others.

**Harvest rate:** life cycle of agricultural products is one season or at most one year, but regarding poplar, it is at least 8 years.

**Price:** price increasing of poplar in comparison with other agricultural products is low, so its profit will be less than agricultural products.

**Other:** feasibility study of poplar plantation and other agricultural products shows that their economic situations are approximately equal for selection; nevertheless, long term return of poplar investment causes farmers prefer other products. They tend to receive annual wage otherwise they cannot wait to receive poplar plantation.

**Poplar plantation cooperative:** Cooperative in each region will help to solve the problem and encourage farmers to plant tree. Harvest, sapling production and sell, and marketing are the sub criteria.

**Harvest:** Powerful cooperative in harvest activities encourages the farmers for poplar plantation.

**Sapling production:** The cooperative helps to provide high quality and productivity of sapling which causes poplar plantation development.

**Sell and marketing:** The cooperative provides proper marketing and sends the product to the market and helps the farmers in selling.

**A.3. Social and cultural group**

There are four sub criteria: population, training programs, decrease of poplar plantation motivation, and native knowledge

**Population is divided into two sub criteria**

**Literacy level:** Illiteracy causes low productivity of farming process with respect to selection of species, plantation distance, irrigation methods, and so on.

**Population growth:** Increase of population and relative growth of wood industry especially in Western and Eastern Azerbaijan give rise to increasing trend of wood consumption. Today, traditional tree plantation is not acceptable regarding future requirements.

**Training programs:** Presentation of technical information regarding plantation, preservation, and harvesting causes participation of the people and development of plantation.

Decrease of motivation of poplar plantation is divided into two sub criteria: insufficient financial support and plantation as a lateral activity.

**Insufficient financial support:** The support system includes farming activities as wheat, rice, barley, and so on; however, poplar and other wood plantation exclude supports from government.

The supports are kinds of subsidies similar to free or cheap seed, fertilizer, poison, and low-interest loans which guarantee the purchase of insurance.

**Plantation as a lateral activity:** Most farmers have agricultural lands, fruit orchards and other economic activities, and the poplar plantation is not a main activity.

**Native knowledge:** Native knowledge brings about the product development. There are two sub criteria: poplar and replacement products.

**Poplar:** *Populus alba* and *Populus nigra* are the main species of poplar in Western and Eastern Azerbaijan, and poplar plantation has a good background in the provinces. People have a good familiarity in poplar farming, preservation, and harvest.

**Replacement products:** Products such as wheat, barley, alfalfa, and pea are replacement products of poplar in the region and have been localized.

**A.4. Technical group**

Technical group has four criteria: proper harvest method, modified species, plantation method, and water providing.

**Proper harvest method:** the method depends on social, economic, and technical status of the region. It is necessary to apply machines and mechanical equipments for improving the product, and then the selection and management of required machines will be reasonable. There are three kinds of harvest methods: traditional, semi mechanization, and full mechanization.

**Traditional:** This method is ancient and traditional and all of the operation is accomplished by work force. In this method, income is low and harvest takes a long time.

**Semi mechanization:** This method is a combination of traditional and mechanization harvest methods which can be done by man force and power of engine. Generally, heavy activities are done by power of engine, and management and control use man force.

**Mechanization:** Applying mechanization and new equipments will have high productivity; however, the farmers cannot use it because it needs high liquidity.

**Modified species:** Development of modified colonies of fast growth species increases production, decreases harvest period, and results in good income. Introduction of modified colonies and species with economic production of less than 10 years and compatible with different regions of Iran is possible. Cooperation between research centers and executive organizations can be effective on this field.

**Plantation methods:****Combination method:**

Plantation with poplar species and one or several years plants as a combination is an appropriate solution for wood production and annual harvest of lands. In the combination method, distance of plantation is important. For maximum utilization of the land and income resources of farmers, poplar plantation can be done in distance and cultivate agricultural products between the tress.

**Unit plantation:**

Almost poplars are cultivated as pure and take a long time to be harvested. In this cultivation, plantation distance is important, and low distance causes low diameter of the tree; on the contrary, in high distance, volume of the tree will be more, but the quantity of wood per hectare is low. Researches show that cultivation distance of 1\*3m<sup>2</sup> is proper, and farmers can obtain income from one year agricultural products for 3-4 years and give rise to decrease of preservation costs.

**Water providing:**

Water provision is vital in poplar plantation. There are different methods to supply water that a farmer has to select the best.

**Water resources:** Water in any region contributes to the region's development. Water is a main resource for agriculture.

**Irrigation methods:** Limitation of water resources makes countries use new methods of irrigation thereby increase of agricultural products in one hectare and maximum productivity of soil and water. There are two methods of irrigation:

**Under pressure method:**

One of the advanced methods to increase irrigation productivity is under pressure irrigation. This system is divided into two methods: rainy and drip irrigation.

*Under pressure, rainy:* water is sprayed on the product via under pressure pipes in drop and dust forms.

*Under pressure, drip:* water is shed under the plant via under pressure pipes in drop form.

**Weighed method:**

Weighed method has three sub criteria or three sub sections:

**Banded method:** banded irrigation is a developed form of flume irrigation. Lands are divided into sloping grounds and form rectangular and align.

**Grooved method:** Land is grooved into furrow form. Depth of furrow is 20cm. The length of the furrow depends on ground slop, soil structure, size, and the form of the farm.

**Flume method:** One of the normal irrigation methods is flume or flooding. Farm is divided into different parts, and every part is smoothed separately. Plantation and irrigation are done in each part.

Application of appropriate rules of conflict against pests:

Pests are the most important factors of damage in poplar plantation. Use of combination method can be effective in this conflict, also recognizing proper poplar species and varieties can be considered in plantation.

## A.5. Structural criteria group

Transportation network, poplar plantation background, wood and paper industries, situation and value of lands, and situation of agriculture in national and provincial level are the criteria in this group.

**Transportation network:** High volume of wood industries requirements is carried out by road transportation. There is a limitation of transportation capacity in this network which gives rise to cost increase of purchased wood. Accordingly, closeness of wood industries factories to poplar wood resources causes decrease of transportation cost regarding transfer of the wood to the factories.

**Poplar plantation background:** Poplar plantation has had a long time background in Western and Eastern Azerbaijan where have vast capable regions. Rivers, spring, and permanent flumes in mountainous regions of the provinces give rise to poplar cultivation in the lands. Poplar plantation is common near the rivers and farms and is an income resource in emergency conditions which also solves wood requirements' problem in different urban and rural regions.

**Wood industries:**

Iran has capable regions regarding existence of abundant wood resources where wood industries can be established especially in North Western of the country where there are abundant poplar wood resources. Western and Eastern Azerbaijan give rise to development of poplar plantation due to the existence of match factories, paper box factories, paper making, and so on.

**Situation and value of lands:**

In the provinces there are many lands which can be allocated to poplar cultivation. Lands include river costs and full water valleys that are favorable for wood plantation.

**Situation of agriculture in national and provincial level:**

Agriculture in Iran is a custom and most agricultural lands are in small areas. Agriculture in Iran has not been well mechanized, also in the provinces; the lands are in their traditional form and carried out in small grounds.



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