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Sustainable Management of Saravan Sylvan Park Using Stochastic Dynamic Programming

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Abstract

The present study sustainable management of Guilan Saravan Sylvan Park was planned. The used method in the form of decision support model in three10-year period was studied for parks of various states and with considering the economic, ecological and social criteria during the years 2008 to 2038. By using hierarchical fuzzy analysis method, the reaching to an optimal level of economic, ecological and social simultaneously and as their combined utility values in various periods, decisions and different states of park is obtained. The results showed that in order to reach to an optimal level of purposes simultaneously, at the beginning of the first 10-year period implementation of ecological decision, at the beginning of the second 10 years period in three considered states for the Sylvan Park implementation of social, ecological and ecological decisions give the most combined utility value of purposes respectively. Results of stochastic dynamic programming showed that implementing the ecological decisions at the beginning of the first 10-year period, implementing the ecological decision by considering the second designed state of park at the beginning of the second 10-year period, and by applying the first designed state of park at the beginning of third 10-year-old period, the implementation of social decisions is desirable to achieve sustainable management in Saravan Sylvan Park. According to the findings, the implementation of these determined decisions can be useful and maximum of desirable use from Park potentials in the economic, social - recreational and conservation and sustainability of indigenous species problems, and reposit the park to the next generation with the best condition.

Keywords:
Decision Support Model, Sustainable Management, Guilan Saravan Sylvan Park

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INTRODUCTION

Forests as part of the renewable natural resources have a major role in a coordinated economic development in the country and run the program properly, which requires enough knowledge of these resources, the potential can be brought into action and show the share of these resources in the national economy fructification as well. Large part of the Iran's natural resources is unused or non-normative used. While the different experiences have shown that they can become sustainable income-causing sources, with proper planning, study and application, and the participation of all involved factors (Gorgin kargi, 2004). Recognizing the importance of forests and their effects on human survival, caused widespread international efforts to plan for sustainable conservation of these natural resources. Considering the limited surface of forests in Iran compared to world average, and severe degradation of forests, especially in recent years, and natural disasters such as floods and droughts caused by the destruction of forests, the necessity of planning is felt more than ever. The program should also imply sustainable life of these resources in long time in addition to providing the economic, social, current generation environmental needs (Safi Samghabadi, 2004). Sustainable exploitation of natural resources requires protecting. In the field of biodiversity conservation and its role in global scale area and regional, different countries have provided special mechanisms for forest management and biodiversity conservation according to the type, extent and their economic importance, (Pilevar, 2007). Criteria and indicators tool for defining, monitoring and evaluation of movement towards sustainable forest management are considered. The term and concept of criteria or principles representing the main condition for stability that can be produced according to the role and social protection of forests shall be judged. Each criterion which has several qualitative and quantitative indicators for measuring and monitoring the consecutive regularly are measured to be determined the effects of forest management. Criteria and indicators of sustainable forest management at the national level may affect the organization of forest policy and forest laws. Currently, almost all countries worldwide in different areas implemented and applied ecological criteria and indicators of sustainable forest management at the national level before preparing in cooperation with FAO and other international agencies (Kokou *et al*., 2007). From 1992 the relevant authorities have equipped mentioned Forest Park and walk in order to create healthy, outing in Guilan Province. Besides regional ecological power have used for the establishment and growth of native species and have provided the conditions so that the native species grow widely (Kahraman *et al*., 2008). Saravan Forest Park includes a part of the low-altitude forests of the northern Alborz province in the southwest Guilan. Topography consists of low elevation portion of Forest Hill Saravan, valleys and streams and several seasonal springs those were the most important and are known springs Deer Valley that in current situation its water is used for drinking and sanitary purposes in the park. The current plant species in the region are, a part related to the years 1984 to 1995 and other part related to years after 1978 (RFU, 2008). Natural Forest Area and transplantation forest in Sylvan Park are 959 and 351/5 hectare respectively. This park includes13 tree species (two main types and 11 types of minor) such as: species of hornbeam, evangelical, oak, alder and needle leaves. In this park there are 13 animal species and 24 bird species.

Forest Park has also features which create Saravan route, and old buildings and historic sites for tourism and promote regional economic power (RFU, 2008). Consider the importance of the park due to proximity to the center of Guilan Province, the value above outing, large size, diversity of plant and animal species, the rivers, providing water for agricultural lands and the area, clean and healthy environment, managing the use and Stable benefit so that taking the needs of current and future generations is very high significance.

In the field of sustainable management and planning and management models, many studies have been conducted. (Iliadis, 2005), applied decision support system in combination with the fuzzy model to estimate risk and risk of long-range forest fires. The results showed that fuzzy methods offers valid and flexible concept that can be used with an appropriate decision-making system. (Chen and Fu, 2005) began to combine fuzzy duplicate model with dynamic programming to solve multiple objectives of multi-stage problems decisions. Seely *et al.* (2004), studied the multiple objective management assessment strategies of forest with applying hierarchical method of decision support system for the 288 thousand hectares of forest in northwestern Colombia. Kotwal *et al.*, (2007) expressed ecological indicators as necessary for forest sustainable management in India. This study has provided a review method of forest sustainable resources management. Kokangul and Susuz (2009), combining hierarchical analysis and mathematical programming were studied in supplier of choice problem with a quantity discount. Ming Wang and Sang chin (2008), have used the linear goal programming priority method for fuzzy hierarchical approach and their applications determine to test new products. Schweickarad and Miranda (2007), review Fuzzy dynamic programming approach toand evaluate the development of costsdistribution in non-categorical and unknown environments. Sheppard and Meitner (2006) used the method of multiple criteria analysis to program sustainable forest management. Based on the results and assessment of participants, methods were expressed effectively as a supportive tool for decision making in the contradictory region Maness and Farrell (2006), studied multi-objective scenario evaluation model for sustainable forest management using criteria and indicators. Balteiro and Romero (2008), forestry decisions examined the existence of several criteria. Balteiro and Romero (2007), examined the use of multiple criteria decision making in forest programming.

Therefore in this study to achieve sustainable management of Forest Park Saravan of Guilan, decision support model was used. Thus for this combination of multiple objective dynamic programming and fuzzy hierarchical approach to sustainable utilization of Forest Park Saravan with three objectives in considering the economic, ecological and social aspects of use and quality and quantity management in the Forest Park and in terms of modeling optimal decisions ultimately prioritized in any period of time were also tested.

MATERIALS AND METHODS

Dynamic programming model expressed in the form of Decision Support Model in this study includes major components, stage programming (time periods), state variables (state of Sylvan Park), decisions and goals. Stages, including three periods of 10 years (n=0, 10, 20 and 30) n=0: start of period of 10 years, n=10: the end of first period of 10 years and n=30: the end of third period of 10-years of management programming. Also the state vectors in the model (the Sylvan Park current state) include the total area of Sylvan Park, an area of plantation region, the number of tree and animal species, state visits, recreational facilities and ecological conditions which were shown with $S_1, S_2, S_3, ... S_9$ parameters. Any Period includes a state vector (Sylvan Park state) represented with $\underline{X}(0, j=1) = \underline{X}(0, s_1, s_2, ... s_9)$ (ZadnikStirn, 2006).

A certain numeric value cannot be determined for some state variables or parameters therefore, the fuzzy logic was used to determine these

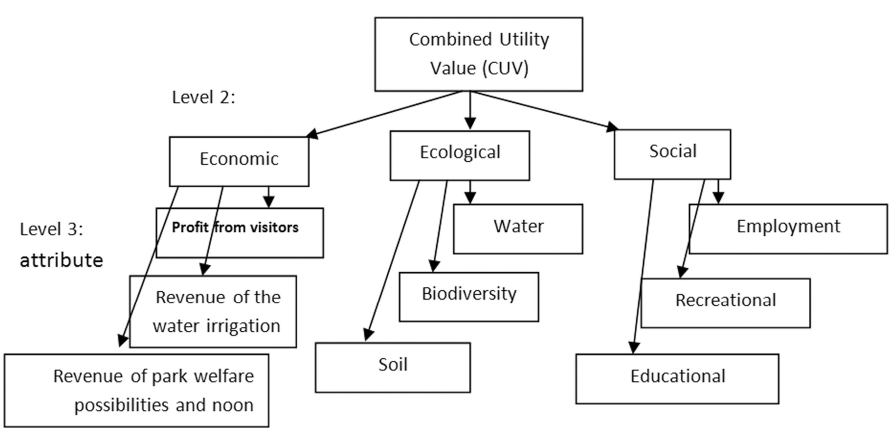

Figure 1: Hierarchy of goals and attributes for combined utility value.

Table 1: Interpretation of entities in a Pair-wise Comparison Matrix.

Value of *aij*	Interpretation
1	Objectives i and j have equal importance
3	Objective i is weakly more important than objective j
5	Experience and judgment indicate that objective i is strongly more important than objective j
7	Objective i is very strongly or demonstrably more important than objective j
9	Objective i is absolutely more important than objective j
2,4,6,8	Intermediate values

Source: Saaty (1980)

numbers. For this purpose, questionnaires were designed and represented to three group; indigenous people, experts and park visitors. Thought of people about Status Quality parameters of Saravan Sylvan Park were expressed with the numbers of 1 to 9 (for 1, 3, 5, 7 and 9) and their intermediate numbers (i.e. 2, 4, 6 and 8) for intermediate values (Kahraman, 2008).

Thus, using fuzzy Analysis Hierarchical Process (FAHP) achieving the overall aim of maximum value of criteria combined utility value was studied at three levels. Three levels include objective, criteria respectively that the direct method cannot determine its value and are determined based on factors or characteristics (fuzzy parameters) expressed in the third level. According to figure 1. In this model, have been compared the desired criteria at different levels with criteria at the higher level and after paired comparisons they have been placed in a structure of Hierarchy according to importance degree. The data have been presented as the quantity form and have been set in the matrix form (Table 1). This matrix used for producing a relative scale among data and for comparing and choosing alternatives. In this way, the problem was determined in the form of a decision tree and the equity value for criteria has been calculated (Kahraman, 2008).

The model hierarchical structure is shown in Figure 1. As can be observed for any of the criteria of economic, ecological and social considered to model, three factors were found in the third level of hierarchical tree method. Considering the capabilities of Sylvan Park because of water resources and free recreation use of Sylvan Park, according to idea of Sylvan Park experts, setting inconspicuous entrance for visitors, revenue from water use in agricultural, revenue of welfare facilities and Non-timber productions in the park, were considered as attributes to achieve purpose of the economic using of the Park. How to use the park properly and introduction of plant and animal species have been expressed in the form of Aspect of educational possibilities for the park to reach the social goal, due to employment creation, by developing Sylvan Park and increasing the number of visitors, travelers and people and their comfort by providing and improving recreation possibilities and increasing contacts, socializing and culture of people and considering to climate and Park Possession of dangerous wild animals and valley. Furthermore, improving water quality (especially Siahrood river water quality for fish nurture), increasing and conserving plant and animal species, increasing the protected area and conservation of soil was considered as attribute related to promoting Ecological criteria.

In decision support model represented, three decision variables were considered in different state. d_1: Investment decision variable (Economic Decision), d_2, Decision variable of forest conservation and sustainability (ecological decision) and d_3, decision variable in relation to the social objective (proper recreation facilities, the use of the natural aspects of the park). The three criteria are economic, ecological and social criteria. To reach the maximum of the criterion in form of overall goals during three time periods of 10 years simultaneously, decision variables and state defined should maximized the value of criteria Combined Utility Value. So, at first using Fuzzy Hierarchical Process in every state and decision, for example the state $\underline{x}(0, j=1)$ and economic decision (d_l) based on weighting and paired comparisons and triangular fuzzy membership function have been obtained the value I_k for each criterion, and ultimately the Combined Utility Value (CUV) for this state and decision. According to the study of dynamic, this action for all desired states and Decisions had been repeated until Combined Utility Value of these three criteria to be obtained in each transition from one state to the next state simultaneously (ZadnikStirn, 2006).

Equation (1) shows that transfer function vector (decision transfer of a state and time to the next state and time) has been obtained experimentally. Also Equations 3, 4 and 5 express the cumulative effects of factors $t_{(k)}$ on the criterion k, fuzziness membership function and value of criteria Combined Utility Value respectively. α, β Parameters in the following equation are indicating limited value of characteristics considering to state x, based on the questionnaire. k = criteria, $t_{(k)}$ = factors and V_k = criteria weight. W_x= weights for all $t_{(k)}$ based on factors Paired comparisons $t_{(k)}$, are calculated and normalized according to AHP, to be placed their scale between zero and one. Equation $\sum_{t(k)} w_{x,t(k)} = 1$ should be established in the model too. Also, for determining consistency Ratio in the AHP method that shows obtained priorities confidence level (weights), was used the following equation.

$$CR = C.I/R.I \quad (1)$$

The *R.Iare* in Table 2 that was determined based on dimension of matrix *(n)*. C.I after normalizing the numbers and getting the λ_{max} calculated according to the following formula.

$$C.I = \lambda_{max} - n/n-1 \quad (2)$$

N is the number of rows or columns of the matrix (Darabi, 1993 and Kahraman *et al*., 2008).

If the C.R is gained less than 0.1 based on experience. It is acceptable consistency. But if C.R is more than 0.1 comparisons must be done again (Darabi, 1993).

$$\underline{x}(n+1, j^*) = f(\underline{x}(n, j), d(m, \underline{x}(n, j))) \quad (3)$$

$$I_k = \sum_{t(k)} w_{x,t(k)} \mu_{x,t(k)} \quad (4)$$

$$\mu_x = \begin{bmatrix} 0 \ for x \prec \alpha \\ 1 - \dfrac{\beta - x}{\beta - \alpha} \ for \ \alpha \le x \le \beta \\ 0 \ for x \succ \beta \end{bmatrix} \quad (5)$$

Multi-objective dynamic programming method showed in Eq.(7) for achieving optimum management shows maximizing value of Combined Utility Value of economic, ecological and social criteria subject to the limited decision in the transition from one state to the next state. Also by drawing a network of state drawn inside the circle, decision line to connect a state to the next state, and using the Bellman returns equation, it is used to reach optimal decisions in any state subject to the maximum distance of the final state off the target state is zero. As a result optimal decision in each state and each stage can be determined which is expressed as follow (ZadnikStirn, 2006).

Table 2: R.I the numbers based on the number of rows or columns of the matrix.

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
R.I	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

Source: Asgharpour (1998)

Table 3: Statistical results of economic decisions in 2008 $\underline{x}(0, j=1)/d_1$

Decision attribute	d_1 (x)	α	β	μ(x)/d_1
Profit from the visitors entrance	3.15	2.3	4.28	0.43
Proceeds from the water supply for agriculture	3.68	1.6	4.65	0.69
Income from non-wood products facilities and parks	3.75	1.9	4.4	0.74
Water quality	3.85	2.24	4.25	0.76
Biodiversity	4	2.45	4.36	0.82
Soil protection	3.15	1.98	4.18	0.54
Employment possibilities	3.25	2.11	3.98	0.61
Recreational facilities	3.98	2.75	4.2	0.85
Educational and Cultural Facilities	3.6	2.75	3.86	0.77

Source: Asgharpour (1998)

$$g(x\_(n,j)) = \max_{\text{all connections from } x\_(n,j) \text{ to } x\_(n+1,j^*)} (g(x\_(n+1,j^*)) + CUV(x\_(n,j),x\_(n+1,j^*),d(m,x\_(n,j))); \quad (7)$$
$$n = N-1, N-2, ...0,$$
$$and \quad g(x\_(N,j^{**})) = 0$$

$g(x\_(N,j^*))$ Is expressing the maximum distance between the final state and the target state.

Objective function considered in the dynamic programming model was defined, based on the Bellman optimal equation, as the Eq (8) in this study:

$$\max \sum_{t=0}^{T-1} U_t(x_t, v_t) + S(x_T)$$
$$\begin{Bmatrix} v_t; t = 0,1,......T-1 \\ v_t \in \Omega \end{Bmatrix}$$
$$Subject.to$$
$$i) \quad x_{t+1}^i = G_t^i(x_t, v_t)$$
$$\forall i = 1.......n$$
$$t = 0,....,T-1 \quad (8)$$
$$ii) \quad x_0^i = \overline{x}_0^i$$
$$given \quad \forall i = 1.......n$$

In the above equation, x_t is state vector (state) in a given time, v_t is vector of decision variables(control) which Is determined by the decision maker in each period, U(0) is the objective function that in general is a function of all the states and decisions in each period (stage), G (.) A series of internal constraints and interconnected of the decisions and state variables and is defined as a limited set of possible decision variables (Dreyfus, 2002). Formulation of question in "Stochastic Dynamic Programming "(SDP) with limited number of stages, are in this study as follow generally.

$$\underset{D_t}{Max} \underset{K_t}{E}\left[\sum_{t=1}^{T} R_t\{I_t, D_t, K_t\} + F\{I_{T+1}\}\right] \quad (9)$$
$$for \quad I_1 \quad given, \quad I_{t+1} = w_t\{I_t, D_t, K_t\}$$

T= Stage number, =State number,

D_t = Decision number,

$R_t\{I_t, D_t\}$ =Return stage,

$W_t\{I_t, D_t\}$= Transfer state and $F\{I_{T+1}\}$ = Final value of state.

K_t =Number of stochastic events, $R_t\{I_t,D_t,K_t\}$ = Stochastic recursion and

$W_t\{I_t,D_t,K_t\}$= Stochastic transition (Kennedy, 1986).

RESULTS

Analysis attributes (values x) were obtained for the state, different time periods and economic, ecological and social decisions based on analysis of questionnaires as samples results of the first state and economic decisions in the first 10 years period and $x(0, j=1)/d_1$ is shown in Table3. α,β Show the values of the attributes considering the lowest and highest observed value result of the questionnaire. In addition, $\mu(x)$ has been obtained based one equation (5) for every decision. $\mu(x)$ Or membership function for each attribute shows suitable attribute level for the purpose or criteria. According to Table 3, maximum and minimum observed values of each attribute can be obtained with economic decision in 2008. Also in this period it will be observed that with regard to economic decision, membership function for the revenue of welfare possibility and sale of non-wood products showed the highest value in compared to two other attribute of economic decision and imply the more importance of these attribute to achieve desirable economic criterion level and implement the relevant decisions. Therefore, it is necessary that the furnishing of welfare possibility be considered in Sylvan Park future plans. Most of those respondents expressed unwillingness to pay entrance fee for park by which economic desirable level of Park is raised so the benefits from the park entrance fee have less importance in achieving economic goal. Also, applying economic decision, values of membership functions were determined for attributes ecological and social criteria, to achieve combined Utility level of all three economic, ecological and social criteria. Biodiversity and recreational facilities were most appropriate attribute to reach the desired level of ecological and social criteria respectively with implying economic decision.

Matrix of criteria and factors paired comparisons was determined in the different states, stages and decisions of the formation and weight (priority) of each criterion. For example, paired comparisons with related criteria in the first period (beginning of period 10 years) and comparing the factors of economic criteria for current

Table4: Paired comparisons with related standards $\underline{x}(0, j = 1) / d_1$

Criterion	Economic	Ecological	Social	Weights
Economic	1	1/4	1/6	0.09
Ecological	4	1	1/3	0.27
Social	6	3	1	0.64
λ_{max}=3.06			C.I=0.03	

Table 5. Comparison of factors than the economic criteria in $\underline{x}(0, j = 1) / d_1$

Ration to economic criterion	Economic	Ecological	Social	Weights
Income of admission	1	1/4	1/3	0.13
Water income for agricultural	4	1	1/4	0.28
Income of welfare possibilities	3	4	1	0.59
λ_{max} =3.2			C.I=0.1	

state in Sylvan Park and economic decision are shown in Table 4 and 5. Numbers of each cell of this table represents a criterion priority over another, according to the time, decision and considers the state in the dynamic programming model to achieve the desired goal.

Weight or criteria priority *(γ_k)* and factors *(W_x)* are shown in the different states and time periods according to different decisions in the Table (6) to (9). Although x_ (0, j = 1) to x_ (20, j = 2), expresses state first at the beginning of first period of 10 years (start planning) and second state at the end of 10-year-third respectively.

As observed in the tables 6 to 9. Prioritize (weights) related to paired comparisons of criteria and factors related to any criteria in time, certain state and decisions have been determined using Hierarchical process and represent weight or Degree of importance of each factor for the relevant criteria and the ultimate goal. According to the obtained weights, determined Combined Utility Value is shown in the Table 10.

According to the table 10, at the beginning of the first 10-year period implementing ecological decision shows the most Combined Utility Value due to greater attention to social aspects

Table 6: prioritization criteria in different states and decisions *d_1, d_2, d_3*

Decision	*d1*			*d2*			*d3*		
Criteria / State	Economical	Ecological	Social	Economical	Ecological	Social	Economical	Ecological	Social
$\underline{x}(0, j = 1)$	0.25	0.59	0.16	0.07	0.63	0.3	0.09	0.28	0.62
$\underline{x}(10, j = 1)$	0.26	0.61	0.127	0.1	0.68	0.22	0.08	0.28	0.63
$\underline{x}(10, j = 2)$	0.51	0.33	0.16	0.21	0.73	0.06	0.09	0.28	0.62
$\underline{x}(10, j = 3)$	0.68	0.25	0.06	0.2	0.71	0.08	0.08	0.3	0.6
$\underline{x}(20, j = 1)$	0.6	0.26	0.14	0.09	0.7	0.2	0.07	0.71	0.22
$\underline{x}(20, j = 2)$	0.12	0.64	0.24	0.07	0.71	0.217	0.09	0.69	0.22

Table7: Factors Prioritize toward economic criteria in different stats and decisions *d_1, d_2, d_3*

Decision	*d1*			*d2*			*d3*		
Criteria / State	Income of admission	Income of water for agricul-tural	Income of welfare possibili-ties	Income of admis-sion	Income of water for agri-cultural	Income of welfare possibili-ties	Income of admis-sion	Income of water for agri-cultural	Income of welfare possibili-ties
$\underline{x}(0, j = 1)$	0.25	0.59	0.16	0.07	0.63	0.3	0.09	0.28	0.62
$\underline{x}(10, j = 1)$	0.26	0.61	0.127	0.1	0.68	0.22	0.08	0.28	0.63
$\underline{x}(10, j = 2)$	0.51	0.33	0.16	0.21	0.73	0.06	0.09	0.28	0.62
$\underline{x}(10, j = 3)$	0.68	0.25	0.06	0.2	0.71	0.08	0.08	0.3	0.6
$\underline{x}(20, j = 1)$	0.6	0.26	0.14	0.09	0.7	0.2	0.07	0.71	0.22
$\underline{x}(20, j = 2)$	0.12	0.64	0.24	0.07	0.71	0.217	0.09	0.69	0.22

Table 8: Factors Prioritize toward ecological criteria in different stats and decisions d_1, d_2, d_3

Decision	d1			d2			d3		
Criteria / State	Water quality	Bio diversity	Soil protection	Water quality	Bio diversity	Soil protection	Water quality	Bio diversity	Soil protection
$\underline{x}(0, j=1)$	0.59	0.29	0.1	0.62	0.28	0.09	0.58	0.3	0.12
$\underline{x}(10, j=1)$	0.22	0.71	0.07	0.22	0.7	0.1	0.62	0.28	0.09
$\underline{x}(10, j=2)$	0.28	0.62	0.09	0.24	0.06	0.69	0.22	0.69	0.09
$\underline{x}(10, j=3)$	0.65	0.27	0.08	0.05	0.21	0.73	0.33	0.57	0.1
$\underline{x}(20, j=1)$	0.25	0.67	0.07	0.19	0.69	0.14	0.24	0.7	0.06
$\underline{x}(20, j=2)$	0.22	0.69	0.09	0.05	0.24	0.7	0.12	0.3	0.58

Table 9: Factors Prioritize toward social criteria in different stats and decisions d_1, d_2, d_3

Decision	d1			d2			d3		
Criteria / State	Employment	Social-Recreation	Cultural	Employment	Social-Recreation	Cultural	Employment	Social-Recreation	Cultural
$\underline{x}(0, j=1)$	0.12	0.66	0.22	0.22	0.7	0.07	0.18	0.75	0.06
$\underline{x}(10, j=1)$	0.72	0.22	0.05	0.21	0.12	0.67	0.73	0.2	0.05
$\underline{x}(10, j=2)$	0.62	0.28	0.09	0.07	0.73	0.19	0.27	0.65	0.08
$\underline{x}(10, j=3)$	0.21	0.73	0.05	0.05	0.74	0.2	0.28	0.63	0.08
$\underline{x}(20, j=1)$	0.62	0.29	0.09	0.1	0.23	0.67	0.22	0.72	0.05
$\underline{x}(20, j=2)$	0.65	0.25	0.09	0.07	0.71	0.22	0.08	0.22	0.7

Table10: Combined Utility Value targets in the different conditions, time periods and decisions d_1, d_2, d_3

Combined Utility Value			
Decision / State	d1	d2	d3
$\underline{x}(0, j=1)$	0.72	0.86	0.75
$\underline{x}(10, j=1)$	0.57	0.47	0.7
$\underline{x}(10, j=2)$	0.38	0.66	0.47
$\underline{x}(10, j=3)$	0.62	0.75	0.47
$\underline{x}(20, j=1)$	0.44	0.59	0.55
$\underline{x}(20, j=2)$	0.41	0.69	0.45

of parks and of the gradual loss of its ecological aspects. At the beginning of second10-year period and first with state park, three decisions, social, ecological, and ecological value of the most desirable combination have been showed. Ten year period beginning in the third to first and second respectively in the state, social and ecological decision to implement the most desirable combination of value shad goals. The data, in fact, part of Input data in to dynamic scheduling software designed based on dynamic programming model, optimized decisions in any period of time and optimal route planning will be set for the period.

Using the built model have been obtained, the answer of Dynamic Programming for 3 stages and discount rate of 0,witha maximum of three states in each stage and10-year periods interval. Results from solving deterministic dynamic programming model are shown in the table 5. According to the table, the state and optimal decisions were obtained in each period for the Saravan Sylvan Park of Guilan implying Stochastic Dynamic Programming model.

Results show that at the beginning of the first10-year period, optimal decisions ecological decision that showed most Present value of economic, ecological and social criteria obtained the considered appropriate Combined Utility Value in this period. At the beginning of second 10 years, second state was obtained as desirable state Park and optimum decision is the perform-

Table 11: Different optimal decisions in different stages of implementation of Stochastic dynamicPlanning

Stage	State	Decision	Return stage (Combined utility value)	Expected value
Third stage	1	Social	0.78	0.78
	2	Ecological	0.73	0.73
	3	Economical	0	0
Second stage	1	Social	0.70	1.45
	2	Ecological	0.66	1.41
	3	Ecological	0.75	1.50
First stage	1	Ecological	0.86	2.32
	2	Economic	0	0
	3	Economic	0	0

ance ecological decision. Also at the beginning of third 10 years the first state of park and social decision was shown as most desirable state and decision for the next 10 years programming. At the end of the third10-years period that is the final year programming. Combined Utility Value has been represented as a distance value of the target year that considering it as Target year, determined zero value for it.

Since the plan for Sylvan Park has been considered, procedures, conditions and decisions can be determined for the future and the percentage of chance might be a more of a status decision on next steps to go (In other words, each Decision may be causing another situation in next time periods.) Thus the stochastic dynamic programming model may be a better approach for randomly determining optimal decisions made in the made model, because of the possibility of a percentage point to reach out and create the next state then, sustainable management of Saravan Sylvan Park. In designed model any decision was considered with a 0.5 chance of causing two next situations in each time period. Optimal decisions obtained from the results of stochastic dynamic programming model are shown in Table 11. According to the table seen in the first, second and third situation at the beginning of the third 10-year period (third stage), respectively, social, ecological and economical decisions are the most desirable and most optimal decisions. In this course the most appropriate situation and decision are the first situation of Sylvan Park and social de-

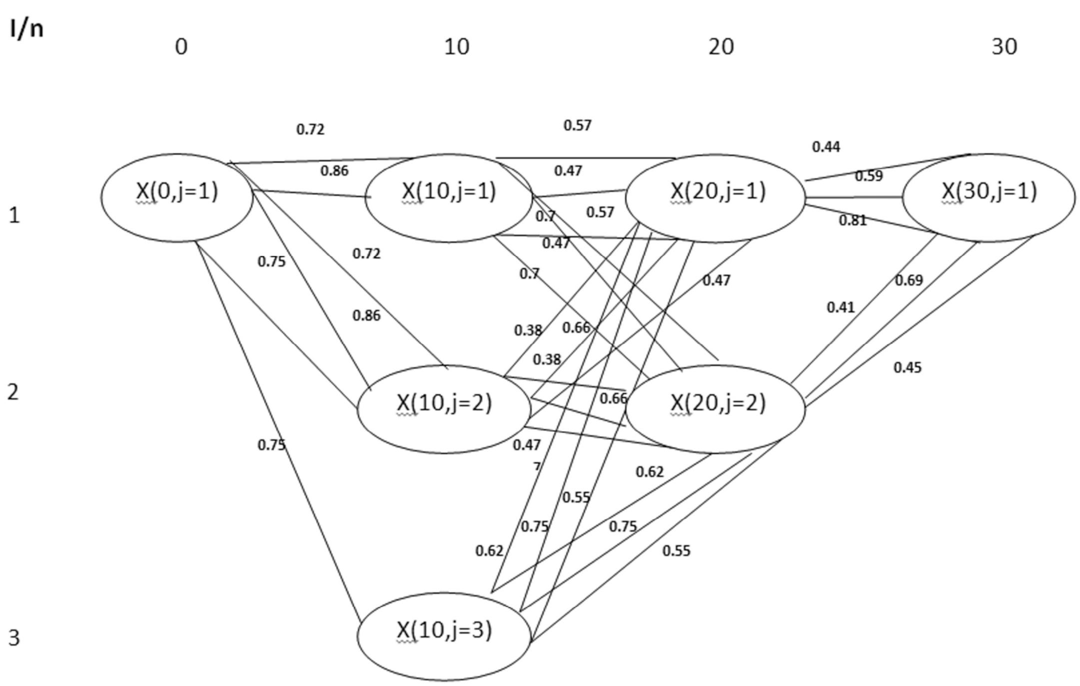

Figure 2: Network Design for Path Expression optimal decisions in stochastic dynamic multi-objective programming method.

cision. In the second stage of planning in the first, second, and third states, social, ecological and ecological decisions are optimal, respectively. In this period, ecological decision performance showed maximum combined utility value in third state of Sylvan Park. In the first stage of the programming ecological decision was shown the best decision for achieving sustainable management of the park. The results showed that too much attention to the social aspects of Sylvan Park have caused the loss of many native plant and animal species of the area in recent years, that in the first stage ,for receiving sustainable management in the park should be done to economic, social and ecological Aspects of the park with ecological decisions. This process continues to begin third stage. Social decision was optimized in the third stage performance due to the realization of park ecological criterion and highest expect value has been showed for the sustainable management in Saravan Sylvan Park.

Since this study, for solving a dynamic programming model used Bellman returns equation method. Considering the situation and considering the optimal decisions at the end of the third10-years period for beginning the first10-year period, the total amount of present value for the Saravan Sylvan Park of Guilan was 2.3 that compared to the implementation of decisions and the other status at the highest level.

Also, diagram of optimal decisions path in total programming period (network Dynamic programming) in the study area, is shown in Figure 2, according to results of stochastic dynamic programming model.

In this figure, states considered for study have been expressed within the circle. The numbers on the lines that connect two circles (the state) together represents combined utility value with performing any decision. In the figure 2, optimization decisions were marked with barb during the considered period and as recursive equation of third period to the beginning of the first programming period, as the optimal decisions are with d_3 (social decisions), d_2 (ecological decisions) and d_2 (ecological decisions) in each period.

CONCLUSIONS

In the present study, Decision Support Model has been built for sustainable management of Guilan Saravan slyvan Park. Hierarchical Analysis method was done for all periods, states and decisions considered for dynamic programming model, the combined utility value of all three criteria has been obtained in any period of time, state and decision simultaneously and for determining the state and optimal decisions in any time period, dynamic programming model has been entered The results showed that performance at the beginning programming is the most important ecological criteria planning at the beginning, and in future periods economic as well as ecological criteria ,in accordance with criteria in different state and economic, ecological and social decisions. The factor prioritizing towards economic criteria in different states and decisions showed that among the considered factors for economic state, obtained profit of park admission showed lowest importance according to free admission and unwillingness to pay and revenue of welfare facilities and water for agriculture showed highest importance in arriving at economic desirable level because of agriculture water demand, existence of extensive water resources and providing security for those staying overnight in the park.

Prioritizing factors towards ecological criteria in different states and decisions showed that the biodiversity in different periods and states is the most important factor for sustainable management of Sylvan Park and reaching the desired level of ecological towards other attended factors in model should be more considered. Prioritizing results factors towards social criteria in different states and decisions showed that the increasing in job creation in parks and more attention to educational and recreational facilities according to economic and ecological decisions are more important. Furthermore, according to final results dynamic programming model based on criteria prioritizing and factors from the hierarchy analysis process, at the beginning of the first10-yearperiod, the first state by ecological decision performance, at the beginning of the second10-yearperiod, the second state with ecological decision performance and at the beginning of the third10-yearperiod, the first state park with the social decisions performance have been optimized to achieve. Based on the results of the model for obtaining sustainable management in the Sylvan Park Saravan and reaching a desirable level of each combination of values in the three criteria of economic, ecological and social, according to the conditions for the park, according to experts, the implementation of these determined decisions could be useful and from Park potential potency in issues of economic, social – recreational, conservation and sustainability of indigenous species, the maximum desire has been used and the Park will be devolved to the next generation in the best desirable conditions.

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