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Full Length Research Paper

A study of the criteria and indicators used in monitoring forest planning in Caspian and Kheyrud forests

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Sustainable forest management is known as the most effective type of forest management. This mode of management is aimed at enabling sustainable and comprehensive development in forest -related sectors. Practicing sustainable management in forests requires powerful tools in order to ensure achieving objectives of forest management and, at the same time, direct processes in a sustainable way. Forest management plan is the most suitable means to carry out this type of monitoring. Though, the forest management plan is a tool to set in motion, a management scheme. This requires certain proper criteria and indicators in practice. The criteria and indicators have various applications within a forest management plan, including their application in monitoring forest management plans. In fact, the criteria and indicators are themselves derived from the functions practiced in forests. Therefore, knowing a few functions of forests, we can outline monitoring criteria and indicators. This study is aimed at prioritizing the criteria and indicators required for monitoring forest management plans in Caspian forests in general and Kheyrud Forest in particular. This is the first study made using a hierarchical analysis for two functions of wood production and forest conservation in Caspian forests. Formulating these criteria helps monitoring the forest's functions and can be used in determining, measuring, analyzing and assessing sustainability in the forest under study.

Key words: Monitoring criteria and indicators, forest management plan, wood production function, forest conservation function.

INTRODUCTION

Limits of the forest sustainable management are determined by a set of operational criteria and indicators in a variety of positions and regarding local particular needs. In connection with the study, certain criteria and indicators are defined for every monitoring. These criteria and indicators are derived from the people's expectation of forest management. A founder of this attitude states that the criteria and indicators can be used as useful tools to determine parameters of a sustainable forest management (Poore, 2003; Gough et al., 2008; Raison et al., 2001). New indicators are introduced one after another but, nevertheless, there is a controversy on the manner of selecting the criteria and indicators and as well many indicators have been left unmeasured. In reality, criteria and indicators must try to simplify complexities of the world through providing manageable information to help understand the decisions and management of activities in the field (Peng et al., 2002) . The development of C & I for monitoring has been the most popular method. In a relatively short period, about 150 countries adopted certain criteria and indicators (Hickey and Innes, 2008). In fact, these criteria and indicators are well known because 150 countries that possess 97.5% of forests by area are involved in nine processes of formulating region-al and international criteria and indicators (Wijevardana, 2008). Today, methods of prioritizing criteria and indicators have turned into a serious debate in the world and today, the techniques of prioritization are used together with the criteria and indicators under the general title of multi-criteria decision-making methods (Mendoza

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Table 1. The top-down process stages, the modified method introduced by Mendoza and Maccoun (1999).

	Top-down approach
Step 1	Establish an initial (base) set of C&I (e.g. CIFOR Generic Template)
Step 2	Team gives individual judgments on each of the Principles.
Step 3	Based on the results obtained priorities the Principles and Criteria according to their Relative Weights.
Step 4	If possible, eliminate those Principles and Criteria that are rated significantly lower than the others.
Step 5	Show final list to the Team. If the Team is satisfied, the Final List of C&I is identified. If the Team is not satisfied then the process can be repeated from Step 2.

and Prabhu, 2000). The hierarchical analytical method is a good method among others. Unlike the methods already described, this method may produce different results depending on the management location and managers. In fact, this method is based on the knowledge and experience of individuals involved in the management (Mendoza and Macoun, 1999) rather being dependent on qualitative factors that are at work in other methods. In recent years, the idea of sustainable forest management has attracted attentions but, in spite of the existence of high ecological, economic and social values of forests, forest management in Iran does not take advantage of proper criteria and indicators. A look at Caspian forests shows that the forests have two main functions; wood production and forest conservation. Therefore, this study focuses on prioritizing the criteria and indicators used in monitoring forest planning in Caspian forests in general and the Kheyrud forest in particular. This study has been carried out based on hierarchical analysis of the two functions – wood production and forest conservation. This presented method is based on “Guidelines for applying multi-criteria analysis to the assessment of criteria and indicator” by Center for International Forest Research. Formulating these criteria and indicator helps monitoring the forest’s functions and can be used in determining, measuring, analyzing and assessing sustainability in the forest under study.

MATERIAL AND METHODS

The area under study

Research station of Kheyrud, an 80 km^2 area, is located as 7 km east far from Nowshahr. The lowest side of the forest which is its northern border has a height of 10 m above the sea level and spreads up to 2,200 m above the sea level. The forest consists of 80 tree species and 50 shrub species. The soils are characterized by karst topography and most common soil type is calsisols. The most common forest types are hardwoods, dominated by *Fagus orientalis* and *Carpinus betulus* and other tree species such as *Acer velutinum*, *Parrotia persica and Quercus castaneifolia*. Forest use forms such as timber harvesting, hunting, are combined with aspects of forest ecology and conservation. The special forms of use are: educational and research studies. The forest went under the management of the Faculty of Natural Resources, the University of Tehran that intended to use the forest for educational purposes. This forest has eight district and almost all plans are carried out on a compartment basis. Forest management plans have been outlined for three district of the forest.

Research methodology

Monitoring criteria and indicators

These criteria and indictors are used for monitoring the sustainability of forest functions and are derived from internationally accepted standards. However, in order to prioritize the criteria and indicators, the multi-criteria analysis methods has been used. A stepwise method and based on the “Guidelines for applying multi-criteria analysis to the assessment of criteria and indicator” by Center for International Forest Research has been used in this study.

In this method, consultation with a team of experts is required in order to modify that list of suggested criteria and indicators. Then, using an analysis hierarchical process, the criteria and indicators are compared in pairs (Mendoza and Macoun, 1999). The Table 1 summarizes this process. (Table 1)

Step 1

Establish an initial (base) set of C&I (e.g. CIFOR Generic Template). In this step, initial set of C&I have been design for expert’s judgments. The suggested criteria and indicators were also chosen by ranking, in reference to the Holvoet and Muys (2004) research with respect to Iran’s particular conditions.

Step 2

Team gives individual judgments on each of the Principles. This team was five-member group consisting university professors who were chosen equally from forest management and environment departments. The process of receiving opinions of members of the expert team and collecting and analyzing data should be noted if we want to develop a successful multi-criteria analysis method. There are various methods for seeking opinions of individuals. One of the popular methods is the distribution of questionnaire. Based on the assumption that Iranian northern forests have two main functions - wood production and forest conservation, suggested criteria and indicators were derived from international studies and modified with respect to characteristics Iranian northern forests. Therefore, the questionnaire was designed based on pair comparison. This questionnaire focused on two functions, eight criteria and 26 indicators and a 1 - 9 scoring scale was used. The lowest score means least relative importance as two criteria or indicators are compared and the highest score shows the most relatively important pair criteria or indicators that have been considered. Finally, the questionnaires were distributed among the five experts.

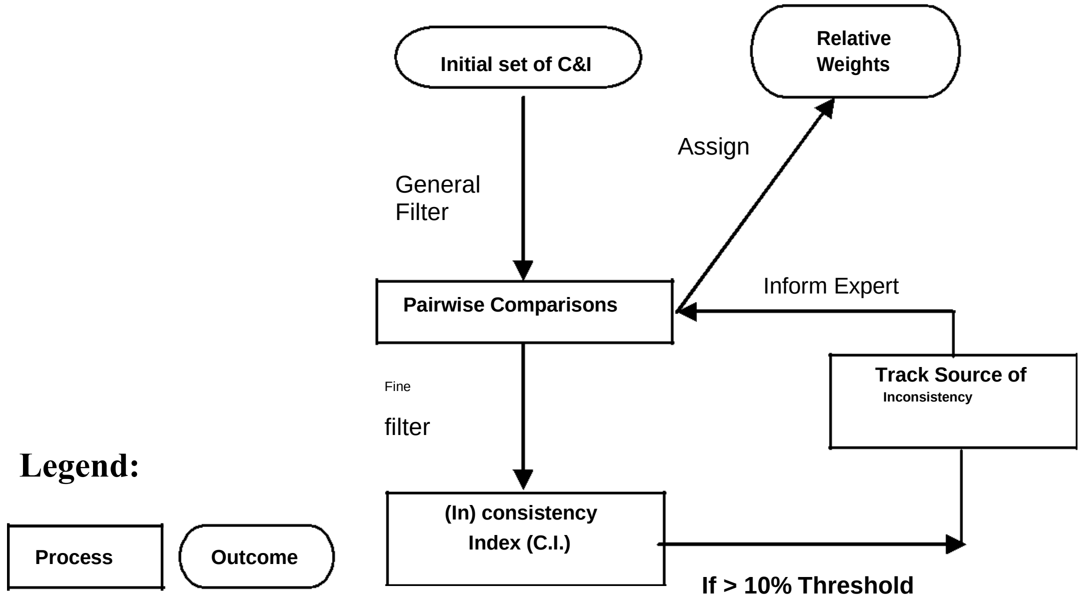

Figure 1. Multi-criteria analysis method for choosing criteria and indicators derived from Mendoza and Macoun (1999) study.

Step 3

Based on the results obtained, priorities of the Principles and Criteria were made according to their Relative weights. The expert team was asked to carry out a comparison judgment on the relative importance of each criterion pairs or indicator pairs in terms of functions or measurements. These judgments are used for the relative weight of criteria and indicators (Figure 1).

Pairwise comparison

For this Pairwise Comparison, a comparison matrix can be generated as follow: This matrix is a way of displaying the data gathered using the set of indicators (Table 2).

Table 2. The pairwise matrix

	a	b	c
a	1.000	7.000	0.167
b	0.143	1.000	0.333
c	6.000	3.000	1.000
Total	7.143	11.000	1.500

(1) The sum of each column is calculated.
(2) Three elements in each column is normalized by dividing by the column sum
(3) The row totals in (2) is divided by the number of Indicators compared. In this example 3
Indicators were compared.
Relative weight of a (0.888÷3) × 100 = 30
Relative weight of b (0.333÷3) × 100 = 11
Relative weight of c (1.779÷3) × 100 = 59

(4) Relative Weights for the Indicators are calculated based on input from other experts.

Calculating the (In) consistency index (C.I.)

The (In) consistency Index (C.I.) is a measure of how logically consistent the judgments of the Expert/participant (Mendoza and Macoun, 1999) are:

(1) The column totals for each Indicator is multiplied by the calculated Relative weights for each Indicator and the normalized elements is added of each row. Using the Indicators for the mentioned example the result would be,
(7.1 × 0.296) + (11 × 0.111) + (1.5 × 0.593) = 4.224.
(2) The number of elements (Indicators compared) is subtracted from the result of (1)
4.224 – 3 = 1.224
(3) The result of (2) is divided by the number of Indicators less one.
1.224 ÷ (3 - 1) = 0.612

Therefore, the Consistency Index for this matrix is 0.61 or 61% as this is above the tolerance Consistency Index of 10% which implies a high degree of inconsistency amongst the judgments of the expert who provided the responses. In the context of the analysis, then, these responses might not give a very reliable estimate of the relative weights of the Indicators. In order to do this, the consistency of each comparison made needs to be calculated. In the matrix above, this means only half the matrix needs to be analysed. For each comparison, a value that reflects the (in) consistency of the judgment can be calculated by multiplying the value assigned to the comparison by the ratio of relative weights (w1/w2) of the two Indicators being compared.

The calculation looks like this, (0.296 ÷ 0.111) × 7 = 18.648 (Table 3). In order to interpret this ratio in a useful way, it needs to be converted to the format 1⁄x since,(0.111/0.296) = 0.375. The ratio (0.111/0.296) can be expressed as approximately 1⁄3. Therefore, to reduce the inconsistency of expert's judgments, the value 7 needs to be moved closer to the value 3. In other words,

Table 3. Multiplying the expert judgment by the ratio of relative weights of the two Indicators being compared.

	a	b	c
A		18.648 (0.296/0.111)×7	0.0831 (0.296/0.593)×1/7
B			0.0624 (0.111/0.593)×1/3
c			

Indicator “a” should be judged more importantly than indicator “b” by a value of 3, not 7. The calculation has been carried out by the CIMAT2 software program. This program has been developed by the Center for International Forest management Research. This program may be used to correct and harmonize the criteria and indicators that can be practiced in a certain region.

Step 4

If possible, eliminate those Criteria that are rated significantly lower than the others. In considering this step, there was no criterion or indicator with significant lower rate than the others.

Step 5

Show final list to the expert team. If expert team is satisfied, the Final List of C&I is identified. If the Team is not satisfied then the process can be repeated from Step 2. In this step, the final list was shown to the team and they were satisfied of the selected C & I.

RESULTS

The conclusions based on the analyses carried out by the expert led to the formation of a set of monitoring criteria and indicators for the two functions of wood production and forest conservation. These results are presented in Table 4. The Tables 5 - 12 were drawn based on the pairwise comparison of criteria and indicators concerning the wood production and conservation. The set of criteria and indicator consist of 8 criteria and 26 indicators.

Concerning criterion 1-1(Harvesting follows and guidelines which minimize negative impacts and is controlled by independent agents). It can be stated that because, negative impacts of harvesting can reduce forest product and prevent forest regeneration. Therefore, 5 indicators were developed to ensure reliable exploitation norms, marking and best forest management practice.

Concerning criterion 1-2 (The sustainable production of forest wood products is ensured). Forest production holds wood and non-wood product. Most of production of kheyrud forest is wood production. Therefore, this criterion is stated for wood product. Indicators have been design based on influence elements such as volume of tree, wood stock and increment.

Concerning criterion 1-3 (Forest regeneration is ensured in natural manner). There are 2 kind of regeneration (natural and artificial) in kheyrud forest; however, natural regeneration is used widely in last years. Therefore, 4 indicators were developed to ensure natural regeneration for valuable tree and wood product.

Concerning criterion 2- 1 (Object, landscapes and ecosystems with value for biodiversity are maintained). This criterion can be stated, because of the importance of biodiversity in natural forest. Forest edge, deadwood and fallen trees, old trees, specific biotope and shrubs are significant habitats and sites for rare fauna and flora. Therefore 5 indicators were developed to ensure all of these elements.

Concerning criterion 2-2 (Natural and semi-natural ecosystems are protected and where necessary restored). This criterion can be stated, because of the importance of protecting natural and semi-natural ecosystem as a significant habitat and sites for fauna and flora. Semi-natural ecosystem in Iranian Caspian forest is characterized by farming and grazing, but there are not such internationally accepted indicators.

Concerning criterion 2- 3 (Silvicalture tending are base on sustainable, un- even age and mixed forest), Iranian Caspian forest are un-even age and mixed forest and most of silviculture tending have been carried out, based on nature-oriented forest management. Therefore the indicators have been stated to ensure stand composition, thinning method and tending of stands.

Concerning criterion 2-4 (Forest edge are gradual or developed towards a more gradual boundary), Forest edge as a significant criterion can be developed to protect biodiversity, but, there are not such internationally accepted indicators.

Concerning criterion 2-5 (Part of forest estate is protected as a reserve, the development of nature and its associated are left free and the migration of organisms are not restricted) . This criterion was stated, because some parts of the forest area are relevant habitat and sites for fauna and flora. This area can be protected as a reserve for migration organisms. For this reason, other form of use such as harvesting and hunting is limited. The indicators were developed to ensure corridors function and forest protected area.

Regarding the use of the pairwise comparison method used to prioritize the criteria and indicators, these results are shown in Figure 2. In this figure, the set of criteria and indicator have been regulated based on Average relative weight of each element.

DISCUSSION

Iranian Caspian forests have high ecologic, economics and social values, but no definite criteria and indicators have been developed for monitoring these forests in order to assess the forest functions. The absence of these factors has prevented us from understanding whether the forest are experiencing a sustainability or not. Consequently, there are no access in acquiring the

Table 4. The criteria and indicators used for monitoring of forest sustainability.

Function	Criteria	Indicator		Code
1			The production forest function is ensured	A
	1-1		Harvesting follows and guidelines which minimize negative impacts and is controlled by independent agents	aa
		1-1-1	Existence of clear and reliable exploitation norms	aaa
		1-1-2	Efficiency in limiting losses during or after exploitation	aab
		1-1-3	Existence of regulations concerning the use of machinery and techniques during or after exploitation	aac
		1-1-4	Marking of the trees to be harvested	aad
		1-1-5	Use of the best forest management practice determine tree exploitability	aae
	1-2		The sustainable production of forest wood products is ensured	ab
		1-2-1	Measurement for volume of tree	aba
		1-2-2	Existence of data regarding age structure, succession stages or diameter classes of the forest cover	abb
		1-2-3	Monitoring changes in wood stock	abc
		1-2-4	Incentives for the use of lesser known woody forest species	abd
		1-2-5	Control of the balance between harvest and increment	abe
	1-3		Forest regeneration is ensured in natural manner	ac
		1-3-1	Monitoring natural regeneration	aca
		1-3-2	Possibility of artificial regeneration of forest wood products	acb
		1-3-3	Possibility for regeneration of valuable harvested species	acc
		1-3-4	Possibility for forest natural regeneration	acd
2			The forest conservation function is ensured	ace
	2-1		Object, landscapes and ecosystems with value for biodiversity are maintained	ba
		2-1-1	Existence of data about occurring ecosystem types	baa
		2-1-2	Measurement for protection of specific biotopes	bab
		2-1-3	Presence of sufficient amount of deadwood	bac
		2-1-4	Protected and/or old trees are identified and are not felled during harvesting	bad
		2-1-5	Monitoring expansion of bushes and/or shrub vegetation	bae
	2-2		Natural and semi-natural ecosystems are protected and where necessary restored	bb
	2-3		Silvicalture trending are base on sustainable,un-even age and mixed forest	bc
		2-3-1	Giving priority to the prevention of natural trees reduction	bca
		2-3-2	Existence of prescriptions about maximal portion of forest under pioneer species	bcb
		2-3-3	Existence of prescriptions concerning light regulation through thinning	bcd
		2-3-4	Existence of regulation for conservation stands of monospecies, even age and uniform	bce
	2-4		Forest edge are gradual or developed towards a more gradual boundary	bd
	2-5		Part of forest estate is protected as a reserve, the development of nature and its associated left free and the migration of organisms is not restricted	be
		2-5-1	Degree of fragmentation or connecting(corridor function)	bea
		2-5-2	Monitoring the protected forest area and its changes	beb
		2-5-3	Leaving sections of the forest untroubled	bec

* There are not such internationally accepted criteria.

Table 5. The relative importance weight and incompatibility rate for the criteria related to function 1.

criteria	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average weight
1-1	19	37	10	10	16	18
1-2	16	14	25	38	22	23
1-3	66	49	65	52	62	59
C.I	0.0216	0.0573	0.0135	0.0715	0.0756	

Table 6. The relative importance weight and incompatibility rate for the indicator related to criteria 1-1.

Indicator	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average weight
1-1-1	12	19	14	22	5	14
1-1-2	12	19	9	20	5	13
1-1-3	12	13	18	25	13	16
1-1-4	27	20	21	15	15	20
1-1-5	36	29	38	19	62	37
C.I	0.0122	0.0842	0.0562	0.107	0.0851	

Table 7. The relative importance weight and incompatibility rate for the indicator related to criteria 1-2.

Indicator	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average weight
1-2-1	19	18	7	8	48	20
1-2-2	18	20	25	22	16	20
1-2-3	22	20	12	8	12	15
1-2-4	10	23	29	24	6	18
1-2-5	32	20	28	38	18	27
C.I	0.018	0.015	0.011	0.101	0.103	

Table 8. The relative importance weight and incompatibility rate for the indicator related to criteria 1 - 3.

Indicator	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average weight
1-3-1	15	18	19	14	22	18
1-3-2	14	22	9	9	8	13
1-3-3	30	33	26	41	30	32
1-3-4	42	28	45	36	40	38
C.I	0.039	0.107	0.072	0.019	0.073	

Table 9. The relative importance weight and incompatibility rate for the criteria related to function 2.

criteria	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average weight
2-1	38	49	15	18	8	26
2-2	19	11	10	25	7	14
2-3	23	15	23	23	15	20
2-4	9	12	24	10	17	14
2-5	11	12	28	24	53	26
C.I	0.066	0.049	0.066	0.078	0.108	

Table 10. The relative importance weight and incompatibility rate for the indicator related to criteria 2 - 1.

Indicator	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average weight
2-1-1	30	47	54	22	13	33
2-1-2	19	36	11	22	30	23
2-1-3	16	6	6	24	31	17
2-1-4	10	5	16	24	21	15
2-1-5	25	5	14	9	6	12
C.I	0.019	0.038	0.056	0.007	0.079	

Table 11. The relative importance weight and incompatibility rate for the indicator related to criteria 2 - 3.

Indicator	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Avg. weight
2-3-1	27	33	27	27	53	33
2-3-2	14	43	23	10	12	21
2-3-3	16	17	9	29	8	16
2-3-4	42	7	41	34	27	30
C.I	0.018	0.109	0.109	0.031	0.057	

Table 12. The relative importance weight and incompatibility rate for the indicator related to criteria 2 - 5.

Indicator	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Avg. weight
2-5-1	14	26	20	65	58	37
2-5-2	57	33	42	12	11	31
2-5-3	29	41	38	23	31	32
C.I	0	0.0278	0.0952	0.0027	0.0025	

required information on growth changes, volume and other important parameters in the forest. On the other hand, these criteria and indicators are indispensable requirements for monitoring. Of course, these criteria and indicators, which have been developed for two functions of wood production and forest conservation, should be modified and improved with respect to other functions of the forest, and since the functions may overlap to some degree, a more desirable system of criteria and indicators can be designed. The studies of Kotwal et al. (2008) and Angeline et al. (2008) indicate that ecological indicators need to be covered by social and economical indicators. Of course, this issue has been of little emphasis by forest managers. Among the selected criteria and indicators, some were too complicated to be matched with proper indicators. However, discussing these criteria helps finding correspondent indicators in the future. Regarding the use of the pairwise comparison method used to prioritize the criteria and indicators, this approach, which is actually based on the knowledge and experience of the experts who are involved in the forest, can guide us toward our objectives. The simplicity of the pairwise comparison approach in calculations and using the incompatibility indicator reduces errors and as a result, this is a good method to be practiced concerning the Kheyrud forest. Mendoza and Prabhu (2000) made used of multiple criteria decision making techniques (rating, ranking and pairwise comparison) as decision tools for assessing criteria and indicators designed to evaluate sustainable forest management. Results from the study indicate that these techniques were effective tools both for selecting sets of criteria and indicators and eventually for prioritizing them. Naturally, there exist other methods such as network analysis or cognitive mapping that have been used in other studies (Mendoza and Prabhu, 2003; Wolfslehnner et al., 2005; Mendoza and Prabhu, 2006), but it is unlikely to use this method at the beginning because of the complexity of its calculations. Prioritizing criteria and indicators will let us accomplish monitoring the sustainable management of the Kheyrud forest. Though the analysis hierarchical process is based on the knowledge and experience of experts (Kuswandari, 2004) and this is both its advantage and disadvantage, it can still be a good choice because it is a quantitative method and can be modified regarding characteristics of Iranian forests.

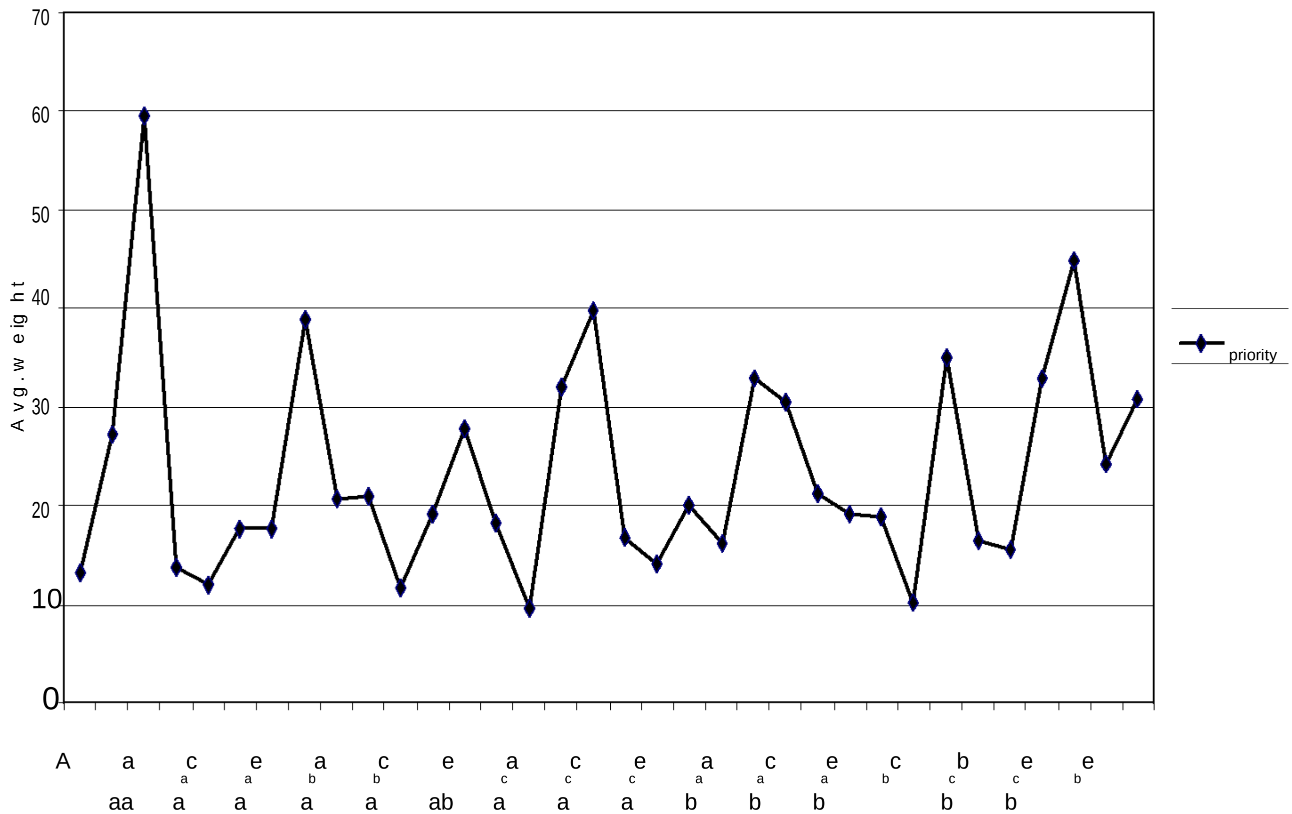

Figure 2. The prioritized set of criteria and indicators based on average relative weight.

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