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An Introduction to Natural Landscape Restoration method based on Landscape Ecology Approach

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Abstract

Problem Definition: Quality of natural landscapes is reduced by unconscious intervention which disrupts ecological process of natural beds. Therefore, to revive the values of natural beds, rectification of disturbed natural landscapes is an important issue. Furthermore, it should be noted that this rectification results in comprehensive restoring the natural landscapes. The landscape ecology is one of the earliest approaches used in conservation of natural capitals and values.

Goal: The main goal of the current research is to present a landscape restoration method based on the landscape ecology approach.

Research procedure: This research has three steps including expression of the research problem, analysis of theoretical bases of the landscape restoration along with the landscape ecology methods, and selection of the proper methods for intervention of landscape designers in natural landscapes using comments of the related experts. These steps are carried out using the descriptive-analytic and survey methods.

Conclusion: Based on findings obtained herein, a landscape restoration method comprising five steps is proposed. These steps include 1) survey and deep observation, 2) assessment in the landscape scale, 3) recognition and ecological perception, 4) design and act, and 5) management and control. The authors briefly name the proposed method as SARDM. The proposed method emphasize on presence of designer at the field. This presence leads to better perception of spatial relation between landscape elements. Moreover, it can be mentioned that the proposed procedure enables landscape assessment in both temporal and spatial dimensions. In addition, it matches the conducted assessment with results obtained in step 1.

Keywords

Landscape restoration; Landscape ecology; Ecological design; Natural landscape.

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Introduction

Landscape ecology science investigates how different ecological processes interact with each others. This science can be utilized in gathering information required for conservation of natural resources. Moreover, ecology can be considered as recognition of interaction between organisms and environment along with relationships between various organisms. The young branch of this science is landscape ecology which investigates effects of several factors such as social-economical processes as well as politics in formation of the landscape (Figure1). In this regard, the mentioned processes and ecological processes have similar importance (Makhzoumi and Pungetti, 1999; Makhzoumi, 2015). The landscape ecology guides landscape architects to design an appropriate and sustainable landscape with regard to environmental, cultural, and aesthetical aspects (Makhzoumi, 2000). Furthermore, this science provides ecological understanding in spatial configuration for designers and planners (Forman, 1990);(Fig. 1).

The landscape ecology is a multidisciplinary science for perception of relationships between spatial patterns and ecological processes. Basis of this science and ultimate goal of it are spatial heterogeneity and sustainability, respectively (Wu, 2013). Wu and Hobbs (2007) introduced the landscape ecology as art and science of studying relationships between spatial patterns and ecological processes at the hierarchical levels of biological organizations along with various temporal and spatial scales. Using the landscape ecology to relate the human interventions with the environmental conditions is inevitable when the human interventions increase in biosphere (Habibi, 2015). In this regard, it should not be forgotten that restoration of damaged zones of landscape mosaic is necessary. Moreover, long-term planning and control leads to proper restoration of landscape projects (Pouryoosefzadeh, Bemanian & Ansari, 2012).

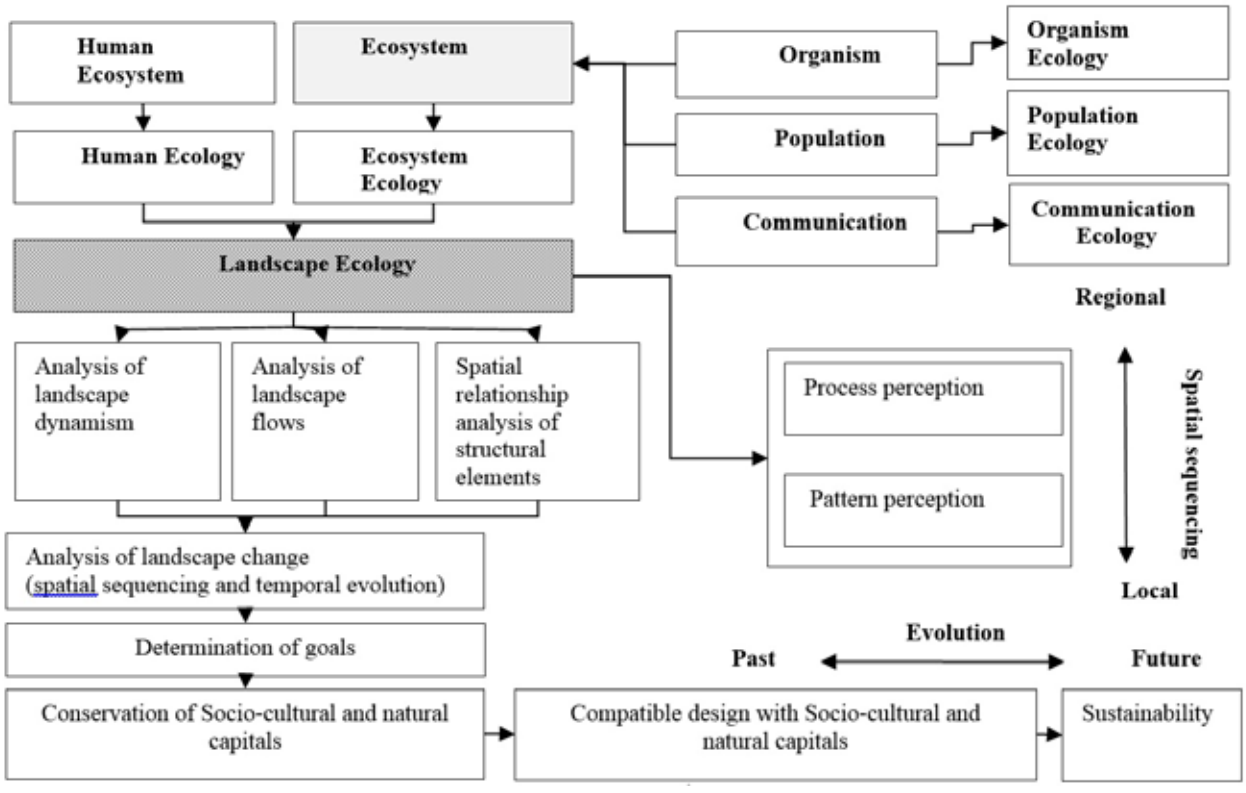

Fig.1. Landscape ecology. Source: authors.

In accordance with the above-mentioned issues, the current study presents a landscape restoration methodology based on the landscape ecology approach and answers the following questions:

1) What is the natural landscape restoration method and process in landscape scale?

2) Are the methods presented by previous researchers in the landscape ecology and design appropriate for use in the landscape restoration?

Literature review

● Landscape restoration

The human interventions and/or natural disturbances change the landscape and interrupt the corresponding structure (e.g. vegetation and animal community) and landscape processes. Due to importance of natural landscape conservation and revitalization, natural landscape restoration approach has been entered in landscape architecture (Pouryoosefzadeh, Bemanian & Ansari, et al., 2012). The most important concern in the natural landscape restoration is to conserve sequences of species, populations, communities and processes (Farina, 2007). The landscape restoration includes ecosystem regeneration, control of environmental pollution, prevention from acidic rain, and conserving habitats (Carins, 1999). Carins (1999) expressed that the landscape restoration can relate human community with natural landscape. It is important to comprehensively study ecological layers, natural and artificial patterns of the landscape mosaic in landscape restoration process. The natural processes and patterns should be analyzed via ecological assessment. The common question arises whether the landscape design methodology can be used for the landscape restoration? Furthermore, is the landscape ecology method applicable for the landscape restoration? In this regard, the different methods of the landscape design and the landscape ecology will be investigated as follows.

Landscape Design method

One of the common methods in the landscape design is Survey, Analysis and Design (SAD) presented in the late 1960s (Turner, 1991). Moreover, based on Turner's (2004) recommendation, this method includes a series of sequential steps as follows: 1) survey the site of interest, 2) site analysis, 3) analysis of client demands, 4) Integration of steps 2 and 3 to obtain an initial conceptual design, and 5) translation of the concept into design. In this type of design, designers use their implicit and intuitive knowledge. Therefore this method is not generalizable (Adib, 2012). In an alternative method, the designer uses design cycles where the outputs of each step are used as inputs for the next step. This method enables the designer to revise the outputs obtained in design cycles. Boyd's loop model includes observation of site and its surrounding features, orientation of design, decision on selecting the appropriate methodologies and actions, and action (Polk, 1999; Bemanian and Ahmadi, 2014).

McHarg and Mumford (1969) proposed an approach to design landscapes using overlaying the various layers (e.g. vegetation and wildlife, hydrology, topography and soil type, social and cultural characteristics, etc.). In this approach, the design process is not a step-by-step method. The ecological design is a holistic approach that results in combination of several professional practices (Makhzoumi, 2015). The landscape ecology and the ecological design merge spatial viewpoints of geographers with functional viewpoints of ecologists. Moreover, it should be noted that, in these approaches, socio-economic and political processes are important as well as the ecological processes (Makhzoumi, 2000). In addition, due to involvement with two types of elements such as objective (i.e. visible elements) and subjective (i.e. invisible elements), the framework of these approaches can be categorized as an exploratory and interactive approach (Makhzoumi, 2015).

One of the methods of landscape ecology design is ecological landscape association. This method investigates complexities of landscape patterns and processes. Moreover, this procedure allows the designers understand function of landscape elements and their importance of use (Makhzoumi, 1997).

Another landscape design method is PAKILDA method that simplifies design process using different diagrams and patterns. The landscape design process has two steps including problem-setting and reflections-in-action. These steps mutually influence each other (W. Filor, 1994).

The present study investigates various landscape design methods along with landscape restoration principles to determine effectiveness, weakness and strengths of these methods through deep interview with five overseas landscape ecology experts. Afterwards, results obtained from deep interviews utilize to prepare a questionnaire comprising open and closed sections. Then, fifty domestic and foreign experts in landscape ecology and restoration are asked to fill in the noted questionnaire. The results demonstrate any mentioned methods cannot be separately utilized as the natural landscape restoration method due to impacts of several factors on landscape restoration process (Table 1).

Research method and materials

Research method used herein is the descriptive-analytic method using survey and correlation assessment. First, a questionnaire is prepared and then distributed between 100 experts in landscape design, environmental design and environments. All these experts are domestic PhD graduates. Moreover, it should be noted that the mentioned questionnaire has three sections including experts' characteristics, Likert-scale (e.g. agree, no idea and disagree) and an open questions. Then, the content-analysis method is used to analyze the data obtained from previous noted deep interviews with five experts along with those achieved from open section of questionnaire distributed between 100 domestic experts. Likert-scale analysis is conducted using SPSS software. Using the mentioned results, a landscape restoration method is proposed based on landscape ecology. Moreover, it is worth mentioning that reliability of two noted questionnaires are assessed using the Cronbach's alpha. Along with that, validity of those questionnaires is analyzed through content-validity carried out by one of the professor of Shiraz University in psychology.

Results

Data gathered from first part of three-section questionnaire (i.e. questions regarding the characteristics of experts) are analyzed by SPSS software. The Cronbach's alpha is obtained 0.81 for all questions. Therefore, this questionnaire shows proper reliability. Based on descriptive analysis of results, male responders have a higher proportion of sample population (i.e. 79 %). Moreover, 83 percent of responders are faculty members of Iranian universities. The remaining responders are researchers who work in different Iranian research institutes. Furthermore, a high and a low percentage of responders have expertise in environment and landscape design, respectively.

The second section of questionnaire contains seven Likert-scale questions. Results of data analysis are shown in Table 2 for these questions. Mean analysis of data obtained for the Likert-scale questions demonstrates the experts concurred with those questions. The open questions and interviews are assessed using the content analysis. The responders determine the priority of interventions on the landscape restoration along with the landscape ecology using investigation of the presented process flowcharts. In this regard, the deep interview is used to determine the noted flowcharts (Table 2).

Discussion

Results show, in the first step, the designer should conduct survey and deep observation for structural elements of landscape mosaic, biotic and abiotic resources, and cultural resource of studied landscape as a resident. This step includes describing the dimension (e.g. interventional, political, natural, economic, etc.), and the resources of studied landscape (i.e. biotic, abiotic, cultural, and social resources). Afterwards, the designer should categorize landscape scale (i.e. local, regional, national, and international) and environmental

Table 1. Feasibility study of generalizability of landscape design methods in landscape restoration based on experts' view.

Method	**Feature**	**Feasibility study of generalizability of landscape design methods in landscape restoration**	**Assessment Indexes**
SAD	Using the survey, analysis and design in design process	This method uses implicit knowledge of designer, however, it does not utilize results of survey step in subsequent design steps. Therefore, due to superficiality in collecting field data and indeterminate processes and assessment scale, this method cannot be generalized into landscape restoration. Along with that, one of the most important steps in landscape restoration process is precise assessment which results in comprehensive cognition of designer	1. **Pathology** (does it investigate pathology in landscape? are the intervention goals based on pathology in bed?) 2. **Survey** (Landscape restoration requires field investigation by designer to comprehensively recognize bed, damage type and disturbances. In this regard, does this method consider the generalization of field investigation and surveys in the subsequent restoration steps for natural landscape?) 3. **Effectiveness scale** (Capitals of natural landscapes can affect natural ecosystems in different scales such as regional, national and international scales. Thus, consideration of effectiveness scale should be investigated in these methods). 4. **Assessment** (Landscape scale should be assessed in these methods because landscape scale assessment, precise recognition of matrix and mosaic landscape is the main part of landscape restoration).
PAKILDA	Transform of from attitude of implicit knowledge to systematic attitude	This method is similar to landscape ecology approach in simplifying landscape processes through drawing patterns and diagrams. However, due to lack of consideration of effectiveness scale of landscapes in design process and also how to assess the landscape process, it cannot be generalized in landscape restoration. Furthermore, it should be noted that landscape assessment play a key role in landscape restoration.	
OODA	Design process based on basic principles of deep observation, design and action	This method does not use assessment in the design process. Hence, it cannot be applicable in landscape restoration.	
ELA	Provide a precise framework of assessment process in temporal and spatial dimensions Analysis of landscape complexities and dynamism of cultural, biotic, and abiotic resources	This method basically benefits from assessment through intervention of other effective factors in design. Although this method precisely utilizes assessment process, the decision making procedure of the designer is not described in it.	

Table 2. Mean analysis of gathered data using SPSS software. Source: authors.

Questions	N	Minimum	Maximum	Mean	Standard deviation
Comprehensive recognition of structural elements and patterns (e.g. cultural, social and natural resources) is the first step in landscape restoration process.	100	0	2	0.15	0.479
Analysis of different layers of the natural landscapes (e.g. hydrology, topography, vegetation and etc) should be done in landscape restoration process.	100	0	2	0.25	0.642
Survey study of landscape designer should be considered as a separate layer in layered analysis done through different computer software.	100	0	2	0.23	0.548
Objective and goals of landscape restoration are determined after layered analysis of landscape resources.	100	0	2	0.04	0.281
Natural landscape evaluation is done in temporal dimension to determine required actions in different zones of landscape mosaics (e.g. conservation, restoration and reconstruction strategies)	100	0	2	0.43	0.685
Landscape restoration method forms same in natural landscape with aquatic and non-aquatic ecosystems.	100	0	2	0.00	0.000
Landscape restoration strategies vary from site-to-site due to their different ecological and cultural feature. However, landscape designer can use a method, which is flexible in different situations.	100	0	2	0.06	0.343

landscape value (i.e. natural reserve, natural monument, cultural monument, and vernacular) (see Feizi et al., 2014, for more details). The survey and deep observation step enables the designer to determine core, buffer, and border zones. Harker et al. (1993) previously implied that those noted determinations. In addition, all structural landscape elements such as patches, corridors, networks, and matrix are analyzed to clarify current condition of the studied landscape. Moreover, temporal change of landscape mosaics plays an important role in the landscape restoration. It should be mentioned herein that the presence of designer is necessary for precise ecological perception of dynamism, disturbance, and complexity of the studied landscape (Table 3).

Second step of the proposed landscape restoration method comprises assessment in landscape scale including ecological, visual, socio-cultural, and economic analysis. All noted analyses are performed in different scales (i.e. from patch scale to mosaic ones). The designer compares results obtained in the survey step with results of second step through evaluating the maps and aerial images of studied area using different softwares. The assessment in the landscape scale are carried out using various landscape metrics to determine ecological structures and networks through measurements of mean patch size, number of patches, mean nearest neighbor, patch density. These measurements are conducted using arc GIS. Moreover, temporal change of patch function along with land use is investigated using remote sensing technique by ENVI software. Table 4 shows details of the present step.

Next step is the precise cognition of landscape based on the above-mentioned evaluations. In this regard, the designer should deeply discern all elements and dimensions of landscape, functional and visual disturbances, current condition, and effectiveness

Table 3. Main items of survey and deep observation step. Source: authors.

Survey				
Landscape description	Description of dimension and elements	Biotic resources	Vegetation	
			Wildlife	
		Abiotic resources	Water resources	
			Climate	
			Morphology	
			Topography	
			Soil conditions	
		Human resources		
Landscape classification	Landscape type	Landscape type in various scale	Local	
			Regional	
			National	
			International	
		Landscape type due to their natural values	Natural reserve	Forest reserve
				Aquatic reserve
			Natural monument	
			Cultural monument	
			Vernacular landscape	
	Landscape zone	Core zone		
		Buffer zone		
		Border zone		
Recognition of dimension and elements	Elements and dimensions	Structural elements	Patch	
			Corridor and flow	
			Habitat	
			Ecosystem	
			Network	
			Matrix	
		Dimensions	Socio- cultural resources	
			Economic resources	
			Political resources	

Table 4. Main items of assessment in landscape scale. Source: authors.

Assessment at landscape, habitat, mosaic and patch scale		
Ecological assessment	Assessment of structural elements	Patch
		Habitat
		Mosaic
		Matrix
	Landscape network assessment	Ecological network
		Flows and corridors
		Physical connection
	Assessment in temporal dimension	Past
		Present
		Future
Assessment of socio- cultural dimension	Identification of native and non-native users	
	Identification of habits and costumes	
	Identification of effective factors on sense of comfort and security	
Visual assessment	Determination of effective factors on visual perception and aesthetic	Variety
		Attraction
Assessment of economic dimension		
Assessment of political dimension		

scale. This step is named as cognition step (Table 5). Therefore the designer should propose appropriate strategies to decrease visual and functional disturbances of landscape patterns and processes. It is worth mentioning that the designer should prioritize goals in landscape, mosaic, habitat, and patch scales and then act (step of design and action). These priorities are design, restoration, conservation, and reconstruction. It should be noted that these priorities might vary from scale-to-scale. As mentioned earlier, the natural capitals have unique values and are irreversible; thus, the conservation is most important priority in comparison with the others. The second most important priority is the reconstruction through design of new patches to connect the different parts of landscape mosaic. Afterwards, implementation of proposed design should be managed and controlled (management and control step).

Table 5. Main items of recognition step. Source: authors.

Recognition in landscape scale		**Recognition in landscape mosaic scale**		**Recognition in habitat scale**		**Recognition in patch scale**	
Identification of disturbance of current status	Low	Identification of disturbance in current status	Low	Identification of disturbance in current status	Low	Identification of disturbance in current status	Low
	Intermediate		Intermediate		Intermediate		Intermediate
	Great		Great		Great		Great
Identification of functional disturbance	Low	Identification of functional disturbance	Low	Identification of functional disturbance	Low	Identification of functional disturbance	Low
	Intermediate		Intermediate		Intermediate		Intermediate
	Great		Great		Great		Great
Identification of visual disturbance	Low	Identification of visual disturbance	Low	Identification of visual disturbance	Low	Identification of visual disturbance	Low
	Intermediate		Intermediate		Intermediate		Intermediate
	Great		Great		Great		Great

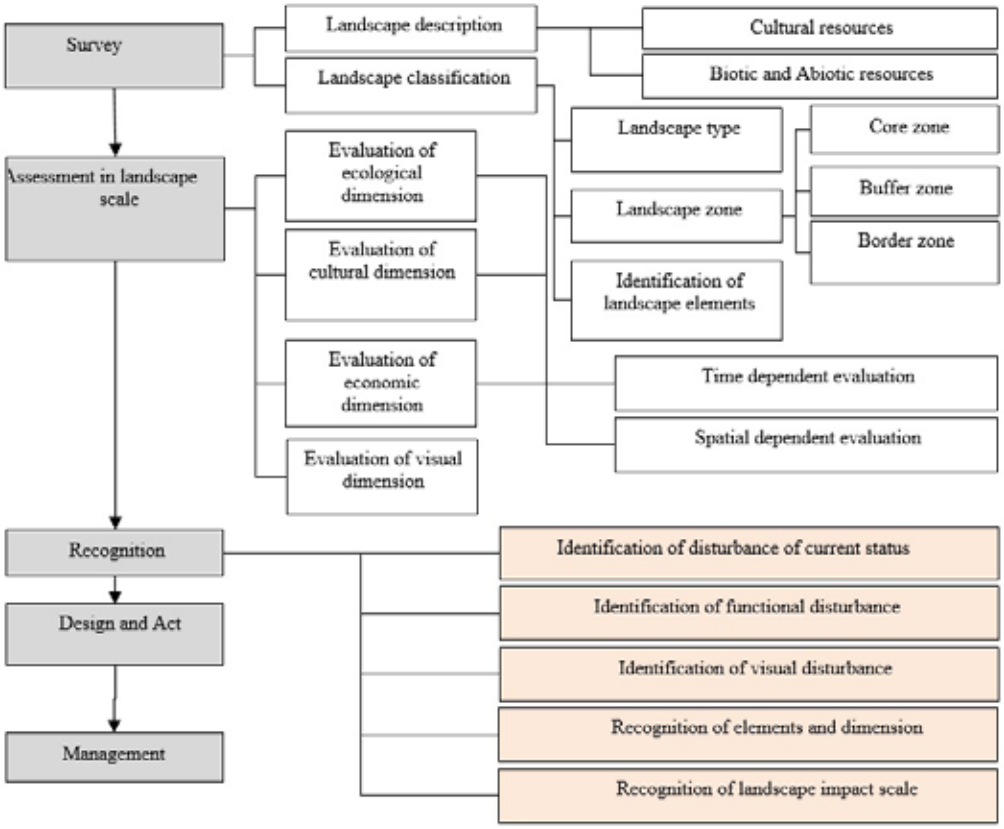

Fig. 2. Research method and materials in landscape restoration. Source: authors.

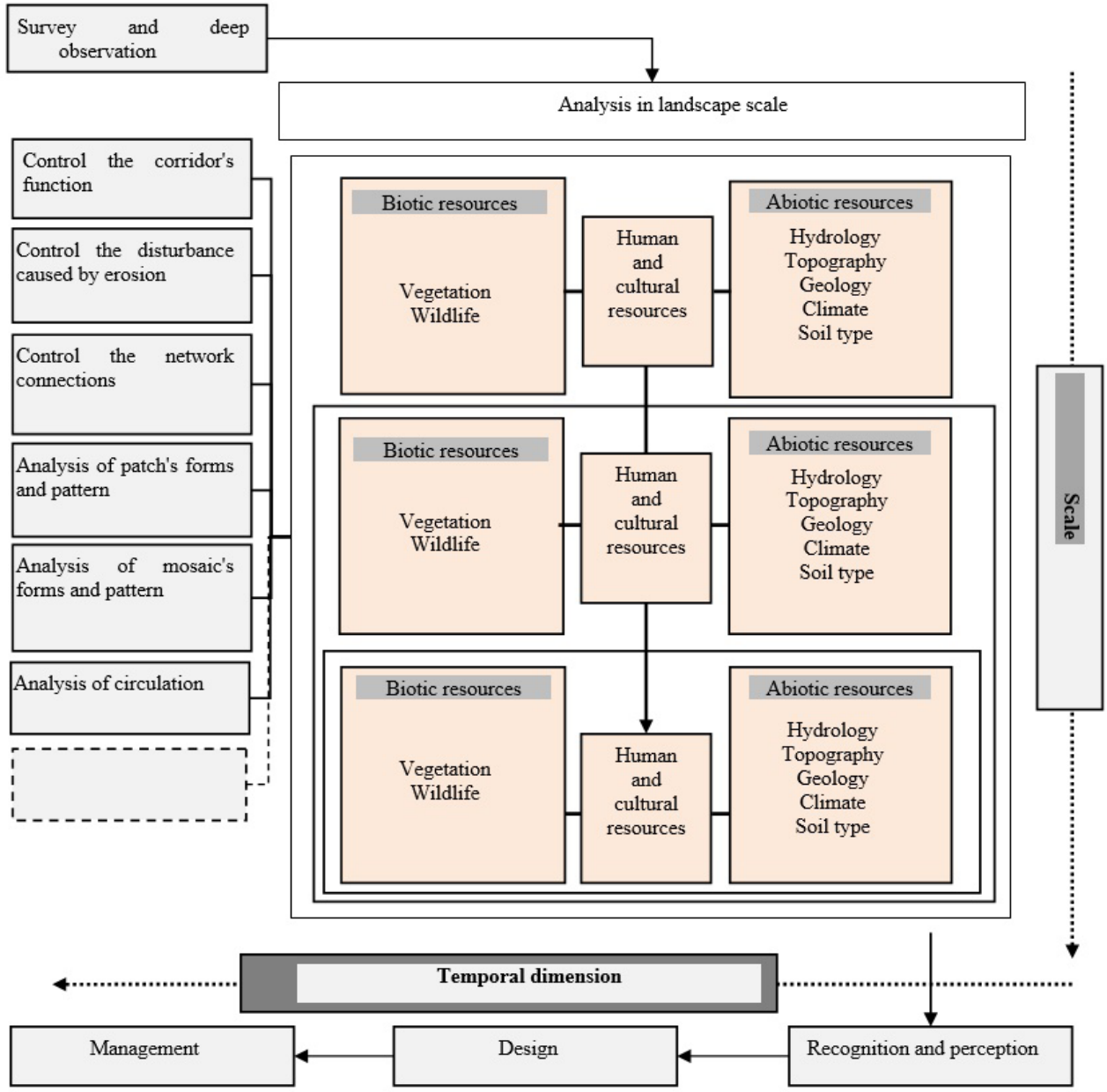

Fig. 3. SARDM method in landscape restoration. Source: authors.

Conclusion

Due to increase of destructive human interventions in natural landscapes, landscape ecology approach has been presented to determine how intervention process should be implemented based on functions and structures of landscape mosaic. The landscape ecology is such a holistic approach that emphasize on the contribution of several experts (e.g. ecologist, landscape and environmental designer, geographer, and planner) to relate manmade systems (i.e. urban, agricultural, and tourism development) with natural systems (e.g. ecosystems, and habitats). This approach emphasizes the conservation of natural capitals using planning as well as the creation of new ecosystems as same as destroyed natural ones. Landscape quality improvement provided by this approach can improve human life quality. In this approach, types of planning, management, and design are considered in the landscape scale. Furthermore, consideration of the aesthetic dimension in design process is one of the most

important capabilities of the landscape ecology approach. It should be mentioned that, similar to the landscape ecology approach, the landscape restoration emphasizes the restoration of natural and ecological situation of studied bed.

The present research shows that the methods of landscape design are not appropriate to restore the landscape. Moreover, the five proposed steps here are required to restore the natural landscape based on the landscape ecology. These steps includes survey and deep observation, assessment in the landscape scale, recognition, design and act, and management and control (Fig. 2). The method proposed in the current study is named as SARDM. In the SARDM, the designer should be present in the field to enable perception of the relationships and the spatial circulation between the structural elements of landscape mosaic. Furthermore, analysis of spatial and temporal dimensions of the landscape can be performed using the proposed method. Therefore, it should be mentioned that the designer could combine survey step with the assessment step using this method (Fig. 3).

Reference list

- Adib, M. (2012). Landscape Architecture and methods of managing the body of knowledge in design process. *Bagh- e Nazar*, 9(22): 55-64.
- Bemanian, M. & Ahmadi, F. (2014). *Landscape ecology and design*. Tehran: Gharn publisher (In persian).
- Carins, J. (1999). Ecological restoration: a major component of sustainable use of the planet. *Renewable resources journal*, 17(1):30-43.
- Farina, A. (2007). *Principles and methods in landscape ecology towards a science of landscape*. Netherland: Springer.
- Feizi, M., Bemanian, M.R., Ahmadi, F. & Asadpour, A. (2014). Sustainable landscape design process based on landscape ecology approach. *Sustainability, development and Environment*, (3): 35-46.
- Forman, R. (1990). The beginnings of landscape ecology in America. In *Zonneveld & Forman, Changing landscape*: *an ecological perspective.* New York: springer.
- Habibi, M. (2015). The position of landscape ecology in recent studies. *Manzar*, 7(32):46-51.
- Hajghani, M. & Ahmadi, F. (2015). A literature review of landscape ecology. *Manzar*, 7(32):60-65.
- Harker, D., Libby, G., Haker, K., Evans, S. & Evans, M. (1993). *Landscape Restoration Handbook*. New York: United States Golf Association.
- Makhzoumi, J. (1997). The changing role of rural landscapes: olive and carob multi-use tree plantations in the semiarid Mediterranean. *Landscape and Urban Planning*, (37):115–122.
- Makhzoumi, J. (2015). Ecology, landscape and ecological design. *Manzar*, 7(32):5.
- Makhzoumi, J. & Pungetti, G. (1999). *Ecological Landscape Design and Planning*. London: E & FN Spon, an imprint of Routledge.
- Makhzoumi, J. (2000). landscape ecology as a foundation for landscape architecture. landscape and urban planning, 50: 167-177.
- Makhzoumi, J. (2015). Borrowed of rooted? The discourse of landscape in the Arab Middle East. In *D.Bruns, O.Kuhne, A.Schonwald, & S.Theile (Eds), Landscape culture- culturing landscapes: The differentiated construction of landscapes*. Wiesbaden: Springer- Verlag.
- Pouryoosefzadeh, S. (2009). *Landscape restoration principle of historical landscape*. M.A thesis. Tehran: Tarbiat Modares University.
- Pouryoosefzadeh, S., Bemanian, M.R. & Ansari, M. (2012). Principles of Landscape Restoration in Natural and Historical Sites. *Bagh-e Nazar*, 9(22): 35-44.
- Turner, T. (1991). *Design methods for landscape architecture and garden design*. Available from: http://www.gardenvisit.com/history_theory/garden_landscape_design_articles/landscape_theory/history_design_methods (18 April 2017).
- W.Filor, S. (1994). The nature of landscape design and design process. *Landscape and urban planning*, (3): 121-129
- Wu, J. (2013). Key concepts and research topics in landscape ecology revisited: 30 years after the Allerton Park workshop. *Landscape Ecol*, (28): 1-11.
- Wu, J. & Hobbs, R.J. (2007). *Key topics in landscape ecology*. Cambridge: University Press.