

GIS-MODELLING OF LANDSCAPE AESTHETIC PROPERTIES TO CULTURAL HERITAGE SITE RESTORATION

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ABSTRACT

Restoration of historic traditional landscapes, are becoming more common elsewhere, brought to life two not an alternative practice: special package of measures for the reconstruction and maintenance of landscape ("management plans for territories") and assessing the acceptability of impacts on the aesthetic properties of the landscape (so called «Landscape Visual Impact Assessment»). The development of management plans for areas associated with a defining of landscape target condition which includes the features of the «reference» sample. The search for such features is carried out within the reconstruction of landscape history using geographic information systems and old maps. Implementation of Visual Impact Assessment requires a preliminary modeling of the structure of visual space relative to inside observers, collecting of photographic images, to identify the role of individual components in shaping landscape scenes, as well as the definition the visual deformations, changing unfavorable aesthetic qualities of landscape. An unwanted change of aesthetic properties can occur as a result of new acts of economic development, and as a result of «wilderning» (revegetation) of cultural landscape. Construction of three-dimensional computer model of cultural landscape in combination with the step-by-step parameterization of various aspects of expected changes allows objectifying the whole process of assessment the validity of impact on aesthetic qualities and, also uses it to solve the conflict issues of development in the territories with high historical, cultural value and natural beauty.

INTRODUCTION

Problems of preserving the historical cultural landscapes (CL) have long became the subject of care for the absolute majority of the European countries, mainly due to the intensification and concentration of (agriculture) leading to universal distribution of big fields and destruction of boundary elements. At the same time the abandoned traditional farmland are decaying [12, 15, 17] and exposed to overgrowing ("revegetation") [3, 11, 24]. Revegetation and connected with it landscape transformation proved to be particularly crucial for the territories of outstanding historical and cultural value –national parks and memorial "open air" museums dedicated to keep examples of centuries-old interaction between the native ethnos and the nature.

The cultural landscape (CL) as a system includes not only visible manmade elements – local (churches and buildings), linear (roads and boundaries) and areal (various fields), but parameters of their mutual organization (structure and composition), tradition of maintaining, and also, - the elements of non-material heritage (national folklore, legends and myths,) which "spiritualizes" a landscape [2, 3, 4]. The simple existence of CL assumes his habitability, otherwise we faced with the need of carrying out the special reconstruction works.

There are two essentially various objects usually distinguish in practice of management [27,28,30]: first - extensive traditional rural territories on which the using of maintaining regimes and an imitation of "landscape physiognomy" considered possible, second –"museum landscapes"- relatively small areas around historical, architectural or archeological monuments for which the conditional "muzeefikation" (almost full conservation) is real. In both cases there is a non-trivial problem of defining "samples" for reconstruction - so called "reference landscapes" [27]. As a "palimpsest" (the term invented by O. Crawford) [19] traditional rural areas always contain the cultural features of different epochs - so far the question "what historical period (time depth) we should "have in mind" while outworking the landscape restoration plans" is disputable [11].

Another, not less serious and debatable problem of landscape reconstruction is connected with aesthetic aspects. It has turned out that the beauty of traditional countryside (unwittingly created

during the centuries-old work of the peasant) in our days requires enormous efforts undertaken in accordance with a specially developed projects, mainly the projects devoted to the aesthetic landscape qualities [15, 6].

Preserving and reconstruction of traditional landscape became an actual problem for many places of outstanding cultural value and natural beauty in Russia, especially in connection with large-scale overgrowing of the former farmland [8]. The solution to this problem, regardless of the area of its manifestation demands both studying of aesthetic landscape properties, and development of the special territory management plan. Experience of the similar research conducted by authors for “Kizhi State Open Air Museum of History, Architecture and Ethnography” is analyzed in this article.

OBJECT AND RESEARCH PROBLEMS

The Kizhi Museum is one of the largest open air museums in Russia. This unique historical, cultural and natural complex is a particularly valuable object of cultural heritage of the peoples of Russia. The basis of the museum collection – the Kizhi Ensemble – is the UNESCO World cultural and natural heritage site. Kizhi – the central island of the archipelago "Kizhsky shkher" located in northeast part of the water area of Lake Onega (fig. 1, left).



Fig.1. Kizhi island in northeast part of Lake Onega (left); Church of the Transfiguration – the main monument on the UNESCO World Heritage Site (right)

In spite of the fact that the main subject of protection are unique monuments of wooden architecture (Fig.1, right), both among experts and in a wide public circle the opinion on importance of a landscape as a background of perception has become stronger.

The modern landscape of Kizhi is a typical example of active revegetation: throughout the 20th century agriculture using of the island constantly decreased – arable lands have disappeared, mowing and a pasture allotments were steadily reduced. Once open spaces turn into secondary coppice-meadow landscapes: slopes of fluvial-glacial hills grow with a pine, a mountain ash and a birch, lake terraces – with wood and shrubby willow.

During the last decade the island became an arena of tourism development: total amount of visits (about 120 thousand people a year) tends to increase and that provokes inevitable development of engineering and transport infrastructures (port, the entrance area, means of lighting and protection, etc.). The unique works on restoration of the Transfiguration Church which are carried out since 2011 have demanded expansion of an operational sector with large workshops for wood drying and handling.

Thus, within formerly rural space of the memorial estate appears a number of alien objects and this may lead to loss of authenticity and deformation of landscape aesthetic properties to the level which makes impossible the perception of unique wooden architecture of the Russian North. There was obvious a need of special measures for landscape maintaining which, in turn have to be proved during special research. Tasks of such research have been formulated by authors as follows:

- 1) GIS-modeling of visual structure of Kizhi island in connection with tourists walking geography ("workspaces") and perception;
- 2) identification of a specific visual function performed by separate landscape components (relief, vegetation, manmade features) in formation of landscape scenes;
- 3) definition of the visual deterioration that changed unfavorably aesthetic landscape properties.
- 4) reconstruction of historical land use mosaic for fixing of inherited aesthetic indications and definition the target condition of landscape;
- 5) the territory management plan outworking for providing actions of landscape reconstruction, preservation and care;
- 6) inventing of the operational tool for visual landscape assessment which may be used at placement of new infrastructure facilities and regulation of recreational and tourist pressing.

GIS-MODELING OF VISUAL STRUCTURE OF THE KIZHI ISLAND

A landscape esthetics – the difficult interdisciplinary research area which is closely connected with provisions of so-called "landscape model" of an environmental aesthetics [16, 17], theoretical development of landscape semiotics and iconics [26], emergence of so-called "visual ecology" [9, 31]. However, despite a variety of visual research approaches the GIS-analysis are carried out a role of uniting "basis" for many modern attempts to reveal the landscape aesthetics and this circumstance conducts to accumulating of the multiple, comparable and reproduced data that is extremely important for landscapes management and planning.

According to modern representations there are three groups of the interconnected properties [16] inherent in a landscape as an aesthetics object:

1. The visual spatial visibility-openness set by dividing of landscape space into a separate visual cameras – "viewsheds";
2. Visual features (variables) relating to different landscape components such as dimension, texture, color, orderliness, rhythm and others;
3. The landscape composition determined by number and expressiveness of plans (forward, average, background), an arrangement of separate focuses and attractors, availability and nature of a side curtain; trajectory of visual inertia and other properties.

Modern geographic information systems (in particular, ARCMAP packet products) provide special tools for fixing viewsheds or "visual envelopes" which size and a configuration are determined, first - localization and/or nature of the observer movements, secondly - properties of landscape components (relief "plastic", architectonic and configuration of vegetation, character of the water coastline, etc.). Therefore, when studying visual structure of a specific landscape it is necessary to describe, in the most exact way the observer's provision. Such problem is solved by means of mapping of movements of the perceiving subject (visitor) on the territory, in our case – within the Kizhi island.

Specially made field observations, allowed to clarify that the "tourist geography" consists of more or less simple linear paths (organized excursions and independent walks), loci (stops in front of the monuments), and also areas of different configuration which are created in the course of searching and choosing the vantage points for observing and photographing.

Mapping of excursion tracks, vantage points and places of observation allowed to define statistically the most important observer's locations (i.e., to set - from where exactly the landscape is perceived) and to start the following stage: an assessment of visual structure by means of fixing the boundaries of viewsheds in a special layer of GIS with use of the visibility 3D Analyst tool (ArcMap 10.0 packet) - consecutively for all stops on tourist route.

Then in boundaries of the revealed viewsheds two other groups of the landscape aesthetics properties - visual features of different components and the general composition - were researched. For this purpose, in each viewshed photofixing of landscape scenes was carried out. By "landscape scene" in this operation we understood the fragment of the visual environment restricted to physiological opportunities (first of all - sharpness of a vision's field), perceived by the observer without turns of the head and changes of location. Experimentally it is proved [9, 31] that similar "scene" - ellipsoidal in the form is approximately transferred by a frame of the camera with the wide (15-22 mm) lens in "landscape" orientation.

In the course of field studies on the island have been shot about 1500 photos which then have been subjected to consistently technical rejection, geolinking (georeferencing) and the substantial analysis in a number of parameters (focus and attractors, a side curtain, representation of forward, average and background plans, expressiveness of the horizon's line, the character of the scene's basis and "ceiling") [16, 32]. Further in a special layer of GIS shooting points have been connected by vectors to focal objects. That in combination with scene's analysis has allowed to differentiate all set of scenes on 8 types in accordance with the function in perception of cultural landscape of Kizhi –island (fig.2):

- 1) scenes with a central subject of an exposition (wooden churches and chapels) as the central focus,
- 2) scenes with other monuments of wooden architecture as attractors,
- 3) panoramas of combined scenes which was shot from the dominating vantage points on the island hilltops,
- 4) scenes with several well expressed average and background plans and elements of a landscape as attractors (solitsmall coppice, coastal ranks of trees, stone ridges, bogs),
- 5) the scenes observed from the lake's water area in arrival and departures time of tourist steamships,
- 6) scenes containing various local natural objects (separate trees-solitary, large boulders and so forth),
- 7) visual corridors binding among themselves various vantage points,
- 8) local points of "close looking" at architectural objects.



Fig. 2. Two different types of landscape scene: scenes with several well expressed plans landscape features (left) and scenes observed from the lake's water area (right)

For further studying of the visual roles of separate landscape's components special 3-D model of Kizhi-island have been constructed in the ArcMap ArcScene. The aim of modelling was to reproduce the significant feature of relief (levels of terraces, tops and slopes of various steepness, ledges and buttresses, stone ridges), vegetation cover (accent trees, coastal tree-lane, wood and shrubby tree-groups, meadows of various type) and above all – churches, chapels, rural log huts, windmills and smithies. Then to a 3D model the layers displaying movement of tourists and shoot points are added. By means of detailed cameral analysis of the fotofixing landscape scenes in comparison to three-dimensional model of the Kizhi-island the visual functions of various landscape's elements have been determined. It has become clear that the island relief determines a configuration of the viewsheds covering slope's amphitheatres, and the flat surface of lake terraces. Internal (within viewsheds) filling of scenes is almost entirely determined by a vegetation condition: meadows create visual "floor", dense spherical volumes of bushes, separate trees – accents and focuses at average and front plans, coastal alleys - a side curtain, forest track – edges and "walls" of distance scene with expressed background. The vegetation generally controls property of "openness closeness" of viewsheds: so half-open landscapes can represent meadows with single curtains, or glade with regularly placed trees [6].



Fig.3. 3-D model of Kizhi island executed with the ArcScene toolset GIS ArcMap 10.0

IDENTIFICATION OF VISUAL DEFORMATIONS AND RISK FACTORS

Determination of visual functions of landscape elements has allowed to establish sources of visual deformations and risks which are understood as misstatements, violations and deteriorations in any of three groups of aesthetic landscape qualities (openness-closeness, visual features, composition). Most considerably aesthetic properties change through the transition of landscapes from open and semi-open in semi-closed that inevitably occurs owing to overgrowing of former fields and meadows by trees and shrubby vegetation. Each such transitions "are latently prepared" by the transformation of visual features of separate components during the processes of revegetation (which looks as a mean annual dynamics of a landscape), that unfortunately less noticeable for an unsophisticated eye. For example, textural (character of a surface) and coloristic (color aspect) features of a mixed grass meadow gradually change in case of the cessation of mowing and haymaking, loss of valuable types and their replacement by the rough grass and shrubs, which in turn entails obscuring of a natural relief plasticity and, and finally, visually impoverishes and changes landscape physiognomy.

The visual deformations caused by placement in a landscape of new facilities and constructions can create new undesirable focuses within visual scenes (for example, vertical support of overhead power lines or electric transformer), also can close important visual corridor on the central objects, create an unnecessary side curtain or screen, and finally - to change the texture and color of horizontal surfaces (new road "clothes" from the delivered alien crushed stone) [6].

Determination of a target condition for the cultural landscape by means of reconstruction of "reference" landscape.

Discussion of aesthetic landscape properties with the representatives of various services providing functioning of "Kizhi" (ecology group, museum curator, excursion guides, restoration workshops, Emergency service, engineering service) has allowed to reveal contradictions in idea of what "should be" a landscape of the Kizhi-island. To solve this problem, the authors proposed the concept of "target landscape condition" for implementation in territory management [6, 7].

As target condition for a cultural landscape is possible to define as that allows the managing subject to combine several kinds of land and resource using (which as a rule, not quite compatible among themselves) and to keep (or to recover) desirable aesthetic and ecological properties of the landscape. The target condition could be characterized with the set of parameters [7]:

- authenticity, historicity, "originality";
- aesthetics (relevancy and beauty of separate landscape scenes, preserving visual corridors, harmony of complete image);
- "ecological compatibility" (recreational resistance, level of a biodiversity and rehabilitation potential);
- functionality (possibility for various services to carry out their functions).

The analysis of a target landscape condition for "Kizhi-island" has shown that the most debatable criterion is authenticity directly connected with the question of a "reference" landscape.

To the solution of the question authors have applied the GIS-analysis: the boundary plan of the middle of the 19th century was digitized and overlaid with a layer of specially constructed geomorphological map and a layer fixed so-called "rovnitcu" - stone wall-ridges of various form which was specifically laid out by peasants. Overlay has allowed to reveal that ridges carried out function of boundary elements for division of arable strips), in rear seams of low lake terraces - for marking of haymaking), along ledges of terraces. The arable layer was exempted from stones, and grounds were marked by evident and durable borders; characteristic lines of a natural relief were indirectly emphasized, and exactly all this gave to the landscape special "kizhi-like" character. For the last decades the most part of stone ridges grown with rough grass, raspberry and literally "has disappeared from a look".

Therefore, for the Kizhi -island the reconstruction of historical (authentic) appearance assumes, first of all, reproducing a former field mosaic by preservation of opened meadow and their boundary elements - stone ridges.

MANAGEMENT OF THE TERRITORY FOR PRESERVING ESTHETIC PROPERTIES OF LANDSCAPES

Real needs of preserving aesthetic properties of historical (traditional) landscape require development special a package of measures for reconstruction— so-called "territory management plan".

The management plan is developed under the whole set of tasks among which achievement and maintenance of a target condition one of the major. Spatial units on which actions of the management plan are projected are so-called «working section». The borders working section are fixed by

overlaying of the revealed layers: "reference landscape", functional zones, viewsheds and the valuable green infrastructure. In accordance with that scheme the territory of the Kizhi-island has been divided into approximately 100 sections, for each actual and target conditions have been determined. After that 12 standard regimes reflecting the content and specifics of maintaining are developed; for example - keeping of natural state without intervention (for high moor bogs), transforming the semi-open spaces to the open (for the overgrowing meadows), and sanitary tree-felling and partial disclosure for coppice. For everyone section content, terms and frequency of carrying out actions were entered in the flow charts of the Excel program.

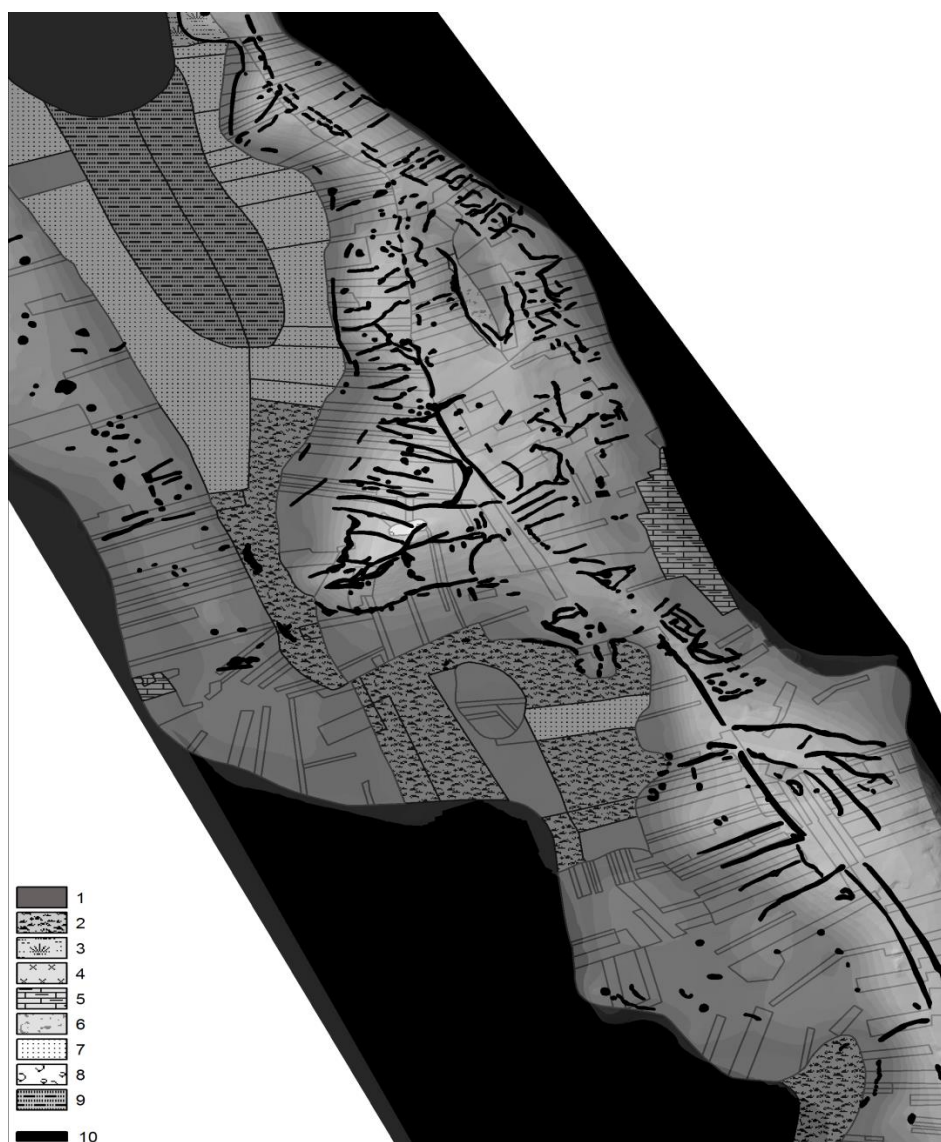


Fig. 4. Kizhi island cultural landscape in the middle of XIX century (fragment). Strips of different land use have been digitized by handwritten land survey sketch and overlaid with the TIN-model:

- 1 – field strip
- 2 – dry hayfield
- 3 – wet hayfield
- 4 – enclosure around the stackyard
- 5 – kitchen-garden
- 6 – water meadow
- 7 – pasture for cattle
- 8 – rocky unused places
- 9 – moss bog
- 10 – "rovnitcu" stone wall-ridges

As special values for appearance of Kizhi- island landscape the mosaic small forest tracks with open meadow spaces - the most difficult expensive actions are free-felling and clearing of shrubby groups, and most of all – the choosing of time lag (periodicity) between moving and haymaking on different types of meadows.

At the final stage of research process working charts were processed for the forecast of labor costs and an assessment of financial aspects of territory management plan implementation. It turned out that realization of management plan requires the creation of separate specialized landscape-care service.

VISUAL ENVIRONMENTAL IMPACT ASSESSMENT

Visual EIA (in the original - "Landscape and Visual Impact Assessment") – some kind of tactical procedure of "quick response" allowing to avoid the undesirable interventions and visual deformations which are irreparably changing all traditional image of the rural landscape [20].

A task of LVIA – an assessment of admissibility of impact on aesthetic properties of landscapes. The assessment consists of several consequently carried out steps which content has been changed by authors [6] in compliance with conditions of the Kizhi -island of and tasks of achieving of target condition.

On the first step the spatial scope of the area affected by potential impact was determined and types of points of perception which get to a specific area were fixed. So, towers of radio relay and cellular communication, are seen from many viewsheds and create new undesirable attractors. Other elements, for example, new transformer substation – are noticeable only within one envelope and are perceived from "a local point". Then were analyzed duration (in absolute values - month, a season, years) and reversibility (a scale framework "reversible-irreversible") of expected impact. Some alien objects (for example – waste containers) appear only during a tourist season, however constructions of engineering and transport infrastructure (the mooring of new cargo port, pier for passenger ships) are built in landscape practically forever.

The following step - determination the specific of influence concerning the above mentioned landscape components which are considered in this case as the "details" of a visual scene capable to change the elementary and composite properties [16, 21]. It is the most difficult to estimate transformation of composite aesthetic properties, in particular so-called "pattern" - a mosaic of fields, meadows and bogs.



Fig.5. Target condition: desirable visual landscape pattern of Kizhi determined by the combination of hay field and tree alleys and small tree-bush groups

Final step of procedure – an assessment of a possibility of elimination, correction or mitigation of the consequences of expected impact. Many "invasions" into the cultural landscape are inevitable (it is impossible, for example, in the territory of the memorial estate without lighting and security

constructions), yet such undesirable objects, can be camouflaged with "protective" coloring, are screened by plants or a "authentic" fencing [22].

Results of an assessment of each stage in the form of numerical indexes are entered in the tables of the Excel program which are specially developed by authors and connected among themselves;

Of course, such assessment – no more than "props of common sense", but experience of real discussions shows that use of VIA tools disciplines participants of the most heated debates and does possible the calm and constructive discussion.

DISCUSSION OF RESULTS

Changing character of land use of the rural zone – on the one hand, and everywhere observed processes of throwing of lands and revegetation – with another, create a number of new risks for aesthetic of landscapes that does actual a task of management of landscapes which can be formulated as transformation from the existing to target landscapes condition. As parameters of transformation both the C aesthetic properties, and the authenticity features relating to a certain historical period can be applied. The tools of modern GIS in combination with methods of photofixing give opportunities for modeling of visual structure of landscapes and research of a role of separate components in forming of specific scenes that allows to estimate the characteristic of aesthetic properties, to a certain extent, (first of all - to map). Entering of "subject" - the observer holding a certain position and moving in space of landscape becomes an important part of such modeling. At the same time further study is required by questions of mapping and an assessment of difficult, composite properties within "landscape model" of a landscape esthetics.

Actual and debatable continues to remain formulated problem of "reference" landscapes as it is model for determination of a target condition of a cultural landscape, especially in the territories which have endured several different and each (in its own way) significant stages of forming. At any rate statement and a reflection of this problem allows to avoid incorrect and fatal mistakes in case of reconstruction of landscapes in the territories of high historical value and natural beauty.

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