Vyacheslav V. Dolotov [1*] **Vitaly A. Ivanov** [2]

[1*] Senior scientist, Shelf Hydrophysic Department, Marine Hydrophysical Institute of National Academy of Science of Ukraine, Sevastopol, Ukraine; Kapitanskaya, 2, 99011, Tel. +38 0692 442622, vdolotov@mail.ru

Corresponding author

[2]Academician of the National Academy of Sciences of Ukraine, Head of the Department of shelf hydrophysics, Director of the Marine Hydrophysical Institute, Sevastopol, Ukraine; Kapitanskaya, 2, 99011, Tel. +38 0692 542528, vaivanov@alpha.mhi.iuf.net

CADASTRAL ASSESSMENT OF CRIMEAN BEACHES AS AN INSTRUMENT FOR SUSTAINABLE COASTAL DEVELOPMENT

ABSTRACT

One of the important steps towards sustainable development of territories is the assessment of the reserves and rate of consumption of natural resources. Such assessments are also supported at the international level. The recreational resources represent the most important type of natural resources for the coastal zone of Crimea. They are the basis for recreational tourism and, therefore, determine the economic status of the peninsula as a whole. Currently, however, the coastal zone of Crimea is being developed quite chaotically. The need for a specialized information system capable of timely reflecting natural and manmade changes in the coastal zones is widely recognized.

The paper presents a system that was developed using ESRI ArcGIS formats capable of not only capturing changes occurring in the environment, but to also identifying options for a more efficient use of the recreational resources of the peninsula. The approach and unique algorithms developed by the authors of this paper were applied to four Crimean beaches.

KEY WORDS: cadastre, beaches, recreational resources, geographic information systems

INTRODUCTION

Assessment of natural resources and environmental management is crucial for sustainable development of territories. At the same time, it represents one of the most important areas of scientific research. Regions where the use of natural resources is a priority for economic development are of a particular importance. One of such regions is the Crimean peninsula. Infrastructure development that facilitates the use of the natural recreational potential represents a crucial economic goal for the region.

In this paper, the recreational potential means an aggregate of natural, cultural, historical, and socio-economic conditions important for organization of recreational activities in a given area [Mironenko and Tverdokhlebov, 1981]. The recreational potential of Crimea, as well as any other type of natural resources, should be zoned and quantified to identify integral resources and recommendations for their most effective utilization. The main difficulty of this endeavor is associated with diverse forms of the recreational potential and its impact on the human body. The particular impacts of individual components, however, have been studied insufficiently.

The solution may be found in the development of a specialized geographic information system (GIS) that specifically targets the recreational potential of Crimea. This GIS should include a detailed and most precise quantitative description of the individual components of the recreational potential of different parts of the peninsula. The most popular recreation objects, i.e., beaches, should be the first priority of the investigation. Such GIS should be a consistently updated and maximally visual cadastre of the recreational resources of Crimea. It should include natural (geomorphological), ecological, climatic, economic, and sociological components. This GIS would aid in future certification of beaches, development of map documents, and various advertisement media.

COMPONENTS OF THE RECREATIONAL POTENTIAL

The most important components of the recreational potential are recreational resources, i.e., components of the environment and objects of human activity that can be used for various types and forms of recreational activities – leisure, tourism, health improvement, etc., due to such qualities as uniqueness, historical or artistic value, originality, aesthetic appeal, and health-improving value [Geography..., 1980]. This recreational potential includes the following elements:

- therapeutic resources (climate, mud, hydro);
- health-improving resources of active recreation (rivers and reservoirs, beaches, forested areas);
- tourist-excursion resources (natural, cultural, historical, and architectural landmarks);
- tourist and recreational infrastructure.

In reality, the recreational resources exist as functional combinations of the components of natural and cultural landscapes that allow developing certain types of recreational activities. This, in turn, helps to create various subtypes of recreational facilities within the same territory.

Table 1. The list factors of the recreational of Crimea

	Factors
1	scenic value of the landscape (alternating open and closed spaces, presence of scenic views, etc.)
2	diversity and alternation of relief forms (depth and density of differentiation, steepness of slopes)
3	diversity of flora and fauna (number of species)
4	presence, size and quality of water bodies (sea, rivers, lakes, and ponds)
5	presence and characteristics of beaches пляжей (see Table 2)
6	presence of unique species, natural features (parks, waterfalls, etc.), monuments of history, culture and art
7	availability of balneological resources (phytoplankton, mineral water, mud, brine, etc.)
8	characteristics of microclimate

The result of recreational use of natural resources is the health effect expressed in increased efficiency, reduced morbidity and mortality, and other social indexes. This social effect always transitions into the economic effect manifested in enhanced productivity, reduced sick leave, and lower health care costs.

In general, all the components of the potential can be expressed as shown in Table 1.

It is quite clear that beaches are the most crucial part of the recreational potential. That is why in the summer, millions of people rush to the sea. Thus, the development of the cadastre of the recreational resources of Crimea should start from the cadastral assessment of its beaches.

ASSESSMENT METHOD

The most important component of the recreational resources, beaches, should be assessed in much detail. In addition to a standard set of geomorphologic research methods, it is necessary to examine and

Table 2. Main characteristics of beaches

| 1	Geomorphologic characteristics
1.1	dimensions (length on the ground and average width)
1.2	type (full or partial profile)
1.3	length of coastline
1.4	curvature (tortuosity) of coastline
1.5	average gradient of the coastal and underwater areas of the beach
1.6	elevation gradient of the coastal beach zone
1.7	direction of exposure
1.8	height and average slope cliff of the beach with incomplete
1.9	composition and size of bearing beach material
1.10	area of the beach, its coastal zone and waters
1.11	area of safe children and adult swimming
1.12	zoning and partitioning
1.13	length and slope of the path to the beach
1.14	share of green area in the beach zone
1.15	presence of individual features (rivers' mouths, gullies, etc.)
2	economic characteristics
2.1	ownership (health-improving and municipal organizations and recreational centers)
2.2	beach accessibility (private, commercial, public)
2.3	presence, length and average width of pedestrian zone (lane)
2.4	infrastructure facilities in the beach zone
2.5	distance from the beaches to build-up and buildable zone and industrial facilities
2.6	distance from the beaches to dormitories (only for therapeutic beaches)
2.7	approximate number of vacationers during the swimming season
3	social characteristics
3.1	accessibility and cost of admittance
3.2	distance from the city or town center
3.3	availability of public transportation
3.4	availability of guarded parking
3.5	number of gear rental centers
3.6	availability, number and the area of tent sites
3.7	number of water and shore amusement rides
3.8	presence of archeological, historical, architectural and art landmarks
3.9	presence of unique plant species
3.10	presence of unique nature landmarks
3.11	availability of balneological resources (mud, mineral waters, etc.)
4	environmental characteristic
4.1	distance form water and air pollution sources
4.2	distance from the main traffic arteries
4.3	availability and number of garbage containers
4.4	frequency of clean-up work in the beach zone
5	climatic characteristics
5.1	number of days in children and adult swimming season
5.2	average water and air temperature during swimming season
5.3	number of sunny, rainy, and stormy days during swimming season
5.4	number of days in upwelling
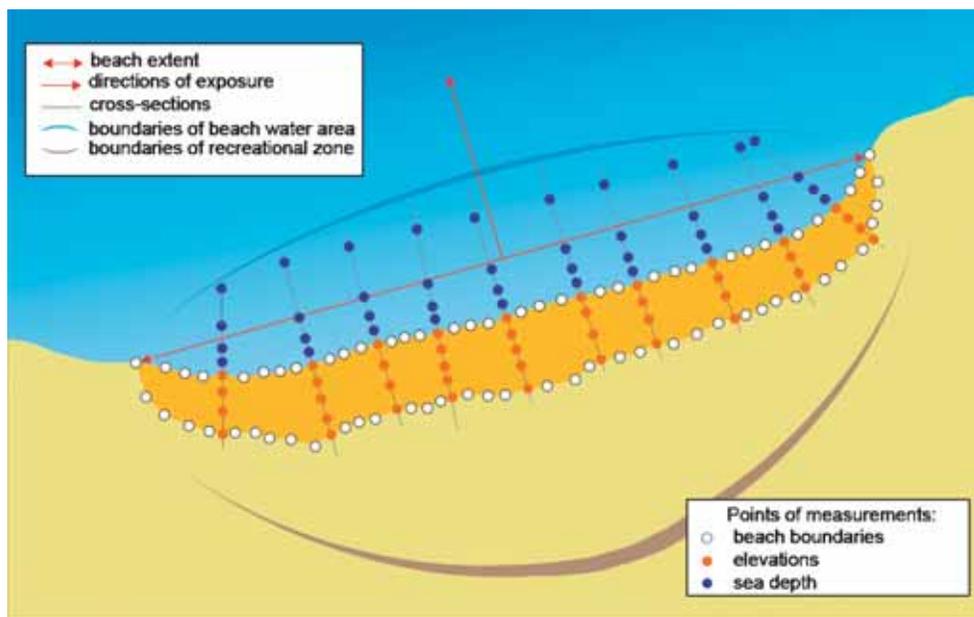
Figure 1. Schematic representation of the assessment procedure

evaluate the individual characteristics of recreational areas surrounding beaches, including their infrastructure (Table 2).

Composition of beach forming material. Global positioning devices are nowadays used to obtain the exact locations of points on the terrain and their elevations. In our studies, we used "Trimble-4600LS" with a few centimeters horizontal and vertical measurement accuracy. Thickness and volume of beach forming material were obtained by ground-penetrating radar "AB-400". The measurements were performed on a series of cross-sectional lines perpendicular to the water's edge; the length of the beach and its heterogeneity determined their number. The individual characteristics of the beaches, including ravines, cliffs, estuaries, etc, were also determined.

The depth of the swimming zone, slope, and bedrock material were identified in the aquatic zones of the beaches, "TM-2A" portable turbidity meter allowed measuring vertical profiles of water transparency with a seven cm resolution. The work procedure is schematically presented in Fig. 1.

The recreational areas bound by the state roads or residential development were also carefully examined. Within these boundaries, all infrastructure elements, green space and its appearance, landfills, waste sites, latrines, sources of fresh water, etc. were described. Potentially dangerous sources of air and water pollution located nearby were also recorded. The implementation of these activities was the first and most time-consuming step.

In the second phase, the obtained data were fed into the GIS as separate map layers. The identification of objects can be facilitated by the use of georeferenced high-resolution satellite maps, including maps obtained from Google Maps. Fig. 2 presents an example of the measurement results for one of Sevastopol beaches (the beach of the village Lyubimovka). Further data processing included calculation of necessary design parameters. Two types of data, specifically, information and control parameters, were calculated and evaluated. The first group was used in the analysis of the state of the recreational areas and included derived values; these parameters were the curvature of beach coastline, area to perimeter ratio, differences in elevation, slopes, etc.

In contrast, the control characteristics, in addition to their information load, also determined the compliance with selected indicators of the regulatory standards for the recreational areas. For this purpose, the cadastral GIS included a set of effectual regulatory standards tables. If necessary, it may be possible to conduct a testing procedure with the results compiled into a table of deviations of actual characteristics of the recreation areas from the regulatory standards (capacity, number of eateries, toilets, garbage containers, tent shelters, cabins for changing clothes, etc.). This undoubtedly contributes to rapid decision-making, quality, and conditions of use of the recreational potential.
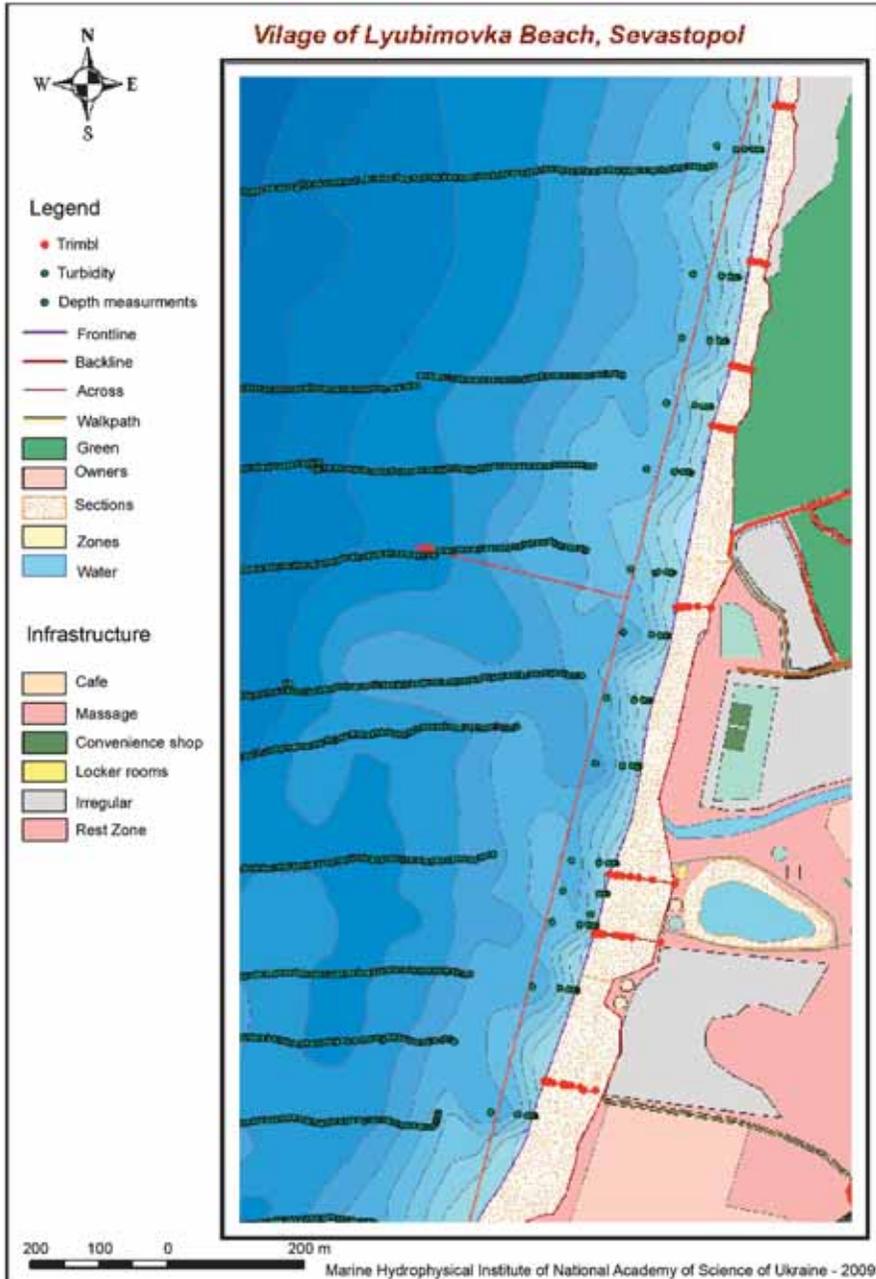

Figure 2. Schematic representation of the assessment procedure at the village Luybimovka beach

BASIC REQUIREMENTS
FOR THE INFORMATION SYSTEM

Like any other inventory, the cadastre of the recreational resources must be as complete and detailed set of field data and derivatives of calculated values as possible. As shown above, the total number of parameters is quite considerable, so the assessment of the individual components and recreational resources in general for a given region was performed using evaluation and presentation algorithms that are commonly used in GIS.

The design of the cadastral structure took into account the following considerations:

- the assessment of the recreational potential should be applied to objects or parts of Crimean regions that have spatial references;
- the cadastre should support at least three languages due to ethnically diverse population of Ukraine and Crimea;
- the cadastre should not be based on regulatory data, which may affect the estimates and vary over time;
- it is necessary to maximally automate processing of the field data and limit pre-processing;
- it is necessary to provide a multi-level selection of studied recreational facilities for the analysis according to various criteria;
- it is necessary to support the cadastre through periodic repeated surveys with varying intervals of measurements for different objects.

The last point suggests that available cadastral data should be divided into the "background" or relatively stable over time, and the "results of individual surveys". The former may include such survey items, as roads, riverbeds, construction, onshore facilities, etc. Furthermore, it is obvious that some measurable parameters, such as parameters of water and air quality, may not have spatial referencing, which involves the creation of a number of additional specialized tables. This in turn, requires insuring linkages between the tables and, consequently, developing a georelational database as the basis for the cadastral GIS.

ESRI ArcGIS is widely used for data processing and the implementation of non-standard analytical operations since this system is extremely popular worldwide and provides the maximum support in Ukraine. The cartographic and tabular data formats were designed considering the requirements of this system. Thus, the cadastre represents a georelational database, consisting on layers of cartographic data in ESRI SHAPE format, i.e., point, polyline and polygonal, including Z-parameters; the associated attribute tables were compiled in DBF format. The cadastre also included additional tables of codes and names of the studied objects, measured parameters, linguistic analogues of rows, regulatory values, and some other entities.

The electronic shell of the cadastre should facilitate a quick input and analyses of available information. This shell can be written in ArcGIS environment or developed for separate modules using modern programming languages. When choosing the implementation of the GIS analytical module, the authors took into account the following:

- ESRI ArcGIS is a multi-purpose system capable of creating, processing, and analyzing spatially distributed objects; the cadastral GIS is unlikely to use a significant portion of its capabilities because, practically, it does not fully utilize its potential to create objects downloaded in the form of ready-made data derived from the measuring devices;
- the cadastral GIS will be provided to many municipal organizations of the coastal cities;
- the ESRI data are open source formats;
- there should be standard cadastral data processing methods capable of generating pre-defined reports;
- given a relatively small size of the studied objects, there is no need to use different projections and re-projection;
- it is desirable to maximally automate loading and processing of data in accordance with the developed procedures.

Undoubtedly, the requirements of ESRI ArcGIS packages to computer's capacity and their considerable cost should also be taken into account. Thus, the authors developed their own access drivers for cartographic and tabular ArcGIS objects using programming environment "Borland Delphi_7". The resulting program represents a universal GIS with a special cadastral toolbar, including the following:

- download of GPS data collected using such devices as "Trimble-4600LS" and "Garmin eTrex" with automatic detection of file structures and formation of a minimal set of map data necessary for carrying out cadastral valuation of beaches;
- creation of the list of beaches monitored by districts or regions, taking into account the structure of beach material and ownership;
- automatic calculation of cadastral characteristics of selected beaches;
- preparation of various types of illustrative materials based on the results of calculations;
- generation of documents for certification of beaches in accordance with approved formats;
- generation of tables of deviations from the regulatory standards for beaches.

The prospects for the analysis and assessment of the recreational potential are constantly improving. It is also possible to develop appropriate tools exclusively in ArcGIS environment.

ASSESSMENT OF CONDITIONS OF RECREATIONAL AREAS

The assessment of conditions and natural features of the recreational areas is a major task. We have already noted that the composition of the recreational potential is diverse, but its impact (mostly positive) on the human body has been insufficiently explored. The assessment is also complicated by the fact that the recreational areas as well as the beaches themselves, belong to organizations of various ownership. In accordance with the certification requirements [Concerning the approval ..., 2002], beaches are classified into three groups: beaches of health care organizations, hotels and resorts, and open public access beaches. Many of the regulatory requirements applied to different categories vary considerably. The recommended assessments of the recreational potential factors also differ significantly. In addition, the regulatory documents assign categories to beaches based on the assessment of their current performance individually for each group.

The author of one of the few research works devoted to the assessment of the impact of Crimean individual recreational factors on the human body [Efremov, 2003] suggests dividing beaches into three classes: beaches of subtropical zone, subtropical zone periphery, and southern steppe zone. For each class, the author proposes to introduce the concept of a "perfect beach", i.e. the beach with the best characteristics. He also presents a list of characteristics for each class of the "ideal beaches" (Table 3); the assessment of the actual beach conditions is done in points and in comparison to the "ideal beach" in each class. The values are derived by Crimean balneology physicians based on the impact of environmental factors on the human organism.

Table 4 presents the list of natural health-improving factors developed by this author. Thus, already at this stage, it is clear that it is possible to evaluate the recreational potential of Crimea using various systems of assessment reflecting different types of classifications, including, those that are based on the evaluation of environmental conditions of recreational objects. Recreation objects and especially their water component are subject to constant environmental analyses during the recreational period. The number of regulated analyzed environmental compounds reaches several hundreds.

In reality, only about 20 water-polluting compounds are most often determined on a five-point scale (Table 5).

Table 3. List of natural features that define the "ideal beach"

№	Categories that define the beach's category		1 category		2 category		3 category	
			value	point	value	point	value	point
1	Average air temperature during swimming season (t, °C)		20–21	3.5	19–20	3.4	18–19	3.2
2	Average water temperature during swimming season (t, °C)		21–22	3.5	20–21	3.3	19–20	3.1
3	Number of sunny days during swimming season (%)		75–80	3.5	70–75	3.3	65–70	2.1
4	Cliff characteristics	availability of vegetation	–	4.0	–	3.7	–	3.0
		absence of vegetation	–	2.0	–	0.8	–	0.6
		rock	–	1.5	–	0.4	–	0
5	Structure of beach-forming material	sand	–	3.0	–	2.3	–	2.0
		fine gravel	–	3.0	–	2.3	–	2.0
		large gravel	–	1.0	–	0.9	–	0.7
6	Bench structure	sand	–	2.5	–	1.3	–	1.1
		fine gravel	–	2.5	–	1.7	–	1.5
		large gravel	–	1.5	–	0.3	–	0.2
		silt or clay	–	0.3	–	0.2	–	0.1
7	Beach sun baths	sand	–	2.0	–	1.8	–	1.7
		fine gravel	–	2.0	–	1.3	–	1.1
		large gravel	–	1.6	–	0.5	–	0.3
8	Bench slope (%)		2	2.0	–	–	–	–
			1	1.8	–	–	–	–
			0.5	1.6	–	–	–	–
	Maximum number of points			24.0		20.0		17.0

Table 4. Physicians-balneologists' expert assessment of the influence of the recreational factors on health-improving processes

	Recreational factors	Score
1	sea bathing	12
2	sunbathing on beach	3
3	sea air	1
4	emotional impact of the sea	1
5	emotional impact of subtropical flora	3
6	mountain forest air	2
7	emotional impact of mountains	2
8	sunbathing in the woods and fields	1

Table 5. Point-value assessment of the quality of the water body

Characteristics	Value
clean	1,5
relatively clean	1,2
low-polluted	0,9
medium polluted	0,7
highly polluted	0,5

Table 6. Classification objects based on recreational uniqueness

Characteristics	Value
Coefficient of environmental value (environmental importance) of water body	
а) unique water bodies	2,0
б) environmentally especially important objects	1,5
в) environmentally important objects	1,2

Table 7. Classification of recreational objects based on their natural value

Parameter	Value
Coefficient of objects with health-improving and recreational:	
Autonomic Republic of Crimea, including	3,6
South coast	7,6
South-eastern coast	4,5
West coast	5,4

There are also classifications based on the uniqueness (Table 6) and value of natural environment of health-improving and recreational facilities (Table 7).

Specially developed computer programs would facilitate handling such diverse classification systems and large number of assessment parameters.

VERSIONS OF CADASTRAL ASSESSMENTS

The cadastral valuation of the recreational resources aids in assessment of the current state and dynamics of recreation objects. A comparative assessment of the studied objects would help to develop measures addressing shortcomings in the organization of consumer services sector supported by these recreational objects.

The most feasible method is the analysis of different types of recreational potential for each object of recreation. In this case, the results can relate to either individual objects, their majority (see Fig. 5 further down), or even the entire group (Fig. 3).

In the latter case, it is feasible to use the method of conditional formatting, which assigns different colors to cells with substantially high or, conversely, low levels of certain types of resources. This table would be would clearly indicate what indicators and objects need improvement; grouping the same color cells would highlight a particular level of development of the whole region (assuming the distribution of objects in the table corresponds to their location on the ground). This method of analysis can be extremely effective in making decisions about the development of recreational areas in individual regions.

The recommendations of the World Bank [Integrated ..., 1993; Koptyug, 1992] indicate that it is quite difficult to operate with a list of dozens or hundreds of parameters in the decision-making process. For timely decision-making, the number of indicators should be limited to a dozen. Therefore, we suggest using the minimal number of integral indicators, calculated from the full list. In this case, and in accordance with the fundamentals of recreational geography [Kuskov, 2004], three major components of a recreational facility or region deserve special attention: natural, economic, and social (culturological). The natural component describes dynamic changes caused by natural or anthropogenic impacts. The

Beaches Codes	Andreevka	Kacha	Orlovka	Lyublimovka	Odissei	Mokrousova	Uchkuevka	Toistyi Mys	Konstantinovskyi	Starosevernyi	Karantinnaya	Khersones	Solnechnyi	Pesochnyi	Park Pobedy	Omega	B. Abramovka	Golubasya Bukhta	Karavella	Tsarskyi	Yashmovyi	Vasili	Serebryanyi	Zolotoi	BO Chf	Batiliman	Laspi
RSDST	1.15	1.15	1.39	1.15	1.15	1.15	1.15	1.06	1.15	1.06	1.09	1.15	1.04	1.06	1.15	1.04	1.09	1.15	1.48	1.50	1.45	1.30	1.24	1.35	1.24	1.24	1.24
WALK	1.61	1.67	1.72	1.78	1.67	1.94	1.78	1.61	1.89	1.89	1.78	1.78	1.89	1.94	2.00	2.00	1.89	1.15	1.56	1.56	1.56	1.56	1.61	1.17	1.89	1.88	1.88
WIDTH	1.10	1.21	1.35	1.41	1.26	1.15	1.20	1.15	1.12	1.08	1.13	1.10	1.25	1.47	1.12	1.10	1.18	1.15	1.07	1.14	1.31	1.28	1.23	1.25	1.20	1.41	1.18
W_QUAL	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.20	0.90	1.50	1.20	1.20	1.50	0.90	1.50	1.20	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
KE	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.20	1.00	1.00	1.00	1.00	1.00	1.50	1.50	1.50	1.50	1.50	1.50	1.50	2.00	2.00	2.00
AREA	2.16	2.45	2.36	2.62	2.02	1.97	2.28	1.77	1.74	1.36	1.50	1.43	1.67	1.92	1.81	2.08	1.84	1.64	1.48	1.82	2.10	2.27	1.94	2.14	1.45	1.85	1.85
PLANT	1.05	1.03	1.03	1.02	1.50	1.30	1.70	1.10	1.00	1.00	1.00	1.00	1.20	1.30	1.50	1.10	1.10	1.00	1.10	1.10	1.05	1.05	1.10	1.15	1.09	1.90	1.90
SPORT	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.02	1.00	1.00	1.00	1.00	1.18	1.00	1.00	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.20	1.00	1.08
GAMES	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.01	1.00
WC	1.00	1.00	1.00	1.00	1.00	1.00	1.04	1.02	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.01	1.07	1.08	1.00	1.00	1.00	1.00	1.00	1.00	1.20	1.06	1.08
CAFE	1.00	1.00	1.00	1.00	1.00	1.01	1.04	1.45	1.00	1.00	1.00	1.00	1.15	1.05	1.05	1.05	1.17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.16
WATER	1.00	1.00	1.00	1.00	1.00	1.00	1.45	1.45	1.00	1.00	1.00	1.00	1.74	1.11	2.53	2.47	1.17	1.42	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.16
SLOPE	1.46	1.43	1.43	1.43	1.43	1.43	1.43	1.43	1.35	1.43	1.43	1.43	1.35	1.35	1.35	1.35	1.35	1.35	1.43	1.43	1.43	1.50	1.50	1.50	1.50	1.50	1.50
STUFF	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.20	0.80	1.50	1.50	0.80	1.50	0.80	1.50	1.50	1.20	1.20	1.20	1.20	1.50	1.50	1.50
CURV	1.06	1.06	1.01	1.01	1.02	1.11	1.04	1.04	1.09	1.05	1.02	1.00	1.09	1.19	1.05	1.08	1.07	1.18	1.07	1.05	1.03	1.02	1.03	1.03	1.05	1.06	1.06
BENCH	1.47	1.20	1.43	1.20	1.20	1.10	1.43	1.20	1.20	1.20	1.20	1.43	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.45	1.45	1.20	1.20	1.44
CLIF_H	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.49	1.49	1.48	1.49	1.45	1.45	1.44	1.44	1.44
DISTANCE	0.77	0.83	0.85	0.87	0.94	0.96	0.97	0.98	0.98	0.99	0.98	0.97	0.97	0.96	0.94	0.93	0.92	0.88	0.88	0.87	1.00	0.85	0.84	0.82	0.75	0.74	0.74
TRANSP	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.70	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	1.00	0.70	0.52	0.52	0.70	0.70	0.70
ACCESS	0.80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.50	1.00	0.80	0.80	1.00	1.00	1.00	1.00	0.50	1.00	0.50	0.50	1.00	0.50	1.00	1.00	0.80	0.50	0.50
ROAD	2.08	2.08	2.08	2.11	2.34	2.34	2.36	2.36	2.08	2.36	2.11	2.36	2.38	2.38	2.08	2.36	2.34	2.11	2.08	2.08	2.38	2.30	2.38	2.08	2.08	2.03	2.36
CARS	1.50	1.50	1.50	1.50	0.50	0.50	1.50	1.35	1.50	1.50	1.50	1.16	1.16	0.92	1.35	1.16	1.35	1.50	0.50	0.50	1.16	1.02	1.16	0.50	1.02	1.02	1.02
SAFETY	1.00	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.40	1.50	1.50	1.50	1.50	1.50	1.50	1.30	1.00	1.00	1.00	1.40	1.00	1.30	1.00	1.00	1.00
OCOAST	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.40	1.50	1.50	1.50	1.50	1.50	1.50	1.30	1.40	1.40	1.50	1.40	1.30	1.30	1.50	1.50	1.50
QWATER	1.50	1.40	1.40	1.40	1.40	1.40	1.40	1.50	1.40	1.30	1.30	1.50	1.40	1.40	1.40	1.20	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
TRASH	1.00	1.00	1.00	1.00	1.00	1.01	1.02	1.05	1.00	1.00	1.00	1.00	1.07	1.01	1.00	1.02	1.02	1.13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.03	1.08
ATTR_W	1.00	1.00	1.00	1.00	1.09	1.09	1.04	1.00	1.00	1.00	1.00	1.00	1.18	1.00	1.00	1.06	1.00	1.42	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
ATTR_C	1.48	1.40	1.34	1.30	1.34	1.23	1.23	1.15	1.20	1.08	1.15	1.15	1.15	1.15	1.15	1.04	1.08	1.11	1.30	1.34	1.40	1.18	1.18	1.26	1.54	1.58	1.57
POLL_A	1.04	1.02	1.06	1.34	1.34	1.34	1.34	1.34	1.40	1.18	1.04	1.36	1.23	1.23	1.43	1.63	1.40	1.63	1.04	1.23	1.91	1.51	1.41	1.64	1.60	1.41	1.07
POLL_W	1.00	1.00	1.00	1.00	1.00	1.09	1.02	1.23	1.00	1.00	1.00	1.00	1.37	1.11	1.19	1.06	1.00	1.42	1.00	1.00	1.05	1.00	1.00	1.00	1.00	1.16	1.00
LEASE	1.00	1.00	1.00	1.00	1.00	1.00	1.02	1.34	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
TENT	1.00	1.00	1.00	1.00	1.00	1.79	1.78	1.78	1.00	1.00	1.00	1.00	1.78	1.78	1.00	1.78	1.78	1.00	1.00	1.00	1.00	1.00	1.00	2.36	2.04	1.78	1.78

Figure 3. The resultant table of characteristic parameters of Sevastopol beaches in Crimea

economic component includes multiple financial relationships among holidaymakers and the administration, infrastructure entities of objects, and the objects themselves.

This group can also include cost indicators of the recreational resources that, as it will be shown below, are the well-founded parameters. The social component reflects the level of accessibility of the recreational potential and, to some extent, characterizes the prestige and attractiveness of a recreational facility. In the authors' opinion, the integral indicators listed above do not necessarily have to share the same data sources.

It is logical to compute the following three main integral indicators of the recreational objects: **coefficient of natural dynamics (CND)**, **factor of recreational impact (FRI)** and **generalized measure of prestige (GMP)**. However, this list does not fully reflect the economic component. In this regard and given a relatively certain, for a given time interval, land value in any region of Crimea, additional equally important economic components of the recreational potential should be calculated: **cost of parcel of land** occupied by recreational facilities (**CPL**), total **value of the recreational facility** including FRI (**VRF**), and **cost of recreational resources (CRR)** defined as savings in the average wages in the country multiplied by FRI and the duration of the recreational period.

Furthermore, GMP can be subdivided into its individual components: **indicator of natural attractiveness (INA)**, **climatic prestige index (CPI)**, and **service**

comfort index (**SCI**). Finally, for a complete description of a facility or region, the list may be supplemented by two more parameters; these parameters are not integral, but play an important role in choosing recreational objects: **index of natural hazards (INH)** and **level of crime and political tensions in the society (LCPT)**.

All these indexes represent a general list of parameters for calculations; it is possible that only some parameters are used in the analysis.

The implementation of the computational algorithmic system may involve different methods. Some of the indicators listed above can be easily calculated. Thus, CND can be calculated from a number of different geomorphologic indicators. The history of the analyses of the dynamics of actual beaches suggests that the main contribution to the index value is determined by the ratio of current to former areas of beaches and their perimeter to area ratio. Our calculations also took into account changes in the shoreline curvature and slopes in the beach zone.

CPL is determined by the regulatory documents considering its use for agricultural purposes; similarly, VRF can be calculated as the product of multiplication of CPL by FRI [Efremov, 2003]. CPI, in turn, is calculated from the amount of positive and negative climate indicators characterizing each object, and SCI – from the number and capacity of infrastructure facilities, taking into account the regulatory requirements for facilities of various ownership. RNA represents the summary assessment of specific components that contribute to natural

Table 8. Point-value assessment of recreational zones of Crimea [Main …, 2004]

Recreational zone	Zone name	Distance to sea, km	Points
№ 1	Subtropicalя	0–5	14–16
№ 2	Near sea	0–0,5	11–13
№ 3	First zone	0,5–5	7–12
№ 4	Second zone	5–25	4–6
№ 5	Central	More than 25	1–2
№ 6	Mountain-forest	–	5

Table 9. Point-based assessment of beaches under different ownership

Beach ownership	Beaches of health-improving and resort institutions				Beaches of recreational and retreat facilities, hotels, camps, etc.				Municipal, town, public, etc. beaches			
Beach category	I	II	III	IV	I	II	III	IV	I	II	III	IV
Point values	3,0	2,8	2,6	2,4	2,4	2,2	2,0	1,8	1,8	1,6	1,4	1,2

attractiveness, including all kinds of individual regional characteristics. The parameter "market value" frequently applied to coastal areas of Crimea therefore corresponds to VRF as it implicitly takes into account FRI.

INH and LCPT are assessed on a ten-point scale.

FRI represents the most complex calculated parameter and may be determined from the multiplication of the individual parameters for separate components that characterize the natural recreational potential, and points assigned based on the "ideal factor" (Table 3), locations (Tables 7 and 8) and the category

(Table 9). The categories of the beaches were defined from their correspondence to the regulatory standards [Standards..., 2003] (Table 10).

The individual indicators were evaluated in two phases: independently and as part of the integral index. All indexes were divided into three groups. The first two groups of parameters reflected changes in a degree of influence of a specific indicator as a function of its value and depending if it varies in direct proportion or logarithmically. Percentage of vegetation in the beach zone may serve as an example of an index in the first group and the distance to the sources of pollution –
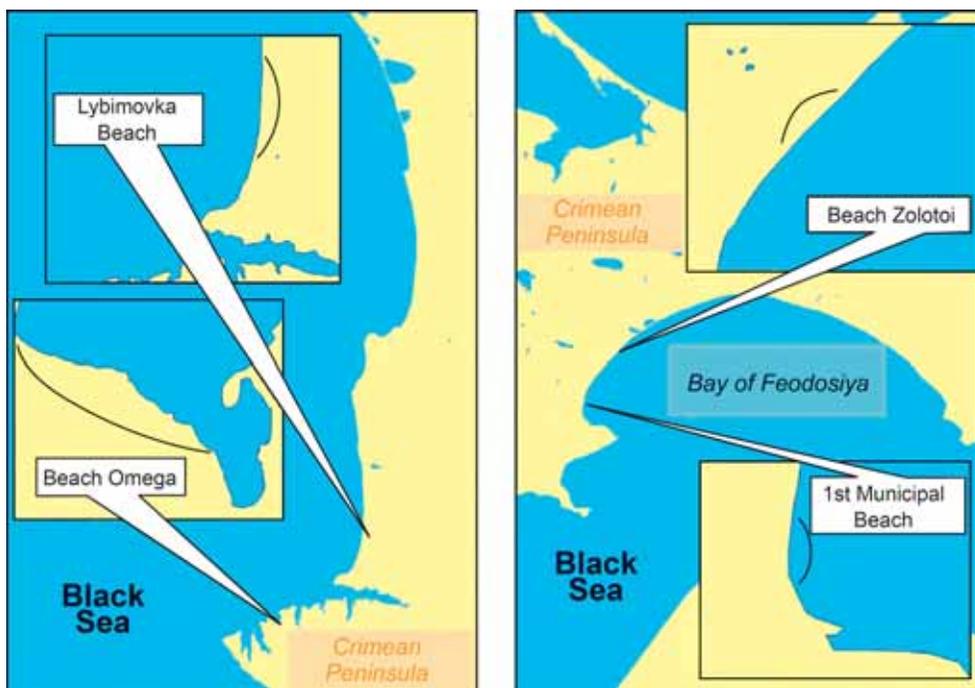

Figure 4. The studied Sevastopol (left) and Feodosiya (right) beaches

Table 10. Parameters used in the assessment of the beaches categories

N	Parameters	Beaches of health-improving and resort institutions				Beaches of recreational and retreat facilities, hotels, camps, etc.				Municipal, town, public, etc. beaches			
		I	II	III	IV	I	II	III	IV	I	II	III	IV
1.	Distance to build-up and buildable zone, main traffic areas, railroads, and industrial facilities (m)	>1000	1000-700	700-500	500-400	>500	500-300	300-100	<100	N/A			
2.	Distance from the beaches to dormitory (m)	<300	300-500	500-800	800-1200	<500	500-800	800-1200	1200-1500	N/A			
3.	Slope of the path to the beach (degrees)	3	4	5	7	7	9	12	15	N/A			
4.	Average slope value of the beach water zone in the swimming zone	0.05	0.07	0.10	0.15	0.10	0.12	0.15	0.20	0.10	0.12	0.15	0.20
5.	Mechanical composition of beach forming material (mm)												
	а) sandy beaches	0,5– 1,0	0,5–1,0	0,25–0,5	0,1–0,25	0,5–1,0	0,5–1,0	0,25–0,5	0,1–0,25	0,5–1,0	0,5–1,0	0,25–0,5	0,1–0,25
	б) gravel-pebble beaches	<20	25–50	50–100	50–100	<20	25–50	50–100	50–100	<20	25–50	50–100	50–100
6.	Beach width (m)	>35	35–30	30–25	25–20	>35	35–30	30–25	25–20	>35	35–30	30–25	25–20
7.	Water properties in the swimming zone	According to sanitary standards and regulations (SSaR) (Table 5)											

Note: the category is assigned based on specific parameters as the mean arithmetic value defined from the first six rounded parameters.
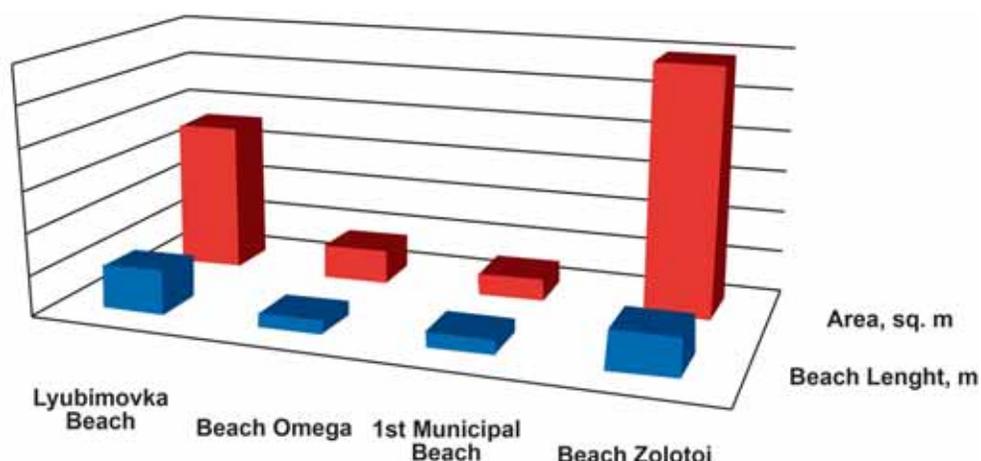
Figure 5. Comparative analysis of the beaches based on geomorphologic features

in the second. The third group combines indicators determined by the regulatory documents and calculated as the actual to regulatory performance ratio. Four Crimean beaches with maximally varying values of individual indexes were selected for the evaluation of the algorithms for computing the integral parameters. These beaches are located in sufficiently distant from each other, but similar in respect to climatic conditions Crimean regions (Feodosiya and Sevastopol). Two beaches (municipal and outside the city limits) were selected within each region (Fig. 4).

Beaches "Omega" and "Kameshki" (the 1st Municipal beach of the city of Feodosiya) are inside the city limits. The beach of the village Lyubimovka and the famous "Zolotoy" beach of the city of Feodosiya are outside the city limits (Fig. 2). These beaches are located on the open seashores, while the municipal beaches are in different size bays. A special feature of the village Lyubimovka beach is the presence of the mouth of a perennial river Belbek. The values of the basic parameters of the studied beaches are given in Table 11. The comparison of geomorphologic characteristics (Fig. 5) shows that "Zolotoy" beach has the greatest area; the village Lyubimovka beach is about 1,5 times smaller despite the fact that its perimeter and length are somewhat greater

due to intense unevenness of its shoreline. The area of the 1st Municipal beach of Feodosiya ("Kameshki") is the smallest, although it is slightly greater than the extent of "Omega" beach. All studied beaches have shallow slopes, which increases the foot traffic.

Mean elevation differences within the beaches are also insignificant, but the slopes of wave-cut niches in the Lyubimovka village beach in some areas are quite noticeable, which makes it difficult getting in and out of the sea, especially for children. Beach "Omega" is the best in this respect. For the same reason, the areas of zones that are safe for children and adult swimming are minimal on the village Lyubimovka beach.

They are only approximately one-fifth and one-third, respectively, of the areas of other beaches, despite the fact that the size of two of these beaches is much smaller (Fig. 6).

The calculation of the cadastral characteristics of the beaches included measurement of a large number of additional environmental, economic, and social characteristics. The ownership, category, and category coefficient of beaches were determined from Tables 10 and 12; the coefficient reflects the level of comfort compared to public municipal beaches.

Table 11. Values of the main cadastral parameters of the beaches

№	Parameters	Units	Arenation	"Omega"	"Kameshki"	"Zolotoi"
1	Beach length in a straight line	m	2083	630	724	1860
2	Length of the coastline	m	2097	690	751	1863
3	Perimeter	m	4311	1466	1569	3872
4	Area	m^2	72854	16329	10286	118835
5	Average width	m	48	18	12	71
6	Coastline tortuosity		1,0067	1,0952	1,037	1,002
7	Average difference in elevation on shore	m	1,37	1,916	1,150	1,860
8	Average slope on shore	tg	0,029	0,106	0,096	0,026
9	Average slope of near-shore zone	tg	0,097	0,066	0	0
10	Average difference in elevation for the beach sea bottom	m	4,18	0,982	2,03	2,23
11	Average beach sea bottom slope	tg	0,084	0,0196	0,029	0,064
12	Average bench slope	tg	0,0136	0,0183	0,026	0,054
13	Average slope of wave-cut niche	tg	0,407	0,192	0,35	0,30
14	Exposure	degree	280	31	83	126
15	Area of water zone of the beach shallower than 0,5 m	m^2	14645	12070	16690	3171
16	Area of water zone of the beach shallower than 1,5 m	m^2	27898	32957	34605	7968
17	Rivers and ravines density	%	10	0	0	0
18	Cliff height	m	12*	0	–	–
19	Cliff slope	tg	0,8*	0	–	–
20	Type of beach-forming material		pebble/sand	pebble/sand	pebble/sand	sand
21	Size of beach grain material	cm	5/0,2	1,5/0,1	2/0,1	0,2
22	Percent of green area	%	18	7	11	4

* In the cliff zone.

In order to calculate the recreational potential of the beaches and FRI, first, the actual beneficial factors were assessed (Table 13) (all studied beaches belong to the second category).

The total FRI values correspond to a scale used by Zenkovich [1962]. The values can decrease if conditions of the beach zone do not comply with the environmental requirements and increase if there are additional positive considerations (Table 14).

Table 15 shows the adjusted results for the studied beaches. Despite the apparent

Table 12. Categories of the studied beaches

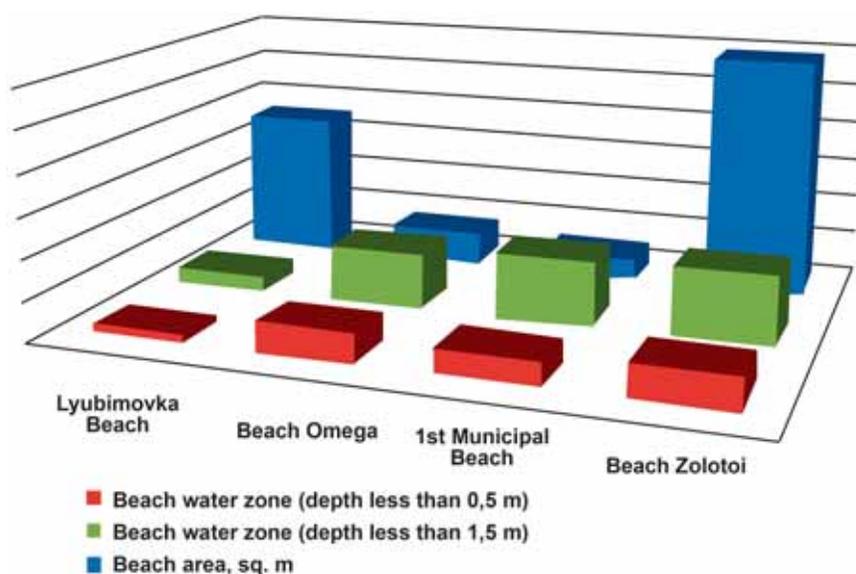| №	Parameter	Village Lyubimovka	"Omega"	"Kameshki"	"Zolotoi"
1	Ownership	resort	municipal	municipal	resort
2	Beach category	2	3	3	1
3	Category coefficient	2,2	1,4	1,4	2,4

Figure 6. Analysis of zones safe for children and adult swimming and land area of the beaches

popularity of "Zolotoy" beach and high values of the corresponding recreational impact factors, its integral FRI value is lower than, for example, the same index of the Lyubimovka village beach. Relatively low FRI values of "Omega" and "Kameshki" beaches are not surprising. The cost of land allotted for a beach, is determined by the regulatory documents and a current market value. However, the latter often already includes FRI and, therefore, it is preferable to use the actual values. Thus in 2000, the value of land occupied by the studied beaches was estimated at 30–42 thousand dollars per

hectare [Efremov, 2003]. Recently, the value of land has increased 100 times to about 5 thousand dollars per one hundred square meters. The cost of the same size plot in the cities centers can be an order of magnitude higher.

Without going into details of pricing and exclusively for the goals and objectives of comparing parameters of the beaches, we will accept the latest data as true. Then, the price per unit area of the beaches and sites in general is as follows (Table 16).

Table 13. Values of recreational factors' impact

№ п/п	Parameter	Village Lyubimovka	"Omega"	"Kameshki"	"Zolotoi"
1	Sea swimming	8	3	3	10
2	Sunbathing on shore	2,5	1,5	1,0	2,5
3	Sea air	0,9	0,7	0,5	0,9
4	Emotional impact of the sea	0,8	0,4	0,6	0,8
5	Arenation	0	0	0	2
6	Stone therapy	2	0	0	0
7	Acupuncture	1	2	2	0,5
	Total	15,2	7,6	7,1	16,7

Table 14. Environmental parameters of the beaches

№ п/п	Parameter	Village Lyubimovka	"Omega"	"Kameshki"	"Zolotoi"
1	Value coefficient	5,4	5,4	4,5	4,5
2	Coefficient of status of the regions	1,5	1,5	1,5	1,5
3	Coefficient of water quality	1,5	0,7	0,7	1,5
4	Coefficient of environmental value	1,2	1,0	1,0	1,2
5	Index of cleanness of the coastal zone*	1,2	0,8	0,8	1,5
6	Environmental status	1,0	0,8	0,8	1,0
7	Reduced coefficient of green area	0,77	0,605	0,665	0,56
	Result of multiplication of parameters	13,5	2,2	2,0	10,2

*Assessment criteria: 0,8 – dirty beach (grass on shore); 1,2– clean beach, presence of garbage containers; 1,5– clean beach (daily clean-up even during winter).

Table 15. The resultant factor of recreational impact considering the environmental situation in the beach zone

Parameter	Village Lyubimovka	"Omega"	"Kameshki"	"Zolotoi"
FRI	205	17	14	170

Table 16. Cost of land designated for beaches (in thousands of dollars)

Parameter	Village Lyubimovka	"Omega"	"Kameshki"	"Zolotoi"
Cost of 1 ha of beach	500	5000	5000	500
Total cost of beach	3642	8165	5143	5942

Table 17. Cost of the recreational resources of the beaches (in thousands of dollars)

Parameter	Village Lyubimovka	"Omega"	"Kameshki"	"Zolotoi"
Cost of the beach as an object of recreation	746610	138805	72002	1010140

Table 18. The cost of recreational resources of the beaches

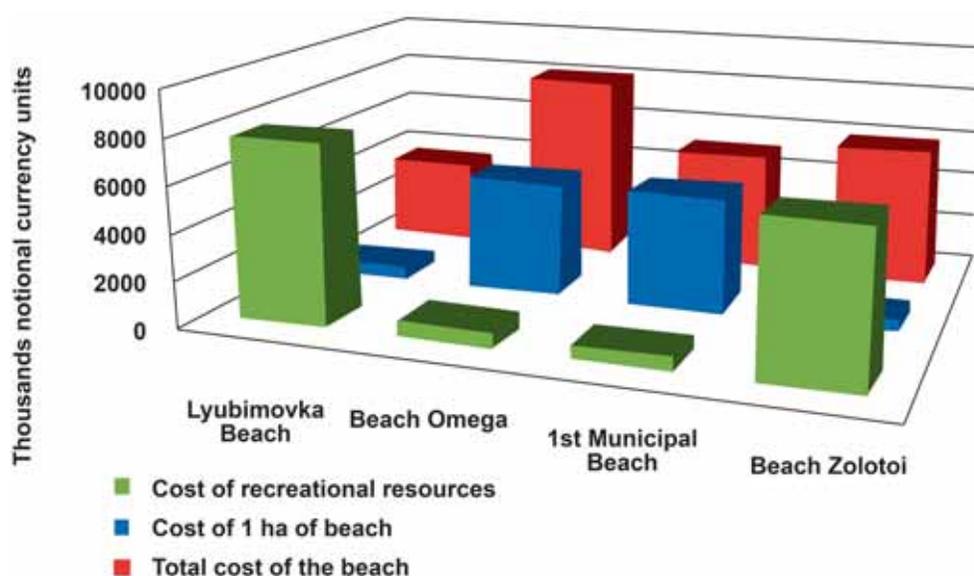| №	Parameter	Units	Village Lyubimovka	"Omega"	"Kameshki"	"Zolotoi"
1	Duration of swimming season	Days	150	150	146	146
2	Cost of recreational resources	Thous. dollars	7779	645	531	6452

Figure 7. Comparative analysis of cost indicators of the beaches

It is then possible to estimate the cost of the beach in terms of its recreational value by multiplying the cost of land by FRI. The results are presented in Table. 17.

To calculate the value of the recreational resources of the beaches (CRI), it is necessary to have data on the duration of the swimming season for different beaches and the average wage during the calculation period. The duration of the swimming season for adults according to climatic data [Company..., 2008] is given in Table. 18. The average wage in Ukraine was 253 dollars per month in 2007 (i.e., 1265 hryvnas) [Kinakh, 2007]. The summary and comparative description of the cost values is shown in Fig. 7.

The index of natural attractiveness characterizes the effects of a beneficial externality of the beaches. One of the ways to determine this indicator is through the results of sociological surveys of people that use the beach. This is a subjective evaluation method. The objective method involves a calculation of scores for each factor affecting the result. In the absence of sociological surveys, this study used the second method.

Several available indicators of the natural attractiveness are summarized in Table 19. The

Table 19. Parameters of natural attractiveness of the beaches

№	Parameter	Village Lyubimovka	"Omega"	"Kameshki"	"Zolotoi"
1	Individual natural features	River Belbek mouth	–	–	Unique attractive properties of sand
2	Unique plant species	–	-	-	–
3	Historical landmarks	–	Zone of excavation of ancient settlement	–	–
4	Other attractiveness factors	–	–	–	–
	Total score	1	1	0	1

Table 20. Climatic parameters of the beaches

№	Parameter	Units	Village Lyubimovka	"Omega"	"Kameshki"	"Zolotoi"
1	Duration of the swimming season for adults	days	150	150	146	146
2	Duration of the swimming season for children	days	102	102	74	74
3	Number of sunny days in the swimming season	days	100	100	50	50
4	Number of rainy days in the swimming season	days	10	10	20	20
5	Number of stormy days in the swimming season	days	6	6	15	15
6	Number of upwelling days	days	2	2	34	34
	CPI		1,23	1,23	0,47	0,47

Table 21. Parameters of infrastructure development of the beaches

№	Parameters	Units	Village Lyubimovka	"Omega"	"Kameshki"	"Zolotoi"
1	Beach capacity	persons	12142	2114	1714	19806
2	Beach accessibility	score	1	1	1	0,75
3	Distance to the city center	km	5,4	0	0	4,7
4	Transfers	number	2	0	0	1
5	Access roads	number	3	5	5	5
6	Open parking	number	100	10	0	20
7	Guarded parking	number	0	30	0	0
8	Distance from the beach to public transport stops	m	360	100	200	150
9	Cafés and restaurants	number	0	20	2	7
10	Other service sites	number	0	0	0	2
11	Cabins for changing	number	3	5	7	12
12	Play grounds	number	0	2	2	1
13	Rental centers	number	0	2	0	1
14	Toilets	number	0	2	1	6
15	Garbage containers	number	10	3	5	10
16	Площадь тентовых площадок	m²/%	1625/2	490/3	1280/12	480/1
17	Water amusement rides	number	2	2	1	2
18	Amusement rides on shore	number	0	1	1	1
	SCI		0,48	6,1	5,7	0,62

Table 22. Integral parameters of the beaches' conditions for 2007

№	Parameters	Village Lyubimovka	"Omega"	"Kameshki"	"Zolotoi"
1	Cost of parcel of land under the beach (thous. dollars)	3642	8165	5143	5942
2	Factor of recreational impact, score	205	17	14	170
3	Cost of the beach as an object for recreation (thous. dollars)	746610	138805	72002	1010140
4	Cost of recreational resources (thous. dollars)	7779	645	531	6452
5	Indicator of natural attractiveness	1	1	0	1
6	Climatic prestige index	1,23	1,23	0,47	0,47
7	Service comfort index	0,48	6,1	5,7	0,62
8	Index of natural hazard	0	0	0	0
9	Level of crime and political tensions in the society	0	0	0	0

studied beaches do not differ significantly by the attractiveness factor. This statement does not apply to other Crimean beaches, many of which, on contrary, have the extraordinary richness and variety of factors of the natural attractiveness.

CPI was calculated from the relevant climatic parameters (Table 20). The values of individual parameters were taken from Podgorodetsky [1988]. As expected, the integrated CPI for the studied beaches was not very informative, since each pair of beaches had the same values of the individual parameters. However, this conclusion should not be extended to all cases of the assessment of the beaches because the climate of Crimean regions is very diverse.

SCI is largely defined by the presence and a number of infrastructure objects on the beach and their locations and accessibility (Table 21).

The computation of the resultant integral index was performed using specially developed algorithms and the regulatory requirements. Analysis of the table shows that the beaches located near the city limits have the most developed infrastructure. The low value of SCI of the Lyubimovka village beach, in comparison with "Zolotoi" beach of Feodosiya may be specifically explained by its location that involves at least two transfers.

The calculation of this parameter was made only for the purpose of a demonstration and does not pretend to absolute accuracy of the estimates, since the survey of the beaches was carried out in different seasons and much of the infrastructure, operating in the summer, could be closed for the winter. Also, when evaluating areas of the awnings of the tent sites, only structures that are required to have awnings in the summer were taken into account, whereas in reality, additional awnings can be installed at the beaches. In order to provide a comprehensive cadastral assessment of the individual SCI factors, it is necessary to survey beaches during their mass use.

The SCI values given in the last table were calculated using a simplified procedure. For example, only the count of catering sites, toilets, and cabins for changing clothes was used in the calculations, although the method allows to also handling the capacity of these facilities. Furthermore, this study

does not include the assessment of natural and technogenic hazards (INH) and the level of political tension and crime in the region (UPR), as these indicators are not calculated, but determined by the experts individually for each beach and the region. For the studied beaches, these indexes have zero values, i.e., the situation is completely safe in terms of potential hazards and crime.

The combined effect of the cadastral assessment of the studied beaches is a large set of parameters, as well as a set of generalized summary characteristics (Table 22).

CONCLUSIONS

This study is the result of a three-year research and development work by the authors in the field of cadastral assessment of the recreational resources, specifically, the beaches of Crimea. The main goal of the paper is to summarize and systematize these research activities as well as to describe in detail the main assumptions of the proposed method.

The scope of the cadastral development of Crimean recreational resources was demonstrated using the four studied beaches as an example. Undoubtedly, in Crimea, where recreational facilities are a development priority, the recreational resource potential needs not just one-time, but constant monitoring and assessment.

The assessment of the individual recreational facilities of Crimea must be accompanied by the evaluation of recreational load. Organizations that use these recreational facilities should be also characterized. Data on service capacity of health care organizations, their categories, types of services provided, and other parameters represent the important components for the assessment. ∎

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Vyacheslav V. Dolotov was born in Ivanovo, Russia in 1952. He studied at the University of Chemistry and Technology in Ivanovo (Russia) and received his Ph. D. from the same University in 1981. Since January 1993, he is senior scientist of Marine Hydrophysical Institute of Ukrainian NAS. The focus of his research is on Information Systems development and GIS.

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Vitaly A. Ivanov, academician of Ukrainian NAS. His area of interest includes hydrophysical processes in sea and near shore water.

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