VULNERABILITY OF ENVIRONMENTAL SYSTEMS OF THE FUNCTIONAL URBAN REGION – DETECTION BY DIGITAL TOOL

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Abstract. *Space, as a non-renewable category, is the most valuable resource of Istria including not only landscapes, sea, seabed and the accompanying wildlife but also very sensitive resources such as ground water, seashore and woodlands. The aim of the study was to determine whether it is possible to reduce the negative impact of development activities on space using Geography Information System digital tools (GIS). Digital GIS tools were used in the study of the pressures made by urban infrastructure and services on the environment of the given area to assess the impact of sectoral and other pressures on the selected natural and cultural systems of the coastal region of Istria County. The key concept of the research methodology includes analytical and objective identification of conflicts in the space and provides spatial models for their reduction or complete elimination. The Overlay Method is essentially a type of a spatial model which produces an overlap of different thematic contents, in this case one of the models of the environment content overlaps with a model of pressure of development activities on the selected space element. As a final result, the critical areas are designated and further guidelines and proposals for the redefinition or revision of solutions are offered. A combined digital model and an analytical approach to the study of the impact of development activities on the natural sea system proved to be suitable tools for the assessment of negative effects on the ecological systems of the study area. Ports and aquaculture areas exert the biggest negative impact on the coastal sea which is constantly under direct pressures brought about by activities occurring in the sea itself. In addition to the direct pressure in the sea, the coastline is potentially threatened by human-induced pressures from the mainland.*

Key words: *environment impact, nature, region, coastal sea, spatial models, overlay.*

1. INTRODUCTION

The wider zones of influence of cities and villages were studied as a distinct planning-developmental and programme entity (wider urban system). The system`s processes and relations were monitored and investigated and suitable solutions of spatial planning and development policy were reached in order to get an insight into the complex nature of development [1] and preservation of the natural environment with ecological and recreational resources.

The development goals are primarily aimed at: controlling the growth of large urban areas and providing a balanced concentration of functions, establishing functional relations between urban cores and rural areas - settlements[2], improving living conditions and facilities in peripheral zones (especially in the ones that lack functions and utility equipment).

The study of the pressures exerted by urban infrastructure and services presented in this paper is focused on the relations between development activities and the selected natural and cultural systems of the area, particularly the ecological ones. This study was carried out within the framework of the research on the impacts on ecological systems for the Draft of the proposed changes and amendments to the Spatial Plan of the County of Istria (SPCI), The Republic of Croatia (https://www.istra-istria.hr/index.php?id=2454).

The assessment of the pressures of the Draft of the proposed changes and amendments to the Spatial Plan of the County of Istria, Ibid [3], included the contents which are under direct or indirect impact of some anthropogenic activity [4], such as: pressures on air, water, sea, soil, protected natural areas, biodiversity, cultural heritage, landscape and others.

The research results are presented for each natural and cultural system in a graphic form of the "combined model", which consists of mutually overlapping shp layers (overlays) of the spatial model of environmental contents and the spatial model of pressures (shp is a tag for the file format). In the case of the combined model, all the layers (shp layers), regardless of their overlapping, retained their separate fields with the accompanying descriptions. The combined table has an additional field for the assessment of the pressure. The potential pressure on the element of space [5] was assessed according to the weights defined for each of the environmental contents (The interdisciplinary team of experts jointly defined the range of weight). The graphical data presentation was based on vector data in DWG format of the Draft of the proposed changes and amendments to the Spatial Plan of the County of Istria (SPCI). All DWG layers were converted to shp GIS format and accompanied by tables whose fields contain relevant data for each shp layer. The selected spatial contents contain only those GIS, polygon, line and point of database, which can combine and create different spatial models. By selecting the spatial data or layers (primarily polygons) from the GIS database, different spatial models were created for each of the contents.

Given the subjective nature of the impact assessment, the Overlay method allows expert teamwork and weight correction with the aim of reducing the subjectivity of the assessment to a minimum. The combined model contains all mutually overlapped spatial data with associated descriptive data, whose selection through the Query Builder search engine allows us to select only those data that meet the set requirements.

1.1. Theoretical framework

A scientifically based overlay method was created as a need to incorporate criteria for the protection of the environment, natural resources and cultural values into spatial planning, that is, in the development of spatial and urban plans, the value criteria on the basis of

which the impact of some planned development Activities on existing natural and cultural values should be assessed.

It is believed that Mc Harg is the founder of the overlay method. In the book Design with Nature, published in 1969, he introduced the creation of transparent maps that contained certain elements of the environment. By overlapping some of the transparent maps, the combined composite cards were classified according to different color tones ranging from 1 to 4 [6].

The lack of this manual method is the limitation of the number of composite layers that overlap each other, and that the unified model can clearly define the classification or degree of similarity in the range from 1 to 4.

In 1972, Carl Steinitz first applied the digital processing, analysis and assessment of the impact of planned development activities on the natural environment in the Impact Study on the Interference of Interstate Highway 84 for the Rhode Island area [7]. He developed an innovative method of creating a spatial database and sophisticated evaluation models, ie the model of attractiveness and vulnerability models, on the basis of which he assessed the impact on the natural environment [8].

The revolutionary milestone was accomplished by ESRI, experts introduced a vector database, or spatial entities such as a point, a line, and a polygon instead of a raster (grid) database, linked the spatial entities relational with the descriptive-attribute base, or spatial entities by a point, line, and polygon. One of the first commercial versions of the GIS software was developed in 1982 under the name ARC / IFO and only worked on UNIX operating system [9]. Later on, several pieces of software provided GIS performances such as, MapInfo, AutoCAD-Map, etc.

Environmental Impact Assessment (EIA) is an assessment of the impact of an identified project, program or any human activity with environment impacts and consists of socio economic and environmental aspects. It is the process of identifying, predicting, evaluating and mitigating the biophysical, social, and other relevant effects of development proposals prior to major decisions being taken and commitments made [10]. Accordingly EIA should advance Environmental quality and sustainability objectives between advocates of a technical, rational EIA process and those arguing that EIA is a form of adaptive environmental management and among supporters [11] of the rational technical, community control, and social equity site selection approaches [12]. EIA is defined as a systematic process [13] of determining and managing (identifying, describing, measuring, predicting, interpreting, integrating, communicating, involving, and controlling) the potential (or real) impacts (direct and indirect, individual and cumulative, likelihood of occurrence) of proposed (or existing) human actions (projects, plans, programs, legislations, activities) and their alternatives [14], [15] on the environment (physical, chemical, biological, ecological, human, health, cultural, social, economic, built environment and interrelations) [16]. Highly urbanized areas, such as the city core, are expected to exert greater selective pressure than suburban areas, which tend to have more green space including natural remnants, gardens and parks. Although urban centers and suburban development are confounded by age, urban areas are socially and physically very heterogeneous, differing in their degree of urbanization and hence the strength of the various filters (e.g. remnant habitat area, heat island effects, pollution loads). Understanding and quantifying, i.e., mapping, the spatial distribution of human impacts is needed for the evaluation of tradeoffs (or compatibility) between human uses of the sea and protection of ecosystems and the services [17], [18] they provide. Such mapping will help improve and rationalize spatial management of human activities. Determining the ecological

impact of human activities on the sea Ibid, requires a method or translating human activities into ecosystem specific impacts and spatial data for the activities and ecosystems [19].

2. MATERIALS AND METHODS

Study area Istria (Fig. 1); (Coordinates: 45°15′40″N 13°54′16″E), is the largest peninsula in the Adriatic Sea. The peninsula is located at the head of the Adriatic between the Gulf of Trieste and the Gulf of Kvarner. It is shared by three countries in Europe: Croatia, Slovenia, and Italy. Istria peninsula has always been a treasure trove of diversity, a unique area in which rich green fields, the fertile interior and a long, picturesque coast with numerous islands and bays are harmoniously intertwined. Istria County is the westernmost county of Croatia which includes the biggest part of the Istrian peninsula 2820 km2 out of 3160 km2. The county administrative canter is Pazin; (9227 inhabitants) while economic center is Pula (58594 inhabitants). About 70.7% of the population lives in these 10 urban areas. According to 2011 census, the total population of Istria County is 208055. The coast and the islands of Istria are covered with pine woods and easily recognizable green „macchia". There are so called White, Grey and Red Istria. White Istria is around the mountain peaks, Grey Istria is the fertile inner land, while Red Istria is the blood-red painted land of "terra rossa" near the coastline. Agriculture and the production of ecological food, the olive gardens, and the production of quality wines, is the focus of the agriculture sector of Istria.
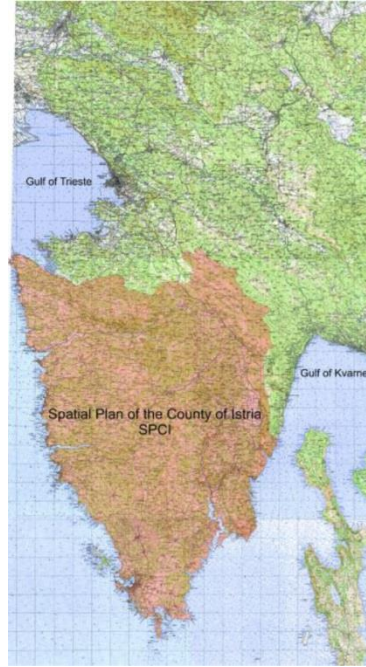

Fig. 1 Location of study area. Source: Official Topographic map T: 100000 (TK100)

2.1. GIS methodology

The roots of GIS are found in disciplines such as landscape planning, forestry, geography and resource management. In the German speaking countries, many textbooks, names of institutions, academic programs, or job titles avoid the term "Geographic" and use "Geo-Informationssysteme" instead. [20].

GIS is an integrated set of computer programs and data used to view and manage space information, spatial relationships analysis, and spatial process modeling, and provides a framework for analytical gathering, organizing and linking of spatial data and information for the purpose of sustainable development [21].

GIS consists of:
- Digital spatial data base, composed of layers,
- Development models or planned activities in the area, which are putting pressure on the components of the environment,

- Impact model, ie constituents of the environment that is subject to pressure,
- Combined spatial models (overlay) based on which analytical estimates, of the pressures of the planned activities at sea, were established.

Component of the environment – planning GIS approach

The advantage of GIS is that it can store almost unlimited amounts of different spatial information (graphical database) and also an unlimited number of descriptive data (attribute database). It is understandable that the database is determined according to the level or scale of the spatial plan and the problems that are the subject of an analytical assessment.

Provided that the GIS database is well defined, it is possible to create development models, impact models and aggregate models by overlapping method, and to obtain analytical and very precise spatial and descriptive (statistical) information about each and every part of the space. The overlapping data retain all their previous spatial and descriptive properties, and it is possible in places where there is a conflict of weighting to estimate the impact [22].The aim of the research was to determine the possibility of reducing negative effects of development activities on space by using the Esri® Arc GIS tools for managing of spatial data. Spatial planning, including the protection of natural resources, is a specific field of science that, like all sciences, requires a well-documented analysis and quantified results in order to achieve its goals [23] of preserving environmental values, promoting the development of the network of settlements and functional urban regions, determining the level of protection, laying down guidelines for the preservation of natural and cultural values of the given area, assessing the needs for exploitation of mineral raw materials, developing recreational and tourism potentials. A scientifically-based overlay methodology [24] [25], is used here with the aim of incorporating criteria of environmental protection of natural resources and cultural values, *i.e.* of developing spatial planning solutions [26], based on the well-defined criteria for the assessment of the impact a certain development activity would have on existing natural and cultural values.

The ArcGIS procedures used to view and manage spatial data, analyze spatial relationships and model spatial processes [27], served as a framework for analytical collection, organization and linkage of spatial data and information, all with the aim of achieving sustainable development. GIS methodology included:

- Digital data, consisting of data layers (Layers)
- Models of natural and cultural components on which the pressure is exerted
- Development models i.e. activities that exert pressure on the contents of the environment,
- Combined models of mutually overlapping (Overlay) natural with development models

The spatial data base was defined according to the level *i.e.* scale of the spatial plan and the issues that were the subject of the analytical assessment. The layers of spatial database were formed in such a way that the Overlay method could be used to create models of development activities [3a], models of impact and combined models.

Thus, we obtained very precise spatial information, *i.e.* analytical and statistical data on every little part of the area, including analytical and statistical data. The overlapping data retained all their initial spatial and descriptive characteristics so that the weighting determined the impact in the areas with a conflict. Depending on typology, combined models represent the interaction of the areas formed by overlapping the contents of the

environment with development activities [28]. To assess the pressure on each individual content, the following three group of spatial models were created:

1. The model of natural and cultural components that might be under pressure of development activities;
2. The model of development activities that might make pressure on natural and cultural components;
3. The combined model - graphic presentation which consists of mutually overlapping (*Overlay*) shp layers, *i.e.* from model 1 and model 2, including all relevant fields which describe individual spatial and descriptive variables.

In a Flowchart (Fig. 2) defining the method of applying the overlap process development of a strategic action within the development of the spatial plan of the Istria County.
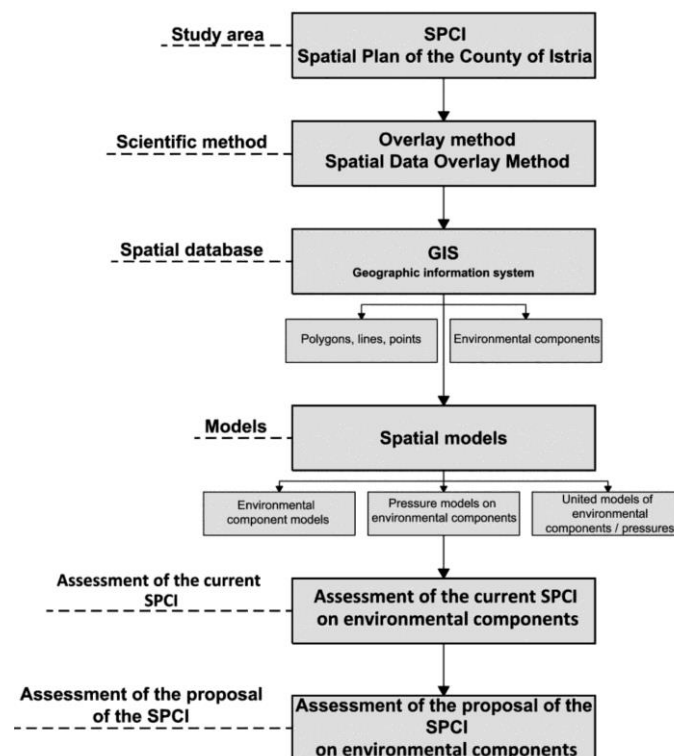

Fig. 2 Procedure of Environmental Impact Assessment (Orig.)

2.2. GIS database

Criteria for the selection of spatial phenomena [29] and their spatial variables were determined on the basis of the recurrence of developmental activities within the framework of the Plan and the impact of the current and planned activities on the selected natural and cultural systems, including socio-economic factors [30]. Due to the large number of different data, the Overlay method could not have been applied if all the available source data of the valid Spatial Plan (*dwg Layers*) had not been transformed into shp. GIS format. The following polygons, lines and points were used:

Polygons
- areas intended for settlement development (greater than 25 ha); existing settlements areas were including within 25 ha
- commercial use - production, mainly industrial use ;
- areas intended for the exploitation of mineral resources;
- residential and resort areas;
- hospitality and tourism use;
- sports and recreational use;
- especially valuable agricultural land;
- valuable agricultural land;
- other agricultural land;
- economic (timber harvesting) forests;
- conservation forests;
- special-purpose forests;
- water surface areas;
- internal coastal sea;
- external coastal sea;
- sea recreation;
- port area;
- aquaculture area;
- national park;
- nature park;
- special reserve of nature;
- forest-recreation area;
- preserve landscapes;
- natural monument;
- monument of park architecture;
- archaeological site;
- especially valuable landscape;
- land affected by erosion;
- land degraded by erosion;
- water supply areas;
- preservation sea area
- boundaries of the inner sea shore
- protected underwater and others.

Lines
(water supply and sewerage systems are not used, but in point shape file it used as wastewater discharge)
- Highway;
- State of roads
- County roads
- first-order railroads
- second-order railroads
- main gas pipeline 75 BAR, for international transport;
- main gas pipeline 75 BAR (terrestrial and submarine), for international transport, alternative sections;
- planned gas pipelines 50/70 BAR (terrestrial and submarine) – the corridor being researched;

- regional gas pipeline;
- regional gas pipeline- the corridor under research
- local gas pipeline;
- potential 400 kV transmission line - the corridor under research;
- 220 kV transmission line;
- 110 kV transmission line;
- 110 kV transmission line, under research, etc.

Points
- facilities for hazardous waste treatment and temporary storage;
- hazardous waste collection center;
- landfill;
- small hydro-power plant;
- thermal power plant;
- wastewater discharge;
- sea port of special international - economic importance;
- sea port of county importance;
- sea port of local importance;
- sea port, special use, national importance PN; nautical tourism, M - marina;
- sea port, special use, national importance DM - dry marina;
- sea port, special use, national importance PI - industrial port;
- sea port, special use, national importance PS - shipyard;
- sea port, special use, national importance PR – recreation port;
- sea port, special use, county importance PN - nautical tourism, M - marina;
- sea port, special use, county importance - mooring;
- sea port, special use, county importance - fishing port;
- sea port, special use, county importance - recreation port;
- mooring for large ships over 100,000 tons;
- abandoned landfill;
- rehabilitation of a mining field.

3. SPATIAL MODELS

By using different spatial variables from GIS database, three models were designed:
1. The sea model consisted of spatial polygons which describe components of the sea, polygons, lines, points.
2. The developing model consisted of spatial polygons which could make impact on Sea model (Model number 1), polygons, lines, points.
3. The combined model consisted of mutually overlapping (Overlay) polygons (shp layers), i.e. from model 1 and model 2, including all relevant fields which describe individual spatial and descriptive variables, polygons, lines, points.

3.1. Creating Sea model - Spatial Model 1

The following layers were used for the creation of the Sea model:
- aquaculture area,
- internal coastal sea
- preservation sea area
- boundaries of the inner sea shore

In the corresponding DBF relational table, a part of the spatial variables (polygons), which describe the structure of the selected polygons (Figure 3). The model of the sea is seen as areas that can be influenced by developmental activities.

Table 1 Attribute table of descriptive data of spatial variables-polygons
for the sea model (Orig.)

Fig. 3 GIS map Sea Model - Natural and cultural components
that might be under pressure by development activities (Orig.)

3.2. Creating developing model - Spatial Model 2

The following layers were used for the developing model:
- areas intended for settlement development (greater than 25 ha);
- existing settlements areas were including within 25 ha
- commercial purpose - production, mainly industrial purpose;
- areas intended for the exploitation of mineral resources;

- residential and resort areas;
- hospitality and tourism purpose;
- sports and recreational purpose;
- especially valuable agricultural land;
- valuable agricultural land;
- port area;

The corresponding DBF relational table shows a part of the spatial variables (polygons) that describe the structure of the selected polygons, and to (Figure 4). The developing activities model see areas that could make impact on the Sea Spatial Model 1.

Table 2 Attribute table of descriptive data of the Spatial Variables-Polygon
for the Developing activities model (Orig.)

| Shape	Id	Gp_sve	M2
Polygon	0	Područja za razvoj naselja > 25 ha	3529459
Polygon	0	Turističko razvojno područje	280106
Polygon	0	Turističko razvojno područje	214490
Polygon	0	Turističko razvojno područje	289781
Polygon	0	Stambeno turistička naselja	554234
Polygon	0	Osobito vrijedno poljoprivredno područje - P1	2580
Polygon	0	Osobito vrijedno poljoprivredno područje - P1	111
Polygon	0	Osobito vrijedno poljoprivredno područje - P1	848
Polygon	0	Osobito vrijedno poljoprivredno područje - P1	307156
Polygon	0	Osobito vrijedno poljoprivredno područje - P1	47453
Polygon	0	Osobito vrijedno poljoprivredno područje - P1	91278
Polygon	0	Osobito vrijedno poljoprivredno područje - P1	153691
Polygon	0	Osobito vrijedno poljoprivredno područje - P1	177490
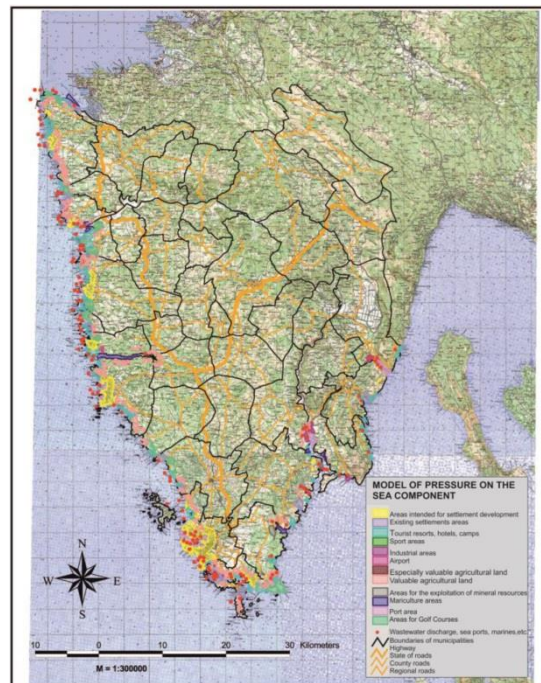
Fig. 4 GIS map - Development Model 2 – Development activities
that might make pressure on natural and cultural components (Orig.)

3.3. Creating Combined model - Spatial Model 3

The Combined model consisted of mutually overlapping polygons from model 1 and model 2, including all relevant fields which describe individual spatial and descriptive variables.

The mathematical expression for the assessment of the impact in the range of 1 to 3 (Orig.), is:

([E3] = " area for exploitation of mineral raw materials (2001-2002") =	1
([E3] = "area for potential exploitation of mineral raw materials") =	1
([Ca_all_] = "Port area") =	1
([Ca_all_] = "Areas for the development of settlements > 25 ha ") =	1
([Ca_all_] = "Special purpose - airport ") =	1
([Ca_all_] = "Predominantly industrial purpose I1") =	1
([Ca_all_] = "Sport") =	3
([Ca_all_] = "Residential and Resort areas") =	1
([Ca_all_] = "Tourist development area") =	1
([Ca_all_] = "Farming - Aquaculture") =	1
([Ca_all_] = "Especially valuable agricultural land - P1") =	2
([Ca_all_] = "Valuable agricultural land P2") = 3 but due to E3 WEIGHT	1
([Golf] = "Golf Course") =	3

Table 3 Attribute table of common descriptive data of spatial variables-
Models 1 and Model 2 polygons for a Combined model (Orig.)

| Shape	Id	E3	Gp_sve	M2	Golf	Ponder	Km2
Polygon	0		Pretežito industrijska I1	446261		1	0.446
Polygon	0		Posebna namjena - aerodrom	466875		1	0.467
Polygon	0		Područja za razvoj naselja > 25 ha	1216053		1	1.216
Polygon	0		Područja za razvoj naselja > 25 ha	3038614		1	3.039
Polygon	0		Područja za razvoj naselja > 25 ha	261877		1	0.262
Polygon	0		Područja za razvoj naselja > 25 ha	28995651		1	28.996
Polygon	0		Područja za razvoj naselja > 25 ha	369827		1	0.370
Polygon	0		Područja za razvoj naselja > 25 ha	1562786		1	1.563
Polygon	0		Područja za razvoj naselja > 25 ha	1137209		1	1.137
Polygon	0		Područja za razvoj naselja > 25 ha	424367		1	0.424
Polygon	0		Područja za razvoj naselja > 25 ha	9041673		1	9.042
Polygon	0		Područja za razvoj naselja > 25 ha	66		1	0.000
Polygon	0		Područja za razvoj naselja > 25 ha	155		1	0.000
Polygon	0		Područja za razvoj naselja > 25 ha	28		1	0.000
Polygon	0		Područja za razvoj naselja > 25 ha	30		1	0.000
Polygon	0		Područja za razvoj naselja > 25 ha	869222		1	0.869
Polygon	0		Područja za razvoj naselja > 25 ha	869222		1	0.869
Polygon	0		Područja za razvoj naselja > 25 ha	2425874		1	2.426
Polygon	0		Područja za razvoj naselja > 25 ha	6482968		1	6.483
Polygon	0		Područja za razvoj naselja > 25 ha	289615		1	0.290
Polygon	0		Područja za razvoj naselja > 25 ha	8		1	0.000
Polygon	0		Područja za razvoj naselja > 25 ha	60		1	0.000
Polygon	0		Područja za razvoj naselja > 25 ha	75		1	0.000
Polygon	0		Područja za razvoj naselja > 25 ha	313187		1	0.313
Polygon	0		Područja za razvoj naselja > 25 ha	2188		1	0.002
Polygon	0		Područja za razvoj naselja > 25 ha	448298	Golf igralište	1	0.448
Polygon	0		Područja za razvoj naselja > 25 ha	1677673		1	1.678
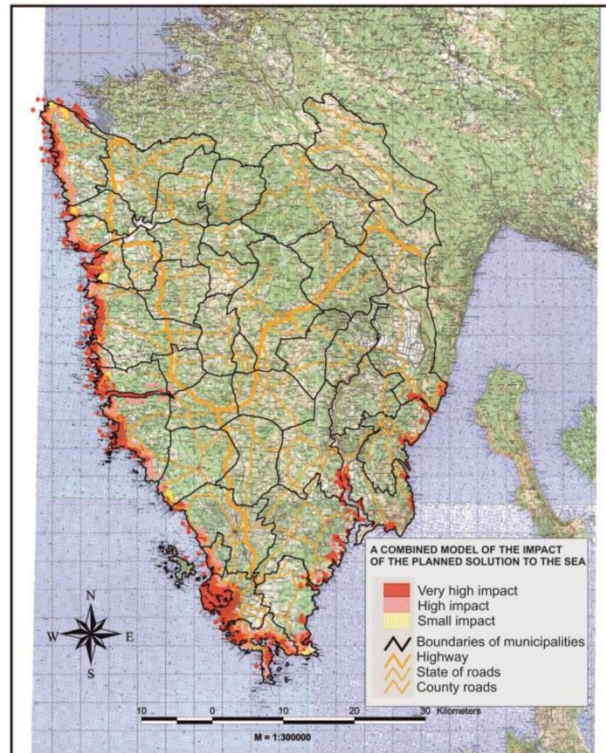
Fig 5. GIS map - Combined Model 3 (Orig.)

Mutually overlapping polygons from model 1 and model 2, including classification in range 1 to 3(Figure 5).

A team comprised of experts, landscape architects, urban planners, biology experts, civil engineers, marine ecology researchers, etc. worked together with the expert team responsible for the development as well as for the changes and amendments of the SPCI spatial plan. They set a range of impacts (1-3) on the components of the Sea Model, Spatial Model 1. The Expert team determined that the greatest impact or Range 1 is exerted by spatial activities in ports, marines, areas for the exploitation of mineral raw materials (see the mathematical expression for the assessment of the impacts, Chapter 3.3).

Rank 2 is exerted by development activities whose impact is considerable, while Range 3 has little impact on the sea. All the listed activities ranging from 1-3, if located in the buffer zone of 1 km of the coast and in contact with the coastline and layers from the sea 1 model, get ranges 1, 2 and 3 (see the Combined Model 3). Map 4 shows all the layers - development activities, and the Combined Model shows the combined impacts of the layers in range 1-3 on the sea.

The Combined Model 3 was obtained as a result of the Overlay Model 1 and the Model 2. The Combined Model 3 has the impacts classified in the range of 1-3 and marked with colors (see the Combined model Figure 5).

4. RESULTS

The pressure of the planned activities and contents covered by the Draft of the proposed changes and amendments to the Spatial Plan of the County of Istria (SPCI) on the sea are presented in the results of the combined model of impact, whose criteria for pressure classification and assessment (weighting) are shown in (Table.3).

Descriptive table no. 4. shows which components must be under pressure of development activities.

The highest pressure on the sea - weight 1, provoke development activities and spatial content such as Area for exploitation of row minerals, Port area, Residential and resort areas, Farming area, etc. (see in Table 4).

Medium Impact - The weight of two pressures on the sea is caused by the developmental spatial features such as: Especially valuable agricultural land, etc. Small pressure on the sea and the vulnerability of the coastal belt must cause Sports - recreational purpose, golf, etc.

Table 4 Conceptual model of the pressure on the sea (Orig.)

Sea Model 1	Development Model 2	Combined Model 3
Natural and cultural components that might be under pressure of development activities	**Development activities that might make pressure on natural and cultural components**	**Sea Model 1/ Development Model 2 Impact - range 1 to 3**
▪ Preservation sea area; ▪ Boundary of the inner sea shore;	▪ Areas intended for settlement development (greater than 25 ha);	1 Very high impact
	▪ Existing settlements areas were including within 25 ha;	1 Very high impact
	▪ Commercial purpose - production, mainly industrial purpose;	1 Very high impact
	▪ Areas intended for the exploitation of mineral resources;	1 Very high impact
	▪ Residential and resort areas;	1 Very high impact
	▪ Hospitality and tourism purpose;	1 Very high impact
	▪ sports and recreational purpose;	3 Small impact
	▪ Especially valuable agricultural land;	1 Very high impact
	▪ Valuable agricultural land;	2 High impact
	▪ port area;	1 Small impact

The areas that exert direct pressure on the marine environment and have the greatest negative impact on the sea are: ports, aquaculture areas, marinas, tourist and other types of ports [31]. Ports and aquaculture areas exert the biggest negative impact on the coastal sea which is constantly under direct pressure brought about by the activities occurring in the sea itself. In addition to direct pressure in the sea, the coastal strip is potentially threatened by anthropogenic pressures [32] from the mainland (Table 5). The study of the effects of the mainland on the sea encompassed activities within the Protected Coastal Area of the County of Istria (PCA) extending in a buffer of 1000 meters (Figure 5) – Combined model 3, from the coastline. The surface area of the mainland exerting pressure on the sea is shown in (Table. 2).

Table 5 The surface area exerting pressure on the sea –
The share of different pressure levels (Orig.)

	Total surface area of the mainland exerting pressure on the sea (in km^2)	The share of individual levels in the total area of Protected Coastal Area of County of Istria mainland (in %)
Very high pressure (1)	96.62	70.70
Medium high pressure (2)	33.76	24.70
Low pressure (3)	6.28	4.60
Total	136.66	100.00

5. DISCUSSION AND CONCLUSION

The combined model showed that the sea part of the coastal belt is under potential anthropogenic pressure of 136.66 km^2 of the mainland (Figure 2). The area of very high pressure amounts to approximately 96.62 km^2 or 70.70% of the Protected Coastal Area (PCA) of Istrian County (IC) mainland. The mainland pressure is primarily related to development activities [33] of the areas for settlement development [34], hospitality and tourism areas, economic (production) areas as well as the areas for exploitation of mineral resources. Coastal sea is further under direct pressure from the activities taking place in the sea, *e.g.* in farming or aquaculture areas on about 13.08 km^2, and from the port and marina areas on about 25.16 km^2.

About 33.76 km^2 or 24.70% of the PCA of IC mainland is under the medium high pressure. This is largely the pressure from agricultural areas and areas for the exploitation of mineral resources. Low pressure (3) covers approximately 6.28 km^2 or 4.60% of the PCA of IC mainland. The structure of individual pressures on the sea is shown in (Table 6).

GIS science is used to make maps for a region and superimpose it with other existing maps about correlating parameters, like road network, soil types, etc. targeting any possible analytical research in a specific area. This scenario requires that we have all the information about the client subjects and related information with regards to the existing scenario of our project with respect to natural resources, access to markets and socioeconomic setting [35].

Table 6 The share of individual pressures within the respective category
of the pressure on the sea in km^2 (Orig.)

Type of anthropogenic pressure	Very high pressure (1)	Medium high pressure (2)	Low pressure (3)
Area for settlement, develop	50.92	0	0
Hospitality and tourism	45.54	0	0
Sports purpose, golf	0	0	4.26
Sport purpose, other , Econom.pur	0	2.33	2.02
Economic purpose – Production	6.32	0	0
Special purpose	0	0.48	0
Espec. valuable agricultural land	0	25.64	0
Valuable agricultural land	0	0	0
Area - exploitation of mineral res.	3.84	5.31	0
Farming area – Aquaculture	13.08	0	0
Port	25.16	0	0

GIS analysis shows that the greatest pressure on the sea is exerted by anthropogenic factors from the mainland in the coastal area (housing, tourism, industry) as well as by activities taking place in the sea, *i.e.* in the port areas, aquaculture areas, marinas, tourist and other ports.

The results of the Overlay method has unequivocally demonstrated that it is necessary to reduce the area intended for the development of settlements, residential and resort areas, exploitation of mineral resources and golf courses in the buffer zone of 1000 meters. Therefore it is forbidden to construct residential buildings and tourist resorts in the buffer zone of 100 meters. The total sleeping capacity has not increased and in some municipalities, it will be further reduced.

It is forbidden to exploit mineral raw materials in the buffer zone of 1000 meters. In the areas intended for sea fish farming, the capacity of growth with a water catchment capacity should be adjusted.

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UGROŽENOST PRIRODNIH SISTEMA FUNKCIONALNO URBANOG REGIONA- DIGITALNA DETEKCIJA

Prostor, kao neobnovljiva kategorija, je najvredniji resurs Istre, uključujući ne samo pejzaž, more, morsko dno i divlje životinje, ali i veoma osetljive resurse kao što su podzemne vode, mora i šuma. Cilj istraživanja je bio da se utvrdi da li je moguće da se smanji negativan uticaj razvojnih aktivnosti na prostoru pomoću Geografskog informacionog Sistema, digitalnog alata (GIS). Digitalni GIS alat je korišćen u istraživanju pritisaka urbane infrastrukture i usluga na životnu sredinu datog područja kao i za procenu uticaja sektorskih i drugih pritisaka na odabranim prirodnim i kulturnim sistemima primorskog regiona Istarske županije. Ključni koncept metodologije istraživanja obuhvata analitičko i objektivno identifikovanje sukoba u prostoru i daje prostorne modele za njihovo smanjenje ili potpunu eliminaciju. Overlay Metoda je u suštini tip prostornog modela koji čini preklapanje različitih tematskih sadržaja, u ovom slučaju jedan od

modela sadržaja životne sredine poklapa sa modelom pritiska razvojnih aktivnosti na izabranom prostoru. Kao krajnji rezultat, kritične oblasti su označene i nude dodatne smernice i predloge za redefinisanje ili revizije rešenja. Kombinovani digitalni model i analitički pristup proučavanju uticaja razvojnih aktivnosti na prirodne sisteme mora pokazao se kao pogodan alat za procenu negativnih efekata na prostornim sistemima. Luke i akvakulturni sadržaji vrše najveći negativan uticaj na obalu mora koja je stalno pod direktnim pritiskom, izazvanim aktivnostima koje se dešavaju u samom moru. Pored direktnog pritiska na more, obala je potencijalno ugrožena ljudskim indukovanim pritiscima sa kopna.

Ključne reči: *životna sredina, uticaj, priroda, regija, priobalno more*