COST-BENEFIT ANALYSIS OF THE IMPROVEMENT OF SPATIAL DATA INFRASTRUCTURE – CASE STUDY CROATIA

ANALIZA STROŠKOV IN KORISTI IZBOLJŠANJA INFRASTRUKTURE PROSTORSKIH PODATKOV – ŠTUDIJA PRIMERA HRVAŠKE

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UDK: 528:004.6:711(497.5)

ABSTRACT

The thesis upon which this paper is based is existence of a spatial data infrastructure in a specific form, at a specific moment and at a specific level, which is directly linked to the level of technological and social development. Establishing a spatial data infrastructure actually means improving the existing infrastructure and can be defined as a number of activities aiming at easier access to and dissemination of the existing spatial data, and easier and more efficient use of them. This paper considers improvement of the spatial data infrastructure in Croatia as a public project of permanent character and of special social interest. Taking into consideration a four-year improvement period, a cost-benefit analysis was made, the financial indicators of which show that the best efficiency is accomplished if the project initial time period is shorter.

KEY WORDS

Spatial Data Infrastructure, improvement, Cost-Benefit Analysis

Klasifikacija prispevka po COBISS-u: 1.02

POVZETEK

Teza, na kateri temelji ta članek, je obstoj infrastrukture prostorskih podatkov v določeni obliki, v določenem trenutku in na določeni ravni, kar je neposredno povezano z ravnijo tehnološkega in družbenega razvoja. Vzpostavitev infrastrukture prostorskih podatkov dejansko pomeni izboljšanje obstoječe infrastrukture, kar lahko definiramo kot številne dejavnosti z namenom, omogočiti lažji dostop do obstoječih prostorskih podatkov in njihovo diseminacijo ter lažjo in učinkovitejšo rabo teh podatkov. Članek obravnava izboljšanje infrastrukture prostorskih podatkov na Hrvaškem kot javni projekt stalnega značaja in posebnega družbenega pomena. Ob upoštevanju štiriletnega obdobja izboljšav je bila izvedena analiza stroškov in koristi, finančni pokazatelji analize pa kažejo, da največjo učinkovitost dosežemo, če je začetni čas projekta krajši.

KLJUČNE BESEDE

infrastruktura prostorskih podatkov, izboljšanje, analiza stroškov in koristi

1 INTRODUCTION

The need to establish and improve the spatial data infrastructure (SDI) can be seen as a purposeful and default goal of each society, which is to ensure overall welfare through economic development. This premise, however, raises the issue of justifiability of financial investment in the spatial data infrastructure (costs and benefits). Finding the right answer to this question is not easy. It is certain that we cannot tell who and what is included in the creation of SDI, what costs these

activities make, and what sources of financing are necessary (Rhind, 2000). Implementation and improvement of SDI includes some significant economic factors: cost-benefit analysis, financing, pricing policy, and the market.

The need to make a cost-benefit analysis for the SDI is of great importance, although they receive very little attention and few works deal with this topic. Researches in the field of economics are essential to facilitate more informed SDI developments in the future (Masser, 2005). The costs are to be seen through many factors, such as: producers of spatial data, software, hardware, communication infrastructure, human resources, etc. The starting point in such research should be the very definition of the SDI and the included factors as well as of those which tend to be included. All current as well as potential users of spatial data have to bear in mind the costs and benefits. It has been long known that investments in digital data have to generate bigger benefits than costs in order to get success. Precise cost-benefit analyses of the implementation and use of geoinformation systems are, unfortunately, very rare (Gillespie, 2000).

This paper sees the establishment of SDI as a public project aiming at improvement of the existing spatial data infrastructure (Cetl, 2007). Taking into consideration a four-year improvement period, a cost-benefit analysis of the spatial data infrastructure establishment was made on the example of Croatia. Croatia is on its way towards full membership in the European Union, so that improvement of the existing national spatial data infrastructure is of key importance, as well as joining the INSPIRE.

2 IMPROVEMENT OF THE SPATIAL DATA INFRASTRUCTURE

SDI has existed for a long time, i.e. since the moment the first spatial data started to be collected systematically and presented on plans and maps (Phillips et al., 1999). The traces go back to ancient times, to Babylon and Egypt. The Egyptian surveyor "harpedonapt" would, according to the plans and schemes, re-do measurements of the parcel boundaries after each flood of the Nile. The basis for building an irrigation system, regulating the Nile and building big constructions was the keeping of spatial data and their use for specific tasks. The development of SDI from ancient times till today is directly linked to the development of the technologies for spatial data collection, information-communication technologies and the level of social development.

Bearing that in mind, we can conclude that SDI has always existed in a certain form, but the level of its implementation has differed according to a particular moment. Against this backdrop, building or establishment of SDI can be seen as improvement or enlargement of the existing one. In line with this, improvement of SDI can be defined as: a number of activities aiming at easier access to and simpler and more efficient use of the existing spatial data. These activities include:

1. Raising social awareness of the importance of spatial data, and managing better coordination and cooperation between all included parties;
2. Customization of the existing spatial data to the appropriate standards and technologies;
3. Design of metadata that will describe the existing sets of spatial data;
4. Creation of a catalogue and the necessary infrastructure.

SDI has several important features which, due to its structure, make it different from other infrastructures. These features can be considered as the following: wide spread, simple use, flexibility, and the groundwork for other activities and services. So far different models of SDI have been presented and implemented worldwide. Most of them show identical or very similar components and attributes. Figure 1 shows the logic structure of SDI.

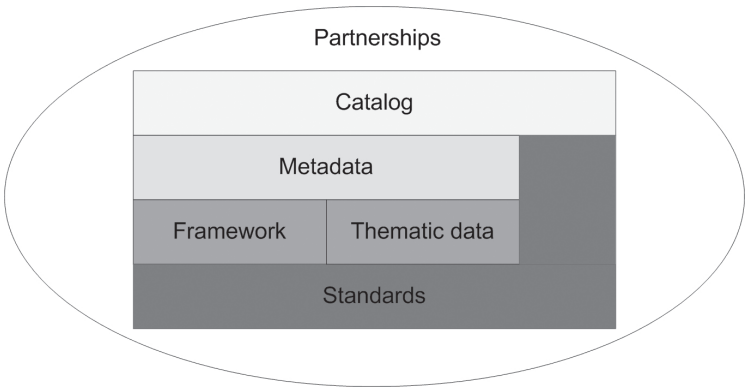

Figure 1. Logic structure of the SDI

Paradigms of the spatial data distribution are to be seen through several time periods from 1960s to 1990s when the concept of spatial data infrastructure started to denote the set-up of standards for spatial data exchange and of the national spatial data infrastructures in the USA, Great Britain, Canada and the European Union (Coleman and McLaughlin, 1997).

Undoubtedly the biggest initiative towards making SDI was President Clinton's Executive Order 12906 (URL 1): "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure," from 1994. This order boosted the SDI improvement not only in the USA, but in the whole world (Cetl et al., 2003).

Looking from today's perspective, the SDI development can be divided into two generations. The first generation was primarily oriented towards technical issues and data as final products (product-oriented), while the second one has been oriented towards users and services (service-oriented). Spatial data users do not only want to access data, but also use various services and analyses, which includes combining different heterogeneous spatial databases and other sources (Donaubauer, 2004). A prerequisite for this new, user- and service-oriented SDI generation is interoperability, i.e. a free flow of data in heterogeneous computer surroundings, based on the relevant international standards.

3 COST-BENEFIT ANALYSIS

3.1 Defining the project of improvement of the existing SDI

SDI develops in line with the development of the background, i.e. economic, technological and

social development. In this context, the SDI improvement at a specific moment, considering its distinctiveness, can be seen as a project with predefined goals and a time limit. If a project is in the public interest, it is referred to as a public project. In this context, the SDI improvement, considering its effects and importance, which are in the interest of whole society, should be seen as a public project, with no alternative characterizations.

The main goal of the SDI improvement is enhancement of the existing state, i.e. creation of the surroundings that will enable a simple and efficient access to the existing sets of spatial data for all interested users. This goal is to be accomplished through a number of activities that will improve the basic components of SDI, which includes customization of the existing spatial data for wider dissemination and creation of a metadata catalog. Production of new spatial data is not considered within this project.

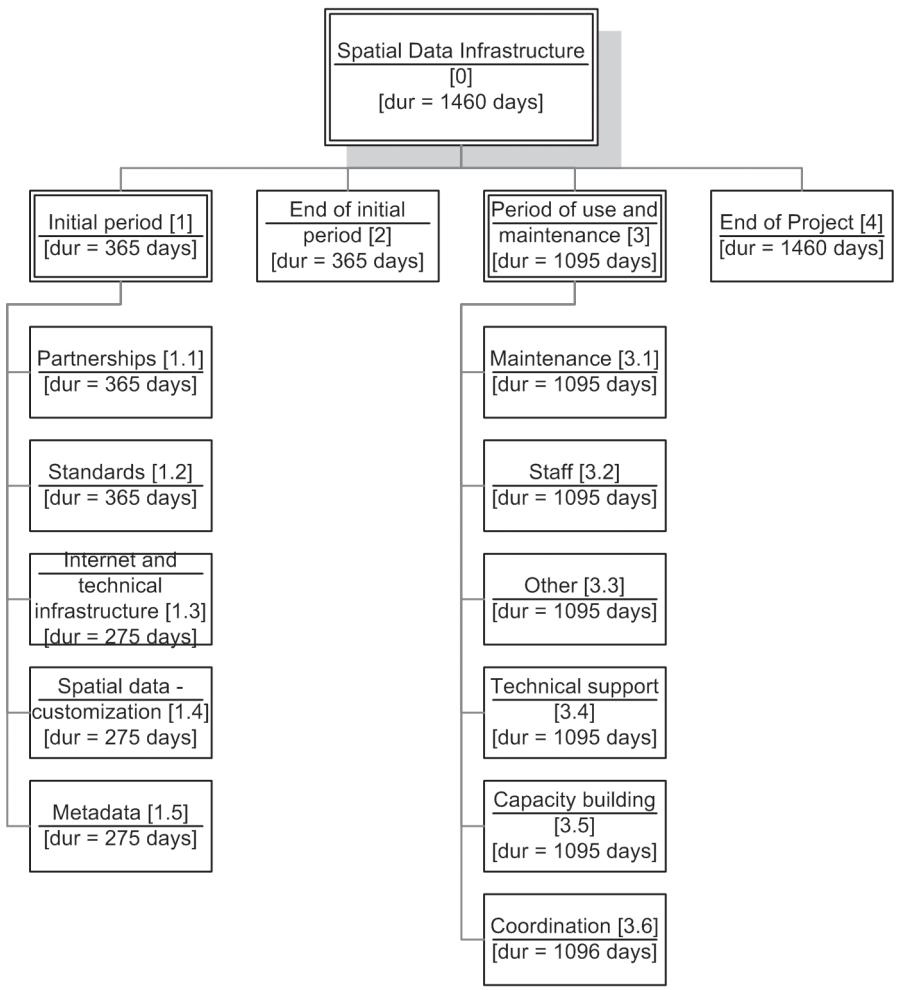

Figure 2. Organization chart of the SDI improvement project

A time period for the SDI project is taken to be 4 years (Figure 2). The first year is an initial period, i.e. a period of capital investments in the improvement of particular SDI parts. After the initial period, the rest is a period of use and maintenance, in which benefits from the SDI set-up are to be seen. Definition of the project as a four-year period can be, in Croatia's context, explained by the following important factors:

1. Enforcement of the new Act on State Survey and Real Estate Cadastre;
2. The new geodetic data and planar cartographic projections in official use (Bašić, 2007);
3. Joining the EU, which requires an organized spatial data and services market, and full readiness to join the INSPIRE.

The initial period includes improvement of the basic SDI components: partnerships, standards, spatial data customization, the Internet and technical infrastructure, and metadata. The result of the initial period is establishment of a catalog as the system central point for the dissemination of spatial data. At the end of the four-year period, the SDI project is to be redefined according to the accomplished results, new technologies and users' requests.

3.2 Cost assessment

Defining everything included within the SDI includes the costs of improvement, as well as other linked activities. The sources and extents of costs are to be considered accordingly:

- Costs of spatial data collection and/or maintenance;
- Costs of the material infrastructure (hardware and net resources);
- Costs of data customization to the appropriate standards, creation of metadata and a catalog;
- Costs of human resources;
- Other costs.

If we start from the assumption that data already do exist, the costs of data collection can be omitted, and only the costs of updating and maintaining data are to be considered further. A cost assessment simulation of the SDI improvement project in Croatia is presented in Table 1.

Task Name	Outline Number	Fixed Cost (HRK)	Fixed Cost (EUR)
Spatial Data Infrastructure	**0**	**46,600,000.00**	**6,418,732.78**
Initial periods	**1**	**36,700,000.00**	**5,055,096.42**
Partnerships	1.1	1,200,000.00	165,289.26
Standards	1.2	1,000,000.00	137,741.05
Internet and technical infrastructure	1.3	10,500,000.00	1,446,280.99
Spatial Data – customization	1.4	9,000,000.00	1,239,669.42
Metadata	1.5	15,000,000.00	2,066,115.70
End of initial period	2		
Period of use and maintenance	**3**	**9,900,000.00**	**1,363,636.36**
End of Project	4		

Table 1. Cost assessment

The cost assessment simulation was made for the initial one-year period and the three-year period of use and maintenance. The monetary unit which was used is the Croatian Kuna (According to the exchange rate list of the Croatian National Bank on the day 28th March 2008. 1 EUR = 7.26 HRK). The costs from the initial period of investment make up the biggest part of the total project costs. The costs are presented for the joint activities, and the biggest amount goes to the creation of metadata, the Internet and technical infrastructure, and the customization of spatial data. The existing studies also show that the costs of creation and maintenance of metadata are high (URL 2). Referencing of the initial costs to the population number or to the area shows that the costs of investment equal HRK 8.27 (EUR 1.11) per capita, or HRK 418.66 (EUR 56.60) per km2. The costs of annual use and maintenance are evaluated at HRK 3,300,000.00 (EUR 454,545.45), and the biggest part covers the staff employment, technical support and capacity construction. The presented cost assessment simulation of the SDI project covers the national level, not taking into consideration the lower, i.e. regional and local levels.

To perform particular activities within the project, it is necessary to ensure the appropriate resources. In this case, the main resources in the initial period are the state budget and credit grants. Besides the main resources, the producers of spatial data are expected to be included as a resource. It is expected that their financial contribution will be low in the initial period and will increase in time. A bigger participation of the producers is to come with the development of new services, which will be offered to meet the users' needs and create added value. A prerequisite for this is the completion of the initial period and the set-up of a functional spatial data frame and a metadata catalog.

3.3 Benefit assessment

Unlike the costs, which can be assessed and approximated with a high degree of certainty, assessment of the benefits is much more complicated. The reason for this is a potentially big number of different applications and users who, by using spatial data and information, create further improvement and revenue in their organizations, which affects indirectly the whole society. The benefits from the creation and improvement of SDI can be divided into several categories:

- Reduction of redundancy, reduction of costs, and widening of the range of production and services for spatial data producers;
- Reduction of costs, and widening of the range of production and services for spatial data users;
- Direct and indirect benefits for the whole society by improving the public information services.

The key factor in the assessment of benefits is the recognition of spatial data as a national asset. If the data are created for only one or two institutions, then there are no benefits for the whole society, which results in redundancies. Re-use of the data and information and sharing of the sources is equally important as the primarily intended use.

If the benefits are seen with regard to easier access to spatial data, they can be expressed as (Annoni, 2004):

1. approx. 2% saving of working time annually spent in the public sector on searching and obtaining spatial data;
2. saving of approx. 10 hours annually spent on the part of spatial data users.

According to the presented criteria, a benefit analysis was made as given in Table 2.

	HRK	EUR
Public sector	4,200,000.00	578,512.40
Private sector and other spatial data users	17,756,000.00	2,445,730.03
Total	**21,956,000.00**	**3,024,242.43**

Table 2. Assessment of direct annual benefits

In the assessment of direct benefits in the public sector, the average of a 40-hour working week and a pay of 100 HRK per working hour was taken into consideration. The 2 % saving of working time, if we calculate it with the assumption of 1000 public officials, amounts up to HRK 4,200,000.00 (EUR 578,512.40) annually. The 10-hour annual saving of time in the private sector and with other users (citizens), assuming that the spatial data and information sector make up 0.4% of the GDP, results in HRK 17,756.000.00 (EUR 2.445.730,03) of direct benefits. Assessment of the total annual direct benefits equals HRK 21,956,000.00 (EUR 3,024,242.43). Experiences from countries with a well developed spatial data infrastructure show that spatial data and information sector make up more than 0.6% of GDP (URL 3).

3.4 Calculations of financial indicators

As the key conditions for deciding on the acceptance or rejection of a project, in a cost-benefit analysis financial indicators are calculated. Most commonly the following are used (Acocella, 1998):

1. Calculation of the net present value (*NPV*);
2. Calculation of the internal rate of return (*IRR*);

If for a project m a set of benefits b_t^m and a set of costs c_t^m are defined in time t, then the sum of the project present value can be expressed as: $B^m = \sum_{t=0}^{n} B_t^m (1+i)^{-t}$ where i is a discount rate, and $(1+i)^{-1}$ a discount factor. The costs can be defined similarly: $C^m = \sum_{t=0}^{n} C_t^m (1+i)^{-t}$.

The absolute net present value is defined as a deduction between the benefits and the costs of a project, i.e.:

$$NPV^m = B^m - C^m \qquad (1)$$

The basic rule for accepting a project is a positive *NPV*, i.e. each project with $NPV > 0$ for the given discount rate is worth implementing. In the analysis of more mutually exclusive projects, the one with the biggest *NPV* is chosen.

The second criterion for decisions is the internal rate of return (*IRR*) which is a discounted rate where the sum of discounted benefits equals the sum of discounted costs. This means that *IRR* is a rate where $NPV = 0$. The of a project is a discounted rate defined in the following equation:

$$\sum_{t=0}^{n} B_t^m (1+i)^{-t} - \sum_{t=0}^{n} C_t^m (1+i)^{-t} = 0 \text{ or } B^m - C^m = 0 \qquad (2)$$

When using *IRR* as an indicator, a project is considered worthwhile and acceptable if its *IRR* is bigger than the social discount rate, for which we can at a certain moment assume that it equals the market interest rate. With mutually exclusive projects, the one with the highest *IRR* is chosen. In comparison to the *NPV*, *IRR* is a more acceptable indicator because it requires no prior choice of the discount rate for the purpose of discounting costs. Generally, projects with a negative net present value or an internal rate of return lower than 5 % do not satisfy. Such projects are to be re-made or rejected.

Besides the presented criteria, as a financial indicator also the ratio between the net benefit and the total costs is used, expressed in monetary units, which is called the return on investment or *ROI*.

On the basis of the cost-benefit analysis of the SDI improvement project in Croatia, it is possible to express the ratio between the costs and the benefits, and calculate the net present value of the project for a four-year period (Figure 3).

Discount rate (0 - 100%)	4,5%				
					Cash Flow in HRK
	Initial	2. Year	3. Year	4. Year	Total
Annual Costs	36.700.000,00	3.300.000,00	3.300.000,00	3.300.000,00	46.600.000,00
Annual Benefits	0,00	21.956.000,00	21.956.000,00	21.956.000,00	65.868.000,00
Net Benefits	-36.700.000,00	18.656.000,00	18.656.000,00	18.656.000,00	19.268.000,00
Net Present Value (NPV) =	-36.700.000,00	17.852.631,58	17.083.857,97	16.348.189,45	14.584.678,99
Return On Investment (ROI) =	41,35%				

Figure 3. NPV and ROI for a one-year initial period (HRK)

The discount rate was taken to be the current 4.5 % rate of the Croatian National Bank. The discount factor is calculated for each year separately, and the project net present value is calculated as a sum from time $t = 0$ (the initial period) to time $t = n$ (in this case four years) according to equation (1). In the initial period, i.e. in the project's first year, there are no benefits, so the net benefit is the "negative" value of the initial costs HRK - 36,700,000.00 (EUR - 5,055,096.42).

The benefits are seen only after the initial period, in the second, third and fourth year of the project, and their net value is calculated as a deduction between the total benefits and costs. The net present value is calculated by multiplying the appropriate discount factor and summing-up for the whole period. Based on the calculations of the ratio between the costs and benefits for a four-year period, the *NPV* of the SDI project equals HRK 14,584,678.99 (EUR 2,008,908.95). The positive net present value of the project justifies its implementation. It is to be mentioned that the NPV amount is not big in absolute terms, which is a direct consequence of the impossibility of assessment of all indirect improvement benefits in monetary units.

The ratio between the net benefits and the total costs or return on investment (*ROI*) equals 41.35 %, which is also a reliable indicator of the project justifiability. If instead of the net present value we calculate the internal rate of return, according to equation (2), we get the *IRR* of 24.48 %. Such an *IRR* is bigger than the social discount rate and it is a reliable indicator of the project justifiability. If the project initial time period is increased to two years, the net present value decreases to *NPV* = HRK 6,448,554.59 (EUR 888,230.66), and the ratio between the net benefits and the total *ROI* to 22.11 % (Figure 4).

Discount rate (0 - 100%) 4,5%

Cash Flow in HRK

	Initial	2. Year	3. Year	4. Year	Total
Annual Costs	18.350.000,00	20.000.000,00	3.300.000,00	3.300.000,00	44.950.000,00
Annual Benefits	0,00	10.978.000,00	21.956.000,00	21.956.000,00	54.890.000,00
Net Benefits	-18.350.000,00	-9.022.000,00	18.656.000,00	18.656.000,00	9.940.000,00
Net Present Value (NPV) =	-18.350.000,00	-8.633.492,82	17.083.857,97	16.348.189,45	6.448.554,59
Return On Investment (ROI) =	22,11%				

Figure 4. NPV and ROI for a two-year initial period (HRK)

In the examination of a two-year initial period, the assumption is that the twice smaller benefits already come up in the second year of investment, but to the costs of investment in the second year the costs of maintenance are added. The costs of maintenance are also twice smaller. The internal rate of return in this case equals 15.36 %, which is still an acceptable indicator of the project justifiability, but also significantly smaller than in the case of a one-year initial period. By expanding the initial period to three years, it is to be expected that in the total annual costs for the second and third year the maintenance costs will rise. In the second year they equal one third, and in the third year two thirds of the total annual maintenance costs. Also, the assumption is that the annual benefits are proportional to this. In this case the project *NPV* is HRK - 1,453,996.87 (EUR - 200,275.05), and *ROI* 1.41 %. The internal rate of return *IRR* is 1.25 %. These financial indicators are not acceptable and in this case the SDI improvement project is to be rejected. If the initial period is expanded to four or more years, the financial indicators show even worse values,

so examination of such cases is not necessary. In Figure 5 the ratios from the aforementioned three cases are presented.

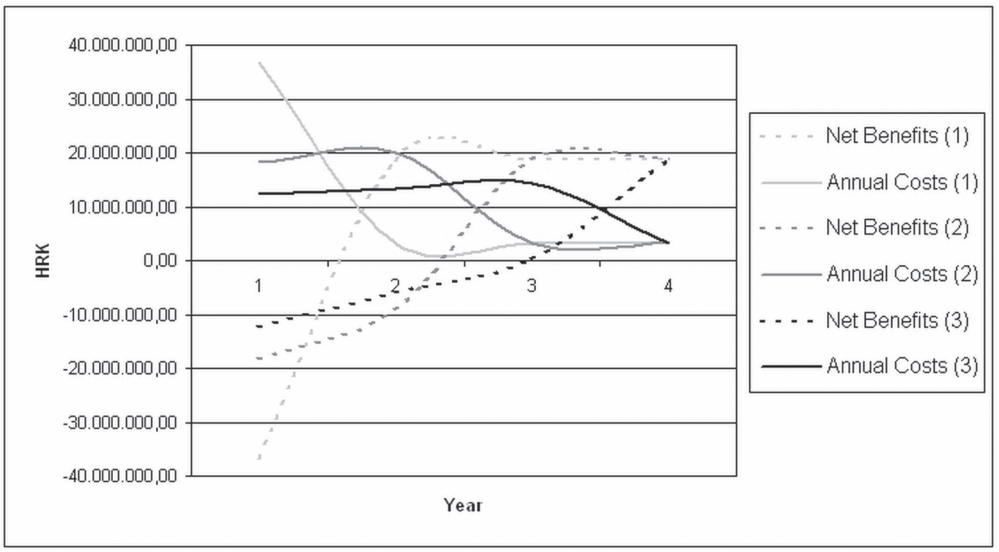

Figure 5. The ratio of net benefits and annual costs (HRK)

The figure shows a ratio of the net benefits and the total annual costs. The particular cases are marked with a number in parentheses, depending on the duration of the initial period in years. It is clear from the figure that the first case (1), in which the initial period lasts one year, is the most suitable, since the lines of the net benefit and the annual costs cross in time much sooner than in other two cases (already in the second year of project). In the second case (2) the lines of the net benefit and the annual costs cross in the third year of the project and in the third case (3) it happens in the fourth year of project. In line with this and with the financial indicators, which are the most suitable for the first case, the initial period should be taken to last one year.

The cost-benefit analysis was made for a four-year period, with a simulation of three cases with different durations of the initial period, i.e. the period of capital investments. It should be taken into consideration that the period of returns brings along various risks with the implementation of particular activities, as well as other details that could cause additional costs. However, the SDI improvement project brings incalculable benefits for the whole society which, along with the calculable direct benefits, undoubtedly justify the project's purpose, so that further risk analyses can be omitted.

4 CONCLUSION

Developing countries and countries in transition are facing the challenge to improve their spatial data infrastructures and provide access to information in line with sustainable development. One of the first tasks in this process is development of the national catalog of spatial data and metadata. The key factors here are the cost-benefit analysis and the choice of an appropriate

financing model, as well as ensuring lasting maintenance and development of the spatial data infrastructure.

Improvement of the existing SDI is to be seen as a permanent public project, for the implementation of which it is necessary to devise an efficient strategy which will review the existing state and evaluate the development level of the existing SDI, examine the needs of spatial data producers and users, clearly define goals of the improvement, and plan the activities, an initial time period and the necessary resources. Each country has to develop such a strategy by itself, using experiences from the countries with highly-developed SDI.

This work sets a four-year period for the SDI improvement, after which a redefinition of the project and further implementation follow. The first year is the initial period of investment, in which the basic SDI components are worked on: partnerships, standards, spatial data customization, the Internet and technical infrastructure, and metadata. Improvement of the SDI components is done as a number of defined activities with support from appropriate resources. After the initial period, a three-year period of use and maintenance follows, after which the project is to be redefined according to the users' requests and new technologies. After defining the project, a cost-benefit analysis was made. For the purpose of examination, a number of cases were considered, in which the initial investment period varied from one to three and more years. The financial indicators obtained from the cost-benefit analysis show that the best results are accomplished if the project initial investment period is shorter.

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Prispelo v objavo: 28. april 2008
Sprejeto: 4. julij 2008

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