Managing European Shorelines and Sharing Information on Nearshore Areas

messina

Case study

SOCIO-ECONOMIC STUDY - Trzęsacz (Poland)

MESSINA PROJECT
COMPONENT 3 : VALUATION OF THE SHORELINE

North East South WEST
INTERREG IIIC

Rewal Community

University of Szczecin

LIST OF CONTENT

Case study made within the Messina project, Component 3.

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SUMMARY

INTRODUCTION

The report is to present tentatively the results of the research on assessment possibilities of the results of undertakings concerning preservation of the coastline against erosion. The research is of methodical and testing character. At the present stage the results cannot constitute basis for formulation for any practical recommendations. As the so-far made attempts in regard to the coastline preservation in Poland (and also in many other countries) lacked any systematic evaluation of effectiveness, the results presented below should be considered as a premise for a development of such methods in the future. However, the above statement does not mean that the costs incurred have never been calculated and that potential losses have not been estimated, but the element of the economic evaluation of the undertakings concerning coastline preservation has not constituted a basic criterion for taking them up or abandoning them.

The research subjects are a stretch of the coast in Rewal commune and the technical undertakings attempted in the recent years to preserve the church ruins in Trzesacz against the collapse from a high cliff. Firstly, the situation of the church ruins and the problem of their preservation have been characterized. Subjects connected with the church ruins in Trzesacz have been presented. Next, an evaluation method, selected from those known in the specialist literature, has been briefly described. The selected method of ‘‘the multi-criteria analysis’’ (MCA) was applied to evaluate six potential variants of the ruins preservation. The analysis is ex-post and has no practical bearing as the decision had been made and the investment had already been carried out. However, it’s essential to compare the variant of abandoning all attempts to preserve the coastline, with at least one variant of acting on them.

1. OVERVIEW OF COASTAL PROCESSES

1.1. Background

Trzesacz it is a small village at the seaside belong to Rewal Community. The village has coast almost one km long, but developed area at present time is about 400 m long. The area is located at the top of 14 m high Pleistocene cliff. Parcels are located about 30-50 m form the range of the cliff. Just at the range of cliff there are located ruins of the XIII century Gothic church (Fig.1).

1880 1903 1998

Fig 1. Ruins of XIII century church in Trzesacz.

Examinations concern the assessment of preservation effects of church ruins in Trzęsacz (Rewal community) there is undertaken in the case study. The ruins are threatened by falling down from the cliff as a result of progressing coastal erosion. It is assumed the, although there is no direct evidences, that the 13th century Gothic church was build about 2 km away form the shoreline. The assessed pace of moving back took the line of the sea shore out in 1280-1880 years with the rate of 5 m per year, but in 1880-2005 years only with 0.5 m/y. According to historical data intense erosion of the cliff caused gradual collapsing of the church. A little fragment of the south wall exists on the edge of the cliff scarcely at present. Value of these ruins is resulting rather from their symbolic meaning, than from aesthetic historical or religious, advantages. The Church in Trzęsacz is a very well known example of progressing erosion processes within the last half century in Poland and is often presented even in school textbooks. From this reason the town and ruins are being visited by school trips as well as other people resting up in a very attractive Rewal community and in surroundings.

A speed of erosion is relatively slow at this place 0,2 m/y and in 84/89 the ruins were protected by seawall made by tetrapods and stones.
At present time a combined protection system was done. The ruins were connected with the cliff and the foot of the cliff was protected by 90 m long seawall made by gabions (sea photo at cover page and at Fig.7).
The goals of this case study are:

- to predict erosion of the Trzesacz coast and their economic results
- to compare the situation presented above to a case if protection would be not done and the ruins would be moved to safety place

Two variants of ruins protection were being considered according to the opinion of the Maritime Office in Szczecin.
The first one suggests continuing protection of the cliff with the use of a new, combined system.
The second one proposes moving the ruins into new safety location.
Both variants were revised and due to lower assessed costs the first option was approved. Direct costs of the preservation of the bank was estimated at the cost of 2.5mln PLN and planed costs of moving ruins, estimated by specialist company reached the range of 12.5 to 25 million PLN,

depending on the chosen technique of moving. However no extra expenditure or possible benefits from both variants were being considered.

The Polish coast is basically consist of soft rocks includes Pleistocene glacial deposits and recent alluvial and littoral zone Holocene sediments. In the general division of the area coastal zone there are two types of coast: a cliff coast consists of Pleistocene deposits, and a barrier-dune coast consists of Holocene deposits. The cliff coast can be found in places where morainic plateaux come directly to the shoreline. A barrier-dune coast has developed where lowland meet the sea. There are two types of the coast: cliff coast and dune coast located at the study area. Their distributions along the coast are presented at Fig.2.

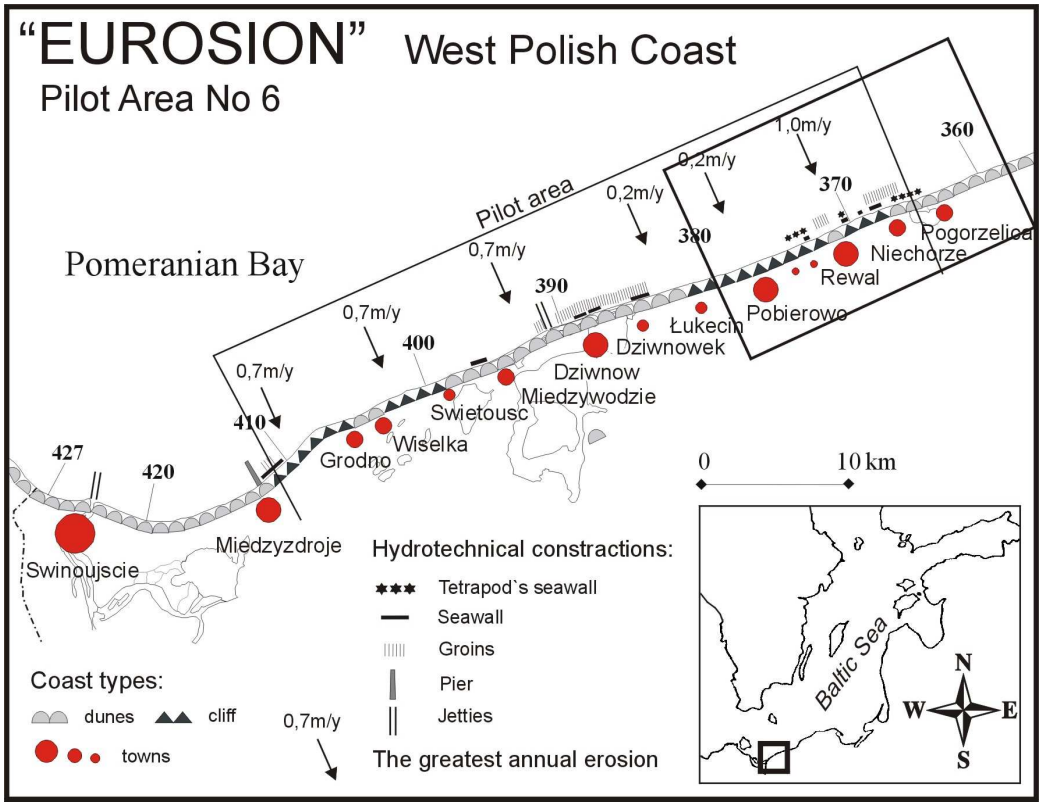


Fig 2. Distribution of coast types at the study area.

Atmospheric circulation create winds regime of the Southern Baltic area. The superposition brings about the predominance of SW and W directions (Fig.3a), throughout the year and in most months, with the exception of spring. The percentage of situation with wind above 6 degrees Beaufort is highest in the period from October to March, and exceeds 15-20% in particular months. In the coastal zone, the highest mean monthly wind speeds (5 - 7 ms^{-1}) from NW, W and SW directions are characteristic for the autumn-winter months, whereas the lowest are recorded from May to August (2,5 - 3,5 ms^{-1}) from NW, W and SW directions (ZEIDLER, 1992), when the Baltic Sea basin is characterised by weak pressure gradients. The autumn-winter season contains the greatest number of days with strong winds (more intensive cyclonic circulation, westerly on the Polish coast). In the coastal waters, the cases of stronger winds are more frequent than on land and reach 20-25%. On a base of wind rose for the Pomeranian Bay the wave climate rose was calculated by ZEIDLER (1992) and was presented at Fig.3b.

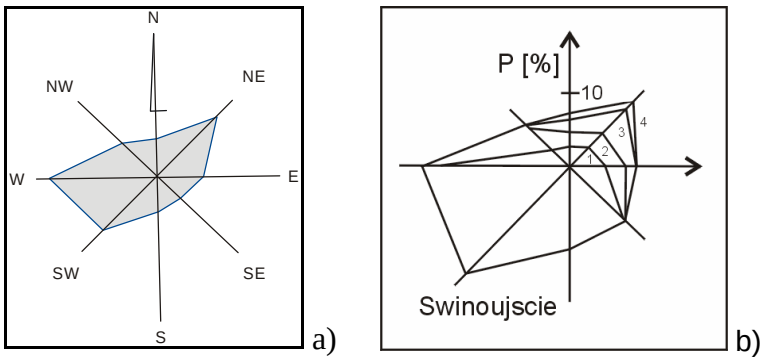


Fig.3. a) Wind rose for the Pomeranian Bay coast.
b) Wave rose for the Pomeranian Bay coast:
(1) 0<H<25 cm; (2) 26<H<50 cm;
(3) 51<H<100 cm; (4) H>101 cm.
from ZEIDLER R.B. et al.,1992.

Longshore currents depend of wind direction and wave climate. They are observed in both east and west directions, but most of them have west direction. It means, that longshore transport predominate in to west direction at this section of the coast (MUSIELAK et al.., 1999).

Generally an erosion of the coast is observed at the study area, but in some places we can find also stable area. An annual rate of coastal changes was calculated on a base of comparison aerial photograph's taken in about 40 years interval and a field observation taken between 1996 - 1999. The spatial structure of the erosion was done by MUSIELAK at al. (1999) and is presented on the Fig.4.

There is collected information about spatial location of urban area also. At the study area there is located community Rewal. His municipalities are located just at the coast and could be affected by coastal erosion. In the Rewal community there are five villages: Pobierowo, Pustkowo, Trzesacz, Niechorze, Pogorzelica and Rewal. All of them are coastal towns or villages, which became holiday resorts in the twenties of the 19th century. Economy of the municipalities is closely connected with resting, tourism and fishing.

Various methods of coastal protection were used at this area. Their location and construction periods are presented at diagram on the Fig. 5.

Effectiveness of the protection is very various. The most effective methods are very expensive like heavy seawall used for protection of the lighthouse in Niechorze and combined seawall in Rewal-Sliwin. They stopped erosion, but in front of the seawall in Niechorze there is almost no beach and strong link side effect. In front of combined seawall in Rewal-Sliwin there is very narrow beach and strong link side effect. Conservation both of them is very expensive.

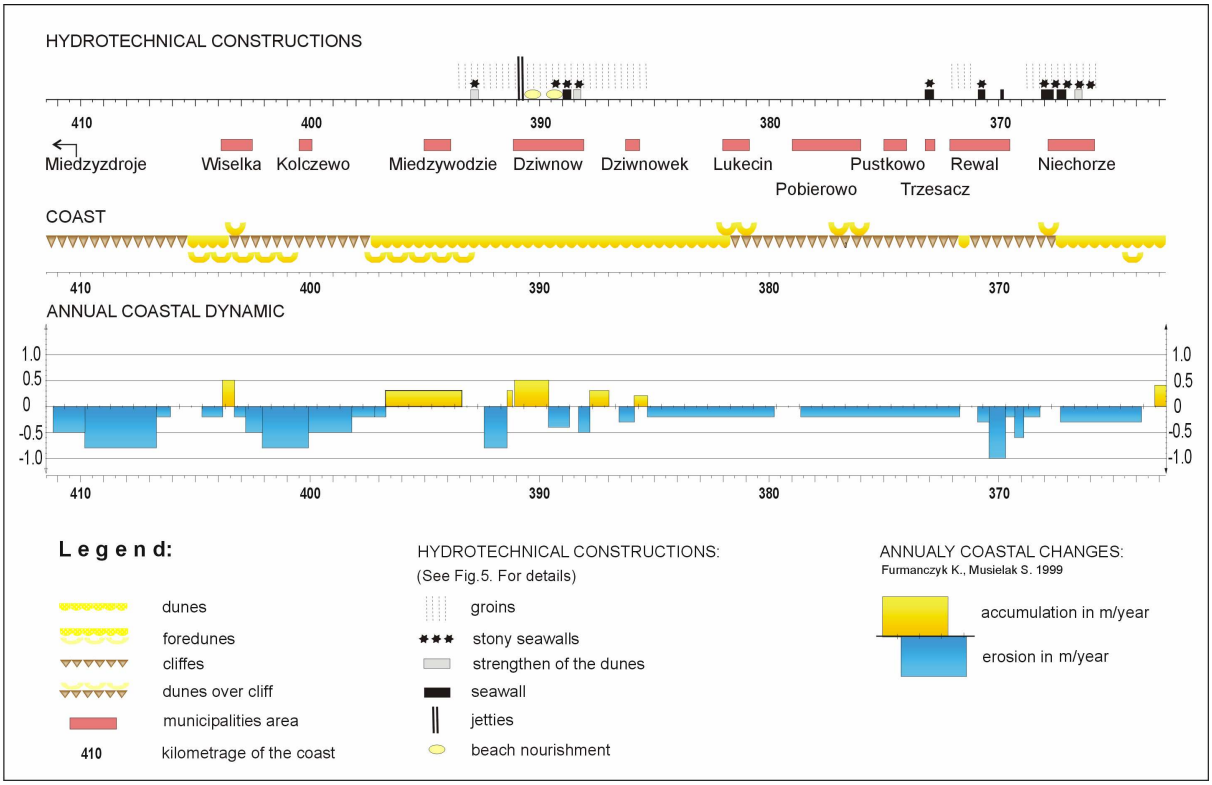


Fig.4. Spatial structure of the erosion

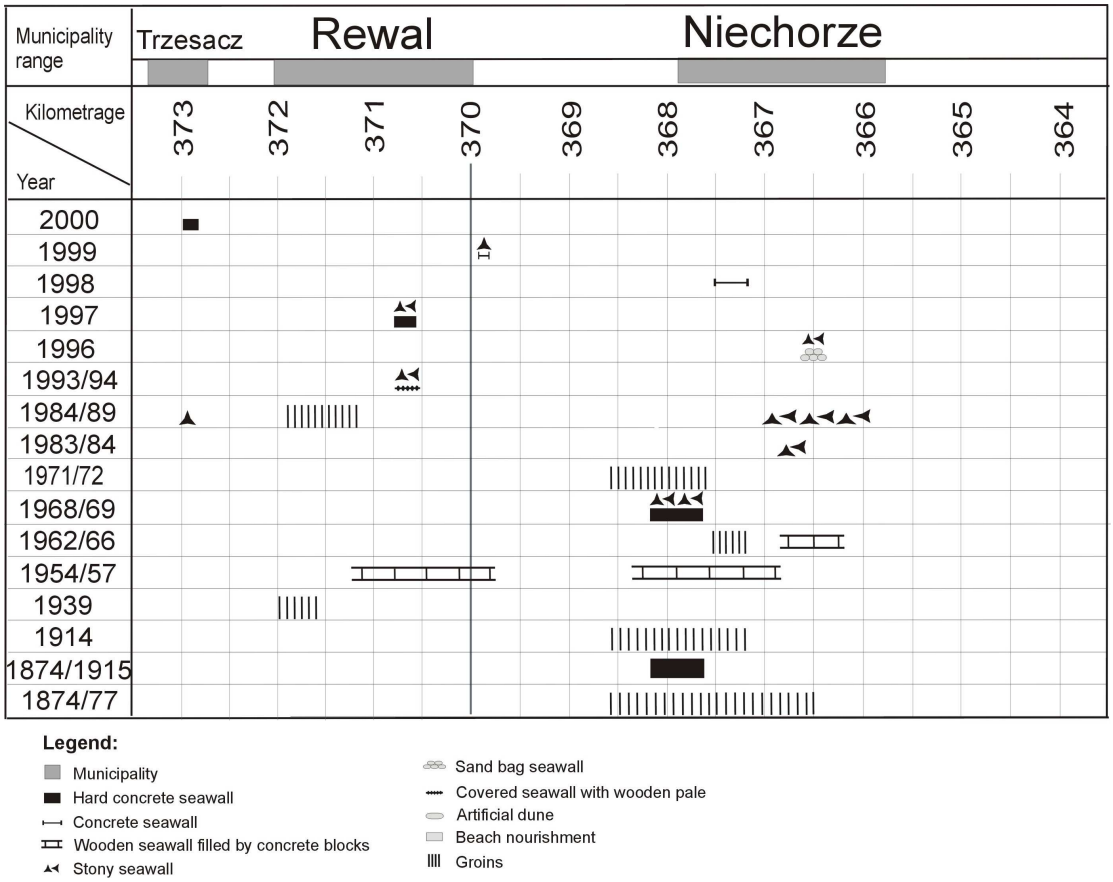
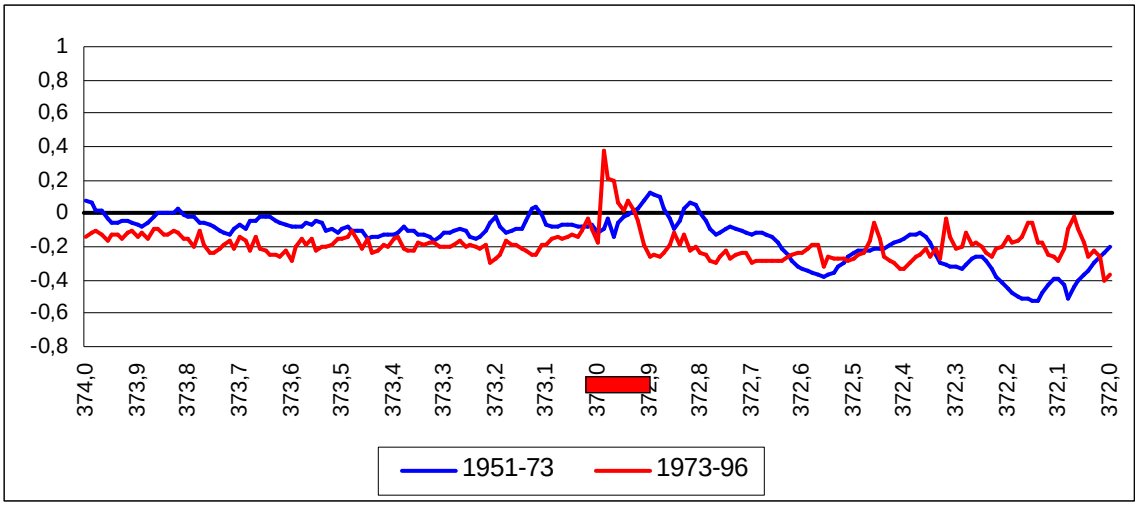


Fig.5. Methods of coastal protection at the study area.

1.2. Active processes and future development.

A coast of the Rewal Community is approximately strait and exposed to NNW.
The coast of Trzesacz consists of Pleistocene glacial deposits. It was relatively stable coast with small annual erosion rate. On a base of Dudzinska (2006) investigation we can define an erosion rate measured form air photographs taken in 1951, 1973 and 1996. Results are presented at Fig. 6 (after Dudzinska 2006). It is interesting that in the period of time 1951-1973 the erosion rate mainly not exceed 0,10 m/year, but in the period of time 1973-1996 was bigger than 0,2 m/year. In the period 1984-1989 the ruins were protected by seawall build by tetrapods and stones. There is visible some asymmetry of erosion rate at the both sides of the church. The western side is more stable than eastern and the erosion rate is smaller at the eastern side.

Fig 6. Diagram of the erosion rate in m/y (cliff foot line changes) at two periods of time (51-73 and 73-96) in Trzesacz. (Dudzinska 2006)



At the summer 2005 the protection system in Trzesacz was finished.

Fig. 7. Combined protection system in Trzesacz 2005. [Phot. J.Stodolny].

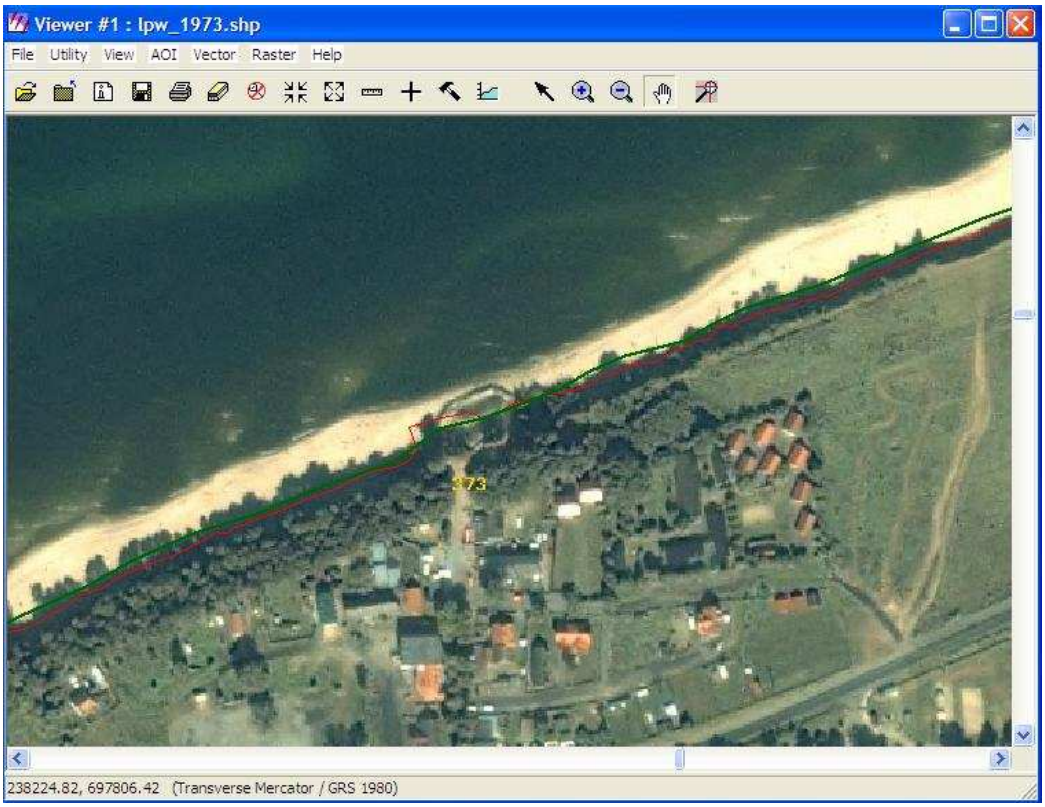


Fig 8. IKONOS image of Trzesacz taken in 2002; (Dudzinska 2006)
Consists of two lines: cliff foot line in 1996 (red) and cliff foot line in 1973 (green).

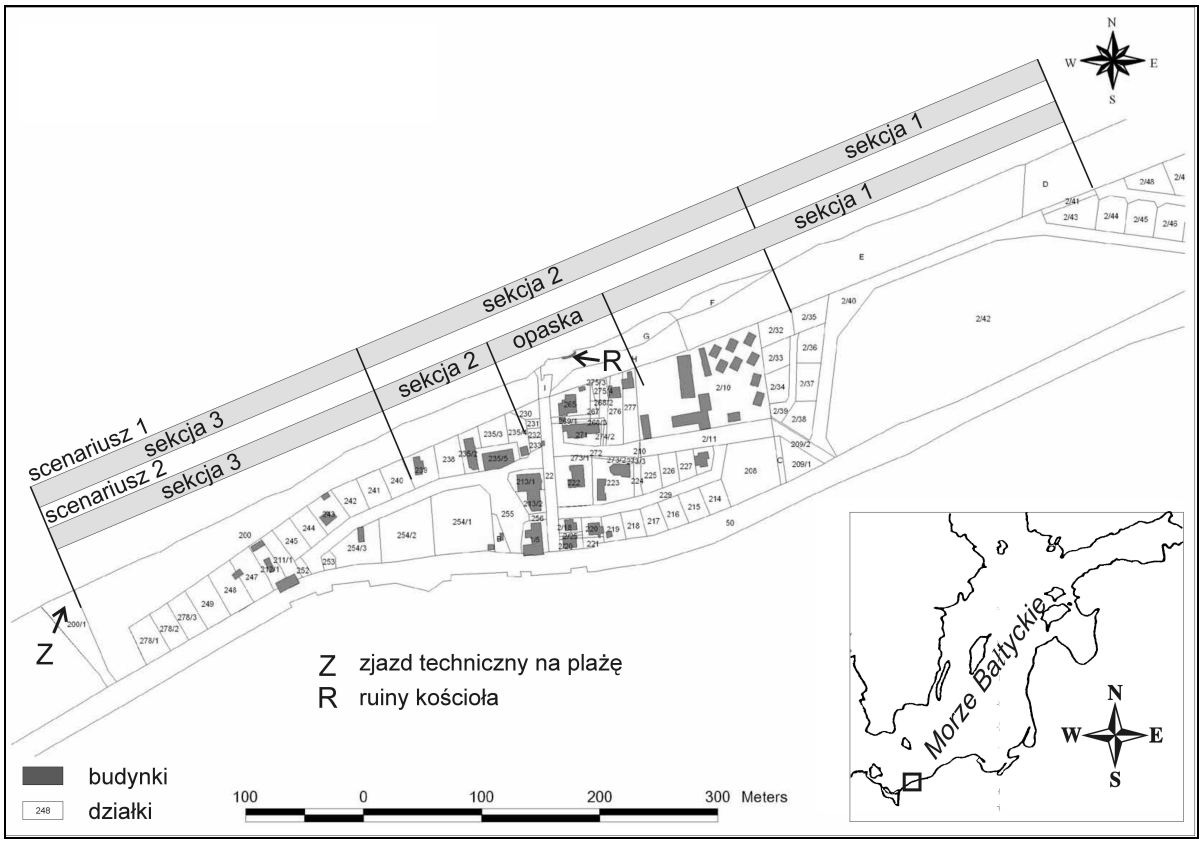


Fig. 9. Area of investigation divided for sections in options: 1 and 2.

It consists of connecting the ruins with the scarp of the cliff and a seawall made by gabions at the foot of the cliff protecting the scarp of the cliff. A length of the seawall is about 90 m. The protected scarp of the cliff was cover by mate suitable for vegetation.
This kind of protection will generate a "link side effect" in both sides of the seawall make erosion of the coast a bit faster.
There were taken two options of activity:

- to continue the process of protection
- not to protect the coast and move ruins to safety place

1.2.1. To continue the process of protection (Option 1).

In case of holding the current state, coast will be eroded. The erosion will intensify by activity of gabion seawall - protecting the Trzesacz Church's ruins and tetrapods seawall – securing emergency way to the beach. Both seawalls will cause increased erosion in the neighborhood of them, especially from the east side.

It was adopted, that:

- Section of the coast that is protected by 115 m long seawall will not be affected by erosion;
- Coastal erosion rate will be similar to the rate observed in 1973-96, because in this time tetrapods' seawall already protected cliff with the ruins (since 1986) and it significantly affected size of erosion in the neighbourhood of this construction.

To assign particular section of the coast and calculate tempo of changes the diagram of cliff foot line (fig.10.) position changes in period of time 1973-96 was analyzed. There were eliminated 4 sections of the coast with different rate of erosion. The length of these sections was: 405m, 115m [section protected by seawall], 100m and 300m.

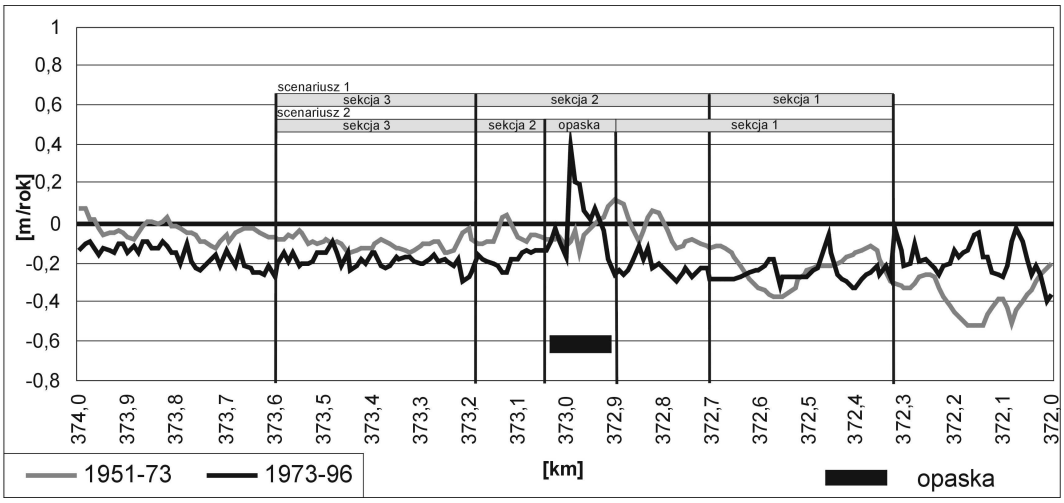


Fig. 10. Changes of cliff foot line in Trzęsacz in years 1951-73 in 1973-96 [m].

In this scenario (option 1) two variants were discussed: optimistic and pessimistic. For the **optimistic** one the erosion rate in the section 1 was assumed for its highest level and for years 1973-96 it will be rated as a value of 0,3 m/y.

Tab. 1. Coastal erosion rate [m/y] in scenario which assume in protection the shore with seawall

	section 1 405m	seawall 120m	section 2 100m	section 3 300mm
Optimistic variant	0,3 m/y	0	0,2 m/y	0,25 m/y
Pessimistic variant	0,6 m/y	0	0,3 m/y	0,4 m/y

For the **pessimistic** variant values of erosion used for calculation were taken in another area. The used rate was noted in Rewal close to, 300 m long, existing since year 1993 defense system of a cliff shore. Those values can be used since the geology of those two areas is very similar.

Based on the analysis of graph presenting changes of cliff foot line in Rewal in a period 1973-96 (fig.11.) it was assumed that effect of a seawall in Trzęsacz will correspond to a lowest erosion rate in a neighbor defense system in Rewal and will ha a value of 0,6 m/y. In section two on a western side of a construction in an optimistic variant an average pace in year 1973-93 which is 0,2 m/y was used for calculations. In a pessimistic variant for this section a maximum value, which is 0,3 m/y, form the same period was used. In a third section it was not possible to take into consideration a defense system constructed in year 2003 to protect the technical and emergency exit. In that situation an erosion rate was assumed with the value of 0,25m/y for a optimistic variant (an average pace in year 1973-96) and 0,4 m/y (optimistic rate increased by 30%).

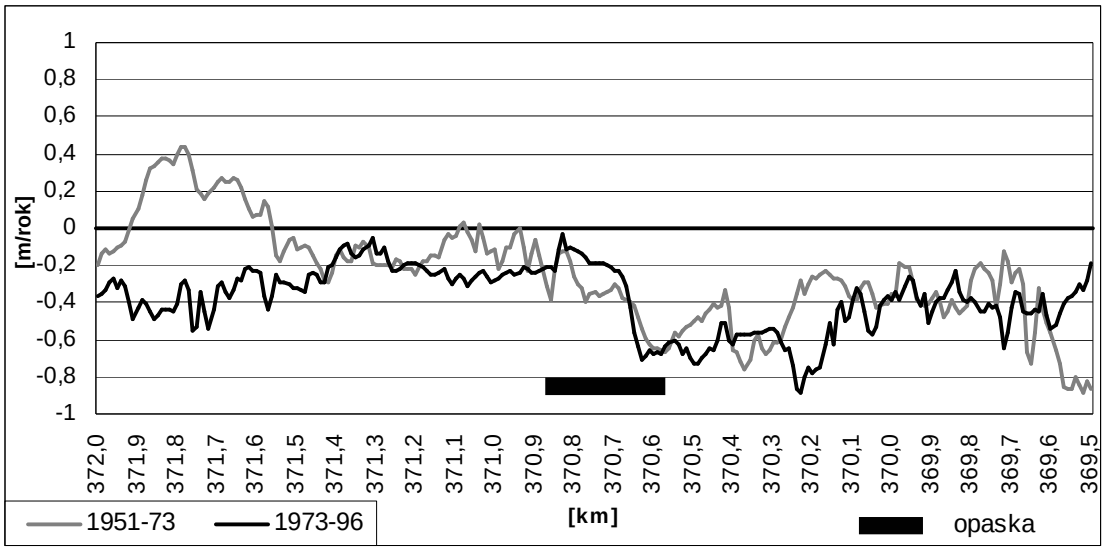


Fig. 11.Changes of cliff foot line position in Rewal, in time periods: 1951-73 and 1973-96 [in m/year].

Following assumptions were adopted for this option:

- erosion pace in the next years will be the same as in year 1973-96 and no information about see level rise and higher storm activity will be included,

- erosion rate of areas that are impacted by seawall will be an indirect value noted between seawall and defense system in cliff area in Rewal,
- erosion rate noted after an impact of a defense system constructed to protect the technical and emergency exit

1.2.2. Not to protect the coast and move ruins to safety place (Option 2).

If there will be no defence and the ruins will be moved to a different location it is supposed that the natural erosion, not disturbed by any defence buildings will occur just like it happened in a period 1951-1973. In order to describe its character and scale a graph of cliff foot line changes for this period was investigated. The results were presented on a three different parcels which vary from each other with the rate of erosion and. They were described as sections with respective lengths of 280m, 340m and 300m.

In the option 2, optimistic and pessimistic variants were taken under consideration. In optimistic variant a value of annual rate of erosion will be equal of average value in each section of the coast in the period of time 1951-73 (Fig. 11). In pessimistic variant a value of annual rate of erosion will be equal of maximum value in each section of the coast in the period of time 1951-73 (Fig. 11). The values of the predicted annual rate of erosion there are in tab. 2 for each section and both variants.

Tab. 2. Coastal erosion rate [m/y] in scenario “to move the ruins”

	section 1 280m	section 2 340m	section 3 300m
Optimistic variant	0,2 m/y	0,1 m/y	0,15 m/y
Pessimistic variant	0,35 m/y	0,2 m/y	0,2 m/y

Following assumptions were adopted for this option:

- erosion pace in the next years will be the same as in year 1951-73 and no information about see level rise and higher storm activity will be included,
- an impact of a defense system constructed to protect the technical and emergency exit will have no additional impact to erosion.

2. VALUES AFFECTED BY COASTAL PROCESSES AND IDENTIFICATION OF STAKEHOLDERS

Subjects Connected with the Church Ruins in Trzesacz

Even though the church ruins in Trzesacz are known in Poland, few private and public subjects are realistically interested in their preservation. The biggest subject is the so-called general public, all those Polish citizens that would negatively perceive total destruction and disappearance of the ruins as a result of the coastline erosion. It is difficult to estimate how big the group is, but it can be assumed that the public opinion organized by the media would condemn passiveness of the authorities in that respect. The authorities representing local community of Trzesacz, Rewal commune and indirectly the whole region of Western Pomerania speak on behalf of that group. They demand preservation of the ruins due to their symbolic, educational and tourist values. The owners and employers of a few shops and stalls are also vitally, but indirectly interested in further existence of the ruins. Souvenir business is seasonal, may relocate easily and most of the offered products are not related to the church ruins. Pecuniary demand for souvenirs, drinks and snacks in Trzesacz itself and in the whole of the commune is high and increasing depending mainly on weather, preferences and wealth of tourists. For the Maritime Office representing public interest in the coastal belt, the most important statutory task is to maintain the coastline and protect the coast against erosion. Some owners of tourist accommodation or shops located nearby the church ruins may feel threatened by erosion as well. It is in their interest to maintain the shoreline and protect the shore, rather than preserve the church ruins.

3. ALTERNATIVES FOR SOLVING THE PROBLEM

Strategy is: a limited protection (to protect the ruins).
There were presented 7 alternative solutions in Multicriteria Analysis.
Two of them were studied in details of the coastal erosion and land value lost presented in Appendix.

4. SOCIO-ECONOMIC STUDY

4.1.Socio-economic description of the Rewal Community

Area

There are seven villages in the commune Rewal: Pobierowo, Pustkowo, Trzęsacz, Rewal, Śliwin, Niechorze, Pogorzelica. The biggest are Pobierowo and Niechorze. All of them are coastal villages, which became holiday resorts in the twenties of the 19th century.

Population

The number of total resident population of the commune Rewal is 3353 (31.12.2001). In 1900 the village Rewal (in that time German) had 144 inhabitants. The main factor of demographic growth was sea-side recreation. In 1896 a narrow-gauge railway was built what increased the

attractiveness of Rewal and the number of visitors. In the thirties of the 20th century one could achieve Rewal from Berlin in 6 hours. Today Rewal is not easy to achieve from the main urban centers of Poland. There is only one good road connection with the transport node of Szczecin (ca 100 km). This road is frequently congested and dangerous in summertime. There are also public inter-city busses from Szczecin to Rewal. Generally, the area is badly connected with the hinterland, especially for non-motorized visitors.

The total area of the whole commune Rewal amounts 4113 ha. The population density is 82 persons per sq. km. The seasonal population (in summer) achieves 26 thousands.
In the last time the population grew from 3138 in 1996 to 3353 in 2001. It is mainly because of immigration from the cities. Newcomers are wealthy people investing in summerhouses and in tourist business. Some of them spend in Rewal only summertime, earning enough money for the whole year. The commune Rewal is rural. The number of flats grew in the years 1996-2001 from 935 to 1011 (108 %). Yearly in the commune has been constructed ca 7500 sq. m of new flats. Most of them are in fact second houses, pensions or private lodgings. The local inhabitants try to extend their houses to get room for tourists' beds or an eating-house. It makes an additional source of income. The rentability of the tourists business on Polish coast depends on weather conditions. By "bad summer" they may be very poor and negatively influence local businesses and commune's budget. The population structure by age and sex group in the commune Rewal is shown on the table 3.

Age / sex	Males		Females		Total	
Children and youth <18	403	25,0%	393	23,2%	796	24,1%
Working population 18-60/65	1089	67,6%	1003	59,3%	2092	63,3%
Older people >60/65	120	7,4%	297	17,5%	417	12,6%

Tab.3. Total population in the commune Rewal by age and sex group (1999).

Typical for the coastal non-urban areas is the domination of females in the age group over 60/65 years. Males dominate under children, youth and working population. The forecasted population trend shows the decline of both young and adult age group and growth of the old people group.

Economy and Employment

Principal activity in the coastal zone, as shown above, is tourism and tourist services. This is a very long tradition of Rewal. It belongs to the oldest seaside resorts on the Baltic. Agriculture and forestry play the secondary role in the commune. There are only ca 800 ha of arable land in the commune Rewal. The coastal and Baltic fishery in Poland suffers several damages because of unfavorable economic circumstances and the lack of public financial support. Some of fishermen are offering sea trips and sea-angling for tourists.
The income per head in the west Pomeranian region lies under below the national average. The coastal communes are relatively rich as compared with the region. An unknown part of the locally earned income is transferred to other places, where the owners of businesses live. Despite of this the coastal communes are able to invest substantial means in the municipal and tourist infrastructure, like roads, sewage systems, street lighting, beach facilities.

Sector of employment	Estimated total employment			
	Persons		%	
	Yearlong	Seasonal	Yearlong	Seasonal
Agriculture, forestry	220	220	18,4	8,0
Fishery	80	80	6,6	2,9
Manufacturing and construction	250	250	20,9	9,1
Transportation, communication	50	50	4,1	1,8
Wholesale, retail trade	100	600	8,3	21,8
Hotels, restaurants	150	1200	12,5	43,7
Business services	70	70	5,8	2,5
Education, health services, administration	280	280	23,4	10,2
Total	1200	2750	100,0	100,0

Tab.4. Yearlong and seasonal employment in the commune Rewal (1999/2000) by sectors.

The number of jobs in the study area can be only estimated because of the lack of accurate statistical data. The result of this estimation is shown on the Table 4. There are about twelve hundred workplaces in the commune Rewal during the whole year. Most of them are communal services (education, health, administration; 23,4 %), in the manufacturing and construction (20,9 %). In agriculture are still more than 200 workplaces (18,4 %). Fishery plays secondary role in the economic base of Rewal – creating only 80 workplaces (6,6 %). In summer (July and August) the employment grows to 2750 workplaces. The tourist-oriented sector dominates. In this time in retail trade, hotels and restaurants works ca 1800 persons. It makes 56 % of the seasonal employment in Rewal.

The main economic sector in the commune Rewal creates tourist services. There are no promising perspectives for fishing or other marine-oriented activities. Beaches are also essential for the economic existence of the whole community. At the moment there is no chance for alternative factor of development.

As shown above, tourism and recreation (sun, sea, sand) is the leading economic function of both communes. The potential of this sector is shown on Table 5. One can see that the recreational potential of the commune Rewal is rather seasonal.

Hotels and other facilities	Objects	Beds		Accommodations
		Yearlong	Seasonal	
Hotels	1	28	28	1 665
Pensions	9	21	332	12 912
Youth hostels	2	60	179	16 722
Holiday camps	93	1224	11 929	776 634
Youth camps	23	82	4844	253 866
Camping, caravan and camping sites	29	-	3638	113 118
Private lodgings	60	-	1076	390 897
Sanatoriums	1	248	284	540 858
Total	218	1 663	22 310	2 106 672

Table 5. Tourist sector in the commune Rewal (1998 and 2003).

Potentially, the health services will be important function in the future. There are yearlong and oriented not so much on sun, sea and sand. Much more important is the marine climate and landscape, comfortable accessibility, good accommodation, and cultural offer. Another future function is yachting and other water sports. The demand for health services and water sports services will grow after joining the EU by Poland.

Development problems

The main problem for the whole coastal zone in Poland is the progressive sprawl of built-up areas. The local physical plans are not enough effective instruments to stop this process. The land owners want to maximize their income by selling land or investing in accommodation facilities. The local governments are also trying to maximize their (indirect) tax revenues from tourist services. In Polish tax system these revenues are the only source for investment in infrastructure. One the one hand the local governments are obliged to protect environment and reasonably manage the coast. On the other hand they are looking for additional budget revenues and new workplaces. In such situation a long-term, sustainable policy is very hard to achieve.

Expanding settlements, especially on the areas endangered by erosion, create source for several local conflicts. Some on these settlements are at high risk. So, the owners and local government support every technical measure which can protect the coast at the moment and in the next future. It is understandable because the erosion of beaches may undermine the economic existence of the commune. The heavy technical constructions protecting the beaches reduce the attractiveness of beaches and whole seaside resorts. Another problem is the high cost of such constructions.

4.2. Multicriteria analysis

Multi-criteria Assessment Method of the Results of Preservation

Among numerous assessment methods of the economic results of investment activities are three basic groups (Persson 2005):

- Cost-Benefit Analysis (CBA) Methods
- Cost Effectiveness Analysis (CEA) Methods
- Multi-Criteria Analysis (MCA) Methods.

The first two methods, the most precise ones, require the data concerning the value of costs and benefits in monetary units. Unfortunately, in case of the church ruins in Trzesacz such data was not available. Therefore, a method of a multi-criteria analysis, designed especially for that purpose, was applied (Tab. 6).

All the evaluation methods of the activities results consist in carrying out evaluation of their different variants (including the so-called zero variant, meaning abandonment of actions) using the same criteria. After calculating the value indicators reflecting the evaluation, variants are ranked from the best to the worst one. Based on that, an *ex-ante* evaluation (i.e. selection of a variant to be realized) or a *mid-term* evaluation (i.e. modification of the project in progress), or an *ex-post* evaluation (i.e. comparison of the results and realization of the project with the assumed goals) can be made. CBA and CEA methods are of clear economic character, they use monetary units of evaluation and criteria of the highest effectiveness of the expenditures, the highest income growth

or lowest cost. However, such analyses disregard ecological, social and cultural results, which cannot be expresses in monetary units.

The essence of a multi-criteria analysis is application of various evaluation criteria of individual variants. The evaluation units are points, allocated in the possibly least arbitrary way. Those points substitute monetary units in evaluation of the expenditures and results, i.e. benefits and losses related to the evaluated undertaking. Owing to that fact benefits and losses, which are difficult to measure in money, may be included in a more objective assessment based on quantitative indicators. It is crucial so that a number of granted points correspond with the importance of a specific criterion for a synthetic assessment. To guarantee that, weighing points granted to individual criteria is applied. Each and every time though, it is a controversial step making the final evaluation more difficult as a result. In order to make scoring correspond with the importance of a criterion for an evaluation, it is enough to lower a number of maximally allocated points. However, the general rule should be the application of equal scoring for all the partial criteria.

Applying MCA method to evaluate the economic results of the preservation of the church ruins in Trzesacz, the criteria were divided into two basic groups: value of costs (expenditures) and value of benefits and losses (Tab.7). On the part of costs three partial criteria were assumed, and on the part of benefits and loses – 13 criteria. Among criteria for evaluation of benefits and losses three areas were singled out: real estate/property value, tourism and recreation related issues and other results as a complementary sphere.

Criteria for evaluation of the costs value include:

- investments, i.e. expenditures for building installations and facilities related to a specific
- variant of preservation,
- maintenance, i.e. running costs for the operation and maintenance of the
- installations and facilities related to a specific variant of preservation,
- operation/use, i.e. other expenditures related to a specific variant of preservation.

Criteria for evaluation of the value of benefits and losses in the management include:

- real estate value of the church ruins,
- value of the buildings on ground neighboring the church ruins,
- value of the technical infrastructure on the ground neighboring the church ruins,
- value of the land neighboring the church ruins,
- cultural value of the ruins.

Criteria for the evaluation of the value of benefits and losses in the sphere of tourism and recreation include:

- cultural value of the church ruins and its direct neighborhood,
- number of people visiting the church ruins,
- scenic value of the church ruins and its direct neighborhood,
- practical use of the vicinity of the church ruins for paragliding,
- access from Trzesacz to the beach at the foot of the church ruins,
- the width of the beach at the foot of the church ruins.

Complementary criteria for the evaluation of other benefits and losses include:

- scale of side effects of the shore erosion,
- actions preventing shore erosion,
- effects for the environment in the direct vicinity of the ruins.

Individual criteria were assigned to points ranging from 0 to 3, in accordance with the observed or expected changes in the phenomena and processes described by them (Tab.8).

Only the criteria of the evaluation of other effects were assigned 0 or 1 point, as they constitute a complementary component of the evaluation. The rules followed in assigning points are presented in Table 3. For expenditures a bigger number of points mean higher expenditures. Points assigned to criteria for evaluation of expenditures, value of the real estate, tourism and recreation and other results are the so-called stimulants. That means that the higher number of points equals a more positive assessment of the potential changes of a phenomenon and of a process assumed as a criterion. For instance, if an increase in value of the real estate on the ground neighboring the church ruins in Trzesacz is expected due to an application of a specific variant of preservation, a number of granted points is 3. If changes are not expected to occur – 2 points are granted. Loss of value generates 1 point. A total loss of a property equals 0 points.

Obviously, such conduct may raise doubts as far as proportion of scoring to changes in value of a real estate is concerned. However, if applied consistently for all the criteria and to evaluate all the variants, it may be assumed that the potential estimate errors lead both to making the scoring as much higher as lower, in order to neutralize each other in the end.

Points granted to each of the variants were added, giving partial evaluations. For the specific spheres of evaluation they are included in the scope as follows:

- costs (C) – from 1 to 9 points[1]
- property value (PV) – from 0 to 12 points
- tourism and recreation (T&R) – from 0 to 18 points
- other results (OR) – from 0 to 3 points.

Points granted to specific criteria served the purpose of calculating four indexes of a final assessment of specific variants, calculated according to the below presented formulas (Tab.9).

Sum of partial assessments SPA=PV+T&R+OR-C+9, where:

C - value of costs in points

PV - property value in points

T&R - results for tourism and recreation in points

OE - other results in points.

It is the simplest indicator, expenditures are subtracted from the sum of benefits, assuming the relation of importance among the specific criteria as follows: C-3, PV-4, T&R- 6, OR - 1. SPA is theoretically included within the range between 0 to 41 points.

[1] It has been assumed that independently from a selected variant there will always be some costs (even minimal ones), which means that value 0 in the criterion ‘operation/use’ does not exist.

Weighted sum of partial assessments WSPA=100x (PV/12 + T&R/18 + OR/3-C/9) +100.In that indicator expenditures are also subtracted from the sum of benefits, but it is assumed that all the criteria weigh equally. WSPA is theoretically included in the range between 0 to 400 points.

Cost effectiveness indicator CEI = (PV+T&R+OR)/C.

This indicator shows how much benefit an expenditure unit, assuming that the relation of importance between individual criteria is, brings in: C-3, PV-4, T&R- 6, OR-1. CEI is theoretically included in the range from 0 to 33 points.

Weighted cost effectiveness indicator WCEI= (PV/12+T&R/18+OR/3) / C/9.

This indicator also shows how much benefit is brought in by an expenditure unit, but on the assumption that all the criteria weigh equally. WCEI is theoretically included in the range between 0 to 27 points.

Values of indicators served the purpose of ranking the evaluated variants from the point of view of the benefits or the most positive ratio of benefits to costs. Based on that qualitative assumption of the executed variant has been made and the best preservation variants for the church ruins in Trzesacz have been selected. Indicator CEI is the most crucial one. Others are supplementary. They serve the purpose of verifying whether the assumed weights of meaning of criteria do not disturb the assumption essentially. As the expression of costs in point may raise objections, effectiveness indicators CEI and WCEI have to be compared with the indicators of the sums of partial assessments SPA and WSPA.

The Assessed Variants of Protection

There were different possibilities of protecting the church ruins in Trzesacz from collapse due to the continuous erosion of the coastline. The Maritime Office in cooperation with the local authorities agreed upon the above variant of protection by building a permanent seawall. While taking up an evaluation of the potential effect of such action, six possible variants[2] were assumed. Consequently they became the subject to an assessment according to the above presented procedure.

Variant 0- do nothing/no action

That variant assumes that despite the threat no actions were undertaken, which sooner or later would bring about the collapse of the ruins down the cliff slope. However, there will be no investment expenditures, nor costs related to the maintenance of the new facilities and the operational running costs, i.e. a routine protection of the coastline is therefore minimal.

Variant 1- Maintain

That variant has been executed. The ruins were anchored in the ground and at the foot of the cliff a cladding seawall, 9 meters broad and 90 meters high was built of Kardzis pyramids and a row of tetrapods laid directly on the fagot at the foot of the cliff. A mat allowing for greenery growth

[2] Prof. dr inż. US Kazimierz Furmańczyk took an active part in the discussions on the variants and introduced many precious comments and ideas.

strengthened the cliff slope. The cost of investment did not exceed 2,5 ml PLN. It was partly covered by the local authorities of Rewal commune.

Variant 2 – Relocation of the Ruins

This variant relies on dismantlement of the church ruins and re-assembling it again in a place not too distant from its original location, but safe from erosion.

The reconstructed ruins could be accompanied by a building housing an educational institution (e.g. a coastline museum). That variant was considered by the Maritime Office in Szczecin, but was rejected due to a high investment cost, estimated for 12,5 to 25 million PLN.

Variant 3 – Pier Construction/ Platform

That variant assumes building of a platform/pier anchored deep in the ground, on which the ruins could be placed in their present condition. The coast would still be subject to further erosion, cliff could subside, but the ruins would be safe. The secured ruins could be accompanied by a building housing an educational institution (e.g. a coastline museum). The advantage of that variant is its demonstrative effect and the disadvantage is a high cost of realization. A detailed assessment of that cost has never been looked into.

Variant 4 – Mark the Position

This variant assumes abandoning coastline protection and allowing for the collapse of the ruins due to the coast erosion. Therefore, it could be connected with variant no 2. The location of an old church would be marked with a column or a mast, or even a special construction.

Variant 5 – Beach Nourishment

This variant assumes intensive and systematic artificial beach nourishment at the foot of the cliff, where the church ruins are located in Trzesacz. It would limit coast erosion and the ruins would not be endangered by collapse. This variant can be applied if the present methods fail to work or their side effects require further intervention. What is especially meant here is heightened erosion at the coastal stretches neighboring the protected cliff with the church ruins.

Variant 6 - Extending Seawall

This complementary variant assumes extension of the already built seawall in order to limit the side effects of the coast erosions at those stretches, which directly neighbor the protected cliff with the church ruins.

Partial Assessments of Variants of Protection

The above variants of protective activities underwent first partial multi-criteria assessments. The results of scoring are presented in Tab. 9. Seen from the point of view of costs, variant 3 is the most costly one, while variant 0 – the abandonment of actions/ do nothing—is the least expensive one.

Marking the position as in variant 4 also costs little. Unfortunately however, both variants equal to consenting the ruins collapse. The executed variant 1 is characterized by average costs.

Variants 2 and 3, which obtained the maximum number of points, stand out positively, seen from the point of view of changes in property value as a result of realization of the specific variants of protection. It is a result of big investments in the accompanying infrastructure, which would contribute to the value increase of the plots and building around the protected ruins. Doing nothing/the abandonment of protective actions or marking the position (variant 0 and 4) will not bring about any improvement in that respect. The executed variant 1 is characterized by an average increase of property value.

Benefits and losses in the area of tourism and recreation constitute, apart from expenditures, the most important set of criteria of a partial assessment of variants. In that respect the biggest number of points was obtained by variant3, i.e. building a pier construction (platform) and accompanying facilities. Variant 2 and 5 were evaluated as not much worse. Variant 5 mean beach nourishment. If there would be a broad, permanent beach with the view to the ruins, the tourist attractiveness of the resort and the whole Rewal commune would increase considerably. Lack of any action is the worst solution for the tourism value of Trzesacz. The executed variant 1 is characterized by an average increase of tourist attractiveness.

The evaluation of other results is only supplementary and refers mainly to the beach. Variants 5 and 6 may bring about the biggest number of negative side effects, as they interfere in the coastal ecosystem most. Variants 0, 2 and 4 do not have a negative impact. The executed variant 1 is characterized by average values of negative side effects. It has to be taken into account that erosion may intensify at the neighboring stretches of the beach and the necessity of undertaking further protective actions interfering in the ecosystem (compare Basinski 2005).

The above partial assessments served the purpose of drawing up a complex evaluation according to four indicators: SPA, WSPA, CEI and WCEI.

Tab. 6. Comparison of different methods used for assessment of undertaking investment.

Method	Assessment Criterion	Units of valuation			
		Capital expenditure	Effects		
			Economic	Ecological	Social and Cultural
CBA	Economic effectiveness / prosperity growth	Money units	Money units	Money units	Money units
CEA	The lowest costs	Money units	Money units		
MCA	Multicriteria	Points	Points	Points	Points

Source: Persson Mats, 2005, *Socio-economic methods for evaluating decisions in coastal erosion management – State-of-the-art*, MESSINA Project, Component 3, Lund University, Lund.

Tab. 7 Assessment scales of costs, benefits and losses caused by the protection of Church Ruins in Trzesacz (Poland)

Costs	Assessment	Cost level estimation	Potential source of financing
Score points			
0	no		
1	low	< 1 mln PLN	Commune, small private investor
2	medium	1 to 10 mln PLN	Maritime Office, regional authority, medium private investor
3	high	> 10 mln PLN	State, big private investor
Benefits and losses			
Score points	Property value:		
0	loss		
1	decline		
2	no change		
3	growth		
Score points	Tourism and recreation:		
0	loss		
1	decline		
2	no change		
3	growth		
Score points	Other effects:		
0	negative		
1	no		

Tab. 8 Elements of partial assessments of different methods of the protection of Church Ruins in Trzesacz (Poland)

Effects	Variant 0 Do nothing	Variant 1 Maintain	Variant 2 Relocation	Variant 3 Pier construction	Variant 4 Mark the position	Variant 5 Beach nourishment	Variant 6 Extending seawall
Costs							
Score range 0-9							
Investment	0	2	3	3	1	2	2
Maintenance	0	2	0	2	1	2	2
Operational costs	1	1	1	2	1	1	2
PARTIAL ASSESSMENT	**1**	**5**	**4**	**7**	**3**	**5**	**6**
Benefits and losses							
Property value							
Score range 0-12							
Church	0	2	3	3	0	2	2
Houses	1	2	3	3	1	2	2
Infrastructure	1	2	3	3	1	2	2
Open land	1	2	3	3	1	2	2
PARTIAL ASSESSMENT	**3**	**8**	**12**	**12**	**3**	**8**	**8**
Tourism and recreation							
Score range 0-18							
Heritage	0	2	3	3	0	2	2
Number of visitors	0	2	3	3	1	2	2
Visual impact on landscape	1	2	1	3	1	2	1
Paragliding	2	2	2	2	3	2	2
Accessibility of beach	2	2	2	2	2	2	2
Width of beach	2	1	2	2	2	3	0
PARTIAL ASSESSMENT	**7**	**11**	**13**	**15**	**9**	**13**	**9**
OIther effects							
Score range 0-3							
Side effects Erosion	0	1	0	0	0	1	1
Preventive measures	0	1	0	1	0	1	1
Environmental effects	0	0	0	1	0	1	1
PARTIAL ASSESSMENT	**0**	**2**	**0**	**2**	**0**	**3**	**3**

Tab. 9 Complex assessment of different methods of the protection of Church Ruins in Trzesacz (Poland)

Indicators and ranks	Variant 0	Variant 1	Variant 2	Variant 3	Variant 4	Variant 5	Variant 6
	Do nothing	Maintain	Relocation	Pier construction	Mark the position	Beach nourishment	Extending seawall
Sum of partial assessments (SPA)	21	24	33	30	21	25	20
RANK OF VARIANT	5 or 6	4	**1**	**2**	5 or 6	3	7
Weighted sum of partial assessments (WSPA)	253	206	328	239	242	183	150
RANK OF VARIANT	**2**	5	**1**	4	3	6	7
Cost effectiveness indicator (CEI)	13,0	4,0	7,0	4,0	5,0	4,2	2,8
RANK OF VARIANT	**1**	5 or 6	**2**	5 or 6	3	4	7
Weighted cost effectiveness indicator (WCEI)	18,2	3,6	7,6	3,4	6,5	3,1	2,2
RANK OF VARIANT	**1**	4	**2**	5	3	6	7

Tab.10 Loss of value of land in the Rewal commune in 1000 PLN as a result of coastal erosion of individual segments of the coast according to different scenarios and variants of the coastal preservation after 20, 50 and 100 years

Coastal protection means		Pessimistic scenario			Optimistic scenario		
		20 years	50 years	100 years	20 years	50 years	100 years
Limited protection							
	segment 1	985238	2464292	4936115	492560	2464292	2464292
	segment 2	121615	303237	604216	81124	202455	2029
	segment 3	479281	1198746	2405939	299515	719031	1498965
	Total	1586134	3966275	7946270	873199	3385778	3965286
In 1000 PLN		1586	3966	7946	873	3386	3965
Without protection							
	segment 1	390565	977362	1958094	223135	390565	1117257
	segment 2	282979	705239	1406681	141711	353498	705239
	segment 3	243861	609189	1216830	182919	457036	913202
	Total	917405	1682601	3364775	547765	744063	1822496
In 1000 PLN		917	1683	3365	548	744	1822

Tab.11. Loss of value of land in the Rewal commune in 1000 PLN as a result of coastal erosion according to different scenarios and variants of the coastal preservation after 20, 50 and 100 years

Coastal protection means	Pessimistic scenario			Optimistic scenario		
	20 years	50 years	100 years	20 years	50 years	100 years
Limited protection	1586	3966	*7946*	873	3386	3965
Without protection	917	1683	3365	*548*	744	1822

Tab.12. Loss of value of land in the Rewal commune in 1000 Euro as a result of coastal erosion according to different scenarios and variants of the coastal preservation after 20, 50 and 100 years

Coastal protection means	Pessimistic scenario			Optimistic scenario		
	20 years	50 years	100 years	20 years	50 years	100 years
Limited protection	397	992	*1987*	218	847	991
Without protection	229	421	841	*137*	186	456

A respect of losses was carried out in the current situation for erosion of the sea edge in the Rewal commune in the purpose of the assessment of possible economic effects for value of land after 20, 50 and 100 years according to of two scenarios of intensity of erosion. This assessment has fragmentary character because isn't enveloping all potential economic losses. It is possible however to recognize that this determining minimum losses, preservations enabling the preliminary comparison to costs of undertakings of the coast are.

5 RESULTS, DISCUSSION AND CONCLUSIONS

Complex Assessment of Variants of Protection

The results of the complex evaluation are presented in Tab. 8. The results of the evaluation according to various indicators are closely correlated. However, the most important indicator is CEI. According to that indicator, undeniably the worst solution would be further extension of the seawall. The executed variant is also not remarkably effective. From an economic point of view the best solution would bean abandonment of all protective actions. In the light of the assumed criteria benefits gained from the undertaken protective investment are little. It is obvious that the decision about protecting ruins was taken based on non-economic premises. Taking that into consideration, the relocation of ruins undeniably has to be recognized as the best variant. Indicator WCEI does not change that assessment, which means that the assumed weights of criteria do not affect the final result. The other indicators SPA and WSPA unambiguously show that variant 2, the relocation of ruins, is the best one. According to the SPA indicator a high position in the ranking was also granted to variant 3 – construction of a pier (platform) upholding the ruins. Variant 5 – beach nourishment, is most dependent on the weights of the criteria. If more importance is to be placed on benefits and losses in tourism and recreation (SPA and CEI), the position of that variant is higher in the ranking.

Conclusions

The aim of the research carried out within the project Interreg III C MESSINA was primarily an international skill-sharing experience in the area of value judgment of a coastline and assessment of the protective actions. Protective actions concerning the church ruins in Trzesacz, which are endangered by erosion, were a subject of the case study. The obtained results, due to the lack of complete financial data, cannot constitute any basis for practical recommendations. In spite of that, it is puzzling that the decision concerning taking up protective actions towards the ruins, based on rational premises, with application of the multi-criteria method of assessment, turns out to be not the most accurate one. What is worse, there is a real threat of intensification of the coastal erosion at the stretches to the east of Trzesacz (compare. Musielak 2005). The beaches of Rewal, Niechorze and Pogorzelica constitute a strategic tourist-recreational asset of the commune. Their exposure to risk and potential extra costs on protective actions may negatively burden the balance of coastline protection action taken in good faith and with a good intention (Borodziuk 2005). A conclusion arises that a gradual introduction of evaluation methods *ex-ante* of all the protective projects on the coast should occur. Within the framework of the project Interreg III C MESSINA a methodological guide will be drawn up, which after translation into Polish should be widely distributed among subjects involved in the issues of preservation and development of the coastal zone.

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7 APPENDIX

PROTECION

section 1 pesymist 100 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
parcel	2/10	7758,182	1552000	200	30	2332,584	466626	0	60,0000
parcel	2/41	242,219	48202	199	100	242,219	48202	0	60,0000
parcel	2/43	826,922	164557	199	69	574,425	114310	0	60,0000
parcel	2/44	728,636	144999	199	2	11,858	2360	0	60,0000
road	2/55	2727,119	542697	199	0	1,738	346	2	60,0000
parcel	2/35	652,724	129892	199	100	651,114	129572	0	60,0000
parcel	2/32	643,399	128036	199	99	635,754	126514	0	60,0000
parcel	2/36	647,055	128764	199	4	25,491	5073	0	60,0000
parcel	2/33	535,552	106575	199	2	9,473	1885	0	60,0000
road	2/39	583,327	116082	199	2	13,336	2654	2	60,0000
forest	D	16440,661	3271692	199	15	2415,504	480685	1	60,0000
field	E	11708,487	2329989	199	100	11708,487	2329989	4	60,0000
grassland	F	894,494	178004	199	100	894,494	178004	3	60,0000
grassland	G	1764,689	351173	199	30	526,690	104811	3	60,0000
forest	H	1989,004	500000	199	43	847,033	168560	1	60,0000
road	2/40	5953,855	1184817	199	43	2574,956	512416	2	60,0000
	2/42	16205,961	3224986	199	8	1327,174	264108	0	60,0000
TOTAL		70302,286	14102465			24792,330	4936115		
section 1 optymist 100 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
forest	D	16440,661	3271692	199	10	1652,948	328937	1	30,0000
field	E	11708,487	2329989	199	74	8671,290	1725587	4	30,0000
grassland	F	894,494	178004	199	100	894,494	178004	3	30,0000
grassland	G	1764,689	351173	199	30	526,690	104811	3	30,0000
forest	H	1989,004	500000	199	32	637,955	126953	1	30,0000
TOTAL		32797,335	6630858			12383,377	2464292		
section 1 pesymist 50 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
forest	D	16440,661	3271692	199	10	1652,948	328937	1	30,0000
field	E	11708,487	2329989	199	74	8671,290	1725587	4	30,0000
grassland	F	894,494	178004	199	100	894,494	178004	3	30,0000
grassland	G	1764,689	351173	199	30	526,690	104811	3	30,0000
forest	H	1989,004	500000	199	32	637,955	126953	1	30,0000
TOTAL		32797,335	6630858			12383,377	2464292		

section 1 optymist 50 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
forest	D	16440,661	3271692	199	5	780,554	328937	1	15,0000
field	E	11708,487	2329989	199	34	3945,518	1725587	4	15,0000
grassland	F	894,494	178004	199	100	894,494	178004	3	15,0000
grassland	G	1764,689	351173	199	29	508,042	104811	3	15,0000
forest	H	1989,004	500000	199	3	60,536	12047	1	15,0000
TOTAL		32797,335	6630858			6189,144	2349386		
section 1 pesymist 20 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
forest	D	16440,661	3271692	199	4	617,230	122829	1	12,0000
field	E	11708,487	2329989	199	26	3048,320	606616	4	12,0000
grassland	F	894,494	178004	199	93	835,076	166180	3	12,0000
grassland	G	1764,689	351173	199	24	431,009	85771	3	12,0000
forest	H	1989,004	500000	199	1	19,310	3843	1	12,0000
TOTAL		32797,335	6630858			4950,945	985238		
section 1 optymist 20 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
forest	D	16440,661	3271692	199	2	301,401	59979	1	6,0000
field	E	11708,487	2329989	199	12	1439,386	286438	4	6,0000
grassland	F	894,494	178004	199	58	518,278	103137	3	6,0000
grassland	G	1764,689	351173	199	12	216,109	43006	3	6,0000
TOTAL		30808,331	6130858			2475,174	492560		

PROTECION

section 2 pesymist 100 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID	erosion
parcel	240	586,975	117600	200	0	1,084	217	0	30,0000
parcel	239	713,489	142800	200	14	103,145	20644	0	30,0000
parcel	238	698,962	140000	200	14	99,612	19952	0	30,0000
parcel	235/2	528,048	105000	199	16	83,235	16551	0	30,0000
parcel	235/3	520,472	104200	200	27	140,824	28193	0	30,0000
parcel	235/4	522,955	104200	199	8	39,950	7960	0	30,0000
parcel	230	246,554	49000	199	0	0,460	91	0	30,0000
forest	200	14059,286	2797798	199	18	2565,864	510607	1	30,0000
TOTAL		17876,741	3560598			3034,174	604216		
section 2 optymist 100 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID	erosion
forest	14059	200,000	2797798	403722	199	14,0000	2029	1	20,0000
TOTAL		200,000	2797798			14,000	2028,755		
section 2 pesymist 50 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID	erosion
forest	200	14059,286	2797798	199	11	1523,81	303237	1	15,0000
TOTAL		14059,286	2797798			1523,81	303237		
section 2 optymist 50 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID	erosion
forest	200	14059,286	2797798	199	7	1017,36	202455	1	10,0000
TOTAL		14059,286	2797798			1017,36	202455		
section 2 pesymist 20 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID	erosion
forest	200	14059,286	2797798	199	4	611,133	121615	1	6,0000
TOTAL		14059,286	2797798			611,133	121615		
section 1 optymist 20 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID	erosion
forest	200	14059,286	2797798	199	3	407,66	81124	1	4,0000
TOTAL		14059,286	2797798			407,66	81124		

PROTECION

section 3 pesymist 100 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID	erosion
road	200/1	1575,872	313599	199,000	4	55,604	11065	2	40,0000
parcel	278/3	679,096	134200	197,616	1	4,482	886	0	40,0000
parcel	249	892,007	179000	200,671	5	41,071	8242	0	40,0000
parcel	248	911,475	182000	199,676	12	110,778	22120	0	40,0000
parcel	247	861,963	172200	199,777	20	170,306	34023	0	40,0000
parcel	212/1	618,740	123200	199,114	21	131,699	26223	0	40,0000
parcel	245	571,544	124400	217,656	47	268,986	58546	0	40,0000
parcel	244	554,543	110200	198,722	62	343,786	68318	0	40,0000
parcel	243	709,014	141000	198,868	68	484,412	96334	0	40,0000
parcel	242	582,124	117000	200,988	69	402,180	80833	0	40,0000
parcel	241	589,010	117600	199,657	56	331,336	66154	0	40,0000
parcel	240	586,975	117600	200,349	54	318,625	63836	0	40,0000
forest	200	14059,286	2797798	199,000	66	9245,416	1839838	1	40,0000
parcel	211/1	604,325	120400	199,231	25	148,176	29521	0	40,0000
Total		23795,974	4750197			12056,857	2405939		
section 3 optymist 100 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID	erosion
road	200/1	1575,872	313599	199	2	30,828	6135	2	25,0000
parcel	245	571,544	124400	218	1	5,791	1260	0	25,0000
parcel	244	554,543	110200	199	12	68,640	13640	0	25,0000
parcel	243	709,014	141000	199	17	122,910	24443	0	25,0000
parcel	242	582,124	117000	201	14	81,401	16361	0	25,0000
parcel	241	589,010	117600	200	2	13,097	2615	0	25,0000
parcel	240	586,975	117600	200	1	8,762	1755	0	25,0000
forest	200	14059,286	2797798	199	51	7199,776	1432755	1	25,0000
Total		19228,368	3839197			7531,205	1498965		
section 3 pesymist 50 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID	erosion
road	200/1	1575,872	313599	199	1	23,631	4703	2	20,0000
parcel	243	709,014	141000	199	0	2,797	556	0	20,0000
parcel	242	582,124	117000	201	0	0,465	93	0	20,0000
forest	200	14059,286	2797798	199	43	5996,951	1193393	1	20,0000
Total		16926,296	3369397			6023,844	1198746		
section 3 optymist 50 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID	erosion
road	200/1	1575,872	313599	199	1	13,220	2631	2	12,5000
forest	200	14059,286	2797798	199	26	3600,003	716401	1	12,5000
Total		15635,158	3111397			3613,223	719031		

section 3 pesymist 20 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID	erosion
road	200/1	1575,872	313599	199	1	8,524	1696	2	8,0000
forest	200	14059,286	2797798	199	17	2399,923	477585	1	8,0000
Total		15635,158	3111397			2408,447	479281		
section 3 optymist 20 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID	erosion
road	200/1	1575,872	313599	199	0	5,221	1039	2	5,0000
forest	200	14059,286	2797798	199	11	1499,877	298476	1	5,0000
Total		15635,158	3111397			1505,098	299515		

NO PROTECION

section 1 pesymist 100 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
forest	D	16440,661	3271692	199	12	1964,750	390985	1	35,0000
field	E	11708,487	2329989	199	67	7874,308	1566987	4	35,0000
grassland	F	894,494	178004	199	0	0,611	122	3	35,0000
TOTAL		29043,642	5779685			9839,669	1958094		
section 1 optymist 100 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
forest	D	16440,66	3271692	199	6	1049,21	208794	1	20,0000
field	E	11708,49	2329989	199	39	4564,53	908342	4	20,0000
grassland	F	894,494	178004	199	0	0,611	122	3	20,0000
TOTAL		29043,64	5779685			5614,36	1117257		
section 1 pesymist 50 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
forest	D	16440,66	3271692	199	6	907,641	180621	1	17,5000
field	E	11708,49	2329989	199	34	4003,12	796620	4	17,5000
grassland	F	894,494	178004	199	0	0,611	122	3	17,5000
TOTAL		29043,64	5779685			4911,37	977362		
section 1 optymist 50 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
forest	D	16440,66	3271692	199	2	345,556	68766	1	10,0000
orne	E	11708,49	2329989	199	14	1616,47	321678	4	10,0000
grassland	F	894,494	178004	199	0	0,611	122	3	10,0000
TOTAL		29043,64	5779685			1962,64	390565		
section 1 pesymist 20 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
forest	D	16440,66	3271692	199	2	345,556	68766	1	7,0000
field	E	11708,49	2329989	199	14	1616,47	321678	4	7,0000
grassland	F	894,494	178004	199	0	0,611	122	3	7,0000
TOTAL		29043,64	5779685			1962,64	390565		
section 1 optymist 20 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
forest	D	16440,66	3271692	199	1	194,603	38726	1	4,0000
field	E	11708,49	2329989	199	8	926,065	184287	4	4,0000
grassland	F	894,494	178004	199	0	0,611	122	3	4,0000
TOTAL		29043,64	5779685			1121,28	223135		

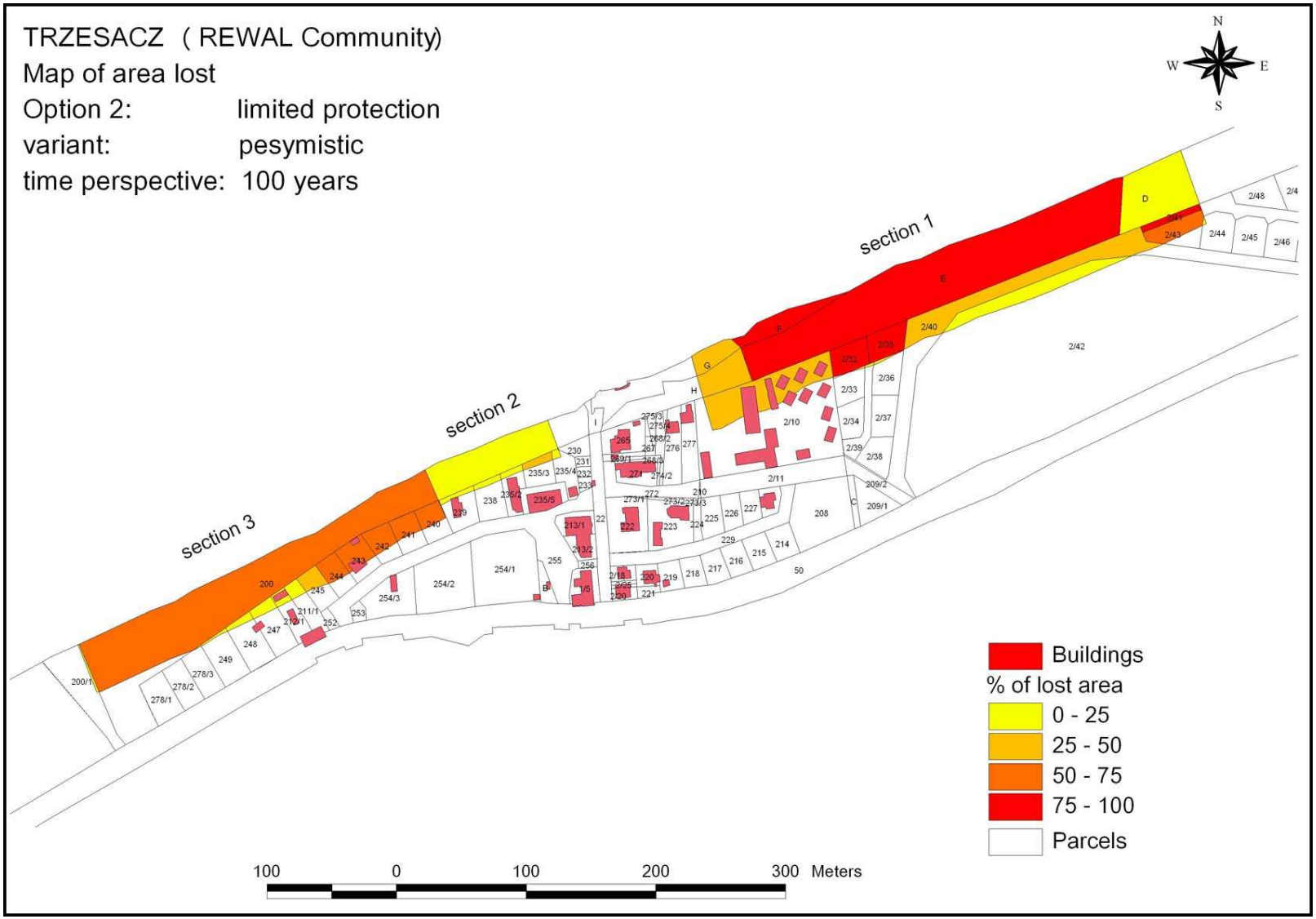
NO PROTECION

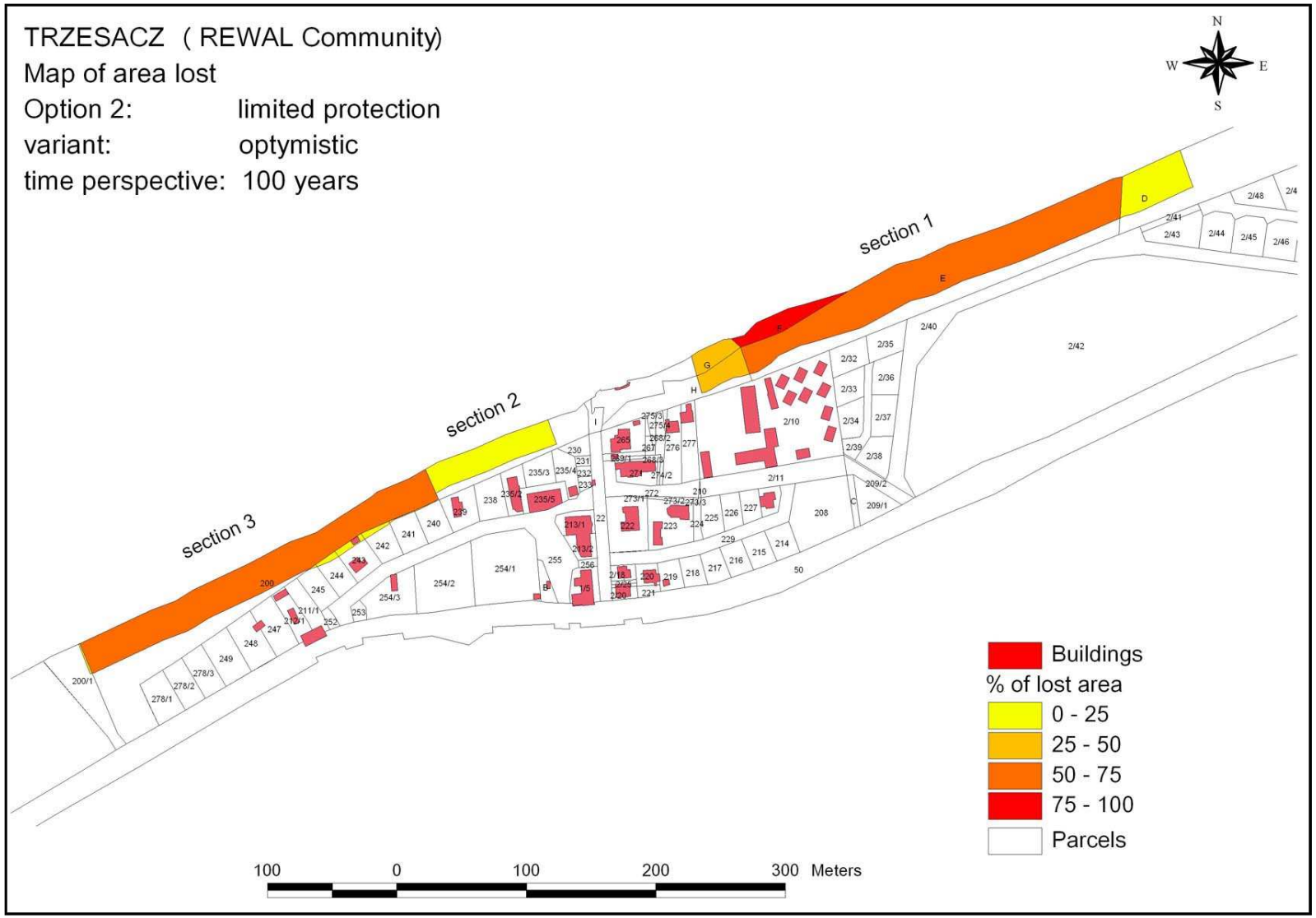
section 2 pesymist 100 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
field	E	11708,487	2329989	199	8	967,063	192446	4	20,0000
grassland	F	894,494	178004	199	100	893,883	177883	3	20,0000
grassland	G	1764,689	351173	199	100	1755,981	349440	3	20,0000
forest	H	1989,004	500000	199	34	675,945	134513	1	20,0000
forest	200	14059,286	2797798	199	18	2582,620	513941	1	20,0000
road	I	229,909	45752	199	84	193,256	38458	2	20,0000
TOTAL		30645,869	6202716			7068,748	1406681		
section 2 optymist 100 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
field	E	11708,487	2329989	199	2	182,701	36357	4	10,0000
grassland	F	894,494	178004	199	85	757,175	150678	3	10,0000
grassland	G	1764,689	351173	199	70	1229,616	244694	3	10,0000
forest	H	1989,004	500000	199	1	13,597	2706	1	10,0000
forest	200	14059,286	2797798	199	9	1308,450	260382	1	10,0000
road	I	229,909	45752	199	23	52,374	10422	2	10,0000
TOTAL		30645,869	6202716			3543,913	705239		
section 2 pesymist 50 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
field	E	11708,487	2329989	199	2	182,701	36357	4	10,0000
grassland	F	894,494	178004	199	85	757,175	150678	3	10,0000
grassland	G	1764,689	351173	199	70	1229,616	244694	3	10,0000
forest	H	1989,004	500000	199	1	13,597	2706	1	10,0000
forest	200	14059,286	2797798	199	9	1308,450	260382	1	10,0000
road	I	229,909	45752	199	23	52,374	10422	2	10,0000
TOTAL		30645,869	6202716			3543,913	705239		
section 2 optymist 50 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
field	E	11708,487	2329989	199	0	34,658	6897	4	5,0000
grassland	F	894,494	178004	199	49	442,039	87966	3	5,0000
grassland	G	1764,689	351173	199	35	618,679	123117	3	5,0000
forest	200	14059,286	2797798	199	5	654,533	130252	1	5,0000
road	I	229,909	45752	199	12	26,465	5267	2	5,0000
TOTAL		28656,865	5702716			1776,374	353498		

section 2 pesymist 20 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
field	E	11708,487	2329989	199	0	20,461	4072	4	4,0000
grassland	F	894,494	178004	199	40	362,058	72050	3	4,0000
grassland	G	1764,689	351173	199	28	493,875	98281	3	4,0000
forest	200	14059,286	2797798	199	4	523,322	104141	1	4,0000
road	I	229,909	45752	199	10	22,291	4436	2	4,0000
TOTAL		28656,865	5702716			1422,007	282979		
section 2 optymist 20 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
field	E	11708,487	2329989	199	0	3,378	672	4	2,0000
grassland	F	894,494	178004	199	21	189,043	37620	3	2,0000
grassland	G	1764,689	351173	199	14	246,073	48969	3	2,0000
forest	200	14059,286	2797798	199	2	261,357	52010	1	2,0000
road	I	229,909	45752	199	5	12,263	2440	2	2,0000
TOTAL		28656,865	5702716			712,114	141711		

NO PROTECION

section 3 pesymist 100 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
road	200/1	1575,872	313599	199	4	69,25	13780,75	2	20,0000
parcel	243	709,014	141000	198,868	0	2,797	556,234	0	20,0000
parcel	242	582,124	117000	200,988	0	0,465	93,459	0	20,0000
forest	200	14059,286	2797798	199	43	6042,207	1202399,193	1	20,0000
TOTAL		16926,296							
section 3 optymist 100 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
road	200/1	1575,872	313599	199	3	53,097	10566,303	2	15,0000
forest	200	14059,286	2797798	199	32	4535,859	902635,941	1	15,0000
TOTAL		15635,158							
section 3 pesymist 50 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
road	200/1	1575,872	313599	199	2	36,2	7203,8	2	10,0000
forest	200	14059,286	2797798	199	22	3025,049	601984,751	1	10,0000
TOTAL		15635,158							
section 3 optymist 50 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
road	200/1	1575,872	313599	199	2	27,472	5466,928	2	7,5000
forest	200	14059,286	2797798	199	16	2269,193	451569,407	1	7,5000
TOTAL		15635,158							
section 3 pesymist 20 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
road	200/1	1575,872	313599	199	1	14,941	2973,259	2	4,0000
forest	200	14059,286	2797798	199	9	1210,492	240887,908	1	4,0000
TOTAL		15635,158	3111397						
section 3 optymist 20 years									
	no of parcel	area	value (PLN)	price/1 sq m (PLN)	% of lost area	area lost	value lost (PLN)	ID_	erosion
road	200/1	1575,872	313599	199	1	11,281	2244,919	2	3,0000
forest	200	14059,286	2797798	199	6	907,911	180674,289	1	3,0000
TOTAL		15635,158	3111397						


TRZESACZ (REWAL Community)
Map of area lost
Option 2: limited protection
variant: pesymistic
time perspective: 100 years
N
W
E
S
section 1
section 2
section 3
Buildings
% of lost area
0 - 25
25 - 50
50 - 75
75 - 100
Parcels
100 0 100 200 300 Meters


TRZESACZ (REWAL Community)
Map of area lost
Option 2: limited protection
variant: optymistic
time perspective: 100 years
N
W
E
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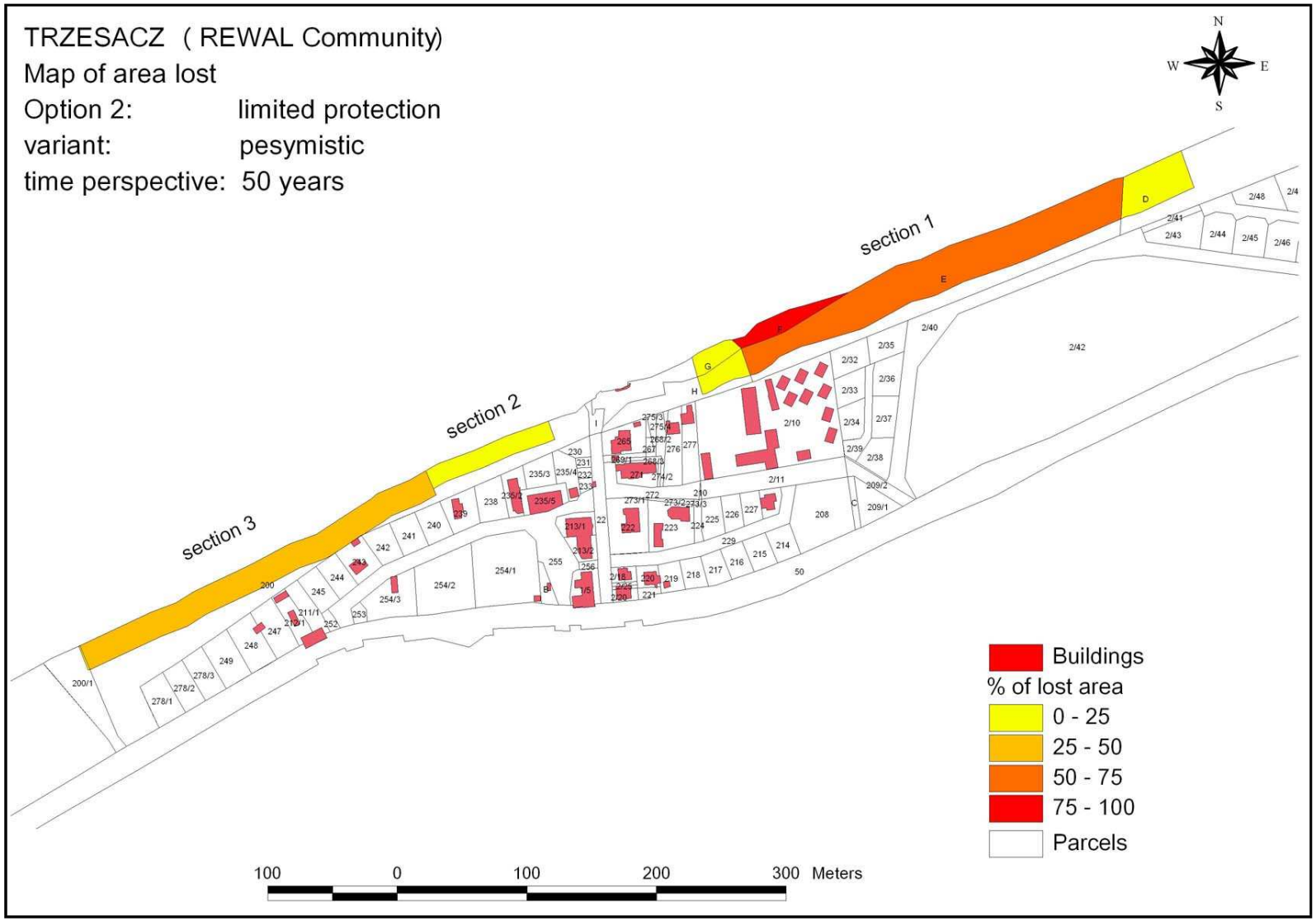
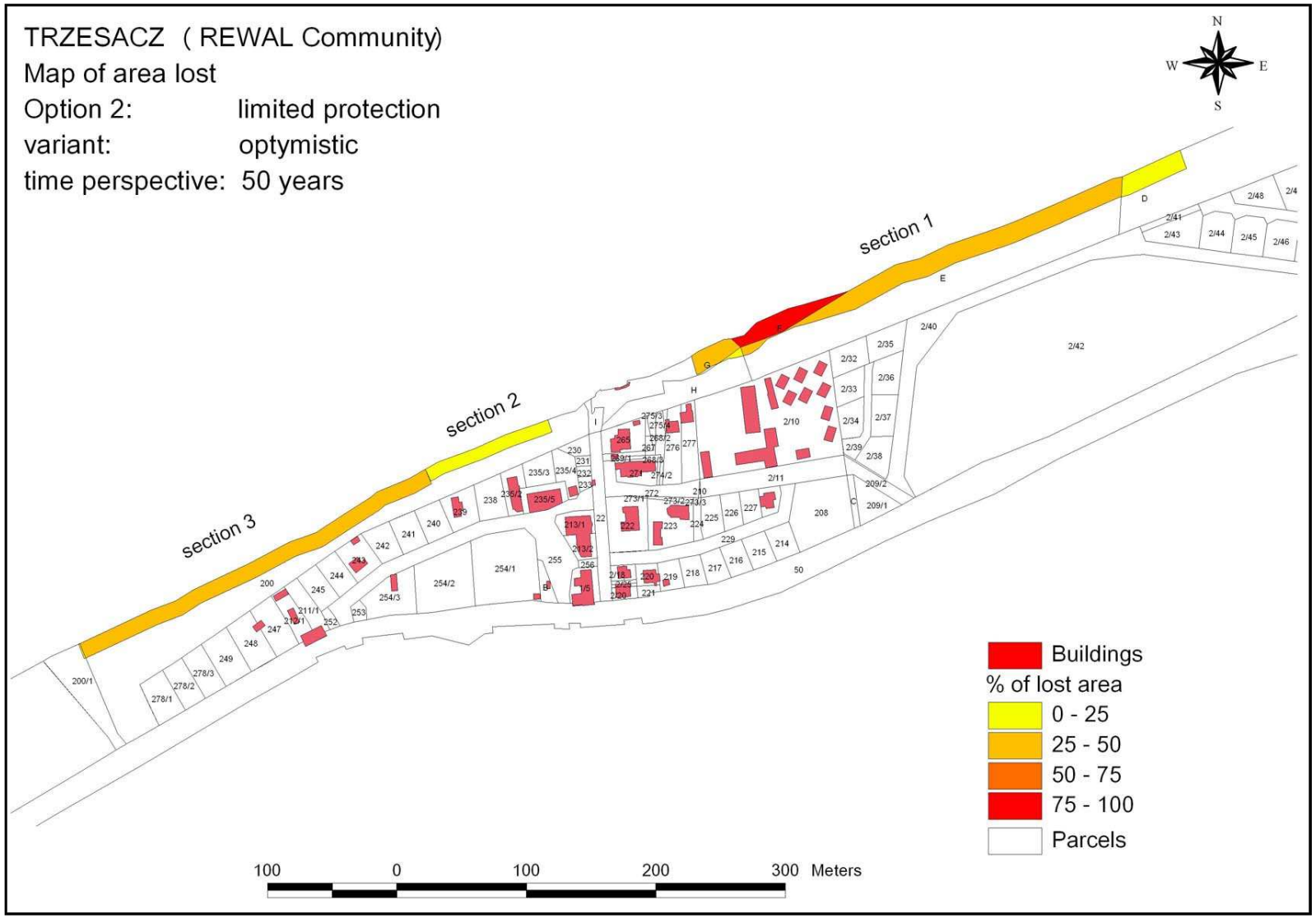
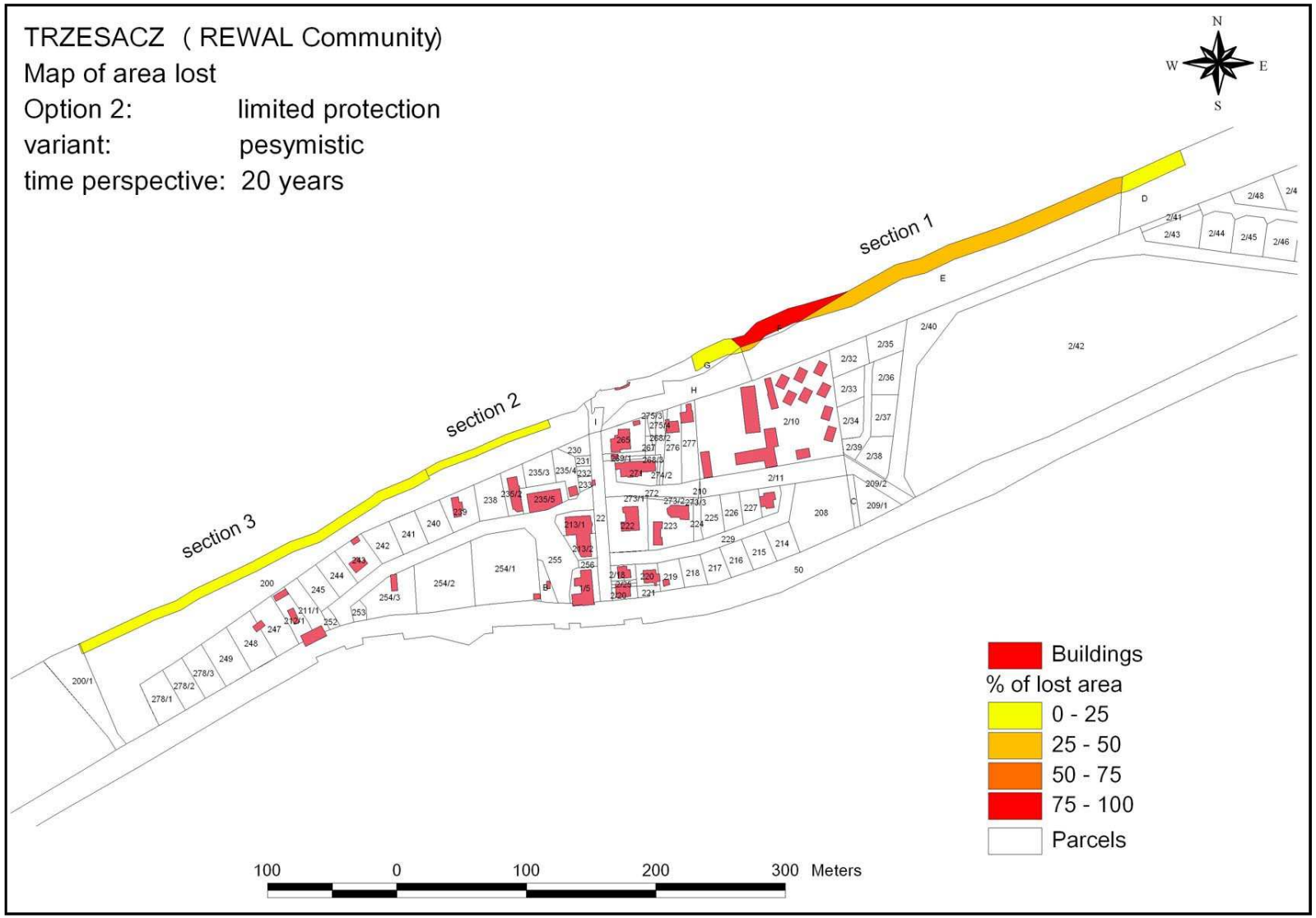
section 1
section 2
section 3
Buildings
% of lost area
0 - 25
25 - 50
50 - 75
75 - 100
Parcels
100 0 100 200 300 Meters


TRZESACZ (REWAL Community)
Map of area lost
Option 2: limited protection
variant: pesymistic
time perspective: 50 years
N
W
E
S
section 1
section 2
section 3
Buildings
% of lost area
0 - 25
25 - 50
50 - 75
75 - 100
Parcels
100 0 100 200 300 Meters


TRZESACZ (REWAL Community)
Map of area lost
Option 2: limited protection
variant: optymistic
time perspective: 50 years
N
W
E
S
section 1
section 2
section 3
Buildings
% of lost area
0 - 25
25 - 50
50 - 75
75 - 100
Parcels
100 0 100 200 300 Meters


TRZESACZ (REWAL Community)
Map of area lost
Option 2: limited protection
variant: pesymistic
time perspective: 20 years
N
W
E
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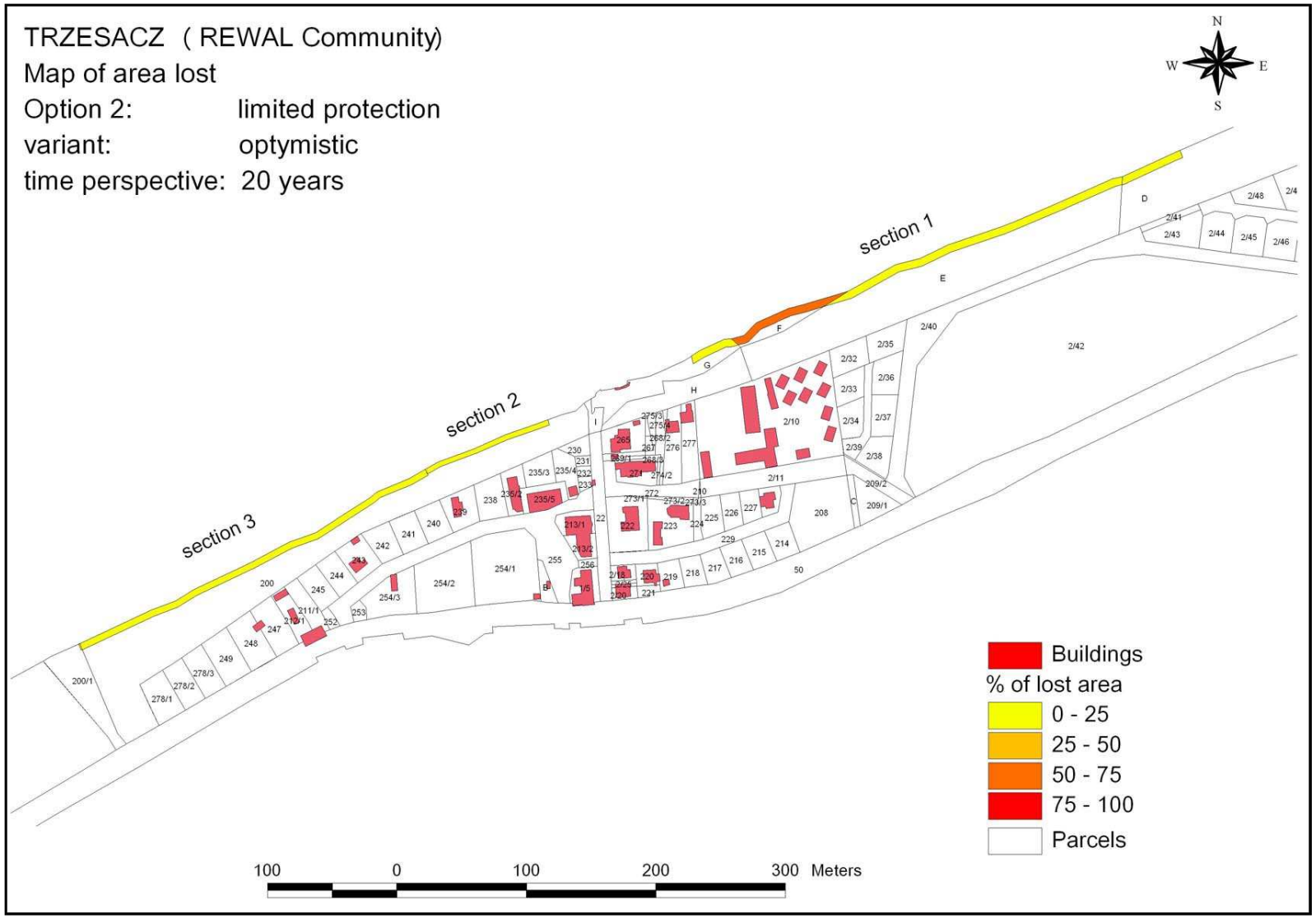
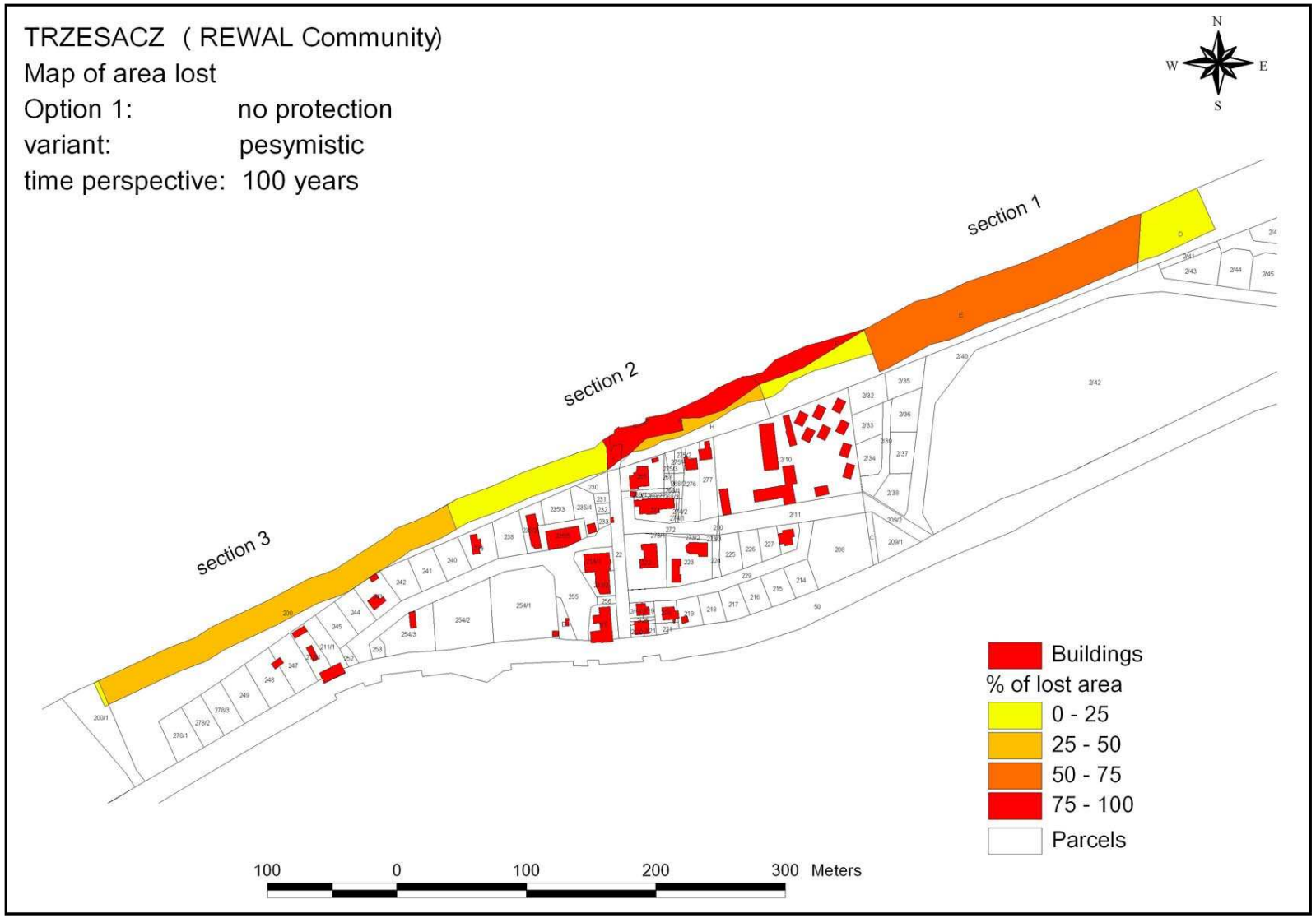
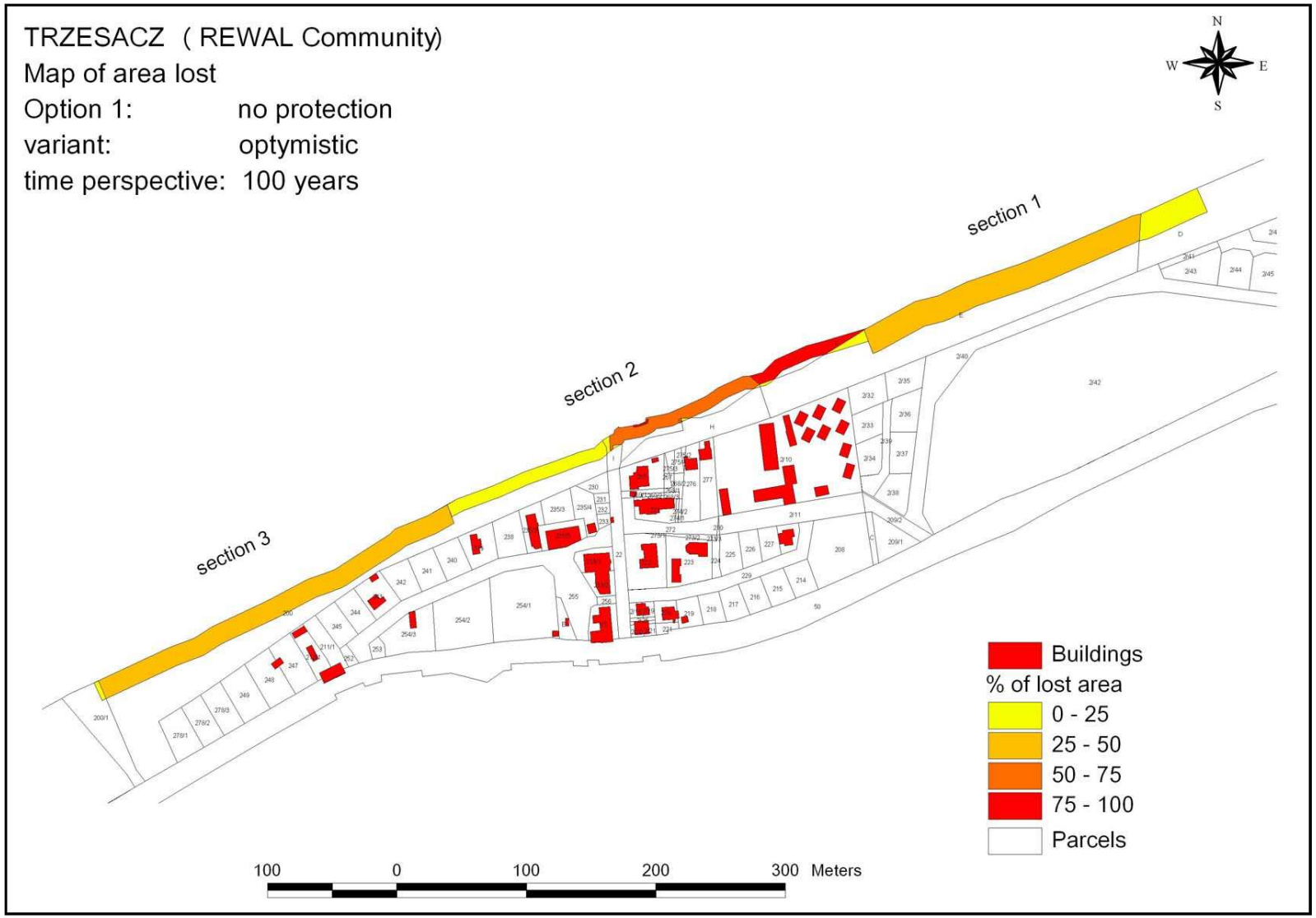
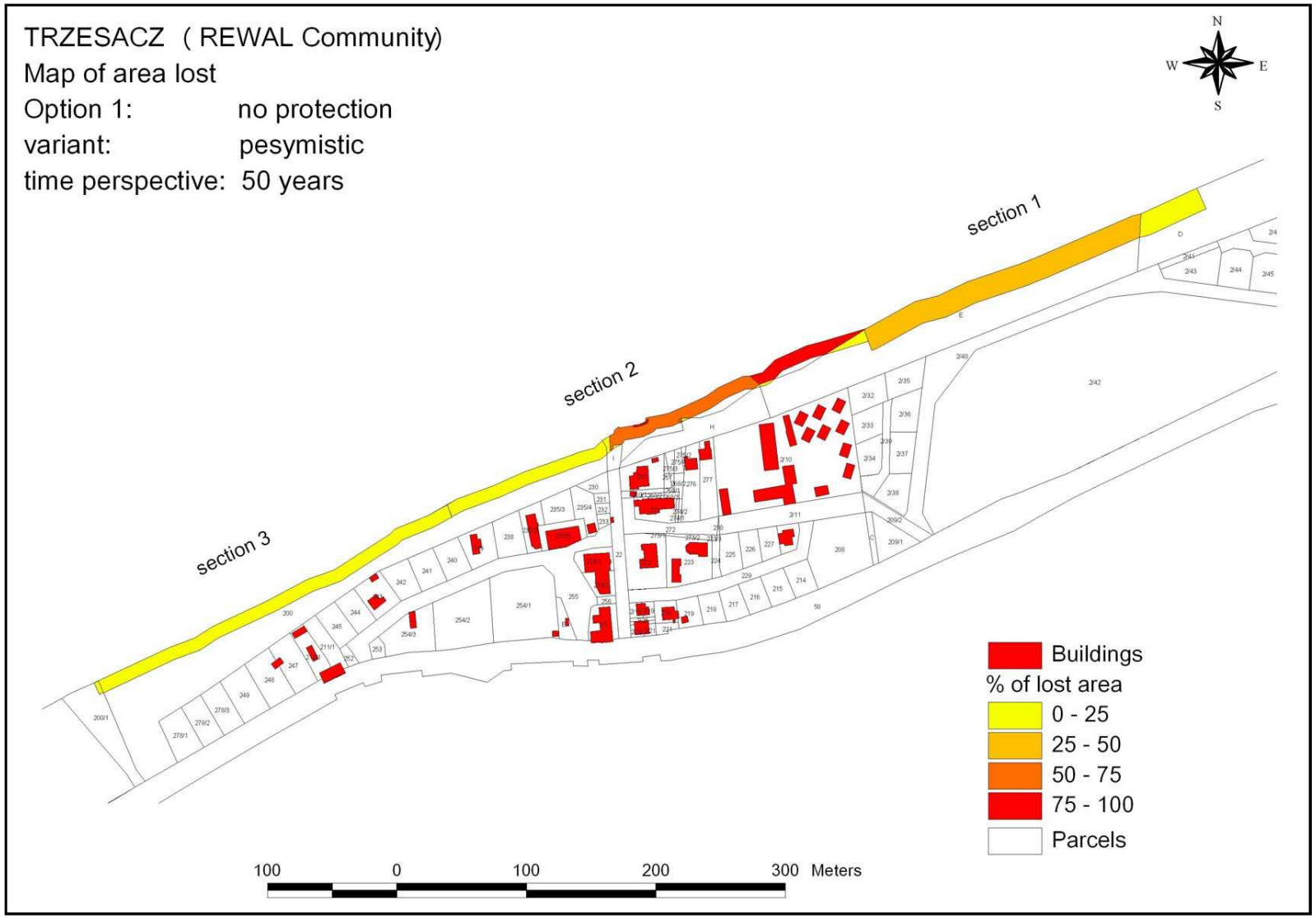
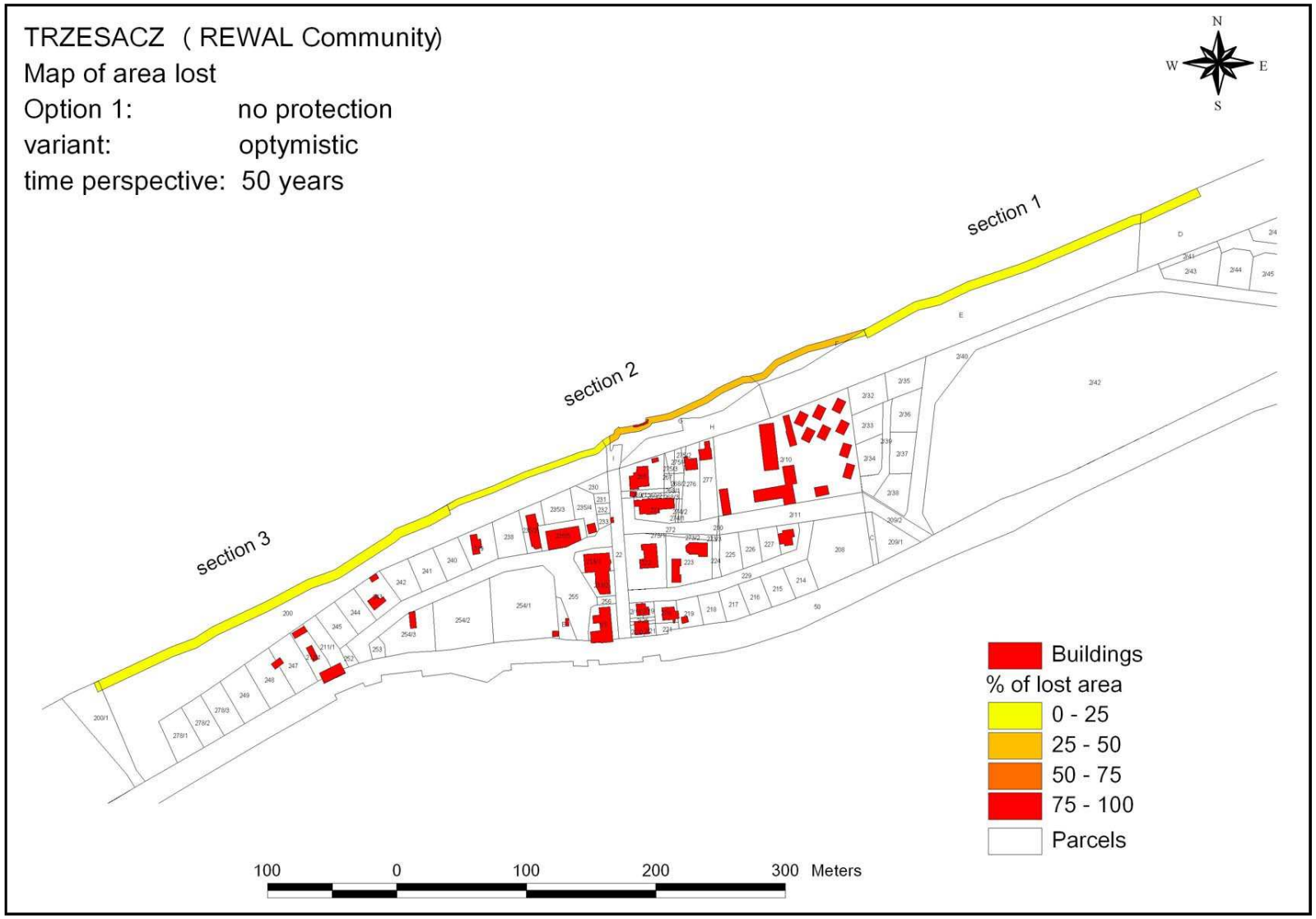
section 1
section 2
section 3
Buildings
% of lost area
0 - 25
25 - 50
50 - 75
75 - 100
Parcels
100 0 100 200 300 Meters


TRZESACZ (REWAL Community)
Map of area lost
Option 2: limited protection
variant: optymistic
time perspective: 20 years
N
W
E
S
section 1
section 2
section 3
Buildings
% of lost area
0 - 25
25 - 50
50 - 75
75 - 100
Parcels
100 0 100 200 300 Meters


TRZESACZ (REWAL Community)
Map of area lost
Option 1: no protection
variant: pesymistic
time perspective: 100 years
N
W
E
S
section 1
section 2
section 3
Buildings
% of lost area
0 - 25
25 - 50
50 - 75
75 - 100
Parcels
100 0 100 200 300 Meters


TRZESACZ (REWAL Community)
Map of area lost
Option 1: no protection
variant: optymistic
time perspective: 100 years
N
W
E
S
section 1
section 2
section 3
Buildings
% of lost area
0 - 25
25 - 50
50 - 75
75 - 100
Parcels
100 0 100 200 300 Meters


TRZESACZ (REWAL Community)
Map of area lost
Option 1: no protection
variant: pesymistic
time perspective: 50 years
N
W
E
S
section 1
section 2
section 3
Buildings
% of lost area
0 - 25
25 - 50
50 - 75
75 - 100
Parcels
100 0 100 200 300 Meters


TRZESACZ (REWAL Community)
Map of area lost
Option 1: no protection
variant: optymistic
time perspective: 50 years
N
W
E
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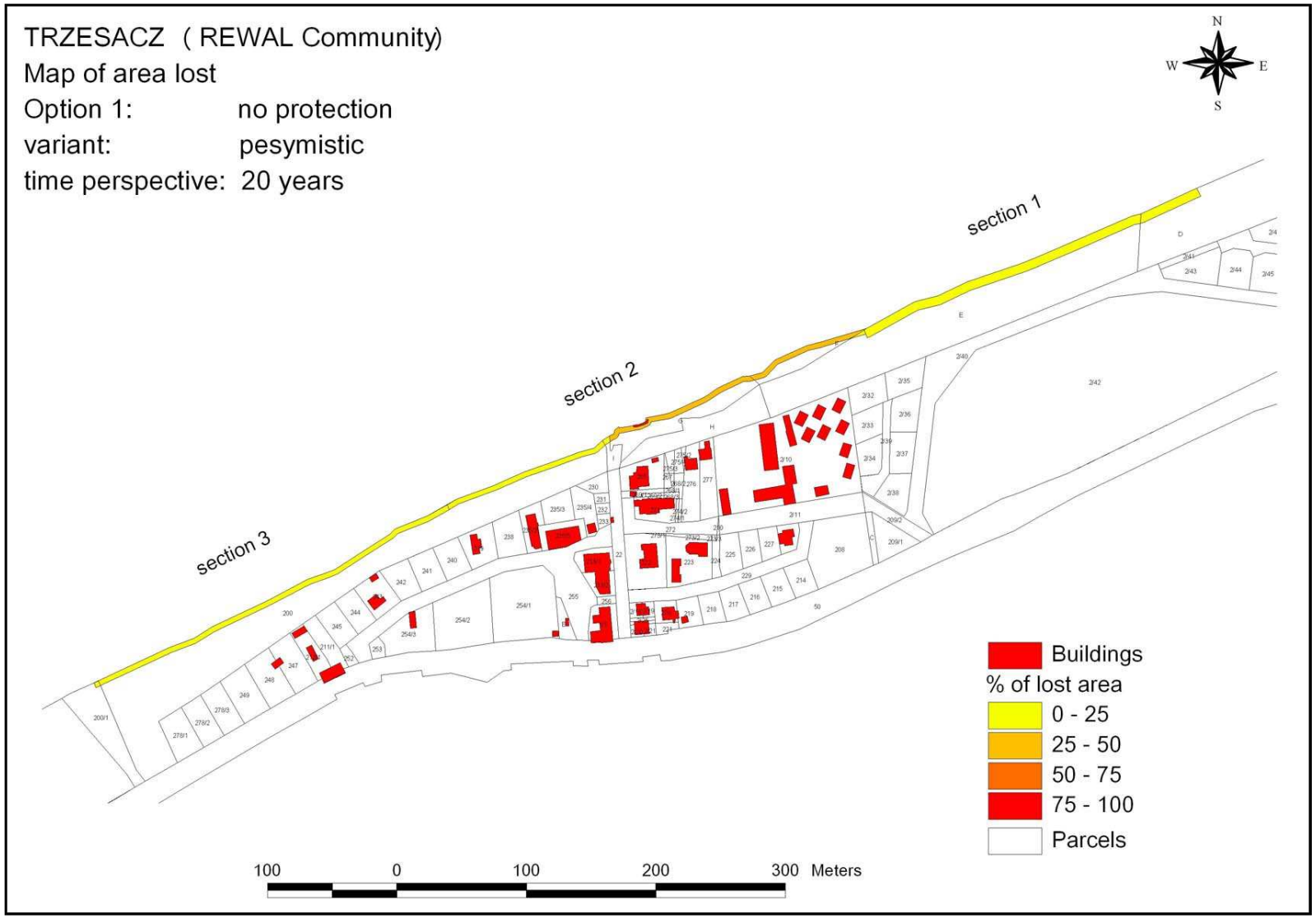
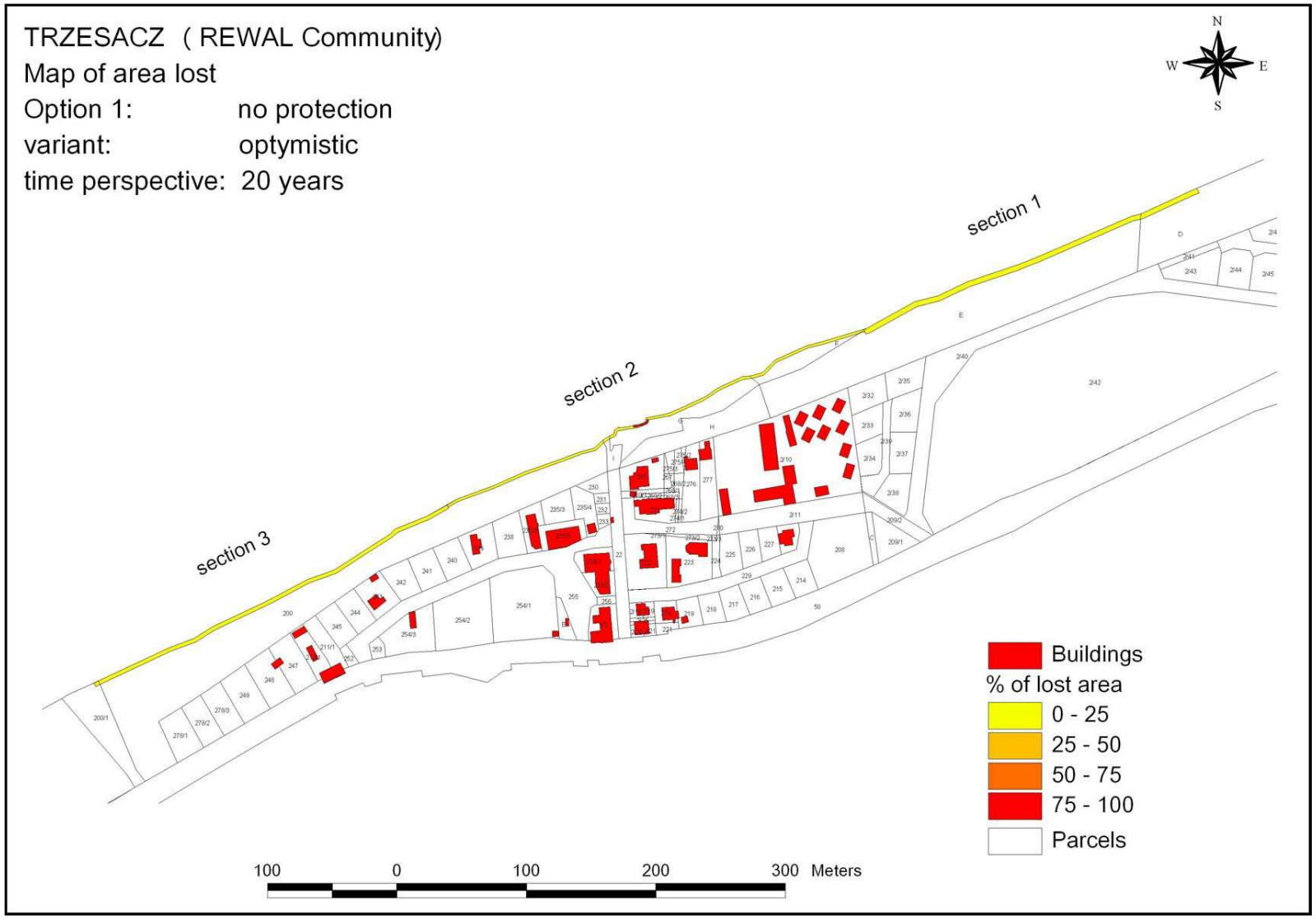
section 1
section 2
section 3
Buildings
% of lost area
0 - 25
25 - 50
50 - 75
75 - 100
Parcels
100 0 100 200 300 Meters


TRZESACZ (REWAL Community)
Map of area lost
Option 1: no protection
variant: pesymistic
time perspective: 20 years
N
W
E
S
section 1
section 2
section 3
Buildings
% of lost area
0 - 25
25 - 50
50 - 75
75 - 100
Parcels
100
0
100
200
300
Meters


TRZESACZ (REWAL Community)
Map of area lost
Option 1: no protection
variant: optymistic
time perspective: 20 years
N
W
E
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section 1
section 2
section 3
Buildings
% of lost area
0 - 25
25 - 50
50 - 75
75 - 100
Parcels
100 0 100 200 300 Meters