TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
CIVIL ENGINEERING | BUDOWNICTWO
1-B/2014

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EVALUATION OF HISTORIC BUILDING CONVERSION OPTIONS IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

OCENA WARIANTÓW ADAPTACJI OBIEKTÓW ZABYTKOWYCH W ASPEKCIE ZRÓWNOWAŻONEGO ROZWOJU

Abstract

Sustainable development is a method of resource management, the effect of which not only meet the needs of the present but also of future generations. Historical monuments as part of national heritage are a resource, which is protected not only in the sense of its cultural value but also has a potential for the creation of socio-economic values. The process of extending the life cycle of a historic building is associated primarily with the analysis of the options for its conversion in the light of various criteria, many of which have a fuzzy character. The aim of the paper regards the proper selection and also description of the criteria for assessing conversion options for historic buildings in the context of sustainable development.

Keywords: sustainable development, historical monuments, conversion, criteria

Streszczenie

Zrównoważony rozwój to taki sposób gospodarowania zasobami, którego efekt nie tylko zaspakaja potrzeby obecne, ale również potrzeby przyszłych pokoleń. Zabytki nieruchome jako część dziedzictwa narodowego stanowią zasób, który podlega ochronie w sensie jego wartości kulturowej i stanowi potencjał do kreowania wartości społeczno-ekonomicznych. Proces wydłużania cyklu życia obiektu zabytkowego wiąże się przede wszystkim z analizą wariantów jego adaptacji w świetle różnych kryteriów, których znaczna część posiada rozmyty charakter. Celem artykułu jest właściwy dobór i zarazem opis kryteriów na potrzeby oceny wariantów adaptacji obiektów zabytkowych w aspekcie zrównoważonego rozwoju.

Słowa kluczowe: zrównoważony rozwój, zabytki nieruchome, adaptacja, kryteria

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Designations:

μ_L^{ij} – Degree of membership μ_L^{ij} of expert opinions to the linguistic variable L
O_L^{ij} – The number of consistent expert opinions for each linguistic variable L
N_{ij} – The number of experts involved in the evaluation
w_L – The weight of linguistic assessment for each linguistic variable
w_{ij}^l – The local weight of the i-th factor of the j-th criterion
w_{ij}^g – The global weight of the i-th factor of the j-th criterion
O_{ij} – The assessment of the i-th factor of the j-th criterion
O_{K_j} – The assessment of the j-th criterion

1. Introduction

Sustainable development is an idea, which is summarised in the first sentence of the WCED report from 1987 – Our Common Future [1]: "At the present level of civilisation, sustainable development is possible, meaning development in which the needs of the present generation can be met without compromising the ability of future generations to meet their own needs".

Historical monuments as one of the cultural heritage resources are one of the elements of sustainable development of civilisation. To confirm this fact, let us cite Article 5 of the Constitution of the Republic of Poland, which says: "The Republic of Poland shall safeguard the independence and integrity of its territory and ensure the freedoms and rights of man and citizen as well as the security of the citizens, **safeguard the national heritage** and protect the environment, being guided by the principle of sustainable development". Thus, historic buildings as part of the national heritage, which are a testimony of history, documenting the past, should be protected and should stimulate the national identity of the society, as well as being the basis for its continuity and development.

Using the potential of a historical monument as part of national heritage carries with it, within the idea of sustainable development, the following benefits [2, 3]:

– Economic benefits,
– Social benefits,
– Benefits of environmental protection,
– Benefits of cultural heritage.

Attempting to preserve the cultural values of a historic building should therefore be combined in synergy with perceiving its socio-economic potential.

In literature [2] we can find the proposal of indicators that can be a measure of a restoration project in the context of sustainable development, regarding both historical monuments (e.g. civil structures) and antiques (e.g. works of art). Each indicator is part of one of the four groups: social benefits, economic benefits, benefits of environmental protection and benefits of cultural heritage.

The purpose of this paper is:

1. The proposed implementation of indicators [2], which as part of these groups, were then partially modified by the authors of this article (new indicators were alternatively introduced, related to the energy efficiency of a historical monument and development of

the infrastructure surrounding it) in order to, as a consequence put together a universal set, needed to assess the best possible variant for the conversion of a historical monument in the context of sustainable development;

When analysing the adaptation variants for historical buildings in a certain location, the indicators mentioned in the table below should always be considered in relation to the local conditions;

2. Using a simple heuristic expert method to evaluate the proposed options for the conversion of a historic building, we find that Polish conditions lack specific methods, which, based on the above sustainable development indicators would assist in making a proper assessment. The method proposed by the authors is further supported by an computational example.

2. Assessment criteria for historic building conversion options

For the purposes of this article, the groups mentioned in the previous section will be referred to as criteria and the indicators related with them as factors.

Assessment of the conversion option of a historic building in the context of sustainable development should be carried out through the prism of the following criteria:

a) **Economic benefits** derived from the use of neglected and abandoned historic buildings (elimination of disused buildings) by giving them a new operational function, which may contribute to increasing property value, making the building available for business activity, development of tourism, job creation, etc.;
b) **Social benefits** achieved through strengthening the sense of national identity and integration (society's emotional bond with the historic building as a testimony of a bygone era), providing a sense of security through the development of the disused buildings, being a victim of vandalism, uncontrolled occupation and their use for beneficial social purposes;
c) **Benefits of environmental protection** are possible as a result of extending the life cycle of the historic building's fabric and services. Reducing building material waste, reducing energy consumption and emissions of harmful substances, are the tangible benefits which cannot be achieve in case of erecting a new building. Environment is also affected by the potential improvement of the energy efficiency of historic buildings during their subsequent operation;
d) **Benefits of cultural heritage** as a result of the preservation and restoration of the past cultural traits of a historical building and their popularisation. Additional factors of cultural heritage benefits are the cognitive values associated with the process of restoration of historic buildings, which translates into gaining greater knowledge about the building and expanding the experiences of the conservation environment.

Thus, criteria are highlighted above, related to the cultural value of the historical building, as well as criteria focused on the future, that is, on its economic and social potential.

Each of the above criteria are influenced by various factors (Table 1), which will be a measure of the conversion option for the historic building under consideration, in the light of the given criterion, in the context of sustainable development.

Table 1

Criteria and their interpretation, source: own work based on [2]

CRITERION OF ECONOMIC BENEFITS
1. Development of the private sector
The state making a historic building available for conducting business activity, which will generate financial revenues to the state budget under the lease/tenancy agreement with the given company.
2. Creating new jobs
New use of the building generating new jobs which reduces the social costs of unemployment and provides a certain revenue for the state budget, such as tourism and the related tourist services.
3. Intensification of payment transactions
The financial benefits associated with creating a brand product as a marketing instrument to promote culture and attracting potential tourists. Examples of branded tourist products include castles, churches, museums, etc.
4. Increase in the value of neighbouring properties
Restoration, renovation, repair, upgrade and conversion of a historic building as well as the rehabilitation of an uninhabited building affects the attractiveness of its surroundings. It is therefore one of the factors raising the value of neighbouring properties.
5. Infrastructure development
The chance for the development of infrastructure in the vicinity of the historic building, making it more attractive. Expanded infrastructure will influence the development of tourism and recreation by, for example, construction or expansion of car parks, bicycle paths, development of local transport, elimination of barriers for people with disabilities, etc.

CRITERION OF SOCIAL BENEFITS
1. Sense of security
Rehabilitation of an uninhibited building improves the safety of the building and its surroundings, eliminating the uncontrolled occupation of the building, eliminating the pathological behaviour of the society, including signs of vandalism, etc.
2. Integration possibilities
The opportunity to integrate the local community by making a historic building available for all kinds of integration events that demonstrate creative social activity.
3. Strengthening a sense of local identity
Restoration of public accessibility to the building for the local community in order to promote the emotional bond of the society with the historic building as a testimony of a bygone era. Identification of the society with the historic building reinforces the sense of local identity.
4. Public participation in the management of heritage resources
Local community's interest in the fate of a historic building, support and active participation in the pursuit of its restoration and proper subsequent operation in the context of the widely defined protection of historical monuments.
5. Solving the urgent needs of the local community
A historic building restoration project meets urgent social needs, solves housing, administrative and educational problems etc.

CRITERION OF BENEFITS RESULTING FROM ENVIRONMENTAL PROTECTION
1. The use of embodied energy
Saving natural resources, reducing energy consumption in technological processes i.e. saving the embodied energy achieved in case of restoration of the historic building, which cannot be generated in the construction of a new facility.
2. Reducing the amount of waste
Recovery and re-incorporation of building materials in the restoration of a historic building minimises the amount of waste compared to the amount of waste generated during the construction of a new facility.
3. Improving energy efficiency
Improving energy efficiency in the operation phase of the historic building by generating energy savings and reduction of greenhouse gas emissions.
4. Improvement of landscape
Restoration of an abandoned historic building eliminates its unsightly appearance, signs of destruction as the effects of neglect and mismanagement. Unsightly appearance of a historic building also adversely affects the perception of the values of its immediate surroundings.
5. Supporting biodiversity
Protection as part of a restoration project, plant species unique for a given place or region, associated directly or indirectly with the historic building.

CRITERION OF BENEFITS OF CULTURAL HERITAGE [4, 5]
1. Growth of heritage resources
As a result of restoration, bringing back and preservation of the cultural values of the historic building, such as the value of authenticity, integrity, uniqueness as well as artistic and historical value, social identity, and others.
2. Popularisation of heritage values
A historic building, after its restoration, creates conditions for the promotion and popularisation of its cultural values with have a direct impact on the recipient.
3. Use of heritage resources
As a result of restoration, a historic building becomes a source of information about its specificity, significance, past use, historical events associated with it.
4. Popularisation of local heritage resources
Exposing the resource as a brand (flagship) product, i.e. a product of cultural material, spiritual, natural and social heritage, inherent and associated with the region.
5. Benefits to professional conservators
A historic building restoration project as well as its implementation constitutes research material for conservators. It is a source of conservation knowledge and skills, for the purpose of gaining new experience and self-education conservation staff.

3. Methodology of building conversion option assessment

3.1. Justification of the selected methodology

It may be noted that the descriptions of the factors in Table 1 are complex and imprecise. It is true that some of the factors above can be identify quantitatively, such as the amount of construction waste generated in the process of converting a historic building, but is a relative value, depending on the type and size of the given historic building. Given the fact that complexity and precision occur in a reverse relation [6], to a qualitative assessment of conversion options is therefore proposed in the light of the above criteria.

The management of cultural heritage resources in the context of sustainable development is an interdisciplinary process and requires the involvement of experts with a broad spectrum of knowledge in sciences, such as architecture, engineering, economics, history, archaeology, anthropology, etc. Therefore, to assess the options for converting a historic building, the knowledge of experts should applied, who using approximate and ambiguous data will express their opinion in a linguistic manner.

Expert opinions may be collected using a questionnaire (in a form of closed questions) [7].

For this reason, assessing the conversion option of a historic building in the light of the given criterion, use of the weighted average method, i.e. the sum of the product of the weights of factors from Table 1 and the assessment of these factors is proposed.

In order to calculate the impact (weight) of these factors on the given criterion, we can use the pseudo-fuzzy scale method [8–10].

It is proposed (in a simplified manner, for the purposes of this article) that the final assessment of the historic building conversion option will be the result of the sum of assessments of conversion options in the light of all four criteria.

3.2. Assessment of the impact of factors on the criteria

The pseudo-fuzzy scale method is used to determine the validity of the factors affecting the assessment of the criterion. The impact of the factors on the assessment of the criterion is determined using a linguistic assessment (expert opinions) of the linguistic variable L and of their corresponding validity scales of linguistic assessments w_L according to Table 2.

Table 2

Assessments of the linguistic variable and their corresponding weights; source: based on [8, 9, 10]

Linguistic assessment	*BD*	*BD/D*	*D*	*D/Ś*	*Ś*	*Ś/M*	*M*	*M/BM*	*B/M*
The weight of linguistic assessment w_L	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1

where: *BD* – very big impact, *D* – big impact, *Ś* – medium impact, *M* – small impact, *BM* – very small impact, (*BD/D*, *D/Ś*, *Ś/M*, *M/BM*) indirect impacts

For each criterion, the same algorithm of the pseudo-fuzzy scale should be used. Thus, for the first ($j = 1$) criterion, the algorithm consists of the following steps:

1. Determining the number of experts involved in the assessment
2. Collecting expert opinions regarding the impact of the i-th factor on the j-th criterion, in accordance with to Table 2.

Determining the degree of membership μ_L^{ij} of expert opinions on the linguistic variable L for each i-th factor of the j-th criterion according to the following formula:

$$\mu_L^{ij} = \frac{O_L^{ij}}{N_{ij}} \tag{1}$$

$i = 1, 2, 3, 4, 5$
$j = 1$

where:

O_L^{ij} – the number of consistent expert opinions for each linguistic assessment regarding the i-th factor with respect to the j-th criterion,
L – linguistic variable,
N_{ij} – the number of experts involved in the assessment.

Calculating the local weight:

w_{ij}^l – of the i-th factor of the j-th criterion:

$$w_{ij}^l = \sum_L^M w_L \mu_L^{ij} \tag{2}$$

$i = 1, 2, 3, 4, 5$
$j = 1$

or

$$w_{ij} = w_{BD}\mu_{BD}^{ij} + w_{BD/D}\mu_{BD/D}^{ij} + w_D\mu_D^{ij} + w_{D/Z}\mu_{D/Z}^{ij} + w_Z\mu_Z^{ij} + w_{Z/M}\mu_{Z/M}^{ij} - w_{Z/M}\mu_{Z/M}^{ij} + w_M\mu_M^{ij} + w_{M/BM}\mu_{M/BM}^{ij} + w_{BM}\mu_{BM}^{ij}$$

where:

w_L – the weight of linguistic assessment,
L – the number of linguistic assessments,
M – the number of values in the scale of validity of linguistic assessments.

Calculating the global weight w_{ij}^g of the i-th factor of the j-th criterion:

$$w_{ij}^g = \frac{\sum_L^M w_L \mu_L^{ij}}{\sum_{i=1}^n w_{ij}} \tag{3}$$

$i = 1, 2, 3, 4, 5$
$j = 1$

where:

n – the number of factors of the j-th criterion.

3.3. Assessment of factors in the light of the criterion

For an expert assessment of given factors of the criterion, the scale of linguistic assessments and the corresponding five-point scale will be used, in accordance with Table 3.

Table 3

Linguistic assessments and their corresponding five-point scale. Based on [10]

Linguistic assessment	very high	high	average	low	very low	Absence of a factor
Five-point scale	5	4	3	2	1	0

Experts analysing the *i*-th factor as part of the *j*-th criterion assign one of the five linguistic assessments to it, which transforms the points scale and indicates the assessment Thus, eventually, assessment of the historic building conversion option in the light of the *j*-th criterion is calculated as the weighted average, as follows:

$$O_K \quad \sum w_{ij} O_{ij} \tag{4}$$

$i = 1, 2, 3, 4, 5$
$j = 1$

where:

O_{K_j} – historic building conversion option in the light of the *j*-th criterion,
w_{ij}^g – the global weight of the *i*-th factor of this criterion,
O_{ij} – point assessment of the *i*-th factor of *j*-th criterion,
n – number of factors of the *j*-th criterion.

3.4. Final assessment of the historic building conversion option in the light of sustainable development

Most preferred among the evaluated historical building conversion options is the option on which the final assessment is calculated based on the following relation is the highest.

$$O_{final} = \sum_{j=1}^{k} O_{K_j} \tag{5}$$

$j = 1, 2, 3, 4$

where:

k – number of criteria.

This is a simplified approach, assuming equal weight for the four criteria. Development of more effective methods of assessment is planned in the future.

4. Computational example

The example concerns the assessment of two conversion options of a post-industrial historic building located in the city of Olsztyn:

1. Conversion of the building into a museum of technology.
2. Conversion of the building for public housing.

For the purposes of assessment, a group of 10 experts was collected, who were asked question with the help of a questionnaire. Then, applying the methodology described in Chapter 3, we obtain the results (Table 4–6).

Table 4

Linguistic assessments of the impact of factors on the criteria and their corresponding weights (source: own work)

Economic benefits	**Development of the private sector**		**Creating new jobs**		**Intensification of payment transactions**		**Increase in the value of neighbouring properties**		**Infrastructure development**	
expert	Linguistic assessment	w_L	Linguistic assessment	w_L	Linguistic assessment	w_L	Linguistic assessment	w_L	Linguistic assessment	w_L
1	*D/Ś*	0.6	*D*	0.7	*Ś*	0.5	*Ś*	0.5	*D*	0.7
2	*Ś*	0.5	*D*	0.7	*D/Ś*	0.6	*D/Ś*	0.6	*BD*	0.9
3	*Ś*	0.5	*BD/D*	0.8	*Ś/M*	0.4	*D*	0.7	*BD*	0.9
4	*Ś/M*	0.4	*D*	0.7	*Ś*	0.5	*Ś*	0.5	*D*	0.7
5	*Ś*	0.5	*BD*	0.9	*Ś/M*	0.4	*Ś*	0.5	*D*	0.7
6	*ŚM*	0.4	*BD/D*	0.8	*Ś*	0.5	*D*	0.7	*D*	0.7
7	*D/Ś*	0.6	*BD*	0.9	*Ś/M*	0.4	*D*	0.7	*D*	0.7
8	*Ś*	0.5	*D*	0.7	*Ś/M*	0.4	*Ś*	0.5	*D*	0.7
9	*Ś/M*	0.4	*BD*	0.9	*Ś/M*	0.4	*D*	0.7	*D*	0.7
10	*Ś*	0.5	*BD*	0.9	*Ś*	0.5	*D*	0.7	*BD/D*	0.8
$w_{ij}^{l} = \sum_{L}^{M} w_L \mu_L^{ij}$	0.49		0.8		0.46		0.61		0.75	
$w_{ij}^{g} = \frac{\sum_{L}^{M} w_L \mu_L^{ij}}{\sum_{i=1}^{n} w_{ij}}$	0.16		0.26		0.15		0.20		0.24	

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Social benefits	**Sense of security**	**Integration possibilities**	**Strengthening a sense of local identity**	**Public participation in the management of heritage resources**	**Solving the urgent needs of the local community**
w_{ij}^{l}	0.3	0.13	0.47	0.49	0.29
w_{ij}^{g}	0.18	0.08	0.28	0.29	0.17
Benefits of environmental protection	**The use of embodied energy**	**Reducing the amount of waste**	**Improving energy efficiency**	**Improvement of landscape**	**Supporting biodiversity**
w_{ij}^{l}	0.73	0.74	0.78	0.45	0.3
w_{ij}^{g}	0.24	0.25	0.26	0.15	0.10
Benefits of cultural heritage	**Growth of heritage resources**	**Popularisation of heritage values**	**Use of heritage resources**	**Popularisation of local heritage resources**	**Benefits to professional conservators**
w_{ij}^{l}	0.8	0.75	0.75	0.47	0.26
w_{ij}^{g}	0.26	0.25	0.25	0.16	0.09

Table 5

Linguistic assessments of factors in the light of the criteria and their corresponding five-point scale (source: own work)

Economic benefits	**Development of the private sector**		**Creating new jobs**		**Intensification of payment transactions**		**Increase in the value of neighbouring properties**		**Infrastructure development**	
expert	Linguistic assessment	pkt	Linguistic assessment	pkt	Linguistic assessment	pkt	Linguistic assessment	pkt	Linguistic assessment	pkt
1	high	4	average	3	average	3	very low	1	very low	1
2	average	3	average	3	high	4	very low	1	low	2
3	high	4	average	3	average	3	very low	1	very low	1
4	high	4	high	4	high	4	low	2	very low	1
5	high	4	high	4	high	4	very low	1	very low	1
6	average	3	average	3	average	3	low	2	very low	1
7	high	4	average	3	average	3	very low	1	very low	1
8	high	4	high	4	high	4	very low	1	very low	1
9	average	3	average	3	average	3	very low	1	very low	1

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10	high	4	average	3	high	4	low	2	low	2
O_{ij}	37		33		35		45		12	
$O_{K_j} = \sum_{i=1}^{n} w_{ij}^{g} O_{ij}$	31,63									
Social benefits	**Sense of security**		**Integration possibilities**		**Strengthening a sense of local identity**		**Public participation in the management of heritage resources**		**Solving the urgent needs of the local community**	
O_{ij}	50		15		46		28		10	
O_{K_j}	32,85									
Benefits of environmental protection	**The use of embodied energy**		**Reducing the amount of waste**		**Improving energy efficiency**		**Improvement of landscape**		**Supporting biodiversity**	
O_{ij}	33		32		41		47		24	
O_{K_j}	36,03									
Benefits of cultural heritage	**Growth of heritage resources**		**Popularisation of heritage values**		**Use of heritage resources**		**Popularisation of local heritage resources**		**Benefits to professional conservators**	
O_{ij}	49		45		41		45		31	
O_{K_j}	43,86									

Table 6

Summary of the assessments of factors in the light of the criteria and the final assessment of the historic building conversion option (source: own work)

PROPOSED FUNCTION BUILDING	**Economic benefits**	**Social benefits**	**Benefits of environmental protection**	**Benefits of cultural heritage**	$\kappa = \sum_{j=1}^{k} O_{K_j}$
	Assessment O_{K_1}	Assessment O_{K_2}	Assessment O_{K_3}	Assessment O_{K_4}	
Conversion of the building for a museum of technology	31,63	32,85	36,03	43,86	**144,37**
Conversion of the building for public housing	16,72	47,68	38,43	28,06	**130,89**

The calculations above show that the most preferred option for the conversion of the analysed historic building is changing its function into a museum of technology. The museum function of the building will bring clear economic benefits and advantages as a result maintaining and

restoring the old cultural traits of the historic building and their popularisation. The benefits related with environmental protection are similar for both options.

5. Conclusions

The article adapted and partially modified the indicators proposed in [7], grouped into four pillars, useful for assessing the most advantageous conversion option for a historical monument in the light of sustainable development.

Since specific methods for assessing conversion options for historic buildings (based on the above indicators of sustainable development) do not exist in Polish methodology, the authors of this article proposed a simple heuristic expert method.

The approach to assessing the conversion option of historic buildings presented in this paper can be used both to assess conversion options of the building itself as well as to assess various building along with the proposed conversions.

Due to the qualitative nature of the assessment, emphasis is placed on the need to develop more effective methods of assessment of the problem based on fuzzy logic in the future, e.g. by developing a fuzzy inference system.

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