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Rating systems for the sustainability assessment of infrastructure

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Subject review

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In light of global changes and in line with the principles of sustainable development, there is a need to find criteria for assessing the sustainability of infrastructure in the construction sector. This paper provides an overview of the theory of sustainability in general and in the construction sector, as well as the policies and strategies at the global and national levels that aim to achieve sustainable development. Various rating systems for the sustainability assessment of infrastructure are listed as a methodology for evaluating the implementation of sustainable approaches in the realisation of new infrastructure projects. The three rating systems for sustainability assessment Envision, BREEAM Infrastructure and Infrastructure Sustainability (IS), which can be used to assess the sustainability of all types of infrastructure and to obtain a certificate for the application of sustainability principles, are presented and discussed in more detail.

Key words:
sustainable development, sustainability assessment rating systems, climate change, sustainability of infrastructure, sustainability of bridges

Pregledni rad

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Sustavi ocjenjivanja održivosti infrastrukturnih građevina

Suočavajući se s promjenama na globalnoj razini te u skladu sa smjernicama održivog razvoja, u građevinarstvu se javlja potreba za pronalaskom kriterija vrednovanja održivosti infrastrukturnih građevina. U ovom radu daje se osvrt na teoriju održivosti općenito i u građevinarstvu te političke smjernice i strategije na globalnoj i nacionalnoj razini koje imaju cilj uspostaviti održivi razvoj. Navest će se različiti sustavi ocjenjivanja održivosti infrastrukturnih građevina kao metodologija vrednovanja implementacije održivih pristupa kod realiziranja novih infrastrukturnih projekata. Detaljnije će se prikazati te dati osvrt na tri sustava ocjenjivanja održivosti, a to su Envision, BREEAM Infrastructure i Infrastructure Sustainability (IS) kojima se može vrednovati održivost svih vrsta infrastrukturnih građevina te dobiti certifikat za primjenu načela održivosti.

Ključne riječi:
održivi razvoj, sustavi ocjenjivanja održivosti, klimatske promjene, održivost infrastrukturnih građevina, održivost mostova

1. Introduction

The world is facing global changes such as climate change, rapid urbanisation, the increasing consumption of non-renewable natural resources, and the emission of harmful gases into water and air. In an endeavour to provide timely and systematic help, the activities of the scientific community have increased in recent years. Efforts are being made to identify all potential changes and the associated risks and hazards in order to introduce preventive and/or mitigating measures and to develop a comprehensive approach to sustainable development in all areas of interest.

This paper provides a brief overview of the activities on sustainable development and preventing the effects of change at a global level through agreements, conferences and strategies aimed at recognizing the problem, i.e. providing a clear response to it and defining the objectives of future actions. An overview of the theory of sustainability will be given, along with guidelines for sustainable development in the construction sector and a list of scientific projects that have contributed to the development of more sustainable approaches to infrastructure projects. This paper focuses primarily on existing rating systems for assessing the sustainability of infrastructure, as such approaches are less researched than for buildings, which formed the starting point for sustainability research in the construction sector, and the development of the first manuals for assessing the sustainability of buildings dates back to the 1990s. An overview of some of the existing rating systems will be given and the three most comprehensive rating systems for the sustainability of infrastructure projects will be presented in detail, namely Envision, BREEAM Infrastructure and IS, which assess all types and sizes of infrastructure and can award official certification for the implementation of sustainable principles at different stages of their life cycle.

The beginnings of sustainable development initially focused on the ecological connotation and the impact of humans on the environment, but have expanded over time to include other areas of influence. The 5 June 1972, when the first UN Conference on the Human Environment began in Stockholm, is considered a turning point in the field of environmental protection. Since 1974, this day has been celebrated as World Environment Day. At this conference, the Declaration of the United Nations Conference on the Human Environment, or the Stockholm Declaration, was adopted as the first international law document to refer to the importance of preserving and protecting the environment. In 1983, the World Commission on Environment and Development (WCED) was founded, and in 1987 it published the report "Our Common Future", from which the most famous definition of sustainable development emerged, defined as "*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" [1].

The following documents have been developed to further support the development of guidelines for sustainable development at the global level: Agenda 21, the Rio Declaration, the UN Framework Convention on Climate Change and the Convention on Biological Diversity adopted at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. The problem was recognized, and a series of conferences were held, leading to goals for the coming period to try to respond globally to the challenges ahead. At the UN summit in New York in 2000, the Millennium Declaration was signed, the leading political document for the interests of the international community, in which the international millennium development goals for the period 2000-2015 were defined. The seventh goal of the millennium development goals was to ensure environmental sustainability. In 2012, an agreement was reached in Rio de Janeiro on the development of global sustainable goals to build on the millennium development goals. The Sustainable Development Goals (SDGs) were formally adopted by all UN member states in New York in September 2015 for the period 2016-2030 and represent the most important determinants of sustainable development in the world today. They consist of 17 Sustainable Development Goals, also known as the Global Goals, and contain 169 demands that were adopted after three years of interdisciplinary consultations. The UN's 17 Global Goals for sustainable development are as follows: 1. No poverty, 2. Zero hunger, 3. Good health and well-being, 4. Quality education, 5. Gender equality, 6. Clean water and sanitation, 7. Affordable and clean energy, 8. Decent work and economic growth, 9. Industry, innovation and infrastructure, 10. Reduced inequalities, 11. Sustainable cities and communities, 12. Responsible consumption and production, 13. Climate action, 14. Life below water, 15. Life on land, 16. Peace, justice, and strong institutions, and 17. Partnerships for the goals. From 2020, the European Commission puts the UN's 17 Global Goals for Sustainable Development at the heart of EU policy [2]. The European Commission has published policy guidelines for the period 2019-2024 and identified six priorities. The priorities are as follows [3]: 1. A European Green Deal, 2. An economy that works for people, 3. A Europe fit for the digital age, 4. Protecting our European way of life, 5. A stronger Europe in the world and 6. A new push for European democracy. The European Green Deal aims to achieve the sustainability of the European Union's economy through the transition to a climate-neutral, environmentally sustainable and circular economy by 2050 [4]. In line with the EU's ambitious policy to make Europe the world's first climate-neutral continent by 2050, the European Climate Law [5] was adopted in 2021, setting legally binding targets for achieving climate neutrality by 2050. In addition, Member States must reduce their net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels [5].

In line with the global goals and activities related to sustainable development and adaptation to climate change, the Croatian Parliament has adopted national strategies: the National Development Strategy of the Republic of Croatia until 2030 (Official Gazette 13/2021) [6] and the Climate Change Adaptation Strategy in the Republic of Croatia for the Period until 2040 with a View to 2070 (Official Gazette 46/2020) [7].

In addition, Croatian legislation, based on the Environmental Protection Act (Official Gazette 80/13, 153/13, 78/15, 12/18 and 118/18) [8] and the Regulation on environmental impact assessment (Official Gazette 61/14 and 3/17) [9], for certain projects the environmental impact assessment is mandatory.
The Regulation contains a list of projects for which an environmental impact assessment is mandatory and a list of projects subject to screening to determine whether or not an environmental impact assessment is required, the mandatory content of Environmental impact study, the criteria on the basis of which the need for an environmental impact assessment is decided and the content of the Environmental Report as part of the assessment procedure on the need for an environmental impact assessment.
According to a literature review, around 50% of all publications on the topic of sustainability and sustainable development were published between 2015 and 2020 [10]. This indicates that the establishment of the Sustainable Development Goals has increased the scientific community's interest in this area of research. The paper [11] analysed the articles published from January 2015 to October 2019 on sustainability research in the construction sector and identified a total of 1846 articles (including 1826 journal articles and 20 conference papers) involving a total of 1546 institutions in 89 countries or regions. It was also found that the *Journal of Cleaner Production* and *Sustainability* were the most attractive journals for publishing articles on sustainability in the construction sector during the specified period and that the United States of America was the country with the largest number of published articles, namely 295 published articles, representing 15.98%, while China was in second place, publishing 262 articles or 14.19% of the articles included in the study [11].
There are various methods for assessing sustainability, and in more recent studies, interdisciplinary research is replacing the initial, purely ecological considerations. The generally accepted scope of the definition of sustainability is determined and characterized by three basic pillars of sustainability: environmental, economic and social (figure 1).

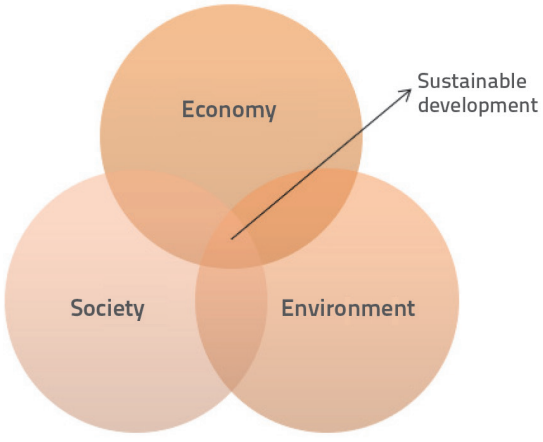

Figure 1. Three pillars of sustainability

The construction industry plays an important role in the economy, economic growth, and society's quality of life and can therefore make a significant contribution at a global level to the identification and promotion of sustainable principles and the establishment of sustainable development. The promotion of sustainability in the construction sector through the evaluation of the sustainability of the construction project should be considered in a synergistic way, encompassing economic viability, environmental acceptability, and the satisfaction of the social needs of the location, as well as beyond. The ecological dimension manifests itself in the conservation of natural resources, plant and animal species and habitats as well as in the minimisation of the release of pollutants into the atmosphere through transport and production. Economic viability should be considered in terms of the life cycle costs of the project, while the social component ensures the fulfilment of societal needs and provides the health, safety and prosperity of the community.
Incorporating more sustainable principles that are already recognized as such and promoting a sustainable mindset in various research projects in the construction sector, but also in other technical sciences and science in general, can be a good step towards sustainable development. Scientific conferences, for example, are usually attended by a large number of people, so thousands of academics in Germany have committed themselves not to use airplanes when traveling less than 1000 km [12], thus contributing to already-recognized, more sustainable solutions to promote sustainable development. Knowledge and already-recognized sustainable frameworks are sometimes difficult to implement in professional practice, precisely because their application is multidisciplinary.
Various existing rating systems for the sustainability assessment of infrastructure with assessment criteria and guidelines for their implementation can serve as a basis and help all those involved in the planning and construction process in their efforts to take into account a sustainability framework when realising new projects that are in line with the global political goals for achieving sustainable development and prosperity.

2. Rating systems

The pursuit of sustainability is recognised and accepted in scientific circles and in research. Numerous scientific projects have been launched to improve knowledge and understanding of the sustainability of infrastructure projects. For example [13] the COST Action C25 entitled "*Sustainability of Constructions: Integrated Approach to Life-time Structural Engineering*" aims to promote the science-based progress of sustainable construction in Europe. The LCE4ROADS project with the full name "*Development of a novel Eco-labeling EU-Harmonized methodology for cost-effective, safer and greener road products and Infrastructures*" aimed to develop a method for assessing the sustainability of road pavements throughout their life cycle, combining environmental, economic, technical and social aspects of sustainability and leaving space for regional specificities [14].

Back in 2003, the European project "*Sustainable Bridges - Assessment for Future Traffic Demands and Longer Lives*" was launched with the aim of not demolishing existing bridges, but improving their condition and increasing traffic capacity, extending their remaining service life and improving the management and strengthening system [15]. The "*Sustainable Bridges*" project, which involved 32 partners from 12 countries from 2003 to 2007, also aimed to increase the use of the European rail network and thus contribute to sustainable development [16].

The PIEVC Protocol (*Public Infrastructure Engineering Vulnerability Committee*) is intended to help engineers design structures that are sufficiently resilient to adapt to possible new conditions due to climate change, trying to anticipate such new circumstances and identify their impact on individual components of the infrastructure [17].

The European research project "*Sustainable Steel-Composite Bridges in Built Environment*" (SBRI), which combines a holistic, integrated methodology for assessing the sustainability of bridges based on economic, environmental, and social aspects, aims to promote the use of steel, i.e., steel-concrete composite bridges, highlighting their benefits throughout the life cycle of bridges [18].

However, it is sometimes difficult to assess whether sustainability has been achieved in practice. In the last decade, various rating systems with recognized sustainable principles, i.e. sustainability criteria, have been developed worldwide to raise the bar for the usual way of planning, designing, building and maintaining infrastructure projects.

We can divide such rating systems into those that serve as a guide for creating a project that follows sustainable principles and do not have the possibility of obtaining a corresponding certificate confirming this, i.e. those that have a developed evaluation system but do not have official recognition and certification for the results obtained. The third type is rating systems with a rating scale for each individual sustainability criterion, third-party verification by an independent body and finally obtaining a certificate to promote sustainability.

Illinois Livable and Sustainable Transportation (I-LAST) is a non-certifiable sustainability rating system that can serve as a guide for sustainable approaches to roadway infrastructure design. Developed in collaboration with the Illinois Department of Transportation (IDOT) Joint Sustainability Group, the American Council of Engineering Companies (ACEC), and the Illinois Road and Transportation Builders Association (IRTBA), I-LAST contains a number of potentially sustainable practices that are applicable to projects, but not all of these are applicable to every project. The role of the design team is to recognize which criteria are applicable to the specific project and, within the applicable framework of the criteria, strive for innovative and sustainable practices and attempt to implement as many creative and sustainable approaches as possible [19]. *Sustainable Transportation Environmental Engineering and Design* (STEED) is an example of another non-certifiable self-assessment guide for implementing sustainable solutions developed by H.W Lochner Inc, a Chicago-based transportation consulting company.

The Infrastructure Voluntary Evaluation Sustainability Tool (INVEST) contains a range of sustainability approaches applicable to infrastructure projects and has been developed to support road authorities in introducing more sustainable solutions into their projects and processes. The first version of INVEST v1.0, released in 2012, was developed by the Federal Highway Administration (FHWA) and sought to capture all positive sustainable practices in transportation infrastructure through research. Invest v1.3 considers the entire life cycle of a project and includes four self-assessment modules, namely: System Planning for States (SPS), System Planning for Regions (SPR), Project Development (PD), and Operations and Maintenance (OM) [20]. This rating system includes an innovative criterion in each module that users of the guide can define to assess sustainable solutions that are not yet part of INVEST, while contributing to the development of future versions of this guide or other assessment tools through examples.

GreenLITES - *Leadership in Transportation and Environmental Sustainability* is a self-certifying rating system for transportation infrastructure that was originally developed for internal use by the New York State Department of Transportation (NYSDOT) for use on its own projects [21].

The Standard for Sustainable and Resilient Infrastructure (SuRe) was developed by the Global Infrastructure Basel (GIB) Foundation in Switzerland. Development began in 2014 with the aim of promoting sustainable and resilient infrastructure, and the first version of the SuRe rating system was published in 2017. SuRe assesses the sustainability of infrastructure projects based on three sustainability aspects, 14 categories and 61 criteria, takes into account the entire life cycle of the project and, through an independent third-party verification, awards a certificate for the results obtained [22].

Greenroads was developed as part of a research project at the College of Washington. The first version 0.95 was released in 2009 as a collaboration between the College of Washington and CH2M HILL. It is currently operated independently by the Greenroads Foundation, founded in 2010, and includes an accreditation and certification program with third-party verification to ensure that projects receive the recognition they deserve for implementing sustainable approaches [23]. Greenroads is a sustainability rating system that incorporates sustainable practices, known as criteria, and assesses the sustainability of road infrastructure projects against mandatory criteria that all projects must meet in order to be included in further assessment, as well as voluntary criteria where the project team itself decides which criteria it meets and to what extent, and on the basis of which it can receive a certificate.

The most comprehensive rating systems for assessing the sustainability of infrastructure projects, which are described in detail in this article and which can be used to assess all types and sizes of infrastructure projects, including airports, bridges, dams, tunnels and others, and receive recognition based on the rating results obtained, are Envision in the USA, BREEAM Infrastructure in the UK and the Infrastructure Sustainability-IS Rating Scheme in Australia.

2.1. Envision sustainability rating system

Envision [24] was developed in a joint collaboration between the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design and the Institute for

Quality of life	Leadership	Resource allocation	Natural world	Climate and resilience
▪ Wellbeing ▪ Mobility ▪ Community	▪ Collaboration ▪ Planning ▪ Economy	▪ Materials ▪ Energy ▪ Water	▪ Siting ▪ Conservation ▪ Ecology	▪ Emissions ▪ Resilience

Figure 2. Envision rating system categories and subcategories

Sustainable Infrastructure (ISI). The first version of Evision, a rating system for assessing the sustainability of infrastructure projects, was published in 2012. Envision has been applied to billions of dollars worth of projects, and the lessons learned and new insights have been implemented in the newer versions of Envision that have followed. The second version of Envision was released in 2015, and the third version, Envision v3, released in 2018, is described in more detail below.

Envision v3 consists of 64 credits that assess the sustainability of a particular project. Each credit in the Envision rating system contains the intent of the credit, metrics, total possible points, description of levels of achievement, description of criteria, description of the mode for achieving a higher level of achievement, evaluation criteria and documentation guidance as well as a list of the related Envision credits.

The credits are divided into five categories and 14 sub-categories. The categories are: quality of life, leadership, resource allocation, natural world and climate and resilience. The categories with the corresponding subcategories are shown in figure 2.

The subcategories consist of credits. Each credit contains a detailed description of how to determine the levels of achievement in the project. Not all credits have all five levels of achievement, which depends on the nature of the credits and the ability to clearly distinguish between them, as well as the criteria for achieving each level. Conventional performance is the usual way of implementing a certain criterion on a project and is not evaluated. The five levels of achievement that are assessed are as follows: Improved, Enhanced, Superior, Conserving and Restorative. Improved level means "*Performance that is above conventional. Slightly exceeds regulatory requirements*". Enhanced means: "*Sustainable performance that is on the right track. There are indications that superior performance is within reach*". Superior means: "*Sustainable performance at a very high level*". Conserving means: "*Performance that has achieved essentially zero negative impact*". Restorative means: "*Performance that restores natural or social systems. Such performance receives the highest award possible and is celebrated as such*". A schematic representation of the rating system for credits that have all five levels of achievement is shown in Figure 3.

The points achieved for the individual credits are added together to obtain the total number of points achieved and form the total Envision score. The final certificate achieved is calculated as a percentage of the total points achieved in relation to all applicable points in the evaluation process for that project. Envision recognizes that not all credits can be applied to all types of projects, which, for verification by an independent body and to obtain a specific certificate, must be explained and covered with accompanying documentation. In total, in all 5 categories, by evaluating 64 credits according to the levels of achievement, it is possible to get a maximum of 1000 points. Figure 4 shows the categories and their score ratios according to the Envision scoring system. Each category promotes innovative methods of achieving sustainability or exceptional attributes that go beyond the requirements of the levels of achievements of the credits and are not yet included in the Envision framework, and awards additional points for these achievements that are not included in the individual category's described rating scale or the total Envision scoring system score.

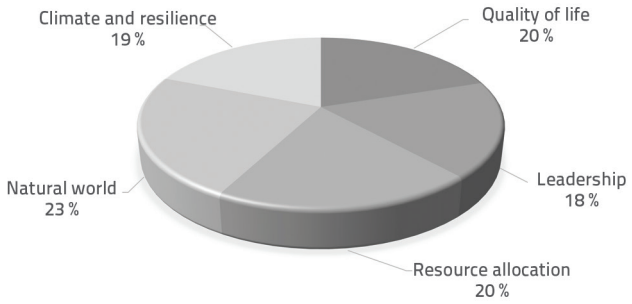

Figure 4. Envision categories and their ratio of points according to the rating system

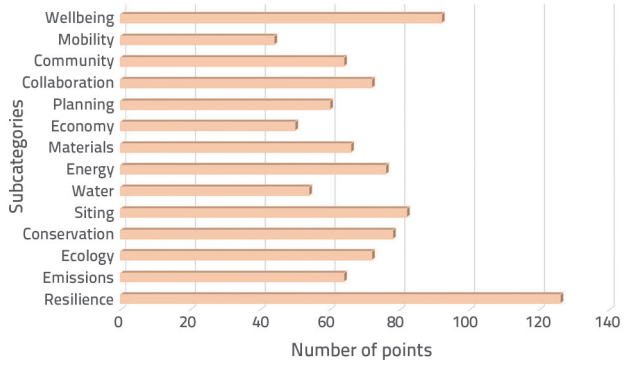

Figure 5. Envision subcategories and their ratio of points according to the rating system

Figure 5 shows the subcategories with the maximum possible score assigned to that category according to the Envision rating system for infrastructure projects. The ISI provides a review by an independent body to assess the sustainability of projects

Figure 3. Schematic representation of the rating system

and gives public recognition to infrastructure projects that, after review, demonstrate a high level of application of sustainable principles, i.e., sustainability credits according to the Envision rating system. Projects can be registered for assessment either after the design phase (at or after 95% completion of the project) or after the construction phase (at or after 95% completion of the construction) to assess compliance with the sustainability criteria of the Envision rating system. To obtain the certificate, projects must achieve at least 20% of the points applicable to the Verified certificate, 30% for Silver, 40% for Gold, and 50% for Platinum.

ENV SP (Envision Sustainability Professional) are engineers who are authorized to use Envision to support the design team in implementing the sustainability criteria and achieving higher levels of sustainability and documenting the planned and achieved levels of achievement according to the guidelines of the Envision manual. After a project has been submitted for assessment of the sustainability levels achieved under the Envision rating system, a qualified ISI verifier reviews the implementation of the proposed levels of achievement and the submitted documentation and accepts or rejects the levels of achievement proposed by the project team.

2.2. BREEAM Infrastructure Projects sustainability rating system

BREEAM Infrastructure (formerly CEEQUAL) is a technical manual that provides a methodology for assessing the sustainability of various infrastructure projects and is intended for use by trained and qualified assessors in accordance with procedural requirements. In 2015 BRE Global bought CEEQUAL and became part of BREEAM, and in October 2022 CEEQUAL was renamed BREEAM Infrastructure. BREEAM Infrastructure is available in two schemes: BREEAM Infrastructure Projects [25] for civil engineering, infrastructure, landscaping and public realm projects and BREEAM Infrastructure Term Contracts [26] for infrastructure maintenance. There are also two editions: the UK & Ireland and an international version. The international version of BREEAM Infrastructure Projects is described below.

BREEAM Infrastructure Projects comprises 8 categories and 30 sub-categories (Figure 6). The categories are: management, resilience, communities and stakeholders, land use and ecology, landscape and historic environment, pollution, resources and transport. Each subcategory (assessment issue) includes: aim, assessment scope, credit summary, assessment criteria, guidance and evidence. If necessary, some assessment issues also contain additional definitions or information. Each credit is assigned the corresponding number of points that can be achieved in the strategy, planning or construction phase if the conditions for this are met in accordance with the instructions and the required evidence. Not all credits have a score for all three phases, depending on their nature. At the beginning of some subcategories, prerequisites are indicated that must be fulfilled in order to rate credit's points in that subcategory.

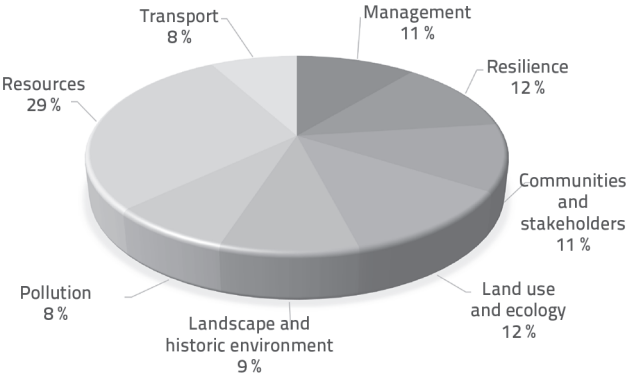

Figure 7. BREEAM Infrastructure Projects categories and their points ratio according to the points system

Figure 7. shows the categories and their points ratio according to the BREEAM Infrastructure Projects rating system. Within the BREEAM Infrastructure Projects rating system, there are a total of 5000 points. Figure 8. shows the distribution of points according to subcategories of the BREEAM Infrastructure Projects scoring rating system.

Management	Resilience	Communities and stakeholders	Land use and ecology	Landscape and historic enviroment	Pollution	Resources	Transport
▪ Sustainability leadership ▪ Environmental management ▪ Responsible construction management ▪ Staff and supply chain social governance ▪ Whole life cycle costing	▪ Risk assessment and mitigation ▪ Flooding and surface water run-off ▪ Future needs	▪ Consultation and engagement ▪ Wider social benefits ▪ Wider economics benefits	▪ Land use and value ▪ Land contamination and remediation ▪ Protection of biodiversity ▪ Change and enhacement of biodiversity ▪ Long-term management of biodiversity	▪ Landscape and visual impact ▪ Heritage assets	▪ Water pollution ▪ Air, noise and light pollution	▪ Strategy for resource efficienty ▪ Reducing whole life carbon emissions ▪ Environmental impact of construction products ▪ Circular use of construction products ▪ Responsible sourcing of construction products ▪ Construction waste management ▪ Energy use ▪ Water use	▪ Transport networks ▪ Construction logistics

Figure 6. Categories and subcategories of the BREEAM infrastructure Projects rating system

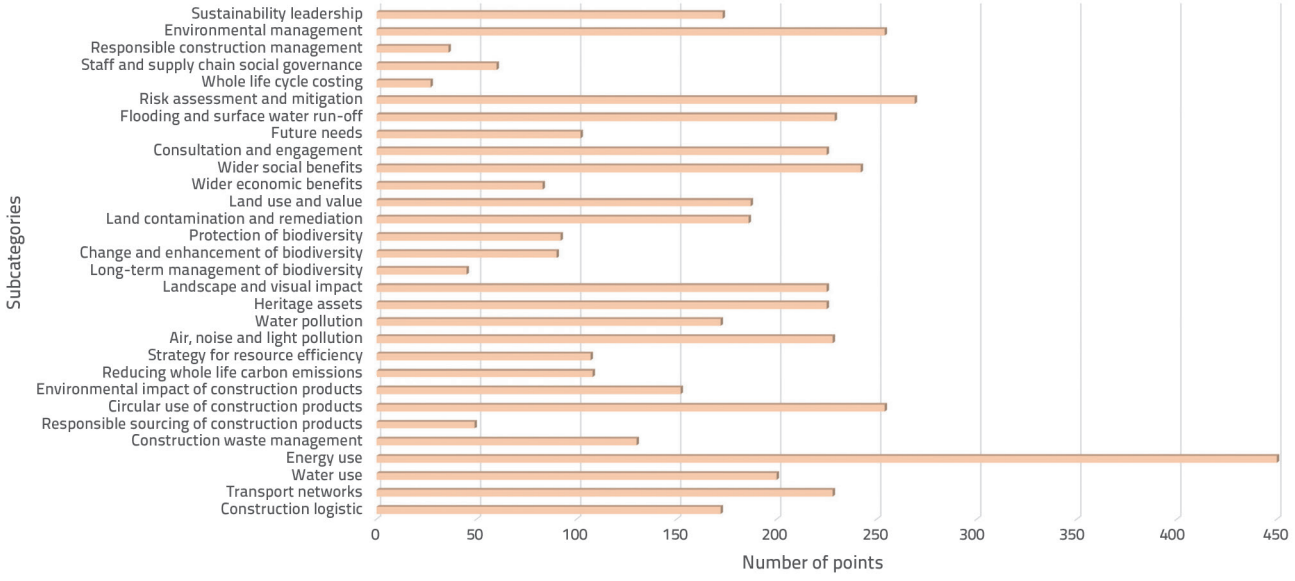

Figure 8. BREEAM Infrastructure Projects subcategories and their score ratio according to the rating system

BREEAM Infrastructure Projects can be used to assess the sustainability of infrastructure projects in three phases: the strategy phase, the design phase, and the construction phase.
There are five different types of assessments that can be carried out with BREEAM Infrastructure Projects. The first type of assessment is an assessment of the whole project. It is submitted jointly by the client, the designer and the principal contractor(s), and the final review and certification take place at the end of the construction phase. Another type of assessment is the strategy and design assessment, which is intended for joint use by the client and the designer and can be carried out before construction work begins. The third type of assessment is a design-only assessment, which is aimed at the designer(s). It can be used in cases where the designer wishes to be recognized for their contribution to sustainability through project certification and the client and contractor do not wish to participate.The fourth type of assessment is design and construction and is intended for a joint application by the lead contractor(s) and the designer(s) and can be used in cases where the designer and contractor wish to be recognised for their contribution to sustainability and the client does not wish to participate. The fifth phase is a pure construction audit which is aimed at the main contractor. It can be used in cases where the contractor wants to be certified for its contribution to sustainability but the client and designer do not want to participate.
The assessment levels are Outstanding > 90, Excellent > 75, Very good > 60, Good > 45, Passed > 30 and Unclassified < 30.
BREEAM Infrastructure Projects awards additional points for innovation, i.e., for innovative sustainable solutions that are implemented in the project and are not part of the rating system. The maximum number of additional points that can be awarded for innovation credits is 10 percent of the total score.

2.3. Infrastructure sustainability – IS rating scheme

The Infrastructure Sustainability (IS) rating scheme was published in 2012 for use in Australia and New Zealand. The Infrastructure Sustainability (IS) rating scheme was developed by ISCA. It became clear that the tools used to assess the sustainability of infrastructure projects were changing the practises previously established in Australia and New Zealand, and the need for a rating scheme that could be applied internationally was recognised. This paper describes the IS International V1.0 Design and As Built (Pilot) [27] from September 2017. This technical manual is a pilot project to introduce IS International, a version of the sustainability assessment rating system for infrastructure projects that could be used for sustainability assessments around the world. This international version of the IS rating scheme was selected for comparison in order to highlight the aspects of the different criteria for developing and developed countries according to this scheme and to emphasise the need to take into account local and national specificities as well as the economic development of a particular country when assessing the sustainability of infrastructure projects. The existing IS (Infrastructure Sustainability) v1.2 [28] was used as the basis for the development of the international IS rating system. In IS International V1.0 Design and As Built (Pilot), there are five categories within which the credits are located. The categories are: a) management & governance, b) using resources, c) emissions, d) pollution & waste, e) ecology, people & places. The categories and sub-categories of the IS rating scheme are shown in Figure 9. Each credit has a title, an aim, and a level of

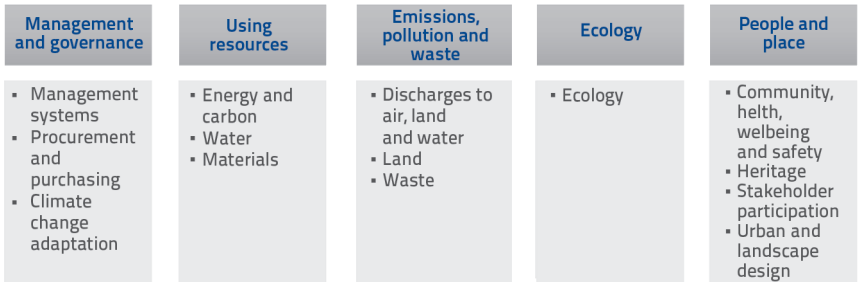

Figure 9. IS rating system categories and subcategories

performance. The levels of performance can be 1, 2, or 3. The three levels of performance are Commended, Excellent and Leading. All referent levels should reflect "beyond business as usual" performance. In some cases, not all three levels are prescribed. In order to achieve the predicted points of an individual indicator, evidence is required to show that the requirements of the individual levels have been met. Figure 10 shows the categories and their score ratios according to the IS scoring system.

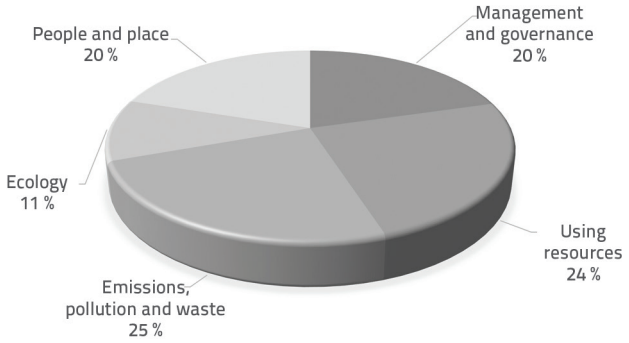

Figure 10. IS rating scheme categories and their points ratio according to the rating system

Figure 11 shows the distribution of points according to the subcategories of the IS scoring system. For some credits, there is a distinction in relation to developing countries that use a different rating scale. Certain points were determined through a survey and a scoring study as part of the development of the original scheme [28]. Some points are "scaled," i.e., the points achieved vary according to the degree of improvement, instead of having three fixed levels. The category score is the sum of the points achieved for each credit and the total score is the sum of the points achieved in all categories on a scale of 100 points.

Scoring is as follows if the total number of points achieved is: Ineligible to apply for a certified rating < 25, Commended 25 to < 50, Excellent 50 to < 75, Leading 75 to 100. To fulfill certain criteria and performance levels, it is necessary to submit evidence that the assessor reviews and evaluates. There are four main stages of the IS International Pilot rating process: Registration, Assessment, Verification and Certification.

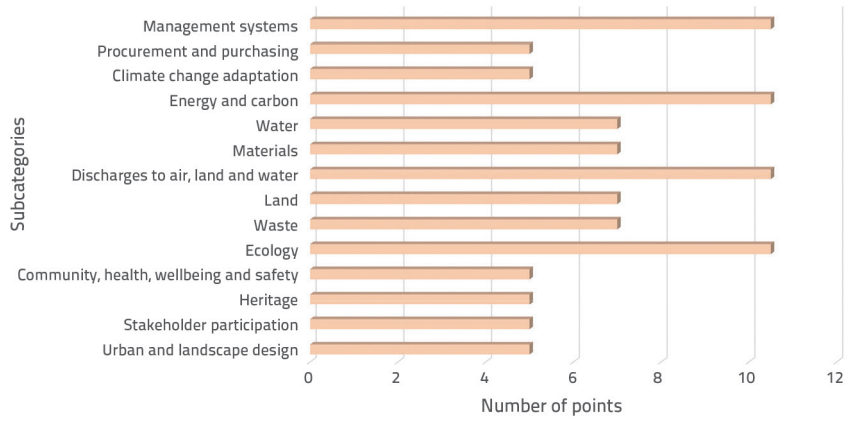

Figure 11. IS subcategories and their point ratio according to the rating system

3. Discussion

Rating systems for assessing the sustainability of construction projects were developed primarily in the 1990s using examples of buildings. The two best-known and oldest rating systems are BREEAM, which was introduced in the UK in 1990, and LEED in the USA, which was introduced in 1998 and applies exclusively to buildings [29]. The first rating systems for assessing the sustainability of infrastructure came into use much later. Various institutions have developed systems to assess the sustainability of roads, highways and other infrastructure for their own needs, but also for the needs of the wider community and society in general. For this reason, rating systems are often limited in their application, i.e. they are only intended for the assessment of a specific size and/or type of infrastructure project and their use is intended for the specific location for which they were developed, while their wider application may lead to problems of interpretation or validity.

Three sustainability systems that can be used to assess all types and sizes of infrastructure interventions in space are described and compared in more detail in this paper (Table 1): Envision, which originated in the USA, BREEAM Infrastructure Projects in the UK and IS in Australia. As there is no international version of Envision, the 2018 version of Envision v3 [24] is described, as well as the international versions of BREEAM Infrastructure Projects v6 [25] from 2022 and IS v1.0 [27] from 2017. Although there is only one version of Envision, originally developed for Canada and the USA, it has been successfully used and implemented for the sustainability assessment of infrastructure projects around the world. The BREEAM Infrastructure Projects and IS rating systems are distinguished by two manuals, one for assessing the sustainability of infrastructure projects on

Table 1. Comparison of rating systems for the sustainability assessment of infrastructure

Sustainability assessment rating systems / Characteristics	ENVISION	BREEAM infrastructure Projects	IS (Infrastructure sustainability)
Year of first publication	2012	2003 (formerly as CEEQUAL)	2012
Country	USA	UK	Australia
Publisher	Zofnass Program for Sustainable Infrastructure at the Harvard University and Institute for Sustainable Infrastructure (ISI)	BRE Global Ltd	ISCA (Infrastructure sustainability council of Australia)
Type of assessment	Third-party verification with a certificate	Third-party verification with a certificate	Third-party verification with a certificate
Types of infrastructure projects	All types of infrastructure projects	All types of infrastructure projects	All types of infrastructure projects
Certificate	Verified > 20 % Silver > 30 % Gold > 40 % Platinum > 50 %	Unclassified < 30 % Pass > 30 % Good > 45 % Very good > 60 % Excellent > 75 % Outstanding > 90 %	% Commended 25 % - 50 Excellent 50 % - 75 % Leading > 75 %
Used version	v3 (2018)	v6 international (2022)	v1.0 international (2017)

their territory and the other for international use. The rating tools have been developed in developed parts of the world and their use in other countries, particularly in developing countries, may raise questions about the credibility of their application. The international version of the IS recognises this problem and the application of certain criteria within the sustainability rating system when carrying out the assessment, forms in particular to developed countries and especially to developing countries. All three rating systems are anticipated to be used in the early stages of the planning and design process to try to incorporate as many sustainable practises as possible into the development of the strategy and the management of the project from its inception to its realisation.

Envision, BREEAM Infrastructure Projects and IS cover similar topics and provide guidelines and frameworks for achieving sustainability by defining sustainability criteria and ways to achieve them for the three pillars of sustainability: environmental, economic and social. However, the analysis of the criteria shows that all three systems are biased towards the environmental dimension, which has the highest total score, to the detriment of the social and economic aspects. In the total number of points for all three rating systems, more than 50% of the total points were awarded to environmental aspects, while the rest was distributed among social and economic aspects.

The ecological dimension is taken into account through the use of resources, energy consumption, conservation of nature and habitats and the release or reduction of pollutant emissions into the atmosphere. The social dimension is considered through the well-being of society and community development, the improvement of people's quality of life and health, and the preservation of cultural and historical heritage. The economic dimension is reflected in the overall economic benefits and costs of the project. With a strong emphasis on the phases of project planning and the development of a project strategy that follows the principles of sustainability theory, they also focus on long-term resilience, taking into account climate change, its impact on infrastructure and the resulting risks.

Envision has 5 levels of achievement per credits and with the final, fifth level of achievement, raises the bar higher than other rating systems, beyond the boundaries of the project and beyond the boundaries of sustainability, by defining a restorative level of achievement. The restorative level of achievement of the credits encourages the creation of positive outcomes that can extend beyond the project itself, i.e. they have an impact beyond the scope of the project, for the benefit of the whole community. Not all sustainability assessment credits have a restorative level of achievement, and to achieve a restorative level it is not enough for the credit to be fully sustainable, but it does raise the bar. For this reason, the Envision rating system may seem more demanding than other rating systems. However, the threshold for assessment and award of certification is lower than for BREEAM Infrastructure Projects and IS.

Envision awards a platinum certificate to projects that achieve more than 50% of the possible points and a gold certificate for more than 40% of the total score. BREEAM Infrastructure Projects has a different rating, so that projects with more than 75% are classified as Excellent and those with more than 90% as Outstanding. In IS, the highest certificate is Leading for more than 75% of the points and Excellent for 50% to 75% of the points achieved.

All rating systems recognize innovation, i.e. innovative sustainable solutions that cannot be assessed on the basis of the sustainability assessment criteria and the points awarded in the manual itself. In the BREEAM infrastructure Projects rating system, it is possible to obtain a maximum of 500 points for innovation, which corresponds to 10 percent additional points from the total score of the rating system. In Envision, it is possible to obtain a maximum of 50

additional points for innovative solutions in the area of sustainability that cannot be assessed according to the criteria of the rating system, i.e. it is possible to obtain a maximum of an additional 5% of the total score. The IS rating system also recognizes innovative sustainable practices and it is possible to receive a maximum of 10% additional points for their implementation.

All three sustainability assessment rating systems cover similar topics and, in their own way, attempt to describe the implementation of sustainable solutions in the realization of infrastructure projects from planning through design, construction, and use, thus providing guidelines and frameworks for achieving infrastructure sustainability.

With this methodology for assessing the sustainability of infrastructure and the development of various rating systems, an attempt has been made to collect as many sustainable practises as possible in each rating system and consolidate them in one place by relating them according to the overall contribution to sustainability and the level of achievement in each criterion, thus helping to raise standards in the planning, design and construction of new infrastructure projects beyond the norm.

4. Conclusion

The methodology of applying the rating systems listed and described in this paper for the sustainability assessment of infrastructure in the initial stages of planning and design provides a broad framework of sustainable approaches that raises the bar beyond standard approaches and is in line with policy guidelines and the Sustainable Development Goals. Obtaining a certificate that depends on the number of points achieved, i.e., implementing sustainable approaches in the realization of infrastructure projects with rating systems that are verified by an independent body - a third party is the goal to strive for when planning new infrastructure. However, the use of available guidelines and rating tools is desirable to help all those involved in the design and construction process by providing them with the best sustainable practises when the certification process itself and obtaining a certificate confirming the implementation of sustainable approaches at the end of the project are not the ultimate goal.

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