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Review paper

Ecosystem Services in Urban Areas Stormwater Management – The Case of Opatija*

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Abstract: Coastal area along the Adriatic Sea is subject to intense and insufficiently regulated tourism-related development. The result is that the spaces with natural cover or previously built ones permeated with greenery are converted into impermeable areas. The problem is exacerbated by steep inclination of the terrain where the runoff jeopardizes the spaces and properties at lower elevation and pollutes the sea. The paper presents the case of Opatija, coastal town situated on the slopes of Učka Mountain. The current state of stormwater runoff and deficiencies in physical planning are analysed. Policy changes are proposed based on ex-ante assessments such as quantitative and qualitative cost-benefit analysis. Given the global anthropogenic threats, a series of international agreements and documents set the targets, methods of assessment and monitoring, indicators, and monetary valuations aimed at preservation and restoring nature-based services in urban areas. Croatian municipalities should reverse current trends of uncontrolled land clearing and deforestation for new developments and get into compliance with new nature restoration requirements, thus preventing further damages, providing green infrastructure, and reducing the risks.

Keywords: Coastal development, Ecosystem services, Nature-based services, Stormwater management, Nature restoration, Opatija.

1. Introduction

Coastal areas and their delicate ecosystems are currently exposed to the pressure of intense tourism-related investment in real estate, while on the other hand local and national regulatory framework, as well as administrative capacities, are insufficient to cope with the challenges that threaten the preservation of indispensable ecosystem services related to climate, water, pollution abatement, provision of habitats, and well-being of

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residents. While cities worldwide are trying to restore greenery through prudent urban planning approaches [1], coastal communities in Croatia are generally replacing natural areas with impermeable surfaces not only on the buildings themselves, but also on paved surroundings, driveways, infrastructure, etc., which they will eventually have to convert back to green. Namely, the anthropogenic threat to planetary boundaries related to biodiversity and ecosystems gave rise to a whole series of international agreements and documents which endeavour to curb the deterioration of natural environment, setting the principles, targets, the methods of assessment and monitoring, proposing also the indicators and monetary valuations.

This paper analyses the case of deteriorating stormwater runoff in the City of Opatija, focuses on the deficiencies in physical planning, proposes the use of quantitative and qualitative holistic cost-benefit analysis which represents an important part of impact evaluations, and finally, focuses on the development of regulation and metrics for nature-based services (NBS). Given the need for holistic approach to the topic, the author applied qualitative research based on observations, authors' previous research and experiences, the reports on current research, and official documents on the subject.

2. Current situation with stormwater runoff

Opatija riviera is subject to an intense and insufficiently regulated tourism-related development mainly in function of the real estate market, and less for immediate tourism operations. Areas with natural cover or previously built areas permeated with greenery are thus converted into fully impermeable areas, see Figure 1.

Tourism along the coast of Opatija, where the steep slopes of Učka Mountain reach the sea and provide favourable climatic conditions for lush Mediterranean vegetation started at the beginning of the 20th century, first as luxurious villas, and later hotels, each structure being surrounded by an immense park.

It is precisely due to the inclination of the terrain and the features of the soil that the runoff jeopardizes areas and properties at lower elevation and pollutes the sea. There exist numerous canyons, streams, and torrents, such as Vrutki stream and Slatina torrent forming the delta in the central part of the City of Opatija, see the map in Figure 2.

Fig. 1 – *View of Slatina area at the beginning of 20th century (above, source: Povijest liburnijske vodoopksrbe i odvodnje, 2009) with arched canal marine outfalls shown, and at present (below, source: author's archives).*

Fig. 2 – *Map of Slatina area, Opatija, considered and its hinterland (source BIOPORTAL, 2024).*

The original rainwater drainage tunnels have been obstructed by new constructions. In addition, clearing of the land for construction purposes results in grates being clogged by shrub and tree cutting and thereby the overflows occur combined with erosion, flooding the areas and carrying mud to lower elevation (Figure 3) and the sea (Figure 4).

Fig. 3 – *Flooded street at Slatina in Opatija, source: "Poduckun.net, 04.08.2023.*

Fig. 4 – *Opatija panorama immediately after intense rainfall shows the discharge of stormwater runoff from torrential canals into the sea, source: Povijest liburnijske vodoopksrbe i odvodnje, 2009.*

3. Spatial planning

Space is a valuable, limited, mostly non-renewable resource shared by many users. The purpose of spatial planning is to ensure its rational and optimum use. Prevailing current practice in Croatia involves technical tasks in spatial planning being carried out by authorized individuals (selected by local self-government unit) who often establish direct contact with potential investors, thereby tailoring spatial plans. Thus, the mosaic-like amendments shaped by investors, presented as progress and new employment opportunities, represent a permanent practice.

Council members are generally unfamiliar with all the details of huge documents full of acronyms and special marks being presented to them before the vote. They make decisions that are sometimes disastrous for the space, even in good faith. In fact, they are often provided only with textual part of the draft plan, without graphical one enclosed. Not uncommonly, they are also the owners of certain land plots and have personal interest for spreading of construction zones and increasing their sales value.

Physical plan for the City of Opatija was enacted on 13.4.2001. Over the next two years, it became evident that voted version was not identical to the published one (there were two or three different copies in circulation and textual and graphical parts did not correspond to each other), therefore the moratorium was introduced. In 2007 a new physical plan was adopted, and in 2009 the development plan of urban area. Physical plan was modified in 2012, 2016, 2021, and 2022, with one currently in course, and the development plan of urban area was modified in 2012, 2013, 2019, and 2021 [2].

An important aspect to highlight is that no Strategic Environmental Assessment accompanying the adoption of physical plans had been carried out whatsoever despite the obligation to do so effective since 2013, with all the amendments proposed having been considered minor by competent body in the county. Furthermore, location and building permits are issued without thorough evaluation.

One of the roles of spatial planning, which is receiving an increasing attention, is the preservation and enhancement of urban biodiversity. In fact, spatial plans are key for addressing land-use changes and govern new urban developments, two of the main drivers to biodiversity loss. They can include interventions related to the creation and/or preservation of green and blue infrastructures and ecological corridors. Given the land-sea interactions in coastal cities such as Opatija, terrestrial, coastal, and marine planning [3] should be integrated.

4. Cost-benefit analysis

Besides the need of taking a comprehensive approach to spatial planning, qualitative and quantitative cost-benefit analysis for local community could be a useful tool for the community to evaluate its development options. Namely, before developing a plan or deciding to add facilities to increase tourist potential, the question should be asked "is it worth it?", whereby the study may be very comprehensive or rough-and-ready, for use by the communities [4]. Some items included may be with reasonably accurate, some are guesstimates, and some unmeasurable. Unmeasurable items should be indicated with a plus (+) for benefits or a minus (-) for costs.

Table 1 presents a cost-benefit framework containing official data on local taxes and contributions for year 2022 for the City of Opatija [5] where personal income tax constitutes the highest share of the municipal budget revenues. Communal contribution is a one-time revenue and is a specific purpose income as is also the communal fee. Real estate transfer tax, a non-dedicated revenue, obviously depends on the number of transactions, real estate units, and market prices. It is to be analysed whether permanent change of ownership and possible speculations contribute to tourism-related operations. Other benefits presented are either state budget or private revenues. The costs of support activities are quantified. Environmental costs and natural capital degradation are considered qualitative in this analysis, although the attempts to provide quantification methods of some of the items are under way, as elaborated further in the following chapter.

5. Ecosystem services in urban areas

Biodiversity preservation in urban areas is becoming a focal point due to the increasing share of urban population living therein. It is important to refer to Sustainable Development Goal 11 to the UN Agenda for Sustainable Development whose mission is to "Make cities inclusive, safe, resilient and sustainable" and the objectives of the Rio Conventions (United Nations Framework Convention on Climate Change, United Nations Convention to Combat Desertification and the Convention on Biological Diversity).

Table 1 – *Proposed structure of quantitative and qualitative cost-benefit analysis for tourism-related real estate developments in the City of Opatija.*

BENEFITS		
	Measurability	*Comment*
Local income	Share in budget revenues in 2022	
Personal income tax	20.43%	Only from residents of Opatija – population steadily falling
Consumption tax	0.76%	
Real estate transfer tax	12.73%	speculations?
Holiday home tax	0.71%	
Tourist tax	1.08%	
Communal contribution	13.05%	one-time
Communal fee	7.52%	monthly
Parking	0.11%	
VAT		State budget revenue
Private revenues		
Preservation of heritage?		• architectural - not • other - insufficiently

COSTS	
	Measurability
Support services	quantitative
Sewer	quantifiable
Water	quantifiable
Streets	quantifiable
Access roads	quantifiable
Parking	quantifiable
Lighting	quantifiable
Medical facilities	quantifiable
Rescue systems	quantifiable
Solid waste management	quantifiable
Damage repairs in public spaces	quantifiable
Environmental costs/natural capital degradation	qualitative
Deforestation (O_2, CO_2, microclimate, pollution, water control)	minus (-)
Loss or permeable surfaces	minus (-)
Erosion	minus (-)
Damage to coastal ecosystems	minus (-)
Noise (construction)	minus (-)
Pollution (dust, emissions – construction)	minus (-)
Landscape degradation	minus (-)
Senses cape degradation	minus (-)
No beach sediment supply	minus (-)
Congestion	minus (-)

Very often, however, cities lack policy tools that consider the value of biodiversity and the ecosystem services they provide [6, 7]. Nature is often viewed as an aesthetic luxury that few can afford to have. On the other hand,

nature comprises ecosystems that regulate the quantity and quality of water and air which are essential to the well-being of a city's residents. Ecosystems moderate ambient and surface temperatures of cities which are often plagued by the urban-heat island effect phenomenon. Most of a city's water supply usually comes from catchment areas within natural ecosystems which play a significant role in purifying the water. Urban greenery within the city replenishes oxygen, sequesters carbon, reduces air pollution, regulates ambient and surface temperature in urban landscapes, provides habitat for animals, reduces soil erosion, in addition to numerous other intangible benefits. Most of the food is derived from biodiversity. Parks and natural areas also create recreational spaces and educational opportunities for residents, contributing to the overall liveability of the city, while frequent contact with nature is essential for psychological and mental well-being of humans [8].

Konijnendijk proposes the 3-30-300 rule for creating greener, healthier and more resilient neighbourhoods [9] stating that everybody should be able to see 3 trees from their home, live in a neighbourhood with at least 30% tree canopy (or vegetation) cover, and be no more than 300 metres from the nearest green space that allows for multiple recreational activities.

Figure 5 shows the terrestrial habitats and the location of Natura 2000 area [10] for the part of the Opatija riviera considered in this paper.

5.1. Development of European legal framework for nature restoration

European Commission drafted a proposal for the Nature Restoration Law, namely the Regulation on nature restoration [11] as a key element of the EU Biodiversity Strategy, calling for binding targets to restore degraded ecosystems, supporting it by the fact that 81% of habitats are in poor status, that every 1 euro invested into nature restoration adds 8-38 euro in benefits, and that one in three bee and butterfly species are in decline [12].

The proposal's specific targets relevant for this study are urban ecosystems anticipating no net loss of green urban space, and of urban tree canopy cover by 2030 compared to 2021, in all cities and in towns and suburbs, and an increase in the total national area of urban green space in cities and in towns and suburbs of at least 3% of the total area of cities and of towns and suburbs in 2021, but 2040, and at least 5% by 2050. In addition, Member States shall ensure a minimum of 10% urban tree canopy cover in all cities and in towns and suburbs by 2050 and a net gain of urban green space that is integrated into existing and new buildings and infrastructure developments, including trough renovations and renewals. Furthermore, the proposal provides for the restoration of the natural connectivity of rivers and the natural functions of the related floodplains, which involve

identifying and removing barriers that prevent the connectivity of surface waters, so that at least 25,000 km of rivers are restored to a free-flowing state by 2030.

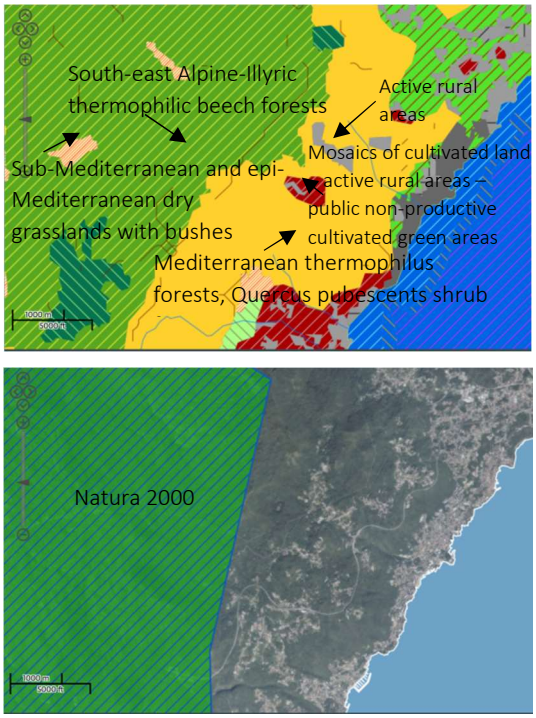

Fig. 5 – *The map of terrestrial habitats (above) and Natura 2000 (below) in Opatija area (source BIOPORTAL, 2024).*

EU countries are expected to submit National Restoration Plans to the Commission within two years of the Regulation coming into force, outlining how they will meet the targets and monitor and report on their progress. Member states must quantify the area that needs to be restored to reach the restoration targets. The quantification shall be based, for each habitat type on the following: the total habitat area and a map of its current distribution, the habitat areas which are not in good condition, the favourable reference area taking into account the documented losses over at least the last 70 years and the projected changes to environmental conditions due to climate change, the areas most suitable for the re-establishment of habitat types in view of ongoing and projected changes to environmental conditions due to climate change, the sufficient quality and quantity of the habitats of the species required for achieving their favourable conservation status, taking

into account the areas most suitable for re-establishment of those habitats and the connectivity needed between habitats in order for the species populations to thrive as well as ongoing and projected changes to environmental conditions due to climate change.

5.2. Ecosystem services metrics

The City Biodiversity Index, launched by Singapore in 2008 at the eighth Conference of the Parties to the Convention on Biological Diversity (Singapore Index), represents a quantitative scoring tool in monitoring and evaluation of cities' biodiversity. Core components include: 1. Native biodiversity in the city (indicators 1-9), 2. Ecosystem services provided by biodiversity (indicators 10-14, whereby indicator 10 is related to regulation of quantity of water and indicator 11 to climate regulation – benefits of trees and greenery, and 3. Governance and management of biodiversity (indicators 15 to 28, where for instance indicator 15 is related to institutional capacity, indicator 16 to budget allocated to biodiversity, indicator 17 to policies, rules and regulations, indicator 18 to status of natural capital assessment in the city, indicator 19 to state of green and blue space management plans in the city, indicators 23 and 24 to participation and partnership, indicator 26 to education, indicator 27 to awareness, indicator 28 to community science, among others). Indicators are then examined based on the rationale for their selection, the method of their calculation, the sources of data for calculation, and the basis for scoring [8].

Furthermore, in 2021, the United Nations Statistical Commission adopted the System of Environmental Economic Accounting - Ecosystem Accounting (SEEA EA) [13], which is a spatially based, integrated statistical framework for organizing biophysical information about ecosystems, measuring ecosystem services, tracking changes in ecosystem extent and condition, valuing ecosystem services and assets and linking this information to measures of economic and human activity. It was developed to address a range of policy demands and challenges, with a focus on highlighting the contributions of nature to the economy and people. SEEA EA applies the accounting principles of the System of National Accounts 2008 (2008 SNA) [14]. While estimates based on this value concept are useful in many contexts, they do not include the monetary value of the wider social benefits of ecosystems, including their non-use values, which some users may find useful. Assessing the importance of ecosystems will therefore require consideration of a wide range of information beyond data on the monetary value of ecosystems and their services.

The Common International Classification of Ecosystem Services (CICES) [15] was designed to help measure, account for, and assess ecosystem

services. Although it was developed in the context of work on the System of Environmental and Economic Accounting (SEEA), it has been widely used in ecosystem services research for designing indicators, mapping and valuation. Given the multitude of contexts within which CICES is expected to be applied, users are free to identify appropriate measurement units, depending on each specific application context and the available data. Ecosystem services are categorized as: 1 - provisioning, 2 - regulation & maintenance, and 3 - cultural. Regulation and maintenance include, among others, the smell reduction, noise attenuation, visual screening, control of erosion rates, buffering and attenuation of mass movement, hydrological cycle and water flow regulation, storm protection, pollination, seed dispersal, regulation of temperature and humidity, including ventilation and transpiration, dilution by freshwater and marine ecosystems, and liquid flows. Cultural services include, for instance, physical and experiential, intellectual, representative, spiritual and symbolic interactions with natural environment, and characteristics or features of living systems that have an existence and bequest value.

Another classification scheme for incorporating common indicators is the European Commission's NBS Impact Evaluation Handbook [16, 17], which provides a general framework of the value of NBS to the community, investors, and policymakers, and illustrates how the NBS impact evaluation framework can be used. For instance, suitable key indicators can be selected from CICES and aligned with NBS valuation standards defined in the EU handbook to establish the economic evaluation criteria for these indicators [18]. The NBS concept is considered to be the evolution of terms used previously to express similar ideas: urban forestry (UF); green and blue infrastructure (GI, BI); and ecosystem services (ESS), ecosystem-based adaptation (EbA), ecosystem-based disaster risk reduction (Eco-DRR), blue–green infrastructure (BGI), low-impact development (LID), best management practices (BMPs), water-sensitive urban design (WSUD), sustainable urban drainage systems (SuDs), and ecological engineering (EE) (see Figure 6). The 12 challenge areas elaborated are: 1. Climate Resilience, 2. Water Management, 3. Natural and Climate Hazards, 4. Green Space Management, 5. Biodiversity Enhancement, 6. Air Quality, 7. Place Regeneration, 8. Knowledge and Social Capacity Building for Sustainable Urban Transformation, 9. Participatory Planning and Governance, 10. Social Justice and Social Cohesion, 11. Health and Wellbeing, and 12. New Economic Opportunities and Green Jobs.

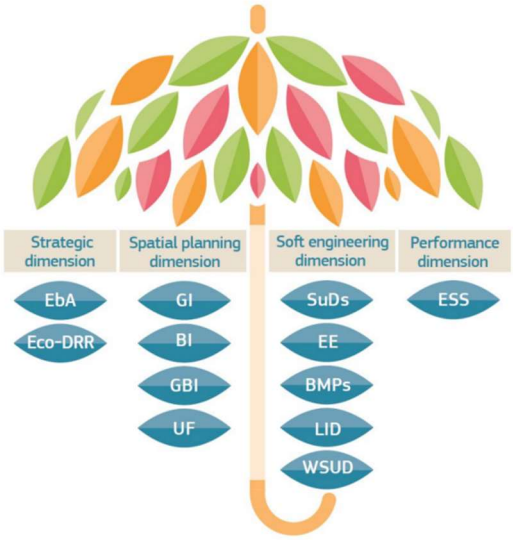

Fig. 6 – *Nature-based solutions as an umbrella concept [16].*

NBS can be grouped based upon their primary objective or function and by the level of ecosystem intervention – type 1 (minimal or no intervention in ecosystems), 2 (extensive or intensive management approaches to improve delivery of ecosystem services relative to conventional interventions), and 3 (highly intensive ecosystem management or creation of new ecosystems). Type 2 NBS involves, among others, the integrated water resource management, while type 3 involves green space, trees and shrubs, soil conservation and quality management, blue-green space establishment or restoration, green built environment, natural or semi-natural water storage and transport structures, and infiltration, filtration, and biofiltration structures. The indicators related to water management involve, for instance, surface runoff in relation to precipitation quantity in mm/%, infiltration rate in % or mm/h, infiltration capacity in mm/d, runoff rate for different rainfall events in m^3/s, run-off score, rainfall storage capacity of NBS in mm/%. There are also indicators related to natural and climate hazards which involve among others disaster resilience. NBS can effectively reduce risks related to hydro-meteorological disasters while simultaneously providing multiple co-benefits. Risk reduction measures consist of structural (physical) measures, such as protective structures (e.g., check dams) or non-structural measures such land use management, land-cover control, and risk mapping.

6. Conclusion

Improper stormwater management results in enormous damage which are exacerbated by new climate phenomena. Therefore, development at vulnerable geographic sites must be given special consideration through proper spatial planning and environmental impact assessment.

Many important effects of tourism development cannot be considered in economic terms. Some aspects are frequently immeasurable, and important costs are often overlooked. Local self-government units are currently financially stimulated for as many new edifices as possible, as shown in the case study. However, that is a one-time revenue because in the long-term they must maintain an expensive utilities and rescue systems. Therefore, a proper cost-benefit analysis provides a framework to identify likely economic impacts, both measurable and unmeasurable. Community members can determine appropriate weights – outweighing is more important than outnumbering.

Metrics for nature-based services are becoming available, as is also the legal framework for nature restoration in urban areas. Therefore, Croatian municipalities should reverse current trends of uncontrolled land clearing and deforestation for new developments and comply with new nature restoration requirements, thus preventing further damage, providing green infrastructure and reducing the risks.

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