IMPLEMENTING GREEN INFRASTRUCTURE AND NATURE-BASED SOLUTIONS IN FLOOD RISK MANAGEMENT IN ROMANIA

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Abstract. The article briefly outlines the European legislative context on Green Infrastructure and Nature-based Solutions (NbS) by highlighting the main initiatives/laws published in the past 15 years, as well as the main definitions and associated concepts. One of the core aspects of the paper is the methodological approach proposed in order to integrate the Green Infrastructure and NbS elements into the Programmes of Measures (PoM) associated to the Flood Risk Management Plans (FRMP) – cycle II, reported to the European Commission – as required by the Floods Directive and approved by GD 886/2023. Compared to the proposed/carried out green measures during cycle I of the Directive's implementation, Romania has taken a big step forward. The implementation of the proposed green measures and NbS depends on numerous factors (local conditions, institutional issues, funding mechanisms, etc). Beyond the obvious benefits, the NbS have several limitations regarding their implementation. In conclusion, the article highlights the factors that favour the implementation of these measures, the restrictions that may appear, as well as the potential financing mechanisms.

1. INTRODUCTION. GREEN INFRASTRUCTURE AND NATURE BASED SOLUTIONS. THE EUROPEAN CONTEXT

Following the approval of the *EU's Biodiversity Strategy (2020)*, the need for the European Commission (EC) to develop a Green Infrastructure Strategy was established, in 2011, in order to reinforce the economic benefits that the EU's Biodiversity Strategy brings and to attract greater investment in Europe's natural capital. Thus, in 2013, the European Commission approved the *EU's Green Infrastructure Strategy* which included four priority workstreams: promoting green infrastructure in key policy areas; improving information, strengthening knowledge and promoting innovation; improving access to finance and developing the Green Infrastructure projects at EU level (European Commission 2013). The EU's Green Infrastructure Strategy supports the full integration of Green Infrastructure into EU policies so that it becomes a standard component of territorial development throughout the Union.

Nowadays, Green Infrastructure and NbS have become essential components of the newest European legislative initiatives, as follows: the *EU's Green Deal*, the *EU's Biodiversity Strategy for 2030*, the Cohesion Fund and the Cohesion Policy, the *EU's Strategy on Adaptation to Climate Change*.

According to the latter, the European Union aims to achieve climate neutrality by 2050 and measures such as Green Infrastructure and Nbs can provide a wide range of benefits to society, from

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carbon storage to clean waterways, while also reducing the impact of climate change and improving flood protection, without bringing any harm to the environment.

According to the *Nature Restoration Law*, recently approved by the European Parliament (Regulation (EU) 2024/1991 of the European Parliament and of the Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869), measures ought to be in place by 2050 for all ecosystems in need of restoration. The law covers degraded terrestrial and marine habitats, pollinators, agricultural ecosystems, urban areas, rivers and floodplains, forests.

Regarding the rivers and floodplains, more than one million artificial barriers, such as dams, spillways and weirs, are built on Europe's rivers (European Environment Agency 2021). The new rules would aim to remove many existing barriers on these EU rivers to ensure a greater continuity throughout the river networks. The law sets a target of at least 25,000 km of free-flowing rivers by 2030. As data on river barriers is still insufficient, one of the aims for these new rules is to draw up an inventory of barriers across the EU. Removal efforts should be focused on outdated and out of use barriers. At the same time, Romania will have to prepare and submit to the European Commission a National Restoration Plan to demonstrate how the proposed targets will be achieved through this law.

All these European approaches and legislative initiatives are nothing more than a series of obvious steps to support and promote the large-scale implementation of Green Infrastructure and NbS in different fields of activity.

Therefore, this article aims to highlight the importance of measures such as NbS and Green Infrastructure, as a strategic approach of major importance in the national legislative initiatives, associated action plans, or investment plans. A relevant example is the Programme of Measures associated with Flood Risk Management Plans – Cycle II (Ministerul Mediului, Apelor și Pădurilor 2023), a methodological approach to which the authors have made an important contribution, focusing on integrated flood risk management, ecosystem conservation, and the consideration of the multiple socio-economic benefits.

In this context, we recall the main provisions of the Floods Directive (European Commission 2007), which uses as a planning tool the Flood Risk Management Plan:

- The first stage – Preliminary flood risk assessment – involves the nationwide identification of significant historical floods and potential future significant floods (in terms of recorded/ potential damage) and the delineation of areas with significant potential flood risk (Areas with Potential Significant Flood Risk – A.P.S.F.R., 526 delineated areas in Romania);
- The second stage – The development of hazard maps and flood risk maps for APSFRs (outlined during the previous step) under different flood scenarios;
- The third stage – The elaboration of Flood Risk Management Plans for all 11 Water Basin Administrations, as well as for the Danube River, based on the above-mentioned maps; the 12 Plans include proposals for flood risk reduction measures for APSFRs as defined during the first stage of the Floods Directive 2007/60/CE implementation.

2. GREEN INFRASTRUCTURE AND NATURE-BASED SOLUTIONS – DEFINITIONS AND CONCEPTS

"Green Infrastructure" is a term that is becoming more commonly used among natural resource professionals. While it may mean different things to different people depending on the context in which it is used, Green Infrastructure is an interconnected network of green space that preserves natural ecosystem values and functions, and provides associated benefits to human populations. Green Infrastructure is the ecological framework needed for the environmental, social and economic sustainability of our nation's natural life support system (Benedict A. M., McMahon T. E., 2002).

Among the main benefits of Green Infrastructure is that it helps protect and restore naturally functioning ecosystems by providing a framework for future development that fosters a diversity of

ecological, social and economic benefits. These include an enriched habitat and biodiversity, the maintenance of natural landscape processes, cleaner air and water, increased leisure opportunities, improved health, and a better connection to nature and a sense of place. Green space also increases property values and can decrease the costs of public infrastructure and services such as flood control, water treatment systems and storm water management (the flood management infrastructure, water treatment plants, and stormwater management techniques) (Mell C. I., 2017).

Green Infrastructure should be carefully planned, designed, and expanded as communities grow. Green Infrastructure planning should be the first step in developing land-use plans, and should be coordinated with planning roads, sewers, water lines and other essential grey infrastructure. Integrated planning and design should connect green and grey in a more effective, economic and sustainable network. Green infrastructure should be:

- designed holistically – Green Infrastructure should be designed to link elements into a system that functions as a whole, rather than as separate, unrelated parts;
- planned comprehensively – our green space systems need to be planned to include ecological, social and economic benefits, functions and values;
- laid out strategically – Green Infrastructure-based systems need to be laid out strategically, to become feasible from a legislative point of view;
- planned and implemented considering the input from the public, including community organizations and private landowners;
- grounded on the principles and practices of diverse professions – Green Infrastructure-based systems should rely on solid science knowledge of professional disciplines such as landscape ecology, urban and regional planning, and landscape architecture;
- funded up-front – like other infrastructure systems, our Green Infrastructure needs to be funded as primary public investments rather than with money left over after all other services have been provided. (Coutts C., Hahn M., 2015; Mell C.I., 2017).

NbS are inspired and supported by nature, and are cost-effective, providing environmental, social and economic benefits and contributing to an increased resilience. In addition, NbS have a particular importance in addressing climate change impacts and managing the biodiversity "crisis" by providing green/ecological solutions. In the NbS category, the following are among the most popular types of measures (Ministerul Mediului, Apelor și Pădurilor 2023):

- Upland and gully woodlands. Afforestation of upper areas of torrential river basins;
- Wider catchment woodland. Large-scale afforestation of hydrographic basins;
- Woodland management. Floodplain and riparian woodlands management;
- Reduction of slope runoff through anti-erosion forest curtains (agroforestry systems);
- Reduction of local slope runoff through earthworks or the use of "surface runoff barriers";
- Improvement of lands affected by deep erosion or surface erosion (by afforestation) – requires terracing, erosion barriers, etc.;
- Promoting and implementing best practices in slope agriculture (e.g., cultivation practices for soil conservation);
- Re-meandering, restoring channel and floodplain features;
- Leaky barriers;
- NWRM – Offline storage areas;
- Coastal management – beach recharge;
- Removing works that regulate flows;
- Assessing the setting back, partial or full removal of flood embankments.

3. THE METHODOLOGY FOR THE INTEGRATION OF GREEN MEASURES IN THE FLOOD RISK MANAGEMENT PLAN IN ROMANIA

In Romania, some elements related to Green Infrastructure and NbS have been integrated, based on a dedicated methodology, in the Programmes of Measures associated with the Flood Risk Management Plans – cycle II, as approved by GD 886/2023 and reported by the Competent Authority (National Administration "Romanian Waters") to the European Commission.

Furthermore, the entire Methodology for the elaboration of the Programmes of Measures (developed with the contribution of the authors under the *Technical Support for the development of methodologies, for the Flood Risk Management Plans* contract closed in 2021 with the World Bank as the beneficiary) has emphasized the integration of as many green measures as possible in the development of the Programmes of Measures, proposed at the level of each *Areas with Potential Significant Flood Risk* (APSFR). All these Programmes of Measures form the core of the Flood Risk Management Plans, elaborated at the River Basin Administration (RBA) level.

These Plans were developed within the framework of a subsequent project, namely *Consultancy services for the elaboration of Flood Hazard and Risk Maps and Flood Risk Management Plans for Romania*. This was a project coordinated also by JBA Consulting (consortium leader), whose client was the World Bank. These consultancy services were foreseen within the framework of the Financing Application called *Strengthening the capacity of the central public authority in the water field for the implementation of the 2nd and 3rd stages of Cycle II of the Floods Directive - RO-FLOODS (SIPOCA Code 734)*, whose final beneficiary was the Ministry of Environment, Water and Forests and the National Administration "Romanian Waters". The main methodological steps taken are shown schematically in Figure 1.

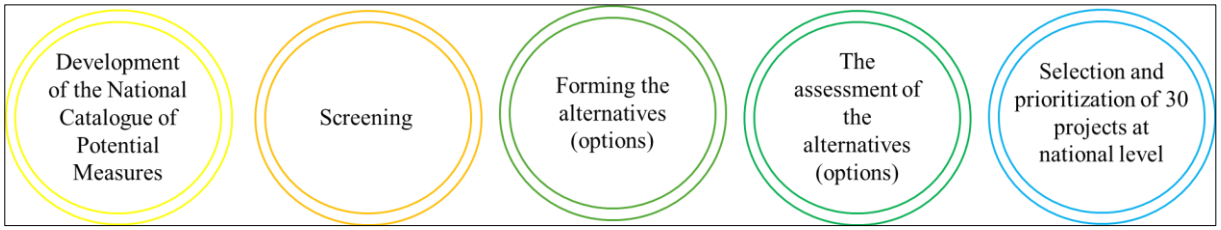

Fig. 1 – Presentation of the main methodological steps followed in the elaboration process of the Programmes of Measures included in Romanian FRMPs.

The Methodology has allowed the identification of prevention, protection, preparedness, response and recovery measures, prioritizing, where possible, non-structural measures and NbS. The integration of NbS into the Programme of Measures aimed to maximize the multiple benefits of the proposed measures. The way in which Green Infrastructure and NbS have been prioritized at all development stages of the Programme of Measures is detailed below, as follows:

- **The Development of the National Catalogue of Potential Measures** (Ministerul Mediului, Apelor și Pădurilor, 2023), according to the typology of measures described in the reporting requirements of the EU Flood Directive. It included a total of 64 measures categories (each measure with its own associated code), among which four measures categories correspond to the typology of green measures, as illustrated in Figure 2.

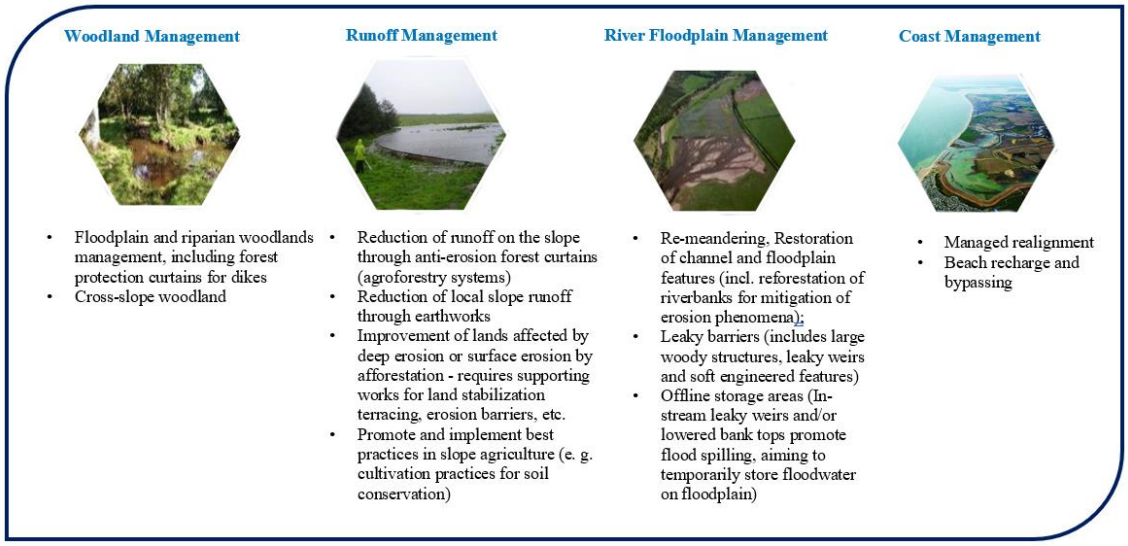

Fig. 2 – Types of green measures proposed in the National Catalogue of Potential Measures.

- **Screening** – the process entailed drawing up a "long list" of potentially viable measures for each APSFR (5500 potential measures in all 526 APSFRs at the national level). The viability of measures was preliminarily assessed based on technical, social, cultural, heritage, environmental and economic considerations. Regarding the "Environment" criterion, the aspects targeted were those mainly related to the negative impacts on the water bodies' status and the negative impacts on Natura 2000 sites/species. Thus, the following issues needed to be considered for this criterion (in other words, the questions that needed to be addressed) have been established:
  - *Is the measure likely to have a negative impact on the water body status?* This was based only on the type of measure and its potential impact. Moreover, only the main structural measures were considered at this stage (reservoirs, dykes, bed regularization works);
  - *Potential impact on upstream/downstream water bodies (Art. 4(8)).* This was also based on the type of measure and the potential impact;
  - *Are there some feasible practical ways to mitigate negative impacts?* Mitigation measures were mainly considered from the Factsheets attached to the Catalogue of Potential Measures associated with the FRMP. In addition, mitigation measures - in order to mitigate the impacts of hydromorphological alterations for rivers, lakes and coastal waters in the River Basin Management Plan (Cycle III) - have been considered to be integrated into the Flood Risk Management Plan strategies (where applicable);
  - *Can the same benefits be achieved by alternative measures?* By answering this question, it was verified whether possible alternative measures were eliminated too early in the Programme of Measures process during the Screening stage. By default, all the NbS proposed at the level of all APSFRs were retained in the screening analysis.
- **Forming the alternatives (options)** (JBA 2023a) - the process consisted in grouping the measures resulting from the screening process ("short" list of measures obtained after the assessment made on technical, social, cultural, heritage, environmental and economic considerations) into alternatives (options) at the APSFR's level; in forming the alternatives, the Methodology recommended was to start from green measures, followed by non-structural measures, "light" structural measures and then "heavy" structural measures. This hierarchical proposal of measures that formed the alternatives is presented in Figure 3.

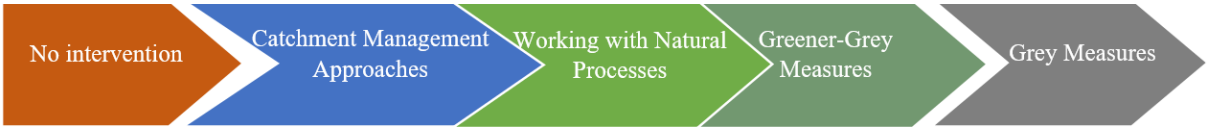

Fig. 3 – Hierarchical approach in order to integrate green measures into the alternatives' (options') development.

The figure schematically illustrates the methodological approach for integrating NbS and Green Infrastructure into Programmes of Measures. The methodology proposes a hierarchical approach for integrating green measures into the formation of alternatives, detailed as follows (Roca *et al.*, 2017):

– **No Intervention**
  - A flood management strategy that allows the natural adjustment of the watercourse without any human activity; it may require changes in the current use of the river and floodplain;
  - The opportunities and constraints for these types of measures are usually linked to the settlement pattern;
  - Avoiding development in the floodplain is an example of a no-intervention measure.

– **Catchment Management Approaches**
  - Management options involve a wide variety of interventions of change in practices to reduce runoff, manage sediments and improve the operation of infrastructure;
  - Examples include: public awareness, fencing of dikes to protect from livestock, optimizing operating rules of existing infrastructure, changing maintenance regimes, and improving how forestry is managed in the upstream catchment and adjusting agricultural practices to reduce runoff and improve soil condition.

– **Working with Natural Processes**
  - Measures which work with and respect the natural hydrology and sediment regime of the river system. These include catchment scale measures for river and floodplain measures to alleviate or delay river discharge, enhance floodplain conveyance, and reduce peak flood levels;
  - The aspirational objective is for a free-flowing river;
  - Suitability is constrained by floodplain slope, urban development and confined valleys.

– **Greener-Grey Measures**
  - Softer structural measures which include natural materials, more natural form or specific measures to enhance or create habitats.
  - In some situations (e.g., Heavily Modified Waterbodies) the natural functioning of a river and its floodplain cannot be restored; in these situations, all possible opportunities to work with natural processes to reach a situation which is as free flowing as possible should be explored.

– **Grey Measures**
  - Hard structural engineering measures, which typically use artificial or concrete materials;
  - Only to be used if all other approaches are exhausted;
  - For grey measures to be acceptable, the project needs to demonstrate compliance with EU Directives (specifically, the revised EIA Directive, the Water Framework Directive, the Habitats and Birds Directives).

- **The assessment of the alternatives (options)** was carried out through a Multi-Criteria Analysis and Cost-Benefit Analysis using the *Appraisal Summary Tool* (AST). The AST integrates 8 environmental indicators *(pollution, biodiversity, fisheries, watercourse functioning, water quality and quantity, soil quality, vulnerability to climate change and CO_2 greenhouse gas sequestration)* in order to illustrate the potential benefits for the baseline situation and the proposed alternative(s). *The biodiversity and river functionality indicators* value the NbS by scoring them in the alternatives' comparison and evaluation analysis. Based on this analysis/assessment, the preferred (recommended) option was selected, which became the Strategy (Programme of Measures) at the APSFR level.

- **Selection and prioritization of 30 projects at the national level** (JBA 2023b) (see their locations in Figure 4), aims to develop the investment and implementation plans for over a 10-year period. One of the criteria for defining of integrated projects refers to the **"existence of green measures"**. Therefore, integrated projects contain, in addition to traditional engineering measures, an important component of green measures. Among these, the most relevant *win-win* measures (supporting the achievement of the objectives of both directives the following types of measures are mentioned, each measure having an associated code (in order to understand the coding of measures, please refer to *the National Catalogue of Potential Measures*, https://inundatii.ro/wp-content/uploads/2023/09/Sinteza-Nationala-PMRI-Ciclul-II.pdf, p 151)): *The re-meandering of waterways, The restoration of channel and floodplain features (incl. the reforestation of riverbanks for the mitigation of erosion phenomena)* (M31-RO17), *Offline storage areas (In-stream leaky weirs and/or lowered bank tops promote flood spilling, aiming to temporarily store floodwater in the floodplain*) (M31-RO19) and *The assessment of relocation, partial or full removal of flood embankments* (M33-RO36). These are the measures ensuring lateral connectivity, improving the morphology of banks and riparian areas, while also reducing the flood risk. Particular importance has also been given to green measures involving afforestation, such as:
  – *Maintaining or increasing the proportion of forested area in the upper basins of watercourses (not only APSFR)* (M31-RO10);
  – *Maintaining or increasing the area of forests intended for: hydrological protection and intended for land and soil protection* (M31-RO11);
  – *The management floodplain and riparian woodlands, including forest protection curtains for dikes* (M31-RO12);
  – *Reduction of slope runoff through anti-erosion forest curtains (agroforestry systems)* (M31-RO13);
  – *Improvement of lands affected by deep erosion or surface erosion (through afforestation) – requiring terracing, erosion barriers, etc.* (M31-RO15).

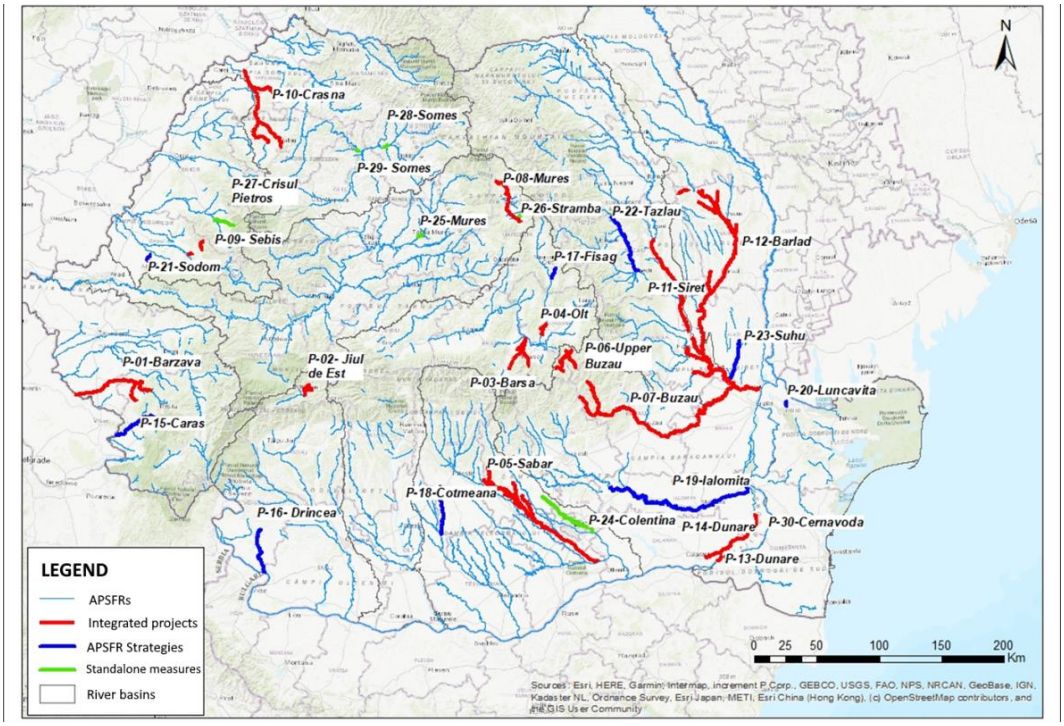

Fig. 4 – Locations of the 30 projects at national level.

In the process of defining potential measures for Integrated Projects, a method for identifying areas with afforestation potential has been applied. Thus, such measures as *M31-RO10* have been proposed on the identified areas for the 30 prioritized projects; at the national level, two aspects of interest have been emphasised, namely: **the maximum theoretical area proposed for afforestation** is **481,127 ha** (time horizon – about 35 years) and **the viable area proposed for afforestation** is **17,213 ha** (time horizon – 10 years). It is important to mention that two correction factors have been applied to the above theoretical/potential land area: an implementability factor, applied to the theoretical area to reflect the one viable to be afforested for flood risk management purposes, and a reduction factor applied so as to reflect what is technically feasible to implement over the next 10 years. The implementability factor is intended to capture the uncertainty of the process of engagement with landowners and stakeholders, which is a very complex and dynamic process that cannot be defined *a priori*.

GREEN INFRASTRUCTURE AND NATURE-BASED SOLUTIONS – CURRENT STATUS, TREND, FAVORABLE CONDITIONS, OBSTACLES, FUNDING MECHANISMS

A comparative status of flood risk management plans – Cycle I vs. Cycle II from the perspective of green measures.

Analysing the elaborated Programmes of Measures, we were able to make a comparative centralized situation of the green measures at the national level, taking into account the first and second Cycles, considering the three main green measures types from the above-mentioned Catalogue (M31-RO17 *River Re-meandering/Restoration*; M31-RO19 *Natural Water Retention Measures*; M33-RO36 *Partial or full dike removal/relocation*).

As shown in the Figure 5, the Flood Risk Management Plans developed in Cycle II contain 80% more green measures than the versions developed as part of Cycle I of the Flood Directive implementation.

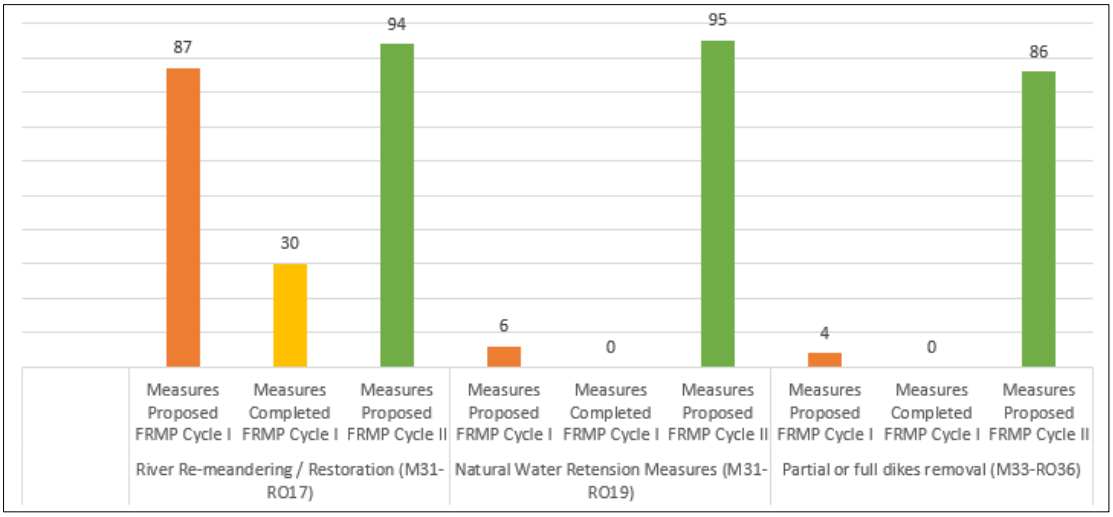

Fig. 5 – Comparative analysis of green measures (Cycle I vs. Cycle II). National situation.

Favourable conditions

Among the main factors that facilitate the development of these projects (which include NbS in Romania) are:

- stakeholder involvement in the implementation of projects that promote Nbs; to overcome mistrust in "soft/green engineering" processes, collaboration, rather than consultation, is needed;

- the existence of a specific legislative framework to promote and support the implementation of these types of solutions;
- the possibility of non-refundable funding;
- the interest of local decision-makers;
- the educational, awareness-raising potential of the population and, in particular, decision-makers regarding the long-term benefits of NbS. In addition to fulfilling its purpose and objective, there is a wide range of additional benefits, such as: wildlife and fish spawning habitat improvement, water quality improvement, natural processes restoration, recreational areas development and enhancement, etc.
- compared to conventional solutions, green approaches are often associated with lower capital costs and a wider range of benefits. In general, green approaches can be financially supported through a wide range of subsidies, can have a lower whole-life cost and can be more cost-effective when combined and integrated with grey solutions.

Obstacles (Difficulties in implementation)

Regarding the restrictions in the implementation of these projects promoting NbS, the main obstacles are related to legal land ownership and the lack of good practices in Romania, in terms of the conceptualization and design of these types of investments.

Moreover, an important limiting factor is that infrastructure elements which integrate NbS provide partial protection for the areas at risk during extreme flood events. At the same time, when discussing various protection measures (e.g., tree plantations, vegetative protections), the effect is not immediate, sometimes requiring 3–5-year cycles, during which the objectives requiring protection, as well as the works themselves, are vulnerable. For this reason, depending on the local hydro-morphological conditions, it is necessary, in certain situations, to bolster these solutions/measures with light, environmentally friendly structural measures (using local materials, such as earth-filled timber works, dry masonry works, etc.) or, where appropriate, with grey infrastructure elements (traditional engineering measures). It is fundamental that the engineering performance of any green measures fulfil the legal requirements. Also, it is important to mention that the targeted standard of protection can be achieved either by an individual (singular) measure or by a set of measures (flood relief scheme) - sized so that, together, they might meet the target standard. In some cases, achieving the target standard of protection may not be realistic due to economic, technical, social, cultural or environmental constraints; in these cases, the target standard of protection may be adjusted, justified, on the basis of a rigorous risk analysis and a techno-economic analysis. In this case, if possible/feasible, some measures will be put forward in order to increase the resilience of flood-exposed targets (individual adaptation measures).

Some additional and limiting factors in implementing NbS, mainly in Romania, include:

- difficult inter-institutional collaboration;
- the lack of awareness and education regarding the benefits and importance of NbS, or a conflict about the existing economic interests;
- the lack of trained specialists for the conceptualization, design and implementation of these types of projects, as well as the lack of an "ecological sense" among decision-makers;
- the existence of compensation mechanisms in order to support the use of privately owned land; there are additional difficulties in Romania because of the land on which measures need implementing to work with natural processes. The land is often outside the area that the River Basin Administrations and the National Administration "Romanian Waters" can use. Complex land transfer and management agreements are needed.

Nowadays, NbS have a great potential to obtain funding from the EU, and in order to be eligible for EU funding, the strategy and projects need to be in line with EU policy, strategy and directives.

Funding mechanisms

The European Commission is helping EU Member States with this green transition, to achieve the objectives of the European Green Pact and the subsequent legislation. With a view to implement Green Infrastructure, the European Commission has developed various funding programs, among which we mention:

- HORIZON Europe - aims to strengthen the European Union's science and technology base, including by developing solutions to address policy priorities such as the green and digital transitions. The programme also contributes to sustainable development goals and boosts competitiveness and growth;
- LIFE – for the funding of water resources management projects; it is divided in three sub-programmes:
  - **Nature and Biodiversity**, which aims to protect and restore Europe's nature, stopping the loss of biodiversity. This sub-programme supports projects that contribute to the implementation of the Natura 2000 network and support the achievement of the objectives of the EU's Biodiversity Strategy 2030;
  - **Climate Change Adaptation** – under which projects can be funded for NbS development and implementation, for different types of areas (rural, urban and coastal), water management, financial instruments, innovative solutions and public-private collaboration on insurance and on the date regarding incurred damages;
  - **Governance and knowledge on climate**, which supports the European Climate Pact's functioning, awareness raising, training and capacity building, knowledge development and stakeholder engagement in the areas of climate change mitigation and adaptation.
- The European Agricultural Fund for Rural Development (EAFRD), the European Agricultural Guarantee Fund, the European Regional Development Fund, Cohesion Funds, etc.

5. CONCLUSIONS

The article provides an overview of the European legislative framework concerning Green Infrastructure and nature-based solutions, along with the key associated definitions and concepts. Building on the authors' experience from two World Bank-funded projects conducted over the past three years in Romania (nationwide projects), the article introduces the proposed methodological approach for integrating Green Infrastructure elements and nature-based solutions into the Programmes of Measures associated with the Flood Risk Management Plans – Cycle II. The discussion emphasizes the evolution/trend of promoting and implementing these measures in Romania, the enabling factors that support their adoption, the potential challenges, and the main available EU funding mechanisms.

In conclusion, based on the analysis presented in this article, Figure 6 offers a schematic representation of the **key drivers for promoting and implementing green measures** in Romania.

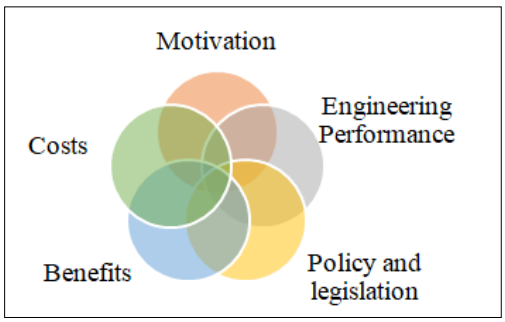

Fig. 6 – Key factors for promoting and implementing green measures.

Therefore, comparing the benefits of these measures against the costs and the reduced environmental impact, we deem it appropriate to more extensively integrate Green Infrastructure and NbS in river basin management schemes. Therefore, the benefits of Green Infrastructure may contribute to climate change adaptation and mitigation. In addition to the water risk phenomena management (floods, droughts), the measures focusing on the implementation of this type of infrastructure offer other benefits as well, such as: improving the local climate, improving water and air quality, ensuring conditions for the development and conservation of biodiversity (including that which is specific to urban areas), facilitating the development and protection of green spaces/recreational areas, and the benefits associated with the population's health and well-being.

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