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Article

The Link between Ecosystem Services and Human Wellbeing in the Implementation of the European Water Framework Directive: Assessing Four River Basins in Europe

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Abstract: This paper explores the relationship between the environment and human wellbeing whilst considering water resource pressures in the context of ecosystem services, before assessing the management actions to facilitate human wellbeing under the European Union's Water Framework Directive (WFD). By focusing on four river basins in four European countries currently working to implement the WFD, we explore the effects of multiple pressures faced within each one on human wellbeing. Under an Ecosystem Services framework, we identify those effects and consolidate them into Human Wellbeing Factors to assess the management actions. Then, by conducting a qualitative content analysis, we assess the effectiveness of each Program of Measures at river basin level and relate them to Human Wellbeing Factors. Findings indicate that factors such as population growth trends intensify the effects of these pressures on human wellbeing. Finally, the paper pinpoints that human wellbeing must remain an ever-present consideration to be weighed against any other competing policy objectives.

Keywords: integrated river basin management; human wellbeing; ecosystem services; policy

1. Introduction

The concept of Human Wellbeing (HWB) is understood to be a multi-faceted term which seeks to represent a state of intrinsic value to an individual or collective, encompassing fundamental components of human existence such as health, freedom of choice, good social relations, a livable environment and security [1–3]. The Millennium Ecosystem Assessment [1], defines human wellbeing as "the opposite end of a continuum from poverty which has been defined as a "pronounced deprivation in well-being" while the United Nations Environment Programme (UNEP) describes it as "the extent to which individuals have the ability and the opportunity to live the kinds of lives they have reason to value" [4].

The MEA places HWB as a core element of their framework, and it has also become a priority in shaping policy on Ecosystem Services (ES) [3,5,6]. ES refer to the "benefits people obtain from ecosystems" [1] and are considered as the fundamental environmental determinants of HWB [4] with each of the ES categories (provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; habitat services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefits) accounting for a given component of HWB [1]. Figure 1 provides a graphical illustration of the corresponding domains of the ES and HWB.

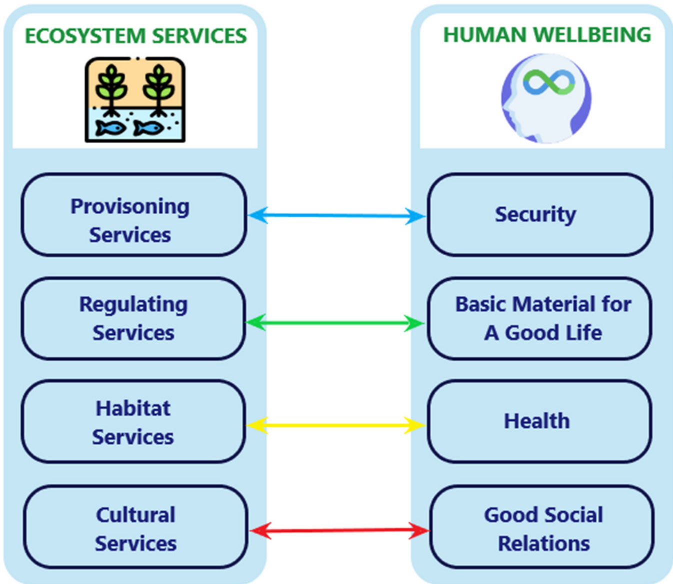

Figure 1. The corresponding domains between Ecosystem Services and Human Wellbeing (icons by Freepik from www.flaticon.com).

The Water Programme of the International Union on the Conservation of Nature (IUCN) goes further to emphasize the fact that just as HWB is impacted by multiple pressures, it also depends on multiple and interrelated ES. In addition, this relationship is often multi-layered and reflects the sustainability of the ecosystem as a whole. The work of the IUCN is illustrated in Figure 2 (Source: IUCN Water [7]). ES are a useful tool for policymakers, acting as a bridge between ecological pressures and HWB, thereby providing a framework for the identification of the impacts of these pressures on HWB. Furthermore, allowing for the subsequent valuation of those impacts in the context of non-market resources, e.g., pressures, results in negative changes to the status of the aquatic ecosystem, resulting in a change in the ecosystem services and thereby their economic value [8]. This is an approach adopted by Ecosystem-based management [9], which seeks to take into account multiple pressures while holistically addressing the balance between ecological integrity and HWB. Figure 3 graphically represents the role of ES in linking resource pressures to HWB.

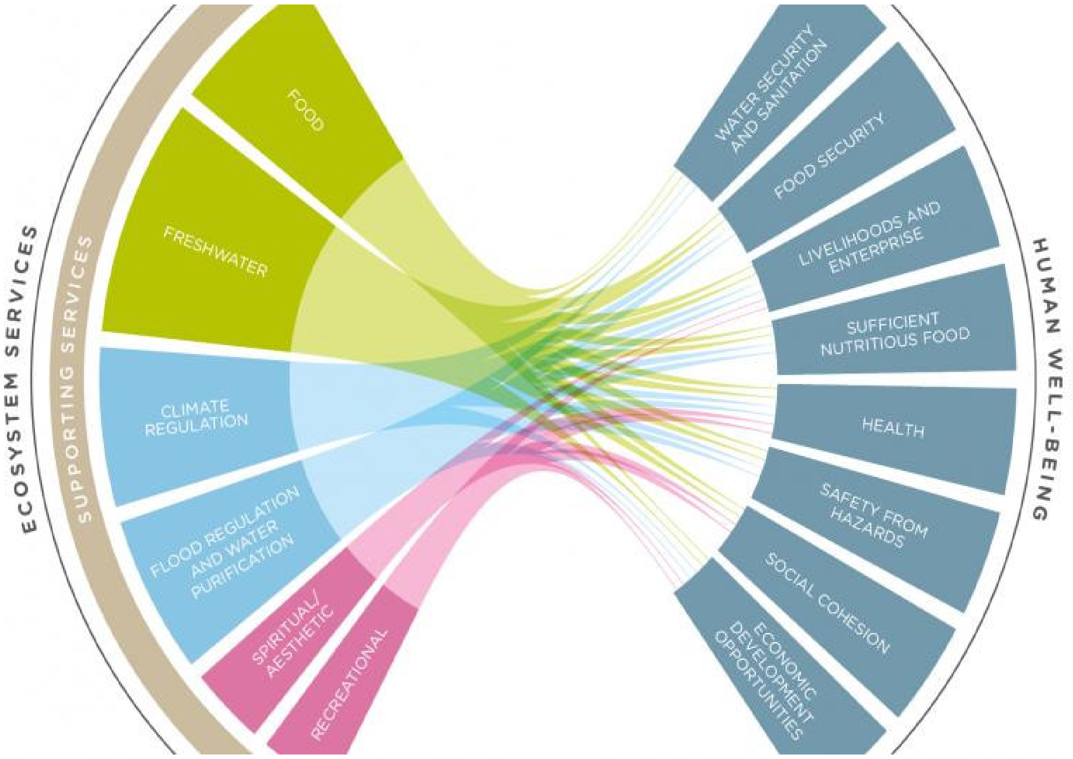

Figure 2. Linking Ecosystem Services and Human Wellbeing.

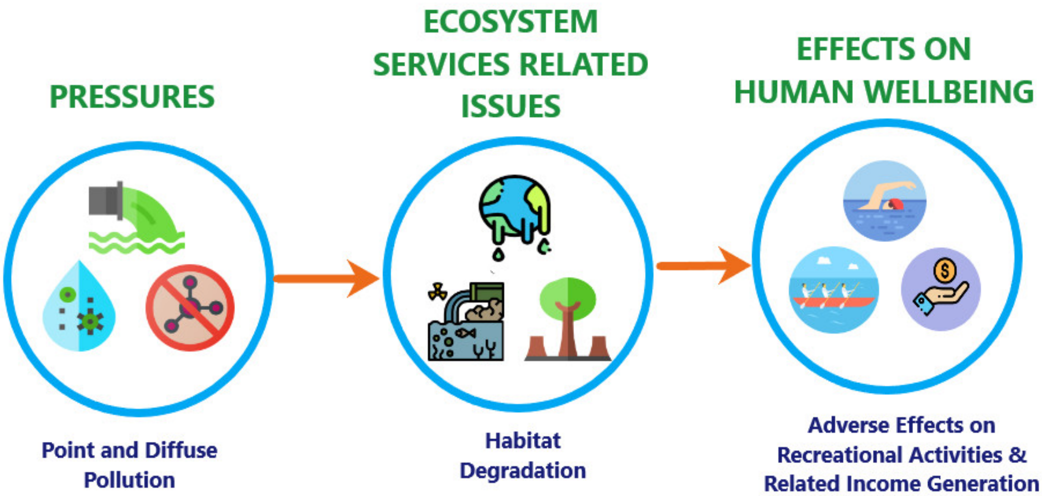

Figure 3. Linking Pressures and Human Wellbeing via Ecosystem Services (Icons by Freepik from www.flaticon.com).

In reviewing the discourse on the link between ES and HWB, the relationship of both concepts to that of sustainable development (SD) cannot be ignored. Breslow et al. [9], identified 'sustainability' as a domain of HWB and extended the definition of HWB to include a satisfactory quality of life, not just in the present but also into the future. As the two concepts go, HWB and SD, a positively synergistic relationship is often postulated from a policy perspective as it is inferred that SD will lead to increased HWB [10–12]. This is reflected in all levels of policy development, from local development plans and frameworks [13–15] to global directives and strategies such as the UN Sustainable Development Goals (SDGs), which has a dedicated SDG (SDG 3) on Good Health and Wellbeing [16].

In the context of human interactions with the environment, UNEP [4] presents three perspectives from which human wellbeing can be viewed; first, human wellbeing as a sum of assets and resources, attributed to wealth accumulated based on environmental contributions to economic growth. This view has negative implications for the environment and argues that physical capital increase and technological development can compensate for any environmental losses suffered—so-called 'weak sustainability' [17]. The second perspective is based on the subjective view of how individuals feel about their lives. This view focuses on the inner world of the individual and how the intrinsic cultural or traditional value of one's environment contributes towards life satisfaction [18,19]. The third perspective considers how the environment enables individuals "to be and to do" by providing certain benefits such as "proper nourishment, avoiding unnecessary morbidity and premature mortality, enjoying security and self-respect, and taking part in the life of the community" [4,20–22]. This perspective provides the context for the understanding of human wellbeing within the paper; whereby the environment is not merely viewed as a source of income generation, but as a facilitator for a good life based on the provision of the aforementioned benefits, otherwise known as ecosystem services.

This paper assesses the extent to which the approach towards Integrated Water Resource Management (IWRM), as set out under the Water Framework Directive (WFD), addresses HWB. Drawing from research conducted as part of the EU FP7-funded project GLOBAQUA (EU Funded GLOBAQUA Project aims to identify the prevalence of and interaction between stressors under water scarcity http://www.globaqua-project.eu/en/home/), the present work aims at examining the impact of the pressures on the water resource faced within the four case study areas in relation to HWB. Afterwards, this study assesses the responses to the effects of these pressures in the form of management actions under the WFD Programs of Measures (PoMs). The PoMs include 'basic measures' curated from other directives, such as The Habitat Directive, The Nitrates Directive, or The Urban Wastewater Treatment Directive, as well as 'supplementary measures', which are additional measures adopted invariably at a local scale to further improve water quality where the basic measures prove insufficient. This paper analyses four European river basins currently working to implement the WFD; Adige River Basin: Italy; Ebro River Basin: Spain; Evrotas River Basin: Greece; and the Sava River Basin: Croatia Serbia Bosnia and Herzegovina and Slovenia.

While it is important to take into account the pressures faced by each of the GLOBAQUA River Basins (henceforth GARBs), it is just as important to consider what the effects of these pressures are, and who is on the receiving end of these effects. That is to say, precisely what the impact of these pressures is on the wellbeing of the stakeholders concerned. As such, the term 'Human Wellbeing' is often adopted in order to incorporate the stakeholders as an 'agent' within this dynamic. Various means and approaches towards the integration of the 'human element' within environmental policy development have been investigated over the years. Giakoumis and Voulvoulis [6] examined WFD using frameworks such as DPSIR (Drivers, Pressures, State, Impacts, Responses) and attempted to incorporate stakeholder perceptions of risk in the context of ES [23,24]. In addition, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IBPES) framework and the concept of 'Natures Contribution to People' (NCP), explicitly attempted to incorporate human wellbeing in the context of ES [25–27].

The next section of this paper presents the data collection process and methods of evaluation, while Section 3 presents the results of the analysis undertaken. Finally, Section 4 concludes the paper.

2. Data Collection & Evaluation Methods

By adopting the same approach as that of the WFD, the paper focuses on the effects of multiple stressors (pressures) on a given water body and how this impacts not just the quality but the quantity of the available water resource. These pressures present in different forms, and originate from various sources, both natural and anthropogenic alike [28–30]. As a requirement of the WFD, pressures facing each River Basin Districts (RBDs) are to be identified within their River Basin Management Plans (RBMPs). A review of the RBMPs for the four GARBs (Adige, Ebro, Evrotas and Sava) was carried out and the major pressures in the GARBs have been identified and prioritised.

2.1. Data Collection

The focus of the study is on four European river basins currently working to implement the WFD; Adige River Basin (Italy), Ebro River Basin (Spain), Evrotas River Basin (Greece), and the Sava River Basin (Croatia Serbia Bosnia and Herzegovina and Slovenia). Data for this work were collected through various sources. First and foremost, a systematic literature review was conducted whilst relying on scientific journals and the grey literature in the form of official reports was looked into in order to characterise the key pressures within the GARBs. In order to identify the Ecosystem Services and the Programmes of Measures relevant to each of the GARBs, a further literature review was undertaken along with the primary data collected from stakeholder workshops and surveys. A total of eight stakeholder workshops (two per GARB) were conducted with approximately 20 participants each in order to identify and prioritise the pressures and ES at the GARB level (GLOBAQUA Sub-Deliverable 10.3: collated report on stakeholders' perception and understanding of preliminary scenarios, ecosystem valuation, land use management, and socioeconomic characterization, and evolution of trends for managing the effects of multiple stressor on aquatic ecosystems under water scarcity). Stakeholders represented a spectrum of water users within the GARBs such as utility companies, farmers associations, researchers and NGOs as well as the local authorities and river basin management agencies. The survey involved 406 participants who were resident in the GARBs aged 18 and above (i.e., voting taxpayers) and aimed at sampling stakeholder perspectives on environmental and water management, ES, climate change impacts and the WFD (GLOBAQUA Sub-Deliverable 10.4: Reporting on the questionnaire results, valuation of ecosystem, policy, perception of PoMs, awareness of water scarcity, perception of risk related to water scarcity and multi-stressor PoMs).

The results of primary data from stakeholder interviews and workshops were incorporated into the review in order to contextualise the concept of Human Wellbeing within the GARBs.

2.2. Evaluation Methods

Using an Ecosystem Services (ES) framework, pressures were linked to various aspects of Human Wellbeing at the GARB level and we subsequently identify their effects. These effects were consolidated into Human Wellbeing Factors (HWBFs), which were adopted for the assessment of the management actions. The identification and assessment of ES at the GARB level were carried out using a two-pronged approach; whereby key ES are highlighted based on identified pressures before these prioritised ES are validated by eliciting stakeholder input at GARB level via a series of workshops. Based on the aforementioned pressures, Water Provisioning, Flood Protection/Erosion Control, Biodiversity and Cultural/Recreational Services were identified as the focal ES at the GARB level.

Another round of stakeholder consultation via a survey saw stakeholders provide feedback on which ES were perceived to have the greatest potential to contribute to human wellbeing in the context of 'local prosperity' (comprised of economic prosperity, cultural identity, quality of living environment, biodiversity and social cohesion), as well as the perceived impacts of pressures on these ES. Table 1 below presents the Pressures, ES and HWB within each of the GARBs, analysing the effects of the various pressures on HWB at GARB level using an ES framework.

Table 1. Linking Pressures to Human Wellbeing: an analysis of the effects of pressures at the GARB level using an ecosystem services framework (developed from GLOBAQUA deliverables 8.1, 8.2, 8.3, 9.2, 10.3; [4,8]).

NOTES	
Type of Ecosystem Service	**GLOBAQUA Priority Ecosystem Service**
Provisioning Services	**Water Provisioning**
Regulating Services	**Flood Protection/Erosion Control**
Habitat Services	**Biodiversity**
Cultural Services	**Cultural/Recreational Services**

GARB	**PRESSURES**	**ECOSYSTEM SERVICES**				**EFFECTS ON HUMAN WELLBEING**
		GLOBAQUA Priority ES	**ES-defined Issues Related to HWB**			
			Most Important	**Most Threatened**	**Most Contribution to Local Prosperity**	
Adige River Basin	(1) Diffused Pollution (From Agricultural and Energy Sectors) (2) Population increase	Water Provisioning	Water for Drinking Water for Irrigation	Water for Drinking	Water for drinking Water for irrigation Water for hydropower	Adverse effects on water quality available for drinking and irrigation Adverse effects on water quantity impacting water availability and scarcity
	(3) Hydromorphological alterations (construction of dams and reservoirs)	Flood Protection/Erosion Control	Flood Control			Increased flood risk
	(1) Diffused Pollution (2) Population increase (3) Hydromorphological alterations	Biodiversity		Biodiversity	Biodiversity	Habitat Degradation
	(1) Diffused Pollution (2) Population increase (3) Hydromorphological alterations	Cultural/Recreational Services	Recreational Activities (Hiking, Mountaineering, Natural Parks) Aesthetic value of the landscape	Aesthetic value of the landscape	Sports and Tourism	Habitat Degradation
Ebro River Basin	(1) Point sources of pollution: urban discharges, industrial biodegradable discharges, discharges of hazardous substances, fish farms, mines, discharges salts, thermal discharges, urban landfills, toxic dumps and hazardous waste, non-hazardous waste landfills (2) Diffuse sources of pollution related to airports, transport routes, contaminated soil, irrigation, urban areas, mining areas, creative areas, meadows, livestock, gas stations. (3) Significant water abstraction related to water supply residential and non-residential purposes—irrigation, and hydroelectric and other uses (4) Morphological changes: weirs and dams, channelling, dams, hydroelectric diversion (flowing plants with diversion canals) (5) Anthropogenic pressures (excluding pollution): population increase, invasion by harmful species and diseases, recreational activities (navigation)	Water Provisioning	Water for drinking Water for Agriculture (Irrigation and Cattle) Water for Industry	Purification of water	Water for drinking Water for irrigation Water for industry	Adverse effects on water quality available for drinking and irrigation Adverse effects on water quantity impacting water availability and scarcity

Table 1. *Cont.*

Ebro River Basin	(4) Morphological changes	Flood Protection/Erosion Control	Flood control	Flood control	Flood control	Increased flood risk
	(1), (2) Pollution (Point and Diffuse sources) (5) Anthropogenic pressures (excluding pollution)	Biodiversity	Protection of endangered or local species	Protection of endangered or local species	Quality of the living environment	Habitat Degradation
	(1), (2) Pollution (Point and Diffuse sources) (3) Abstraction (4) Morphological changes (5) Anthropogenic pressures (excluding pollution)	Cultural/Recreational Services	Education/Research Mental Health—The river as a source of happiness	Cultural identity	Opportunities for Social cohesion	Habitat Degradation Adverse effects on social and mental wellness
Evrotas River Basin	(1) Water abstraction for irrigation (2) Long periods of drought (3) Pollution from agricultural activities (e.g., use of pesticides, olive and orange juice milling), aquaculture/fish farming, urban waste, septic tanks, and mining further constitute pressures in the quality of the water, resulting in the observation of high concentrations for organic loads, solids, nitrogen and phosphorus (4) Deforestation in the mountainous and semi-mountainous areas of the region	Water Provisioning	Water for drinking Water for Agriculture (Irrigation and Cattle)	Water for drinking Water for irrigation	Water for drinking Water for Agriculture (Irrigation and Cattle)	Adverse effects on water quality available for drinking and irrigation Adverse effects on water quantity impacting water availability and scarcity
	(4) Deforestation (5) Morphological pressures: channelisation, reconstruction of embankments using inappropriate methods to deepen stretches of the river (removing riverbed materials) (6) Human interventions: such as removal of natural vegetation	Flood Protection/Erosion Control				Increase in the frequency and intensity of flooding events
	(3) Pollution (4) Deforestation (6) Human interventions	Biodiversity	Conservation of Indigenous species	Protection of endangered or local species Biodiversity	Biodiversity	Habitat Degradation
	(3) Pollution (4) Deforestation (6) Human interventions	Cultural/Recreational Services	Education/Research		Tourism	Habitat Degradation Potentially adverse social and economic consequences

Table 1. *Cont.*

Sava River Basin	(1) Anthropogenic pressures: organic pollution from urban wastewater, industrial organic pollution, nutrient pollution (mainly phosphorus and nitrogen) from industry and agriculture, hazardous substances from industrial activity, pesticides from agriculture, and unexploded ordnance and hazardous materials from the military operations in early 90s, mining activities and land use change (expanding agriculture). (2) Morphological pressures: hydropower plants construction, gravel exploitation, construction of flood protection systems (3) Seasonal Flooding and Drought	Water Provisioning	Water for drinking	Water for drinking	Water for Agriculture Water for Hydropower	Adverse effects on water quality available for drinking and irrigation Adverse effects on water quantity impacting water availability and scarcity
	(2) Morphological pressures (3) Seasonal Flooding and Drought (4) Sedimentation	Flood Protection/Erosion Control	Flood control	Flood plain Flood control		Increased flood risk Habitat Degradation from flood management measures
	(1) Anthropogenic pressures (2) Morphological pressures (3) Seasonal Flooding and Drought (5) Invasive species	Biodiversity	Education/Research	Wildlife Biodiversity (animal and plants)	Biodiversity Quality of the living environment	Habitat Degradation Potentially adverse social and economic consequences
	(1) Anthropogenic pressures (2) Morphological pressures (3) Seasonal Flooding and Drought	Cultural/Recreational Services	Beautiful Scenery	Aesthetic value of the landscape	Winter sports Cultural identity Social cohesion	Habitat Degradation Potentially adverse social and economic consequences

An analysis of the effectiveness of each of the PoMs at the GARB level was carried out by conducting a qualitative content analysis using the textual codification of keywords under the assumption that 'references to' and 'occurrences of' the keywords imply that the measures address the related Human Wellbeing Factor (i.e., explicitly address the issue) before the scores were respectively ascribed to each management activity within the PoMs. Moreover, a codification of 1 or 0 was applied depending on whether or not a particular measure considers a given Human Wellbeing issue. The total number of coded occurrences divided by the total number of measures is used to calculate the percentage coverage under a given Human Wellbeing Factor.

However, we have to acknowledge that the method is not flawless and a limitation of this approach is that by focusing on the extent of coverage within the Programmes of Measures based on the prominence of certain Human Wellbeing Factors (i.e., the quantitative percentage coverage; how much certain factors feature as a proportion of the complete PoM), it does not account for implicit references to given issues within the measures. Therefore, further analysis is required to achieve a deeper understanding of the adequacy of provisions made in addressing the various issues (e.g., are two well-designed and implemented measures out of 20 measures within a PoM all that are required to adequately address flood risk?).

Nevertheless, steps to mitigate this methodological gap and account for more qualitative aspects of coverage and implementation are taken by using data from the aforementioned stakeholder survey, whereby the input is obtained to buttress findings of the content review. The scores are used to determine an Efficiency Index (EI), an overall score ascribed to each GARB Programme of Measures, based on the emergent percentage coverage. More precisely, the Efficiency Index is calculated by dividing the total number of measures relevant to each HWBF by the total number of measures reviewed multiplied by the number of HWBFs considered—in this case, four. Thus, the *EI* is obtained by Equation (1) below:

$$\mathrm{EI} = \frac{\text{Total No. of Measures Relevant to HWBF}}{(\text{Total No. of Measures Reviewed} \times 4)} \tag{1}$$

3. Results and Discussion

While it is important to take into account the pressures faced by each of the GARBs, it is just as important to consider what the effects of these pressures are, and who is on the receiving end of these effects. That is to say, precisely what the impact of these pressures is on the wellbeing of the stakeholders concerned. Any governance structure seeking to develop or implement a given piece of legislation is tasked to do so with the interest of its citizens in mind. As such, the concept of HWB must remain an ever-present consideration to be weighed against any other policy objectives. The results of this analysis are presented with findings and conclusions drawn in the context of a further literature review.

3.1. Initial Explorations

Analysis within Table 1 reveals a range of impacts on HWB which the unique set of pressures exert on the respective GARBs. While there are variations due to the differences in context, the witnessed effects of these pressures on HWB are, for the most part, consistent across all four GARBs.

More precisely, within the Adige River Basin, pollution has adverse impacts on the quality of the water resource available for drinking and irrigation. At the same time, rising population numbers increase the need for abstraction (both for drinking and irrigation), thereby adversely impacting the water availability and scarcity. Furthermore, hydropower production has resulted in further adverse effects on water quality and quantity. Hydromorphological alterations (HA) have significantly changed the flow of the river as well as the conveyance of sediments affecting the flood patterns. These HA coupled with pollution (which is exacerbated by the population increase) have severe consequences for the maintenance of the local habitat and associated wildlife. However, in the case of Adige, feedback from stakeholders on the importance of cultural ES would imply that the degradation of the natural habitat (specifically with regards to impacts on the water quality as a result of pollution) has a secondary (and thereby less) severe impact on associated recreational activities in Adige which are primarily non-water related such as hiking and mountaineering.

Similarly to Adige, in Ebro River Basin pollution has a negative effect on water quality and high abstraction by agricultural, industrial and energy sectors negatively impacts the availability of the resource. In addition, increasing population trends mean that abstraction for residential provision is also set to increase. Furthermore, the high risk of flood poses a threat to both rural (agricultural) and urban areas. With five large cities lying within the river basin, floods in the area are not just disruptive but costly [31]. In terms of biodiversity, the pressures faced by the basin such as pollution, abstraction, morphological changes and other anthropogenic pressures all contribute towards negative impacts on the natural habitat and have an adverse effect on the quality of the living environment. The loss of the natural habitat is not just a major risk factor for endangered species in the region but also affects activities such as education and research. Stakeholders also reported that intangible contributions towards social cohesion and mental wellness are also negatively affected.

In the Evrotas River Basin, while the negative effects of pollution from anthropogenic activities, eutrophication and deforestation serve to lower the quality status of the water resource available for drinking and irrigation, the water quantity presents a pressing challenge as over-exploitation of the resource (mainly in the form of abstractions for irrigation), coupled with long periods of droughts that result in scarcity. Morphological pressures and other associated human activities coupled with other natural pressures has seen an increase in the frequency and intensity of flooding events (flash floods in particular), endangering property and human lives. The same pressures which affect the water quality also contribute to the degradation of the natural habitat in the area. These pressures, along with human interventions (such as the removal of natural vegetation and riverbed material in an attempt to mitigate flooding by deepening stretches of the river) coupled with the effects of deforestation, jeopardise the balance of the local ecosystem and put local species dependent on the habitat at risk. This has particularly severe consequences in this case as the wetlands of the Evrotas river basin are listed as a Natura 2000 site. As such, activities dependent on the rich biodiversity of the area such as research and tourism are negatively affected, which may have economic consequences for the region.

Finally, in the Sava River Basin, anthropogenic and morphological pressures coupled with naturally occurring seasonal flooding contribute negatively to the quality of the water resource available for drinking and irrigation. Furthermore, seasonal droughts reduce the quantity of the resource available to meet local needs. Responses to manage seasonal flooding in the region have resulted in further morphological alterations in the form of flood protection systems which in fact exacerbate the associated morphological pressures and their impacts such as the loss of wetlands. This leads to the degradation of the natural habitat; a situation which is compounded by land-use changes to accommodate for agricultural expansion. The degradation of the habitat reduces the overall quality of the living environment, as well as the dependent wildlife and activities such as education and research. This negative impact impacts the aesthetic value of the landscape, which stakeholders have attributed a sense of cultural identity to and opportunities for social cohesion. Furthermore, the degradation of the habitat reduces opportunities for recreational (and potentially income generating) activities such as winter sports. Invasive species also pose a threat to local biodiversity with potentially negative impacts on economic activities like fishing.

All in all, across all four case studies, constant factors such as population growth trends intensify the effects of these pressures on human wellbeing (GLOBAQUA Sub-Deliverable 9.2: Assessment of the importance of freshwater ecosystem services to the economy and socioeconomic development of the GARBs under the status quo). In addition, climate change impacts [32], particularly in the form of the increased frequency and intensity of extreme weather events such as droughts and floods, have resulted in catastrophic consequences for human wellbeing. In 2014, Sava witnessed severe floods which resulted in 79 casualties and approximately 3.8 billion euros of damage [33]. In addition, 'Habitat degradation' as cited across all four GARBs is a key HWB concern, particularly as it affects income generating activities. This is also reflected by the results of the stakeholder surveys.

3.2. Identifying Management Actions at the GARB Level

This section presents an analysis of the WFD Implementation at GARB Level, taking into account the PoMs being implemented within each GARB. The analysis focuses on the extent to which the stated PoMs cover the core areas of stakeholder concern in the context of the HWB factors identified in Table 2. A review of the PoMs currently being implemented within each of the GARBs was conducted. The reviewed PoMs consist of both technical and non-technical instruments for the control of pollution, the maintenance of environmental standards and development of capacity and awareness [23,32,34–37]. The reviewed PoMs were examined in the context of the effects on HWB identified within Table 1, represented as 'HWB Factors'.

Table 2 proffers a consolidated set of 'HWB Factors' at the GARB level based on the results of the analysis presented in Table 1. These HWB factors are derived on the basis of an ES framework whereby the GLOBAQUA priority ES as examined in Table 1 (i.e., Water Provisioning, Flood Protection/Erosion Control, Biodiversity and Cultural/Recreational Services) constitute a focal unit for the analysis of the main impacts and effects which multiple pressures have on HWB at the GARB level.

The emergent impacts and effects (e.g., Adverse effects on Water Quantity - inadequate water for irrigation leading to potential loss of income; Habitat Degradation: loss of biodiversity having negative effects on dependent sectors such as research and education; Habitat Degradation: reduction in the aesthetic value of the habitat and consequently intangible benefits such as mental health and social cohesion) are consolidated under the umbrella of a single factor (Human Wellbeing Factor: HWBF) which captures all the underlying concerns. These factors are (i) adequate water for drinking, irrigation, industry/energy (quality and quantity), (ii) increased flood risk, (iii) habitat degradation/biodiversity, and (iv) habitat degradation/intangible socioeconomic benefits.

Table 2. Deriving GLOBAQUA River Basins (GARB) Human Wellbeing factors (*Note: Each ES Type Denoted by a different colour).*

Type of Ecosystem Service	GLOBAQUA Priority Ecosystem Service	GARB HWBF
Provisioning Services	Water Provisioning	Adequate Water for Drinking, Irrigation, Industry/Energy (Quality and Quantity)
Regulating Services	Flood Protection/Erosion Control	Increased Flood Risk
Habitat Services	Biodiversity	Habitat Degradation/Biodiversity
Cultural Services	Cultural/Recreational Services	Habitat Degradation/Intangible Socioeconomic benefits

3.3. Relating Management Actions to Human Wellbeing

These four HWBF form the basis of the assessment of the PoMs at the GARB level in order to determine how effective they are as management actions in addressing the effects of the identified pressures on HWB. PoMs within each basin were qualitatively analysed to determine which specific measures and management actions explicitly addressed the HWB issues identified within the GARBS.

Table 3 and Figures 4–8 present a summary of the results of this analysis, highlighting the total number of measures reviewed within each GARB, the total number or measures relevant to each HWB factor, the proportion of 'attention' given to each HWB factor expressed as a percentage, and finally, an efficiency index based on the overall HWB coverage of the PoMs.

Table 3. The analysis of Programs of Measurements (PoMs) at the GLOBAQUA River Basins (GARB) level by considering the Human Wellbeing (HWB) factors* (Developed from the following: GLOBAQUA Deliverables 2.5, 8.1, 8.2, 8.3, 9.2, 10.3; [32,35–41]).

GARB		GARB Human Wellbeing Factors				Efficiency Index
		Water for Drinking, Irrigation, Industry/Energy (Quality and Quantity)	**Increased Flood Risk**	**Habitat Degradation/Biodiversity**	**Habitat Degradation/Intangible Socioeconomic benefits**	
Adige River Basin (87 Measures Reviewed)	**No. Measures relevant to HWBF**	87	10	76	76	**7.2**
	% coverage per HWBF	100%	11%	87%	87%	
Ebro River Basin (19 Measures Reviewed)	**No. Measures relevant to HWBF**	19	11	19	19	**8.9**
	% coverage per HWBF	100%	58%	100%	100%	
Evrotas River Basin (66 Measures Reviewed)	**No. Measures relevant to HWBF**	66	4	61	63	**7.3**
	% coverage per HWBF	100%	6%	92%	95%	
Sava River Basin (87 Measures Reviewed)	**No. Measures relevant to HWBF**	44	24	52	52	**8.3**
	% coverage per HWBF	85%	46%	100%	100%	

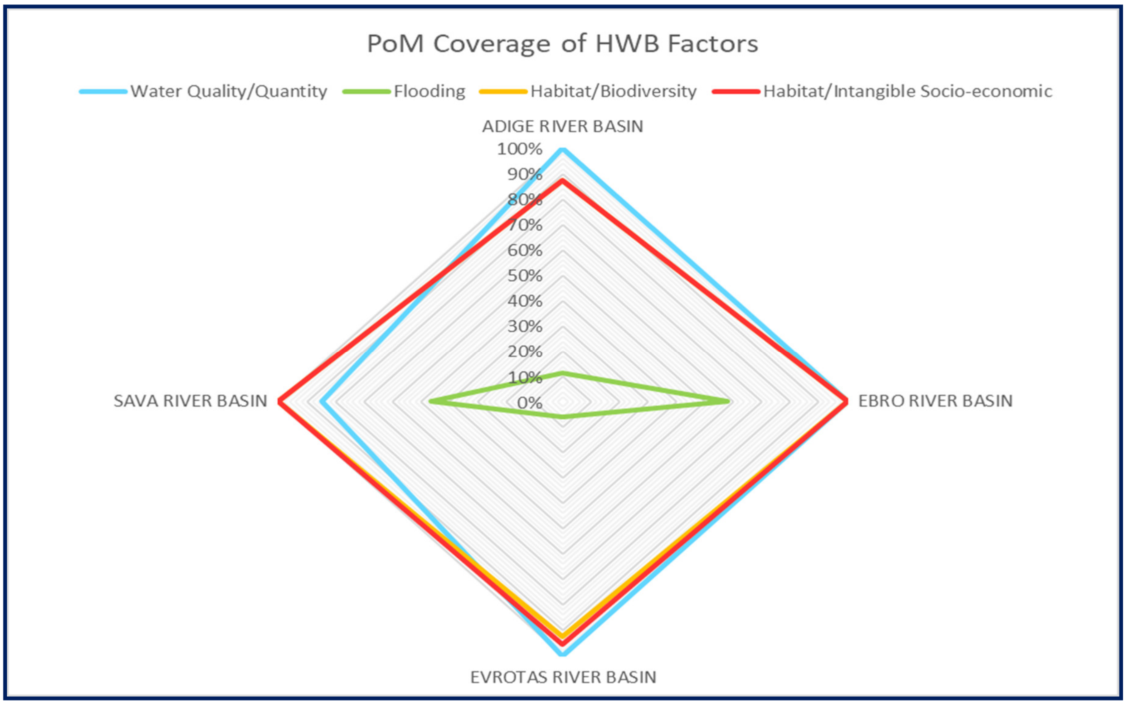

Figure 4. The coverage of Human Wellbeing (HWB) factors within the GLOBAQUA River Basins (GARBs).

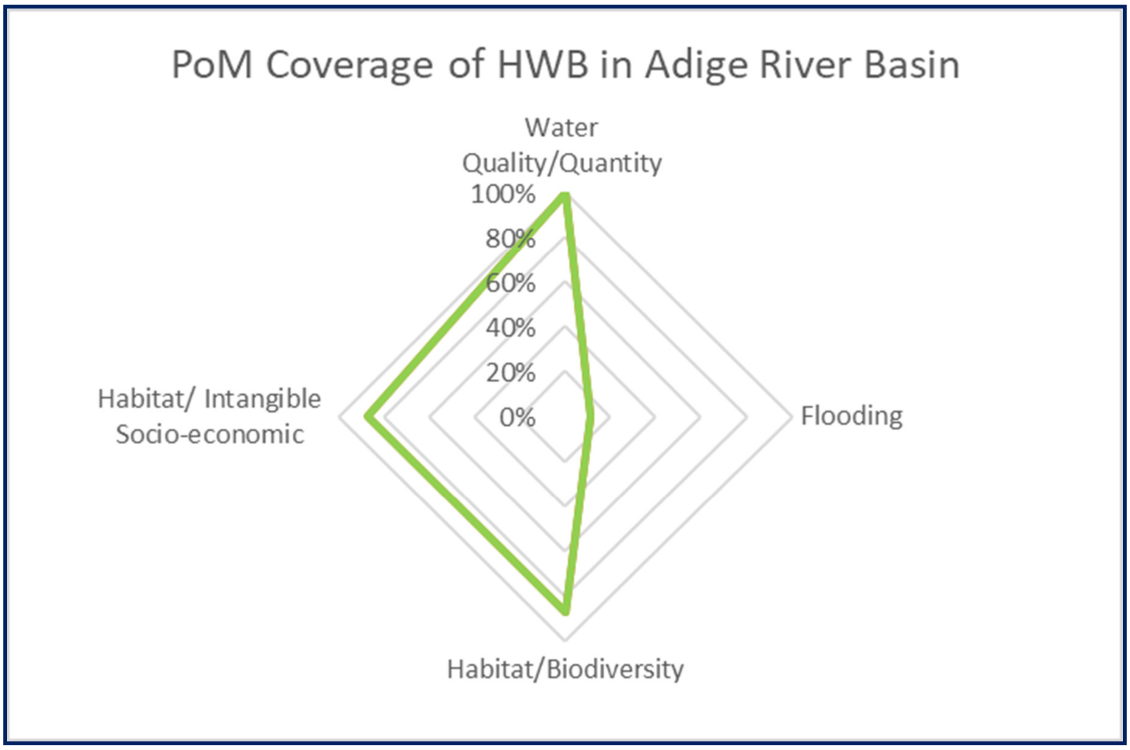

Figure 5. The coverage of HWB factors within the Adige River Basin.

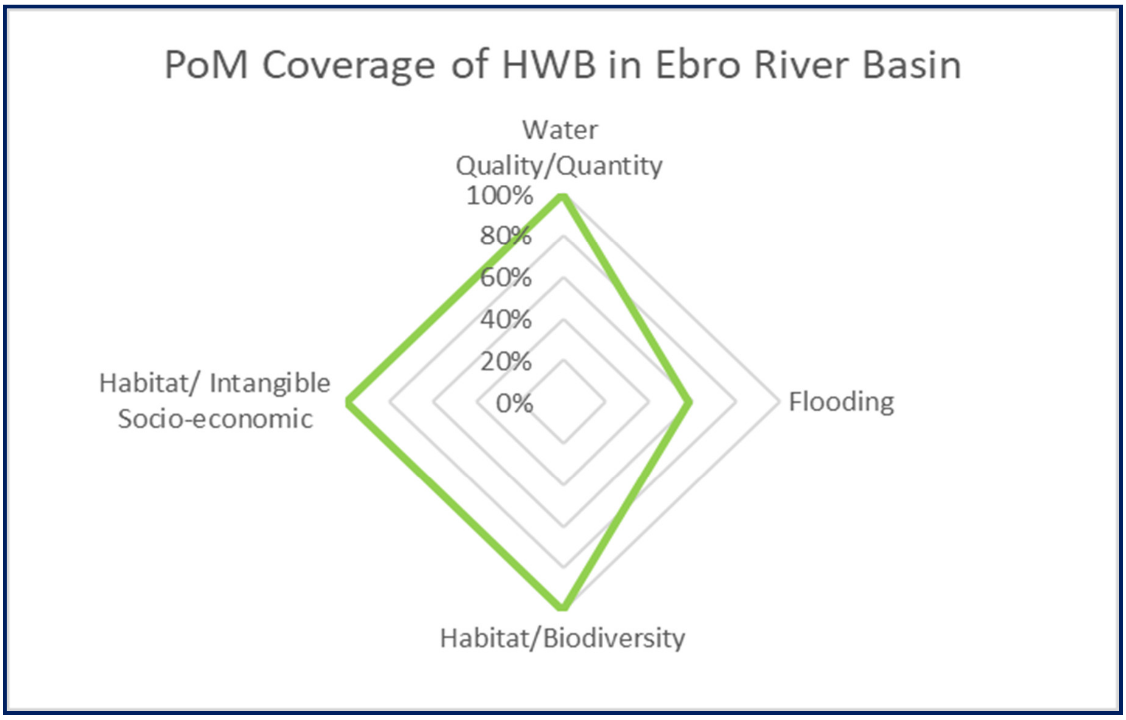

Figure 6. The coverage of HWB factors within the Ebro River Basin.

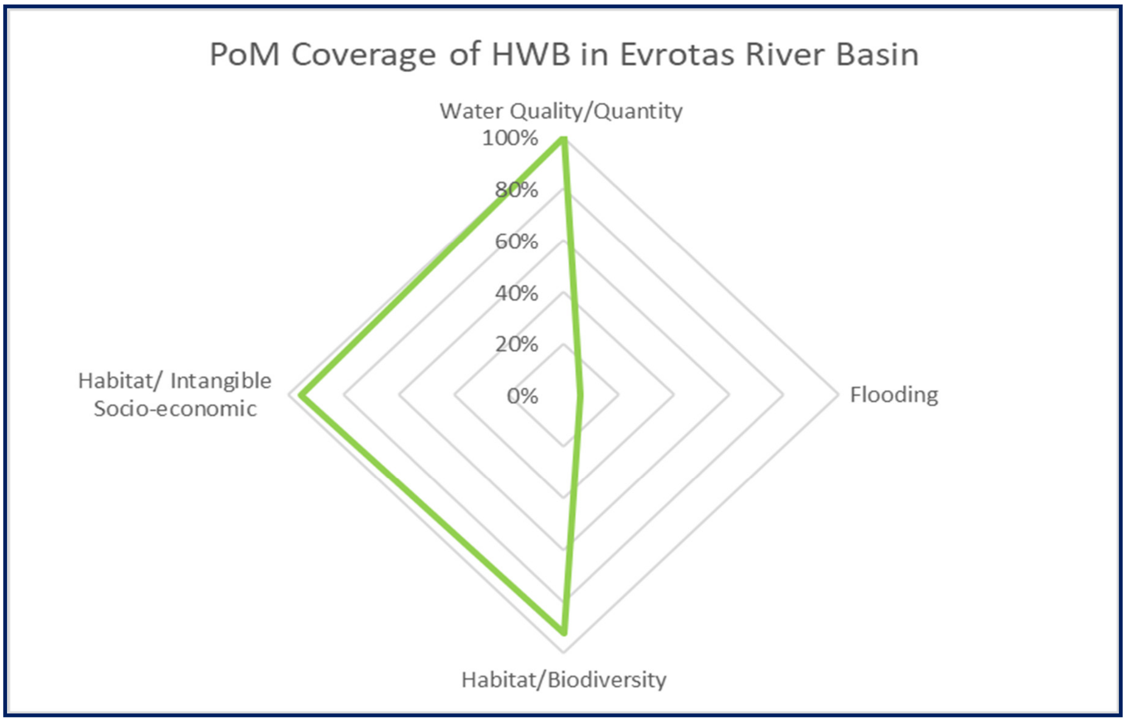

Figure 7. The coverage of HWB factors within the Evrotas River Basin.

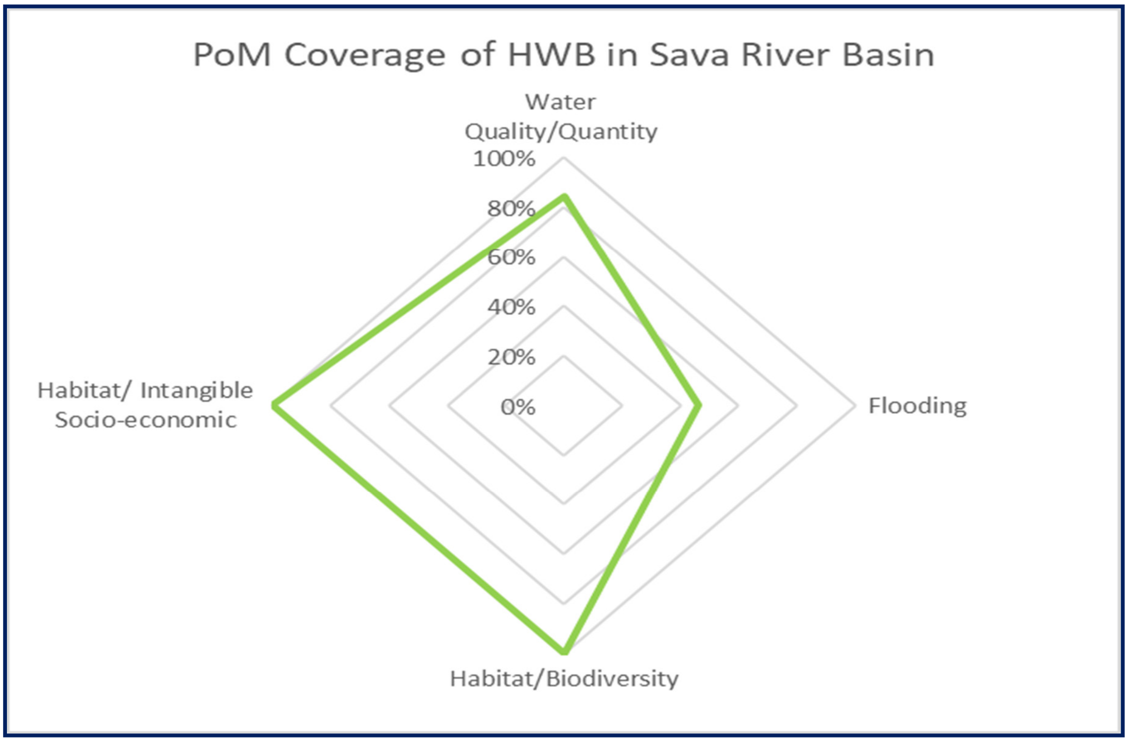

Figure 8. The coverage of HWB factors within the Sava River Basin.

More precisely, the results depicted in Table 3 and Figure 4 show that overall the greatest attention is devoted to management actions which seek to address the effects related to provision of adequate 'Quality and Quantity of Water' to serve human needs such as drinking as well as productive uses like irrigation, energy production and industrial activities. This is unsurprising as the core focus of the WFD and the basis upon which it determines the 'good status' of the water body is the water quality and quantity within each river basin. Coming a close second in terms of priority are effects related to 'Habitat Degradation', both in terms of 'Biodiversity' and 'Intangible Socioeconomic benefits'. Once again, this finding is expected due to the strong correlation between the status of Ecosystem/Habitat health and the status of Water Quality and Quantity. As such, measures which are designed to consider HWB effects related to the adequate availability of good quality water will inadvertently (or otherwise) address the effects on HWB associated with Habitat Degradation. Surprisingly, it would appear that despite the catastrophic effects that 'Flooding' potentially has on HWB, comparatively little attention is devoted to the issue within the context of the PoMs of the WFD. Overall, with an Efficiency Index of 8.9 out of 10, the PoM for the Ebro river basin shows the most effective response to the impacts of pressures on HWB at GARB level as a function of the range of coverage of the various HWB factors. Next is the Sava river basin, with an Efficiency Index of 8.3, followed by Evrotas (7.3) and finally Adige (7.2).

In the Adige river basin (Table 3 and Figure 5), all 87 measures analysed addressed the effects of pressures on HWB with regards to availability of water, both in terms of quality and quantity. In terms of effects on HWB related to habitat degradation (both Biodiversity' and 'Intangible Socioeconomic benefits'), 76 of the 87 measures were found to be relevant. Finally, only 10 of the reviewed measures targeted effects related to flooding and the associated effects on HWB. The Adige river basin achieved an overall efficiency index of 7.2, the lowest score among the GARBs. Despite this, the stakeholder survey reveals that 88% of respondents within the river basin feel that their water resources are well managed. This would suggest that the perception of the negative effects of the pressures on HWB is limited. This impression is reflected by the limited number of stakeholders who perceive their water resources are sometimes at risk (25%). With regards to the specific measures, the highest levels of support were given to measures promoting reusing water or treated wastewater, restoration of natural conservation areas alongside rivers and canals, imposing heavier fines for illegal access to the public water supply network, increasing erosion protection, imposing heavier fines for industries which pollute water resources and the environment, and promoting pollutant (PCP) free pesticides. There was less support for measures aimed at the development of dams and stopping urban development in areas prone to flooding.

In the Ebro river basin (Table 3 and Figure 6), PoM is comprised of a much more compact 19 measures, all of which address the effects on HWB related to availability of adequate water of good quality, habitat degradation in terms of biodiversity, as well as habitat degradation in terms of the wider socioeconomic benefits they provide. Fewer measures targeted issues related to effects of flooding on HWB (11 out of 19), despite a majority of stakeholders indicating that they had observed an increase in the frequency of flooding events. This disconnect between the issues perceived and felt by stakeholders and the issues addressed by the PoM is reflected in the limited faith the stakeholders have in the management of their water resources, with almost 87% of respondents stating that they feel water resources are sometimes at risk; and while the analysis indicated that the Ebro PoMs received an HWB efficiency index of 8.9 (the highest of the four GARBs), only 25% of respondents stated that they felt that the water resources were properly managed. However, when asked, respondents were largely in favour of the proposed measures (less than 10% of respondents indicated that they were some level of opposed), The highest levels of support are given to imposing heavier fines for industries that pollute water resources and the environment, banning the use of some pesticides dangerous for insects (bees) and birds, restoration of natural conservation areas alongside rivers and canals, and banning the use of pesticides and chemical fertilisers on agricultural land above drinking water resources.

A total of 66 measures were reviewed in Evrotas (Table 3 and Figure 7) and, as in the case of the other river basins, the greatest attention is paid to measures related to water quality and quantity (100%). The effects of the pressures on HWB in terms of habitat degradation (both biodiversity and wider socioeconomic issues) also received considerable coverage: 92% and 95%, respectively. Again, as in other river basins, limited coverage (6%) is given to flood-related impacts, despite a majority of stakeholders indicating that they were aware of recent flooding events. Overall, the Evrotas river basin set of management actions received an efficiency index of 7.3. The stakeholder feedback indicated that most respondents are greatly concerned about the state of the local water resources, with over 94% of the respondents believing the water resources are sometimes at risk. At the same time, a mere 9% of respondents stated that they feel that the water resources and services were properly managed. With such low levels of support for how the water resources are being managed, it is surprising that less than 10% of respondents indicated some level of opposition to the proposed measures; with the highest levels of support given to measures geared towards replacing chemical fertilisers with organic fertilisers, banning the use of some pesticides dangerous for insects (bees) and birds, restoration of natural conservation areas alongside rivers and canals, reusing water or treated wastewater, development of vegetated strips alongside urban infrastructure (roads, railways, roundabouts), and enforcing functioning water meters for households and companies. This suggests a gap between measures as stated within the RBMP and the reality of implementation on the ground.

In the Sava river basin (Table 3 and Figure 8), a total of 52 measures were analysed, which resulted in an overall efficiency index of 8.3. Sava is the only case in which not all 100% of the measures target HWB effects to do with water quality and quantity. This is due to the fact that there is a subset of measures exclusively devoted towards addressing invasive species within the river basin which focuses on the biodiversity of the aquatic and non-aquatic habitat, but do not provide for the quality of the water within the aquatic habitat. This additional attention devoted to the maintenance of the natural habitat is reflected in the fact that 100% of the measures address HWB effects related to both aspects of biodiversity and intangible socioeconomic benefits as an aspect of concerns around habitat degradation. Being a transboundary case, there were observed differences in the perceptions of stakeholders depending on their location, particularly with regards to the perception of how well water resources are being managed, with most respondents within the river basin countries being of the opinion that the water resources were not well managed, and Slovenia being the exception where 60% of stakeholders believed that the resources were, in fact, well managed. Overall, there was consistency with regards to other aspects; most respondents believe that the water resources are at risk and also that there has been an increase in recent flooding events. There was also consensus in support for a majority of the measures proposed (less than 10% opposition across all countries), with the highest levels of support given to imposing heavier fines for industries which pollute water resources and the environment, banning the use of some pesticides dangerous for insects (bees) and birds, banning the use of pesticides and chemical fertilisers on agricultural land above drinking water resources, and the promotion of pollutant-free PCPs.

3.4. Enhancing the Efficiency of Management Actions

Based on the findings presented in the previous sections, it would appear that the management actions adopted within the GARBs, for the most part, are effective in managing the effects of multiple pressures on HWB. A notable exception is observed with regards to management actions and measures targeting effects on HWB related to flooding. Given that stakeholder concern regarding flooding is unanimous across all four GARBs and instances of more extreme flood events have been witnessed more frequently in recent times, the apparent lack of attention devoted to flood-related HWB issues would seem counter-intuitive. One possible explanation for this, however, is that while the core mandate of the WFD is good ecological quality by regulating water quality, there are other directives such as the Floods Directive, which have an explicit mandate geared towards targeting flood-related issues and so there is a less pressing need to impose such measures within the WFD PoMs.

The existence of other management actions outside of the PoMs, however, does not account for the perceived implementation gap, as observed most acutely in the case of the Ebro river basin, whereby the management actions as set out within the PoMs in theory sufficiently address the effects of multiple pressures on HWB, but in practice stakeholders do not perceive this as such. This observation echoes the wider challenges of implementing the WFD as identified by Voulvoulis et al. [41], citing discrepancies between how the WFD is being implemented at all stages from the development of RBMPs, to the design, implementation, enforcement and monitoring of the PoMs.

Although in principle, the development of the PoMs ought to be an iterative process, with measures tied directly to identify pressures within the river basins, this has not consistently been the case. While the second round of RBMPs show some improvements when compared to the first round RBMPs in terms of addressing the economic assessment of the Cost–Benefit Analyses, there is still a marked gap in terms of linking the PoMs with the identified pressures and no effort at all given to linking these measures with the tangible effects on HWB [32,35,36,38–41].

There is also a marked lack of consistency in the presentation of the PoMs across the different RBMPs, with some providing very little detail with regards to specific measures, while others provide specific actions including the scope and location in relation to the various measures. Some of these challenges have been acknowledged by the relevant authorities, with steps taken to identify causes (e.g., gaps in the data, in the identification of significant pressures, and within the assessment of impact, etc.) and steps are being taken to rectify the issues in the subsequent management cycles [32].

Finally, in addition to implementation challenges, the WFD presents some fundamental conceptual gaps to explicitly acknowledge concepts such as Ecosystem Services, Sustainable Development and Human Wellbeing. While the WFD adopts an approach which is philosophically aligned with Ecosystem-based management in the development of its RBPMs, attempts are made to quantify the changes of various system components under multiple pressures. However, a crucial step is missing in linking these ES and pressures to HWB primarily through the use of robust non-market valuation methods [20]. Tools such as the MESH (Mapping Ecosystem Services to Human well-being) scenario generation tool, developed by the Natural Capital Project, models the link between ES and HWB and could potentially provide crucial decision support to policymakers and practitioners focusing on sustainable resource management for the benefit and wellbeing of all stakeholders. In light of the important role that sustainable development plays in this policy development process, the project is also developing an extension to the MESH tool, MESH-SDG, which aims to link outputs to SDG indicators and assess performance under various ecosystem change scenarios arising from interventions and management actions related to land-use planning or investment decisions [42].

4. Concluding Remarks

In light of the prevalence of multinational agendas such as the global effort towards sustainable development, there is a pressing need to balance the welfare of the environment and the developmental requirements of the human population. As such, in the context of governance, policy and development, HWB remains a central issue for the development of effective policies to manage natural resources. Despite this, the concept is ambiguous due to its multidimensionality. As such, grounding it in more tangible frameworks such as ES provides a useful means of utilising the concept of HWB and creating concrete links to management challenges and natural resource pressures such as over-exploitation of the resource. Therefore, HWB must remain an ever-present consideration to be weighed against any other competing policy objectives. In particular, policies such as the Water Framework Directive (WFD), seek to effectively manage limited environmental resources, must consider the relationship between the environment and HWB; viewing the environment not merely as a source of income generation, but as a catalyst for improved quality of life by the provision of Ecosystem Services (ES).

In the case of the WFD, while the identified GARB PoMs would appear to cover the majority of the areas of concern in terms of HWB impacts of the pressures, there are also noticeable gaps when it comes to effects such as those associated with increased flood risk. In addition, an observable implementation gap is emergent when stakeholder feedback is considered in contrast with what is presented within the PoMs. This reflects the wider methodological challenges and inadequacies in the process of developing and implementing PoMs in keeping with the WFD mandate. It is worth mentioning that valuation constitutes a crucial step not only in gaining a deeper understanding of the effects of pressures on HWB in the context of ES services but is a fundamental part of the process of developing a robust PoM and meeting the requirements of Article 9 of the WFD. The effective engagement and involvement of stakeholders as part process is essential in order not only to elicit their preferences for valuing services, but also to determine aspects like willingness to pay, in order to efficiently design economic instruments aimed at achieving full cost recovery [1,4,43]. Further research undertaken as part of the GLOBAQUA project addresses these issues, putting forward more effective means of applying these socioeconomic methods in the context of the WFD in order to achieve the best practices.

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