A catalogue of ecosystem-based measures to inspire adaptation in Central Viet Nam

Annex to the UNU-EHS research report: Opportunities for improved flood risk management and adaptation in Hue, Central Viet Nam: Addressing current and future flood risks.

September 2025

Authors

Andrea Ortiz Vargas[1], Jonas Hansohm[1], Nguyen Thi Nhat Anh [2], Hoàng Công Tín[3], Kerstin Büche[4], Felix Bachofer[5], Yvonne Walz[1]

Reviewers

Sally Janzen[1], Caitlyn Eberle[1], Dominic Sett[1]

[1] United Nations University Institute for Environment and Human Security (UNU-EHS)

[2] Private consultant

[3] Faculty of Environment, Hue University of Sciences (HUSC)

[4] geomer GmbH

[5] Earth Observation Center - German Aerospace Center (DLR)

This document was prepared within the FloodAdaptVN project under the Sustainable Development of Urban Regions (SURE) funding priority, sponsored by the German Federal Ministry of Research, Technology and Space (BMFTR).

1. The catalogue

The 16 ecosystem-based measures featured in this annex were selected after assessing and understanding the current risk as explained in the "Flood risks in Hue, Central Viet Nam: An assessment of flood hazard, exposures, vulnerabilities, root causes and impacts" report (Sett and others, 2024). Complementing the results of the "Opportunities for improved flood risk management and adaptation in Hue, Central Viet Nam: Addressing current and future flood risks" report (Ortiz Vargas and others, 2025). This annex provides additional information concerning the potential of ecosystem-based measures to complement existing efforts to reduce flood risk in Hue city.

2. Hue city

Understanding the appropriateness and possible effectiveness of potential flood risk management measures as part of a comprehensive strategy requires an understanding of the hydrology and characteristics of the city as an interconnected landscape. Through a landscape approach, the research team of the FloodAdaptVN project divided the Huong River catchment into four distinct and interconnected regions, namely the mountain, peri-urban, urban and coastal regions (Figure 1).

Figure 1: Different regions in the Huong River catchment are represented in different colours (Illustration by Caitlyn Eberle).

We recognise that the flood hazard dynamics may vary from one context to another and in some cases the ecosystem-based measures need to be also implemented in adjacent catchments. In the context of flood risk in Hue, the Bo River catchment, for example, is also a relevant location for the implementation of measures, as it also influences flood risk in Hue. But for an easier understanding of the relevance of the landscape approach to address flood risk, we demonstrate the implementation of ecosystem-based measures within the basic ecological unit of a catchment, which we exemplified with the Huong River and its regions. These main regions will be used as a framework to present options of ecosystem-based measures that could be applied in each of the catchment segments (Table 1, 2, 3, 4 and 5).

3. Compilation of evidence of flood risk reduction benefits

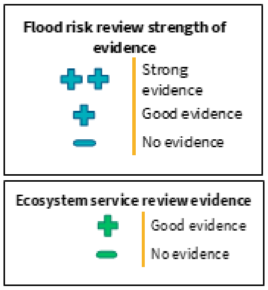

Figure 2: Categories to organize the results of the literature reviews.

The compilation of evidence consisted of two literature reviews to collect evidence of the influence of the ecosystem-based measures on the different components of disaster risk.

The first systematic review focused on how identified ecosystem-based measures reduce flood risk. In it, instances where implementation was documented were classified as “strong evidence”. The second literature review was about the contribution of ecosystem services to reduce flood risk. This compilation of evidence also included the compilation of specific parameters related to flood hazards: infiltration, evapotranspiration, surface run-off, surface-water storage, water discharge and flood routing, due to their relevance as input information for the flood models developed in the project.

The findings from both reviews are presented in the next section with different colours to differentiate them and separate scales of the strength of evidence (Figure 2) to communicate the type of evidence found. Blue represents the results of the “systematic review on how identified ecosystem-based measures reduce flood risk” and green represents the “systematic review on the contribution of ecosystem services to reduce flood risk”.

4. Evidence of how ecosystem-based measures can provide flood risk reduction benefits

Table 1: Visual representation of strength and amount of evidence of the influence of the ecosystem-based measures on the different components of flood risk. One plus sign means good evidence, two plus signs mean strong evidence, and a minus sign means no evidence found. Blue represents the results of the systematic review on how identified ecosystem-based measures reduce flood risk, and green represents the results of the systematic review on the contribution of ecosystem services to reduce flood risk.

Catchment region	Ecosystem-based measure(s)	Documented evidence of flood risk reduction benefits			Documented evidence of provision of ecosystem services relevant for flood risk reduction		
		Hazard	Exposure	Vulnerability	Hazard	Exposure	Vulnerability
Coastal	**Mangroves:** afforestation, conservation, restoration	+ +	+ +	+ +	+	+	+
Coastal	**Sand dunes:** conservation, restoration	+	+ +	−	+	+	+
Coastal	**Coastal forest:** afforestation, conservation, restoration	+ +	+ +	+ +	+	+	+
Urban	**Permeable pavement:** establishment	+ +	+ +	−	−	−	−
Urban	**Urban vegetation:** establishment, conservation	+ +	+ +	−	+	+	+
Urban	**Home gardens:** conservation	−	+	−	+	+	+
Urban	**Green open spaces:** establishment, conservation	+ +	+ +	−	+	+	+
Urban	**Green corridors:** establishment, conservation, restoration	+	+	−	−	−	−
Urban	**Flood-plain:** reconnection, restoration	+	+	+ +	+	+	+
Urban	**Lentic water bodies:** restoration, conservation	+	+	−	+	+	+
Urban	**Lotic natural waterways:** natural drainage path restoration, conservation	+ +	+ +	−	+	+	+
Urban	**Riverbanks:** restoration of riverbanks with bioengineering materials	+	−	−	+	+	+
Peri-urban	**Vegetated filter strips:** establishment, conservation, restoration	+ +	−	−	−	−	−
Peri-urban	**Flood-tolerant rice crops:** cultivation	+ +	+ +	−	−	−	−
Peri-urban Mountain	**Agroforestry in riparian buffers:** establishment, conservation, restoration	+ +	+ +	+ +	+	+	+
Mountain	**Forest:** afforestation, conservation, restoration, sustainable management	+ +	+ +	+ +	+	+	+

Table 2: Documented evidence from literature that supports Table 1 graphics and icons in relation to flood risk reduction benefits. See references for extended evidence.

		Documented evidence of flood risk reduction benefits		
Catchment region	**Ecosystem-based measure(s)**	**Hazard**	**Exposure**	**Vulnerability**
Coastal	Mangroves: afforestation, conservation, restoration	General flood risk reduction (Menéndez and others, 2019; Karanja and Saito, 2018). Physical barrier reducing tidal flooding and abrasion intensity, reducing flood intensity (Utami and others, 2021; van Coppenolle and others, 2018); reduced flood wave velocity(Deb and Ferreira, 2017) and peak flows (Liu and others, 2013); improved flow routing(Montgomery and others, 2022). Removal of nitrogen, phosphorus and other deoxidizing matter from flood water, reducing flood impact (Wang and others, 2010).	General flood risk reduction (Menéndez and others, 2019; Karanja and Saito, 2018). Physical barrier against tidal flooding and abrasion, reducing exposure (Hilmi and others, 2022; Utami and others, 2021; Beck and others, 2022); Storm wave attenuation and coastal protection(van Hespen and others, 2023; Tyagi, 2022; Hamza and others, 2022).	Provision of firewood (Munji and others, 2013; Munji and others, 2014; Karanja and Saito, 2018); Provision of fish as a food source (Karanja and Saito, 2018; Munji and others, 2014; Munji and others, 2013; Debrot and others, 2022); Provision of medicinal resources (Munji and others, 2014; Karanja and Saito, 2018); Contribution/maintenance of biodiversity (Munji and others, 2013); Contribution to recreational opportunities and tourism (Karanja and Saito, 2018).
	Sand dunes: conservation, restoration	Physical barrier reducing wave overwash (intensity), enhanced via vegetation presence (Fernández-Montblanc and others, 2020).	Physical barrier to wave overwash, enhanced via vegetation presence, thereby reducing exposed area (Fernández-Montblanc and others, 2020).	No evidence
	Coastal forest: afforestation, conservation, restoration	Storm wave attenuation with sufficient forest width and density, reducing flood intensity (van Hespen and others, 2023).	Storm wave attenuation with sufficient forest width and density, thereby reducing exposed area (van Hespen and others, 2023).	Provision of firewood (Munji and others, 2013); Provision of fish as a food source (Munji and others, 2013).
Urban	Permeable pavement: establishment	High water infiltration efficiency vs. impermeable surfaces, reducing flood intensity (Rankin and Ball, 2004; Zheng and others, 2019; Liu and others, 2014; Yoo and others, 2016).	Reduced effective flood volume in affected areas due to higher water infiltration efficiency, thereby reducing exposed area (Rankin and Ball, 2004; Zheng and others, 2019; Liu and others, 2014; Yoo and others, 2016).	No evidence
	Urban vegetation: establishment, conservation	Enhanced water interception, infiltration and retention capacity in soil, reducing flood intensity (Zheng and others, 2019; Liu and others, 2014; Reu Junqueira and others, 2022; Lu and others, 2022; Kim and others, 2016; Kim and Park, 2016); Reduced pluvial runoff, reducing flood	Enhanced water interception, infiltration and retention capacity in soil, thereby reducing exposed area (Zheng and others, 2019; Liu and others, 2014; Reu Junqueira and others, 2022; Lu and others, 2022; Kim and others, 2016; Kim and Park, 2016); Reduced pluvial runoff, reducing exposed area (Reu	No evidence

		intensity(Reu Junqueira and others, 2022; Zia and others, 2022).	Junqueira and others, 2022; Zia and others, 2022); Physical barrier dissipating floodwater energy, reducing exposed area (Liu and others, 2023b).	
	Home gardens: conservation	Improved infiltration via porous ground cover in comparison to paved gardens, reducing flood intensity (Kelly, 2018).	Reduced effective flood volume in affected areas due to higher water infiltration efficiency, reducing exposed area (Kelly, 2018).	No evidence
	Green open spaces: establishment, conservation	Enhanced water interception and soil infiltration capacity, reducing flood intensity (Liu and others, 2014; Kim and others, 2016); Mitigated runoff, and thereby intensity (Liu and others, 2014; Zia and others, 2022); Improved evaporation of runoff water, reducing flood intensity (Liu and others, 2014).	Enhanced water interception and soil infiltration capacity, reducing exposed area (Liu and others, 2014; Kim and others, 2016); Mitigated runoff via improved evaporation, reducing exposed area (Liu and others, 2014).	No evidence
	Green corridors: establishment, conservation, restoration	Boost infiltration and water retention capacity of soil, reducing flood intensity (Wang and others, 2010; Staccione and others, 2024).	Boost infiltration and water retention capacity of soil, reducing exposed area (Wang and others, 2010; Staccione and others, 2024).	No evidence
	Floodplain: reconnection, restoration	Dense vegetation reduces flood flow velocities (Komora, 1981).	Dense vegetation reduces flood flow velocities, reducing exposed area (Komora, 1981).	Provision of fish as a food source (Singha and Pal, 2023).
	Lentic water bodies: restoration, conservation	Improved soil water holding capacity, reducing excess runoff and thereby reducing flood intensity (Gautam and Corzo, 2023); Serve as temporary water storage, minimizing flood stress and peak flows, thus reducing flood intensity (Tang and others, 2020b; Javaheri and Babbar-Sebens, 2014; Tang and others, 2020a; Wang and others, 2022); Vegetated wetlands reduce flow speed and flooding extent, reducing flood intensity (Nithin Kumar Reddy and others, 2017).	Barrier reducing flow velocity and flooded area(Rojas and others, 2022); Improved soil water holding capacity, reducing excess runoff and thereby reducing exposed area (Gautam and Corzo, 2023); Serve as temporary water storage, minimizing flood stress and peak flows, thus reducing exposed area (Tang and others, 2020b; Javaheri and Babbar-Sebens, 2014; Tang and others, 2020a; Wang and others, 2022); Vegetated wetlands reduce flow speed and flooding extent, thereby reducing exposed area (Kumar Yadav and others, 2015).	No evidence
	Lotic natural waterways: natural drainage path restoration, conservation	Enhanced water storage capacity via high stream network connectivity/complexity, thus reducing flood intensity (Gao and others, 2020; Yang and others, 2016); Enhanced drainage via high stream	Enhanced water storage capacity via high stream network connectivity/complexity, reducing exposed area (Gao and others, 2020; Yang and others, 2016); Enhanced drainage via high stream	No evidence

		network connectivity/complexity, thus reducing flood intensity (Yang and others, 2016); Natural river embankments enhance flow vs concrete embankments, reducing flood intensity (Li and Wang, 2019).	network connectivity/complexity, thus reducing exposed area (Yang and others, 2016); Natural river embankments enhance flow vs concrete embankments, reducing exposed area (Li and Wang, 2019).	
	Riverbanks: restoration with bioengineering materials (e.g. plants)	Mitigated streamwise velocity and bank erosion under ungrazed grassy cover and forest cover, thus reducing flood intensity(Esfahani and Keshavarzi, 2010; Tomer and van Horn, 2018; Rood and others, 2015).	Mitigated streamwise velocity and bank erosion under ungrazed grassy cover and forest cover, reducing exposed area (Esfahani and Keshavarzi, 2010; Tomer and van Horn, 2018; Rood and others, 2015).	No evidence
Peri-urban	Vegetated filter strips: establishment, conservation, restoration	Filtration of nitrogen and phosphorus-based waste matter in floodwater, reducing flood impact (Yates and Sheridan, 1983).	No evidence	No evidence
	Flood-tolerant rice crop cultivation	Improved river basin water storage capacity via paddy fields in high flow accumulation areas, reducing flood intensity (Osawa and others, 2020).	Improved river basin water storage capacity via paddy fields in high flow accumulation areas, reducing exposed area (Osawa and others, 2020).	No evidence
Peri-urban, and mountain	Agroforestry in riparian buffers: establishment, conservation, restoration	Improved water storage and use by trees(Udawatta and Jose, 2021) Reduced flood discharge and velocity with sufficient vegetation diameter/roughness, thus reducing flood intensity(Ziana and others, 2020; Anderson and others, 2006).	Improved water storage and use by trees (Udawatta and Jose, 2021) Reduced flood discharge and velocity with sufficient vegetation diameter/roughness, thereby reducing exposed area (Ziana and others, 2020; Anderson and others, 2006).	Provision of fruit for consumption, shade, and erosion control (Quandt and others, 2017).
Mountain	Forest: afforestation, conservation, restoration of, sustainable management	Improved below-ground runoff connection to streams, reducing flood intensity (Peskett and others, 2021); Mitigated peak discharge (Bathurst and others, 2011; Díaz and Querner, 2005; Bahremand and others, 2007; Ye Klimenko and others, 2021; Kabeja and others, 2020; Černohous and others, 2017) and delayed flood concentration, reducing flood intensity (Sato and Shuin, 2023); Improved water storage capacity (Zell	Improved below-ground runoff connection to streams, reducing exposed area (Peskett and others, 2021); Mitigated peak discharge (Bathurst and others, 2011; Díaz and Querner, 2005; Bahremand and others, 2007; Ye Klimenko and others, 2021; Kabeja and others, 2020; Černohous and others, 2017) and delayed flood concentration, thereby reducing exposed area (Sato and Shuin, 2023); Improved water storage capacity (Zell and others, 2015) via high root	Provision of fish as a food source (Barros and others, 2020); Provision of forest products to support household incomes (Bauer and others, 2018).

		and others, 2015) via high root density, reducing flood intensity (Lange and others, 2013); Reduced surface runoff directly (Lü and others, 2021) and via reduced soil moisture as a consequence of high transpiration rates, reducing flood intensity (Asbjornsen and others, 2014); High infiltration due to increased porosity of soils under mature forests, reducing flood intensity (Hümann and others, 2011); Absorption of dissolved nitrogen and phosphorus pollutants, reducing flood impact (Bahn and An, 2020).	density, reducing exposed area (Lange and others, 2013); Reduced surface runoff directly (Lü and others, 2021) and via reduced soil moisture as a consequence of high transpiration rates, reducing exposed area (Asbjornsen and others, 2014); High infiltration due to increased porosity of soils under mature forests, reducing exposed area (Hümann and others, 2011).	

Table 3: Documented evidence from literature that supports Table 1 graphics and icons in relation to ecosystem services relevant for flood risk reduction. See references for extended evidence.

		Documented evidence of the provision of ecosystem services relevant for flood risk reduction		
Catchment region	**Ecosystem-based measure(s)**	**Hazard**	**Exposure**	**Vulnerability**
Coastal	Mangroves: afforestation, conservation, restoration	Mangroves provide regulating services, including climate and air quality regulation (Gargaran and others, 2024; Islam and others, 2024; Osewe and others, 2024), carbon sequestration and storage (Gargaran and others, 2024; Kadaverugu and others, 2021; Islam and others, 2024; Rahman and others, 2024; Osewe and others, 2024) , moderation of extreme events (Friess, 2016; Gargaran and others, 2024; Kadaverugu and others, 2021; Islam and others, 2024; Rahman and others, 2024; Osewe and others, 2024), erosion control and soil fertility maintenance (Friess, 2016; Gargaran and others, 2024; Islam and others, 2024; Osewe and others, 2024), and waste-water treatment (Islam and others, 2024; Osewe and others, 2024). All important ecosystem services that support hazard and exposure reduction.		Mangroves provide provisioning services like food (Friess, 2016; Gargaran and others, 2024; Kadaverugu and others, 2021; Islam and others, 2024; Rahman and others, 2024; Osewe and others, 2024), raw materials which include timber (Friess, 2016; Kadaverugu and others, 2021; Islam and others, 2024; Rahman and others, 2024; Osewe and others, 2024), fresh water through ground water recharge (Gargaran and others, 2024; Islam and others, 2024), medicinal resources (Gargaran and others, 2024; Kadaverugu and others, 2021; Rahman and others, 2024), as well as cultural services including recreational opportunities (Gargaran and others, 2024; Islam and others, 2024; Osewe and others, 2024), tourism (Gargaran and others, 2024; Kadaverugu and others, 2021; Islam and others, 2024; Rahman and others, 2024; Osewe and others, 2024), aesthetic values (Islam and others, 2024), and spiritual experiences (Friess, 2016; Islam and others, 2024; Osewe and others, 2024), pollination (Kadaverugu and others, 2021). They also provide regulating services like erosion control and soil fertility maintenance (Friess, 2016; Gargaran and others, 2024; Islam and others, 2024; Osewe and others, 2024), as well as supporting services like habitat creation (Osewe and others, 2024) and maintenance of genetic diversity(Islam and others, 2024). All relevant ecosystem services for vulnerability reduction.

	Sand dunes: conservation, restoration	Sand dunes provide regulating services like erosion control and soil fertility maintenance, carbon sequestration and storage, moderation of extreme events (Barbier and others, 2011). All relevant services for hazard and exposure reduction.	Sand dunes provide provisioning services like fresh water provision through ground water recharge, and supporting services like habitat provision, and recreational opportunities, erosion control and soil fertility maintenance (Barbier and others, 2011). All relevant ecosystem services for vulnerability reduction.
	Coastal forest: afforestation, conservation, restoration	Coastal forests provide regulating services including soil fertility maintenance and erosion control (Islam and others, 2024; Osewe and others, 2024; Maass and others, 2005), climate and air quality regulation (Islam and others, 2024; Osewe and others, 2024; Maass and others, 2005), carbon sequestration and storage (Kadaverugu and others, 2021; Islam and others, 2024; Rahman and others, 2024; Osewe and others, 2024; Maass and others, 2005), moderation of extreme events (Kadaverugu and others, 2021; Islam and others, 2024; Rahman and others, 2024; Osewe and others, 2024; Maass and others, 2005), and waste-water treatment (Islam and others, 2024; Osewe and others, 2024). All relevant services for hazard and exposure reduction.	Coastal forests provide provisioning ecosystem services like provision of food (Kadaverugu and others, 2021; Islam and others, 2024; Rahman and others, 2024; Osewe and others, 2024), raw materials such as timber and fuel (Kadaverugu and others, 2021; Islam and others, 2024; Rahman and others, 2024; Osewe and others, 2024), fresh water through ground water recharge (Islam and others, 2024; Maass and others, 2005), medicinal resources (Kadaverugu and others, 2021; Rahman and others, 2024), and cultural services including recreational opportunities(Islam and others, 2024; Osewe and others, 2024), tourism (Kadaverugu and others, 2021; Islam and others, 2024; Rahman and others, 2024; Osewe and others, 2024), aesthetic values (Islam and others, 2024; Maass and others, 2005), and spiritual experiences (Islam and others, 2024; Osewe and others, 2024). Coastal forests provide regulating services like pollination (Kadaverugu and others, 2021; Maass and others, 2005), soil fertility maintenance and erosion control (Islam and others, 2024; Osewe and others, 2024; Maass and others, 2005), and pest control(Maass and others, 2005). They also provide supporting services like habitat provision (Osewe and others, 2024) , and maintenance of genetic diversity (Islam and others, 2024; Rahman and others, 2024). All relevant ecosystem services for vulnerability reduction.
Urban	Permeable pavement: establishment	No evidence	
	Urban vegetation: establishment, conservation	Urban vegetation contributes with regulating services like erosion reduction and soil maintenance (Russo and others, 2017; Paudel and States, 2023), climate and air quality regulation (Russo and others, 2017; Francini and others, 2022; Liang and Huang, 2023; Paudel and States, 2023; Evans and others, 2022; Derkzen and others, 2015; Amorim and others, 2021; Blanusa and others, 2019), carbon sequestration and storage (Russo and others, 2017; Liang and Huang, 2023; Paudel and States, 2023; Evans and others, 2022; Ruiz-Sandoval and others, 2018; Derkzen and others, 2015; Amorim and others, 2021), moderation of extreme events (Amorim and others, 2021; Blanusa and others, 2019)(Liang and Huang,	This measure can provide food(Russo and others, 2017; Francini and others, 2022; Liang and Huang, 2023; Paudel and States, 2023), raw materials (Paudel and States, 2023), fresh water through groundwater recharge (Paudel and States, 2023; Evans and others, 2022; Ruiz-Sandoval and others, 2018), medicinal resources (Russo and others, 2017; Liang and Huang, 2023), and cultural services, including recreational opportunities (Francini and others, 2022; Liang and Huang, 2023; Paudel and States, 2023; Evans and others, 2022; Derkzen and others, 2015; Amorim and others, 2021; Blanusa and others, 2019; Cheng, 2023), tourism (Paudel and States, 2023; Cheng, 2023), aesthetic values (Russo and others, 2017; Francini and others, 2022; Liang and Huang, 2023; Paudel and States, 2023; Evans and others, 2022; Cheng, 2023), and spiritual experiences (Paudel and States, 2023; Liang and Huang, 2023; Evans and others, 2022; Amorim and others, 2021; Cheng, 2023). Urban vegetation also contributes with regulating services,

		2023; Evans and others, 2022; Derkzen and others, 2015), and waste-water treatment(Paudel and States, 2023; Ruiz-Sandoval and others, 2018). All relevant services for hazard and exposure reduction.	including pollination (Evans and others, 2022), erosion reduction and soil maintenance (Russo and others, 2017; Paudel and States, 2023), biological control (Evans and others, 2022). This measure can also provide supporting services, like habitat provision (Ruiz-Sandoval and others, 2018), and maintenance of genetic diversity (Blanusa and others, 2019). All relevant ecosystem services for vulnerability reduction.
	Home gardens: conservation	Home gardens can contribute to erosion control and soil fertility maintenance (Russo and others, 2017), climate and air quality regulation (Russo and others, 2017; Blanusa and others, 2019; Pinto and others, 2022), carbon sequestration and storage (Russo and others, 2017; Blanusa and others, 2019), and moderation of extreme events(Russo and others, 2017; Blanusa and others, 2019; Pinto and others, 2022). All relevant services for hazard and exposure reduction.	This measure can provide many ecosystem services, namely food (Russo and others, 2017; Pandey and Ghosh, 2023; Pinto and others, 2022), natural medicinal resources (Pandey and Ghosh, 2023; Russo and others, 2017), recreational opportunities (Russo and others, 2017; Cheng, 2023; Pandey and Ghosh, 2023; Pinto and others, 2022), aesthetics values (Russo and others, 2017; Cheng, 2023; Pandey and Ghosh, 2023), spiritual experiences (Cheng, 2023; Pinto and others, 2022), pollination (Pandey and Ghosh, 2023), erosion control and soil fertility maintenance (Russo and others, 2017), and genetic diversity maintenance (Russo and others, 2017; Blanusa and others, 2019; Pandey and Ghosh, 2023). All relevant ecosystem services for vulnerability reduction.
	Green open spaces: establishment, conservation	Green open spaces can contribute with regulating services, namely erosion control and soil fertility maintenance (Paudel and States, 2023; Sarı and Bayraktar, 2023), climate and air quality regulation (Paudel and States, 2023; Derkzen and others, 2015; Pinto and others, 2022; Cheng, 2023; Luo and Patuano, 2023; Sarı and Bayraktar, 2023), carbon sequestration and storage (Derkzen and others, 2015; Cheng, 2023), and moderation of extreme events (Paudel and States, 2023; Derkzen and others, 2015; Pinto and others, 2022). All relevant services for hazard and exposure reduction.	This measure can contribute with many provisioning services, namely the provision of food (Paudel and States, 2023; Pinto and others, 2022; Cheng, 2023; Luo and Patuano, 2023), raw materials (Cheng, 2023), and fresh water (Paudel and States, 2023; Cheng, 2023). Green open spaces also contribute with cultural services, namely, recreational opportunities (Derkzen and others, 2015; Pinto and others, 2022; Cheng, 2023; Luo and Patuano, 2023; Sarı and Bayraktar, 2023), tourism (Cheng, 2023), aesthetic values (Cheng, 2023), and spiritual experiences(Pinto and others, 2022; Sarı and Bayraktar, 2023). This measure also provides regulating services, namely erosion control and soil fertility maintenance (Paudel and States, 2023; Sarı and Bayraktar, 2023), pollination (Paudel and States, 2023; Cheng, 2023), and biological control (Paudel and States, 2023). Lastly, this measure can also provide supporting services, namely habitat provision (Paudel and States, 2023; Luo and Patuano, 2023; Sarı and Bayraktar, 2023) , and conservation of biodiversity (Sarı and Bayraktar, 2023). All relevant ecosystem services for vulnerability reduction.
	Green corridors: establishment, conservation, restoration	No evidence found	
	Floodplain: reconnection, restoration	Floodplain reconnection or restoration can contribute with regulating services like erosion control, soil fertility maintenance (Jakubínský and others, 2021; Barnett and others, 2016), climate and air quality regulation (Jakubínský and others, 2021; Barnett and others, 2016), carbon	This measure provide many ecosystem services, namely provision of food and water (Jakubínský and others, 2021; Barnett and others, 2016), provision of raw materials (Jakubínský and others, 2021), opportunities for tourism (Jakubínský and others, 2021), recreational opportunities and aesthetics values (Jakubínský and others, 2021; Barnett and others, 2016), erosion control and soil fertility maintenance (Jakubínský and others,

		sequestration and storage (Barnett and others, 2016), moderation of extreme events (Jakubínský and others, 2021; Barnett and others, 2016), and waste-water treatment (Jakubínský and others, 2021). All relevant services for hazard and exposure reduction.	2021; Barnett and others, 2016). All relevant ecosystem services for vulnerability reduction.
	Lentic water bodies: restoration, conservation	Restoration or conservation of lentic water bodies can contribute with ecosystem services like erosion control and soil fertility maintenance (Chatanga and Seleteng-Kose, 2021; Sheergojri and others, 2024; Inácio and others, 2022; Agaton and Guila, 2023), climate and air quality regulation (Langan and others, 2018; Chatanga and Seleteng-Kose, 2021; Sheergojri and others, 2024; Xu and others, 2018; Agaton and Guila, 2023), carbon sequestration and storage (Chatanga and Seleteng-Kose, 2021; Acreman and others, 2011; Sheergojri and others, 2024), moderation of extreme events (Langan and others, 2018; Chatanga and Seleteng-Kose, 2021; Acreman and others, 2011; Sheergojri and others, 2024; Inácio and others, 2022; Xu and others, 2018; Agaton and Guila, 2023), and waste-water treatment (Chatanga and Seleteng-Kose, 2021; Acreman and others, 2011; Sheergojri and others, 2024; Inácio and others, 2022; Xu and others, 2018; Agaton and Guila, 2023). All relevant services for hazard and exposure reduction.	This measure can contribute with many ecosystem services, namely provision of food (Langan and others, 2018; Chatanga and Seleteng-Kose, 2021; Acreman and others, 2011; Sheergojri and others, 2024; Inácio and others, 2022), raw materials (Langan and others, 2018; Acreman and others, 2011; Sheergojri and others, 2024; Inácio and others, 2022), fresh water (Chatanga and Seleteng-Kose, 2021; Acreman and others, 2011; Sheergojri and others, 2024; Inácio and others, 2022; Xu and others, 2018; Agaton and Guila, 2023), and natural medicinal resources (Sheergojri and others, 2024). Lentic water bodies also contribute through the provision of cultural services, namely recreational opportunities (Acreman and others, 2011; Sheergojri and others, 2024; Inácio and others, 2022; Xu and others, 2018; Agaton and Guila, 2023), tourism (Chatanga and Seleteng-Kose, 2021; Sheergojri and others, 2024; Inácio and others, 2022), aesthetics values (Acreman and others, 2011; Sheergojri and others, 2024; Inácio and others, 2022), and spiritual experiences (Sheergojri and others, 2024; Inácio and others, 2022), regulating services, namely pollination (Sheergojri and others, 2024; Inácio and others, 2022), biological control (Sheergojri and others, 2024). Additionally, this measure also provides supporting services, namely habitat provision (Chatanga and Seleteng-Kose, 2021; Acreman and others, 2011; Sheergojri and others, 2024; Xu and others, 2018; Agaton and Guila, 2023) and maintenance of genetic diversity (Chatanga and Seleteng-Kose, 2021; Acreman and others, 2011; Sheergojri and others, 2024; Inácio and others, 2022; Agaton and Guila, 2023). All relevant ecosystem services for vulnerability reduction.
	Lotic natural waterways: natural drainage path restoration, conservation	Restoration or conservation of lotic natural waterways can provide regulating services like soil erosion control and soil fertility maintenance (Hanna and others, 2018; Basak and others, 2021; Vidal-Abarca Gutiérrez and others, 2023), climate and air quality regulation (Vidal-Abarca Gutiérrez and others, 2023), carbon sequestration and storage (Kaiser and others, 2020; Brown and others, 2018; Basak and others, 2021), moderation of extreme events (Kaiser and others, 2020; Brown and others, 2018; Hanna and others, 2018; Basak and others, 2021), and waste-water treatment (Basak and others, 2021; Vidal-Abarca	This measure contributes with many ecosystem services, namely provision of food (Kaiser and others, 2020; Brown and others, 2018; Hanna and others, 2018; Basak and others, 2021), raw materials (Vidal-Abarca Gutiérrez and others, 2023), fresh water (Kaiser and others, 2020; Brown and others, 2018; Hanna and others, 2018; Basak and others, 2021), and medicinal resources (Vidal-Abarca Gutiérrez and others, 2023). Lotic water channels also contribute through cultural services, namely recreational opportunities (Kaiser and others, 2020; Brown and others, 2018; Hanna and others, 2018; Basak and others, 2021), tourism (Vidal-Abarca Gutiérrez and others, 2023), aesthetics values (Kaiser and others, 2020; Hanna and others, 2018; Basak and others, 2021; Vidal-Abarca Gutiérrez and others, 2023) and spiritual experiences (Kaiser and others, 2020; Brown and others, 2018; Hanna and

		Gutiérrez and others, 2023). All relevant services for hazard and exposure reduction.	others, 2018; Vidal-Abarca Gutiérrez and others, 2023). regulating services, namely pollination (Vidal-Abarca Gutiérrez and others, 2023), soil erosion control and soil fertility maintenance (Hanna and others, 2018; Basak and others, 2021; Vidal-Abarca Gutiérrez and others, 2023). The measure also provides supporting services, namely habitat provision (Kaiser and others, 2020; Hanna and others, 2018; Basak and others, 2021; Vidal-Abarca Gutiérrez and others, 2023) and maintenance of genetic diversity (Kaiser and others, 2020; Vidal-Abarca Gutiérrez and others, 2023). All relevant ecosystem services for vulnerability reduction.
	Riverbanks: restoration with bioengineering materials (e.g. plants)	This measure can provide ecosystem services like carbon sequestration and storage, erosion control and soil fertility maintenance, moderation of extreme events, waste-water treatment (Norman, 2020). All relevant services for hazard and exposure reduction.	For vulnerability reduction, this measure can provide services like erosion control and soil fertility maintenance, and habitat provision (Norman, 2020).
Peri-urban	Vegetated filter strips: establishment, conservation, restoration	No evidence found	
	Flood-tolerant rice crop cultivation	No evidence found	
Peri-urban, and mountain	Agroforestry in riparian buffers: establishment, conservation, restoration	Agroforestry can provide regulating services, namely erosion reduction and soil maintenance (Xiao and Xiong, 2022; Yang and others, 2024; Fagerholm and others, 2016; Torralba and others, 2016), climate and air quality regulation (Asbjornsen and others, 2014), carbon sequestration and storage (Silva-Galicia and others, 2023; Fagerholm and others, 2016; Castle and others, 2021), moderation of extreme events (Fagerholm and others, 2016), and waste-water treatment (Farinaccio and others, 2024). All relevant services for hazard and exposure reduction.	This measure provides many provisioning services like food (Farinaccio and others, 2024; Xiao and Xiong, 2022; Yang and others, 2024; Silva-Galicia and others, 2023; Fagerholm and others, 2016), raw materials (Fagerholm and others, 2016). The measure also has the potential to provide cultural services including recreational opportunities, tourism, aesthetic values (Fagerholm and others, 2016), and spiritual experiences (Fagerholm and others, 2016; Silva-Galicia and others, 2023; Yang and others, 2024). Agroforestry also contributes with regulating services, namely pollination (Farinaccio and others, 2024; Fagerholm and others, 2016), erosion reduction and soil maintenance (Xiao and Xiong, 2022; Yang and others, 2024; Fagerholm and others, 2016; Torralba and others, 2016), biological control (Fagerholm and others, 2016).Lastly, this measure provides the supporting service of genetic diversity maintenance (Farinaccio and others, 2024; Xiao and Xiong, 2022; Yang and others, 2024; Silva-Galicia and others, 2023; Fagerholm and others, 2016; Torralba and others, 2016; Castle and others, 2021; Beenhouwer and others, 2013). All relevant ecosystem services for vulnerability reduction.

Mountain	Forest: afforestation, conservation, restoration of, sustainable management	This measure can provide regulating services, namely erosion control and soil fertility maintenance (Osewe and others, 2024; Maass and others, 2005; Borma and others, 2022; Nelson and others, 2020; Galicia and Zarco-Arista, 2014; Quijas and others, 2019; Bhatt and others, 2024; Joshi and Joshi, 2019; Liu and others, 2023a; Das and Mallick, 2023), climate and air quality regulation (Osewe and others, 2024; Maass and others, 2005; Ruiz-Sandoval and others, 2018; Borma and others, 2022; Galicia and Zarco-Arista, 2014; Quijas and others, 2019; Bhatt and others, 2024; Joshi and Joshi, 2019; Liu and others, 2023a), carbon sequestration and storage (Osewe and others, 2024; Maass and others, 2005; Borma and others, 2022; Nelson and others, 2020; Galicia and Zarco-Arista, 2014; Quijas and others, 2019; Barua and others, 2020; Ingaramo and others, 2017; Paré and others, 2024; Joshi and Joshi, 2019; Liu and others, 2023a; Das and Mallick, 2023), moderation of extreme events (Osewe and others, 2024; Maass and others, 2005; Borma and others, 2022; Barua and others, 2020), and waste-water treatment (Quijas and others, 2019). All relevant services for hazard and exposure reduction.	This measure provides provisioning services like food (Osewe and others, 2024; Maass and others, 2005; Borma and others, 2022; Nelson and others, 2020; Galicia and Zarco-Arista, 2014; Quijas and others, 2019; Bhatt and others, 2024; Barua and others, 2020), raw materials (Osewe and others, 2024; Nelson and others, 2020; Galicia and Zarco-Arista, 2014; Quijas and others, 2019; Bhatt and others, 2024; Barua and others, 2020; Ingaramo and others, 2017; Paré and others, 2024; Joshi and Joshi, 2019; Liu and others, 2023a), fresh water (Maass and others, 2005; Ruiz-Sandoval and others, 2018; Borma and others, 2022; Nelson and others, 2020; Galicia and Zarco-Arista, 2014; Quijas and others, 2019; Paré and others, 2024; Joshi and Joshi, 2019), and medicinal resources (Borma and others, 2022; Nelson and others, 2020; Galicia and Zarco-Arista, 2014; Bhatt and others, 2024; Joshi and Joshi, 2019; Das and Mallick, 2023). Forests also contribute with cultural services, namely recreational opportunities (Osewe and others, 2024; Borma and others, 2022; Nelson and others, 2020; Galicia and Zarco-Arista, 2014; Quijas and others, 2019; Bhatt and others, 2024; Barua and others, 2020; Ingaramo and others, 2017; Joshi and Joshi, 2019; Liu and others, 2023a; Das and Mallick, 2023; Motiejūnaitė and others, 2019), tourism (Osewe and others, 2024; Borma and others, 2022; Nelson and others, 2020; Galicia and Zarco-Arista, 2014; Quijas and others, 2019; Bhatt and others, 2024; Barua and others, 2020; Ingaramo and others, 2017), aesthetic values (Maass and others, 2005; Nelson and others, 2020; Quijas and others, 2019; Bhatt and others, 2024; Motiejūnaitė and others, 2019), and spiritual experiences (Osewe and others, 2024; Borma and others, 2022; Galicia and Zarco-Arista, 2014; Bhatt and others, 2024; Barua and others, 2020; Joshi and Joshi, 2019; Motiejūnaitė and others, 2019). Forests also contribute with regulating services, namely pollination (Maass and others, 2005; Borma and others, 2022; Quijas and others, 2019; Barua and others, 2020), erosion control and soil fertility maintenance (Osewe and others, 2024; Maass and others, 2005; Borma and others, 2022; Nelson and others, 2020; Galicia and Zarco-Arista, 2014; Quijas and others, 2019; Bhatt and others, 2024; Joshi and Joshi, 2019; Liu and others, 2023a; Das and Mallick, 2023), and biological control (Maass and others, 2005; Borma and others, 2022; Quijas and others, 2019; Das and Mallick, 2023). Lastly this measure can provide the supporting services of habitat provision (Osewe and others, 2024; Ruiz-Sandoval and others, 2018; Borma and others, 2022; Quijas and others, 2019; Bhatt and others, 2024; Paré and others, 2024), and genetic diversity maintenance (Borma and others, 2022; Galicia and Zarco-Arista, 2014; Barua and others, 2020; Liu and others, 2023a). All relevant ecosystem services for vulnerability reduction.

Table 4: Results of the literature review showcasing the evidence of the influence of the ecosystem-based measures for 6 different variables relevant for flood modelling. One plus sign means good evidence, two plus signs mean strong evidence and a minus sign means no evidence found

Catchment region	Ecosystem-based measure(s)	Infiltration	Evapotranspiration	Surface run-off	Surface-water storage	Discharge	Flood routing
Coastal	**Mangroves:** afforestation, conservation, restoration	−	−	−	−	−	+
	Sand dunes: conservation, restoration	−	−	−	−	+	−
	Coastal forest: afforestation, conservation, restoration	−	−	−	−	−	−
Urban	**Permeable pavement:** establishment	+	−	++	+	+	−
	Urban vegetation: establishment, conservation	++	−	+	++	+	−
	Home gardens: conservation	+	−	−	−	−	−
	Green open spaces: establishment, conservation	++	−	+	−	+	−
	Green corridors: establishment, conservation, restoration	+	−	−	−	−	−
	Flood-plain: reconnection, restoration	−	−	+	−	+	−
	Lentic water bodies: restoration, conservation	−	−	+	+	+	−
	Lotic natural waterways: natural drainage path restoration, conservation	−	−	−	++	+	−
	Riverbanks: restoration of riverbanks with bioengineering materials	−	−	−	−	−	−
Peri-urban	**Vegetated filter strips:** establishment, conservation, restoration	−	−	−	−	−	−
	Flood-tolerant rice crops: cultivation	−	−	−	++	−	−
Peri-urban Mountain	**Agroforestry in riparian buffers:** planting, conservation, restoration	−	−	−	++	++	−
Mountain	**Forest:** afforestation, conservation, restoration, sustainable management	+	++	++	++	++	−

Table 5: Documented evidence from literature that supports table 3 graphics and icons. See references for extended evidence.

Region of the catchment	Ecosystem-based measure(s)	Flood hazard parameters positively influenced
Coastal	Mangroves: afforestation, conservation, restoration	Flood routing (Montgomery and others, 2022)
	Sand dunes: conservation, restoration	Discharge (Fernández-Montblanc and others, 2020)
	Coastal forest: afforestation, conservation, restoration	No evidence
Urban	Permeable pavement: establishment	Surface run-off (Rankin and Ball, 2004; Zheng and others, 2019; Li and others, 2019; Liu and others, 2014; Reu Junqueira and others, 2022), infiltration (Liu and others, 2014; Zheng and others, 2019; Yoo and others, 2016), surface-water storage (Yoo and others, 2016; Zheng and others, 2019), discharge (Liu and others, 2014)
	Urban vegetation: establishment, conservation	Surface run-off (Zheng and others, 2019), infiltration (Zheng and others, 2019; Kim and Park, 2016), surface-water storage (Kim and Park, 2016; Zheng and others, 2019), discharge (Liu and others, 2014)
	Home gardens: conservation	Infiltration (Kelly, 2018)
	Green open spaces: establishment, conservation	Infiltration (Kim and others, 2016; Liu and others, 2014), surface run-off (Liu and others, 2014), discharge (Liu and others, 2014)
	Green corridors: establishment, conservation, restoration of	Infiltration (Wang and others, 2023; Staccione and others, 2024)
	Flood plain: reconnection, restoration	Surface run-off (Jiang and others, 2023), discharge (Jiang and others, 2023)
	Lentic water bodies: restoration, conservation	Discharge (Qaiser and others, 2012; Gautam and Corzo, 2023; Javaheri and Babbar-Sebens, 2014), surface-water storage (Gautam and Corzo, 2023; Tang and others, 2020b; Wang and others, 2022), surface run-off (Rojas and others, 2022; Qaiser and others, 2012)
	Lotic natural waterways: natural drainage path restoration, conservation	Surface-water storage (Gao and others, 2020; Xu and others, 2020), discharge (Xu and others, 2020; Li and Wang, 2019)
	Riverbanks: restoration of riverbanks with bioengineering materials (e.g. plants)	No evidence
Peri-urban	Vegetated filter strips: establishment, conservation, restoration	No evidence
	Flood-tolerant rice crop: cultivation	Surface-water storage (Osawa and others, 2020)
Peri-urban, and mountain	Agroforestry in riparian buffers: establishment, conservation, restoration	Surface-water storage (Udawatta, 2021), discharge (Ziana and others, 2020; Anderson and others, 2006)

Mountain	Forest: afforestation, conservation, restoration of, sustainable management	Discharge (Bathurst and others, 2011; Díaz and Querner, 2005; Bahremand and others, 2007; Hou and others, 2018; Bathurst and others, 2017; Kabeja and others, 2020; Černohous and others, 2017; Ye Klimenko and others, 2021), surface-water storage (Lange and others, 2013; Zell and others, 2015), evapotranspiration (Bathurst and others, 2022), surface run-off (Bathurst and others, 2022; Reinhardt-Imjela and others, 2018; Hümann and others, 2011; Lü and others, 2021), infiltration (Hümann and others, 2011)

4. References

References

Acreman, M. C., and others (2011). Trade-off in ecosystem services of the Somerset Levels and Moors wetlands. *Hydrological Sciences Journal*, vol. 56, No. 8, pp. 1543–65. DOI: 10.1080/02626667.2011.629783

Agaton, Casper B., and Patricia M. Guila (2023). Ecosystem Services Valuation of Constructed Wetland as a Nature-Based Solution to Wastewater Treatment. *Earth*, vol. 4, No. 1, pp. 78–92. DOI: 10.3390/earth4010006

Amorim, Jorge H., and others (2021). Regulating and Cultural Ecosystem Services of Urban Green Infrastructure in the Nordic Countries: A Systematic Review. *International journal of environmental research and public health*, vol. 18, No. 3, DOI: 10.3390/ijerph18031219

Anderson, B. G., I. D. Rutherfurd, and A. W. Western (2006). An analysis of the influence of riparian vegetation on the propagation of flood waves. *Environmental Modelling & Software*, vol. 21, No. 9, pp. 1290–96. DOI: 10.1016/j.envsoft.2005.04.027

Asbjornsen, H., and others (2014). Targeting perennial vegetation in agricultural landscapes for enhancing ecosystem services. *Renewable Agriculture and Food Systems*, vol. 29, No. 2, pp. 101–25. DOI: 10.1017/S1742170512000385

Bahn, Gwon-Soo, and Byung-Chul An (2020). Analysis of Environmental Purification Effect of Riparian Forest with Poplar Trees for Ecological Watershed Management: A Case Study in the Floodplain of the Dam Reservoir in Korea. *Sustainability*, vol. 12, No. 17, p. 6871. DOI: 10.3390/su12176871

Bahremand, A., and others (2007). WetSpa Model Application for Assessing Reforestation Impacts on Floods in Margecany–Hornad Watershed, Slovakia. *Water Resources Management*, vol. 21, No. 8, pp. 1373–91. DOI: 10.1007/s11269-006-9089-0

Barbier, Edward B., and others (2011). The value of estuarine and coastal ecosystem services. *Ecological Monographs*, vol. 81, No. 2, pp. 169–93. DOI: 10.1890/10-1510.1

Barnett, Analie, Joseph Fargione, and Mark P. Smith (2016). Mapping Trade-Offs in Ecosystem Services from Reforestation in the Mississippi Alluvial Valley. *BioScience*, vol. 66, No. 3, pp. 223–37. DOI: 10.1093/biosci/biv181

Barros, Daniela d., and others (2020). Effects of deforestation and other environmental variables on floodplain fish catch in the Amazon. *Fisheries Research*, vol. 230, p. 105643. DOI: 10.1016/j.fishres.2020.105643

Barua, Sepul K., Marco Boscolo, and Illias Animon (2020). Valuing forest-based ecosystem services in Bangladesh: Implications for research and policies. *Ecosystem Services*, vol. 42, p. 101069. DOI: 10.1016/j.ecoser.2020.101069

Basak, Sayantani M., and others (2021). Social benefits of river restoration from ecosystem services perspective: A systematic review. *Environmental Science & Policy*, vol. 124, pp. 90–100. DOI: 10.1016/j.envsci.2021.06.005

Bathurst, James C., and others (2011). Forest impact on floods due to extreme rainfall and snowmelt in four Latin American environments 1: Field data analysis. *Journal of Hydrology*, vol. 400, 3-4, pp. 281–91. DOI: 10.1016/j.jhydrol.2010.11.044

Bathurst, James C., and others (2017). Forest Impact on Flood Peak Discharge and Sediment Yield in Streamflow. In *River System Analysis and Management.* Sharma, Nayan, ed. Singapore: Springer Singapore. DOI: 10.1007/978-981-10-1472-7_2

Bathurst, James C., and others (2022). Partial afforestation has uncertain effect on flood frequency and peak discharge at large catchment scales (100–1000 km 2), south-central Chile. *Hydrological Processes*, vol. 36, No. 5, art. e14585. DOI: 10.1002/hyp.14585

Bauer, T., and others (2018). The socio-economic impact of extreme precipitation and flooding on forest livelihoods: evidence from the Bolivian Amazon. *International Forestry Review*, vol. 20, No. 3, pp. 314–31. DOI: 10.1505/146554818824063050

Beck, Michael W., and others (2022). Return on investment for mangrove and reef flood protection. *Ecosystem Services*, vol. 56, p. 101440. DOI: 10.1016/j.ecoser.2022.101440

Beenhouwer, Matthias de, Raf Aerts, and Olivier Honnay (2013). A global meta-analysis of the biodiversity and ecosystem service benefits of coffee and cacao agroforestry. *Agriculture, Ecosystems & Environment*, vol. 175, pp. 1–7. DOI: 10.1016/j.agee.2013.05.003

Bhatt, Honey, and others (2024). Community perception about ecosystem services assessment from forests managed under different regimes in Hindu Kush Himalaya. *Environmental and Sustainability Indicators*, vol. 24, p. 100463. DOI: 10.1016/j.indic.2024.100463

Blanusa, Tijana, and others (2019). Urban hedges: A review of plant species and cultivars for ecosystem service delivery in north-west Europe. *Urban Forestry & Urban Greening*, vol. 44, p. 126391. DOI: 10.1016/j.ufug.2019.126391

Borma, L. S., and others (2022). Beyond Carbon: The Contributions of South American Tropical Humid and Subhumid Forests to Ecosystem Services. *Reviews of Geophysics*, vol. 60, No. 4, art. e2021RG000766. DOI: 10.1029/2021RG000766

Brown, Antony G., and others (2018). Natural vs anthropogenic streams in Europe: History, ecology and implications for restoration, river-rewilding and riverine ecosystem services. *Earth-Science Reviews*, vol. 180, pp. 185–205. DOI: 10.1016/j.earscirev.2018.02.001

Castle, Sarah E., and others (2021). The impacts of agroforestry interventions on agricultural productivity, ecosystem services, and human well-being in low- and middle-income countries: A systematic review. *Campbell systematic reviews*, vol. 17, No. 2, e1167. DOI: 10.1002/cl2.1167

Černohous, V., V. Švihla, and F. Šach (2017). Contribution to assessment of forest stand impact on decrease of flood peakflow discharge. *Zprávy Lesnického Výzkumu*, vol. 62, No. 2, pp. 82–86.

Chatanga, Peter, and Lerato Seleteng-Kose (2021). Montane Palustrine Wetlands of Lesotho: Vegetation, Ecosystem Services, Current Status, Threats and Conservation. *Wetlands*, vol. 41, No. 6, DOI: 10.1007/s13157-021-01470-1

Cheng, Xin (2023). A Review of Empirical Studies of Cultural Ecosystem Services in National Parks: Current Status and Future Research. *Land*, vol. 12, No. 10, p. 1912. DOI: 10.3390/land12101912

Das, Abhishek, and Priyanka H. Mallick (2023). The trend of forest ecosystem services assessment in eastern India: a review for future research insights. *Environmental monitoring and assessment*, vol. 195, No. 5, p. 615. DOI: 10.1007/s10661-023-11218-5

Deb, Mithun, and Celso M. Ferreira (2017). Potential impacts of the Sunderban mangrove degradation on future coastal flooding in Bangladesh. *Journal of Hydro-environment Research*, vol. 17, pp. 30–46. DOI: 10.1016/j.jher.2016.11.005

Debrot, Adolphe O., and others (2022). Early increases in artisanal shore-based fisheries in a Nature-based Solutions mangrove rehabilitation project on the north coast of Java. *Estuarine, Coastal and Shelf Science*, vol. 267, p. 107761. DOI: 10.1016/j.ecss.2022.107761

Derkzen, Marthe L., Astrid J. van Teeffelen, and Peter H. Verburg (2015). Review: Quantifying urban ecosystem services based on high-resolution data of urban green space: an assessment for Rotterdam, the Netherlands. *Journal of Applied Ecology*, vol. 52, No. 4, pp. 1020–32. DOI: 10.1111/1365-2664.12469

Díaz, R.A, and E. P. Querner (2005). Estimating climate change effects upon flood risk reduction by afforestation. In *Impact Assessment and Decision Making.* Franks, Stewart W. and Thorsten Wagener, eds. Wallingford: International Association of Hydrological Sciences.

Esfahani, Fariba S., and Ali R. Keshavarzi (2010). How far must trees be cultivated from the edge of the flood plain to provide best river bank protection? *International Journal of River Basin Management*, vol. 8, No. 1, pp. 109–16. DOI: 10.1080/15715121003714894

Evans, D. L., and others (2022). Ecosystem service delivery by urban agriculture and green infrastructure – a systematic review. *Ecosystem Services*, vol. 54, p. 101405. DOI: 10.1016/j.ecoser.2022.101405

Fagerholm, Nora, and others (2016). A systematic map of ecosystem services assessments around European agroforestry. *Ecological Indicators*, vol. 62, pp. 47–65. DOI: 10.1016/j.ecolind.2015.11.016

Farinaccio, F. M., E. Ceccon, and D. R. Pérez (2024). Could agroforestry restore ecosystem services in arid lands? An analysis through the weight of the evidence approach. *Agroforestry Systems*, vol. 98, No. 2, pp. 507–21. DOI: 10.1007/s10457-023-00927-y

Fernández-Montblanc, T., E. Duo, and P. Ciavola (2020). Dune reconstruction and revegetation as a potential measure to decrease coastal erosion and flooding under extreme storm conditions. *Ocean & Coastal Management*, vol. 188, p. 105075. DOI: 10.1016/j.ocecoaman.2019.105075

Francini, Alessandra, and others (2022). The Contribution of Ornamental Plants to Urban Ecosystem Services. *Earth*, vol. 3, No. 4, pp. 1258–74. DOI: 10.3390/earth3040071

Friess, Daniel (2016). Ecosystem Services and Disservices of Mangrove Forests: Insights from Historical Colonial Observations. *Forests*, vol. 7, No. 9, p. 183. DOI: 10.3390/f7090183

Galicia, Leopoldo, and Alba E. Zarco-Arista (2014). Multiple ecosystem services, possible trade-offs and synergies in a temperate forest ecosystem in Mexico: a review. *International Journal of Biodiversity Science, Ecosystem Services & Management*, vol. 10, No. 4, pp. 275–88. DOI: 10.1080/21513732.2014.973907

Gao, Yu-qin, and others (2020). Change of stream network connectivity and its impact on flood control. *Water Science and Engineering*, vol. 13, No. 4, pp. 253–64. DOI: 10.1016/j.wse.2020.12.004

Gargaran, Jan P., and others (2024). Mangrove ecosystem in Asia: review and synthesis of ecosystem services and economic valuation methods. *Environmental and Experimental Biology*, vol. 22, No. 2, pp. 59–70. DOI: 10.22364/eeb.22.06

Gautam, Kabita, and Gerald Corzo (2023). Evaluating the impact of ponds on flood and drought mitigation in the Bagmati River Basin, Nepal. *Hydrology Research*, vol. 54, No. 10, pp. 1163–80. DOI: 10.2166/nh.2023.050

Hamza, Amina J., Luciana S. Esteves, and Marin Cvitanović (2022). Changes in Mangrove Cover and Exposure to Coastal Hazards in Kenya. *Land*, vol. 11, No. 10, p. 1714. DOI: 10.3390/land11101714

Hanna, Dalal E., and others (2018). A review of riverine ecosystem service quantification: Research gaps and recommendations. *Journal of Applied Ecology*, vol. 55, No. 3, pp. 1299–311. DOI: 10.1111/1365-2664.13045

Hilmi, Endang, Amron, and Dandhy Christianto (2022). The potential of high tidal flooding disaster in North Jakarta using mapping and mangrove relationship approach. *IOP Conference Series: Earth and Environmental Science*, vol. 989, No. 1, p. 12001. DOI: 10.1088/1755-1315/989/1/012001

Hou, Jingming, and others (2018). Assessing Slope Forest Effect on Flood Process Caused by a Short-Duration Storm in a Small Catchment. *Water*, vol. 10, No. 9, p. 1256. DOI: 10.3390/w10091256

Hümann, Marco, and others (2011). Identification of runoff processes – The impact of different forest types and soil properties on runoff formation and floods. *Journal of Hydrology*, vol. 409, 3-4, pp. 637–49. DOI: 10.1016/j.jhydrol.2011.08.067

Inácio, Miguel, and others (2022). Mapping lake ecosystem services: A systematic review. *The Science of the total environment*, vol. 847, p. 157561. DOI: 10.1016/j.scitotenv.2022.157561

Ingaramo, Roberta, E. Salizzoni, and Angioletta Voghera (2017). Valuing Forest Ecosystem Services for Spatial and Landscape Planning and Design. *Valori e Valutazioni*, vol. 19, pp. 65–78. Available at https://siev.org/wp-content/uploads/2020/02/19_06_Ingaramo-et-al_Eng.pdf

Islam, Mohammad A., and others (2024). Mangroves of Malaysia: a comprehensive review on ecosystem functions, services, restorations, and potential threats of climate change. *Hydrobiologia*, vol. 851, No. 8, pp. 1841–71. DOI: 10.1007/s10750-023-05431-z

Jakubínský, Jiří, and others (2021). Managing floodplains using nature-based solutions to support multiple ecosystem functions and services. *WIREs Water*, vol. 8, No. 5, art. e1545. DOI: 10.1002/wat2.1545

Javaheri, Amir, and Meghna Babbar-Sebens (2014). On comparison of peak flow reductions, flood inundation maps, and velocity maps in evaluating effects of restored wetlands on channel flooding. *Ecological Engineering*, vol. 73, pp. 132–45. DOI: 10.1016/j.ecoleng.2014.09.021

Jiang, W., J. Yu, and S. Xu (2023). Impact of urbanization in the meixi river basin on flood process in piedmont plain area. *Water Resources Protection*, vol. 39, No. 3, pp. 74–81.

Joshi, A. K., and P. K. Joshi (2019). Forest Ecosystem Services in the Central Himalaya: Local Benefits and Global Relevance. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, vol. 89, No. 3, pp. 785–92. DOI: 10.1007/s40011-018-0969-x

Kabeja, Crispin, and others (2020). The Impact of Reforestation Induced Land Cover Change (1990–2017) on Flood Peak Discharge Using HEC-HMS Hydrological Model and Satellite Observations: A Study in Two Mountain Basins, China. *Water*, vol. 12, No. 5, p. 1347. DOI: 10.3390/w12051347

Kadaverugu, Rakesh, and others (2021). Multiple values of Bhitarkanika mangroves for human well-being: synthesis of contemporary scientific knowledge for mainstreaming ecosystem services in policy planning. *Journal of Coastal Conservation*, vol. 25, No. 2, DOI: 10.1007/s11852-021-00819-2

Kaiser, Nina N., Christian K. Feld, and Stefan Stoll (2020). Does river restoration increase ecosystem services? *Ecosystem Services*, vol. 46, p. 101206. DOI: 10.1016/j.ecoser.2020.101206

Karanja, Joseph M., and Osamu Saito (2018). Cost–benefit analysis of mangrove ecosystems in flood risk reduction: a case study of the Tana Delta, Kenya. *Sustainability Science*, vol. 13, No. 2, pp. 503–16. DOI: 10.1007/s11625-017-0427-3

Kelly, D. A. (2018). Impact of paved front gardens on current and future urban flooding. *Journal of Flood Risk Management*, vol. 11, S1, DOI: 10.1111/jfr3.12231

Kim, Hyomin, Dong-Kun Lee, and Sunyong Sung (2016). Effect of Urban Green Spaces and Flooded Area Type on Flooding Probability. *Sustainability*, vol. 8, No. 2, p. 134. DOI: 10.3390/su8020134

Kim, Hyun W., and Yunmi Park (2016). Urban green infrastructure and local flooding: The impact of landscape patterns on peak runoff in four Texas MSAs. *Applied Geography*, vol. 77, pp. 72–81. DOI: 10.1016/j.apgeog.2016.10.008

Komora, J. (1981). Effect of tree vegetation on flood water runoff within flood plains. *VODOHOSPOD. CAS.*, vol. 29, No. 5, pp. 514–37.

Kumar Yadav, Pawan, and others (2015). *Investigation of the Effects of Wetland Vegetation on Coastal Flood Reduction Using Hydrodynamic Simulation*. In *Volume 1: Symposia. ASME/JSME/KSME 2015 Joint Fluids Engineering Conference,* Seoul, South Korea, 26/07/2015 - 31/07/2015American Society of Mechanical Engineers.

Langan, Charlie, and others (2018). Tropical wetland ecosystem service assessments in East Africa; A review of approaches and challenges. *Environmental Modelling & Software*, vol. 102, pp. 260–73. DOI: 10.1016/j.envsoft.2018.01.022

Lange, Benjamin, Peter F. Germann, and Peter Lüscher (2013). Greater abundance of Fagus sylvatica in coniferous flood protection forests due to climate change: impact of modified root densities on infiltration. *European Journal of Forest Research*, vol. 132, No. 1, pp. 151–63. DOI: 10.1007/s10342-012-0664-z

Li, Jiada, and others (2019). Construction Cost-Based Effectiveness Analysis of Green and Grey Infrastructure in Controlling Flood Inundation: A Case Study. *Journal of Water Management Modeling,* DOI: 10.14796/JWMM.C466

Li, Yuqi, and Chunlian Wang (2019). How ecological embankment strategy and its effects on flood control in the Jinhua River Basin. *Acta Ecologica Sinica*, vol. 39, No. 16, DOI: 10.5846/stxb201812052667

Liang, Danchen, and Ganlin Huang (2023). Influence of Urban Tree Traits on Their Ecosystem Services: A Literature Review. *Land*, vol. 12, No. 9, p. 1699. DOI: 10.3390/land12091699

Liu, Huiqing, and others (2013). Numerical study of the sensitivity of mangroves in reducing storm surge and flooding to hurricane characteristics in southern Florida. *Continental Shelf Research*, vol. 64, pp. 51–65. DOI: 10.1016/j.csr.2013.05.015

Liu, Shiliang, and others (2023a). Review of Valuation of Forest Ecosystem Services and Realization Approaches in China. *Land*, vol. 12, No. 5, p. 1102. DOI: 10.3390/land12051102

Liu, Shuyu, and others (2023b). Experimental study on the buffering effects of urban trees group in dike-break floods. *Scientific reports*, vol. 13, No. 1, p. 17096. DOI: 10.1038/s41598-023-44024-7

Liu, Wen, Weiping Chen, and Chi Peng (2014). Assessing the effectiveness of green infrastructures on urban flooding reduction: A community scale study. *Ecological Modelling*, vol. 291, pp. 6–14. DOI: 10.1016/j.ecolmodel.2014.07.012

Lu, Wei, Wei Xia, and Christine A. Shoemaker (2022). Surrogate Global Optimization for Identifying Cost-Effective Green Infrastructure for Urban Flood Control With a Computationally Expensive Inundation Model. *Water Resources Research*, vol. 58, No. 4, art. e2021WR030928. DOI: 10.1029/2021WR030928

Lü, Yingshuo, Yaohan Wang, and Xi Zheng (2021). Influence of forest landscape pattern on flood mitigation in Beijing Plain based on SWAT model. *Acta Ecologica Sinica*, vol. 41, No. 10, DOI: 10.5846/stxb202005281379

Luo, Sitong, and Agnès Patuano (2023). Multiple ecosystem services of informal green spaces: A literature review. *Urban Forestry & Urban Greening*, vol. 81, p. 127849. DOI: 10.1016/j.ufug.2023.127849

Maass, J. M., and others (2005). Ecosystem Services of Tropical Dry Forests: Insights from Long-term Ecological and Social Research on the Pacific Coast of Mexico. *Ecology and Society*, vol. 10, No. 1, DOI: 10.5751/ES-01219-100117

Menéndez, Pelayo, and others (2019). Assessing the effects of using high-quality data and high-resolution models in valuing flood protection services of mangroves. *PloS one*, vol. 14, No. 8, e0220941. DOI: 10.1371/journal.pone.0220941

Montgomery, J. M., K. R. Bryan, and G. Coco (2022). The role of mangroves in coastal flood protection: The importance of channelization. *Continental Shelf Research*, vol. 243, p. 104762. DOI: 10.1016/j.csr.2022.104762

Motiejūnaitė, Jurga, and others (2019). Cultural ecosystem services provided by the biodiversity of forest soils: A European review. *Geoderma*, vol. 343, pp. 19–30. DOI: 10.1016/j.geoderma.2019.02.025

Munji, Cecilia A., and others (2013). Vulnerability to coastal flooding and response strategies: The case of settlements in Cameroon mangrove forests. *Environmental Development*, vol. 5, pp. 54–72. DOI: 10.1016/j.envdev.2012.10.002

Munji, Cecilia A., and others (2014). Floods and mangrove forests, friends or foes? Perceptions of relationships and risks in Cameroon coastal mangroves. *Estuarine, Coastal and Shelf Science*, vol. 140, pp. 67–75. DOI: 10.1016/j.ecss.2013.11.017

Nelson, H. P., and others (2020). A review of tropical dry forest ecosystem service research in the Caribbean – gaps and policy-implications. *Ecosystem Services*, vol. 43, p. 101095. DOI: 10.1016/j.ecoser.2020.101095

Nithin Kumar Reddy, C., S. Asadi, and A.V.S. Prasad (2017). Evaluation of flood management for Krishna River Bank Stretch of Andhra Pradesh State. *International Journal of Civil Engineering and Technology (IJCIET)*, vol. 8, No. 1, pp. 302–06.

Norman, Laura M. (2020). Ecosystem Services of Riparian Restoration: A Review of Rock Detention Structures in the Madrean Archipelago Ecoregion. *Air, Soil and Water Research*, vol. 13, 117862212094633. DOI: 10.1177/1178622120946337

Ortiz Vargas, Andrea, and others (2025). Opportunities for improved flood risk management and adaptation in Hue, Central Viet Nam: Addressing current and future flood risks.

Osawa, Takeshi, Takaaki Nishida, and Takashi Oka (2020). High tolerance land use against flood disasters: How paddy fields as previously natural wetland inhibit the occurrence of floods. *Ecological Indicators*, vol. 114, p. 106306. DOI: 10.1016/j.ecolind.2020.106306

Osewe, Erick O., and others (2024). Review of forest ecosystem services evaluation studies in East Africa. *Frontiers in Ecology and Evolution*, vol. 12, art. 1385351. DOI: 10.3389/fevo.2024.1385351

Pandey, Bhanu, and Annesha Ghosh (2023). Urban ecosystem services and climate change: a dynamic interplay. *Frontiers in Sustainable Cities*, vol. 5, art. 1281430. DOI: 10.3389/frsc.2023.1281430

Paré, David, and others (2024). Connecting forest soil properties with ecosystem services: Toward a better use of digital soil maps—A review. *Soil Science Society of America Journal*, vol. 88, No. 4, pp. 981–99. DOI: 10.1002/saj2.20705

Paudel, Shishir, and Sarah L. States (2023). Urban green spaces and sustainability: Exploring the ecosystem services and disservices of grassy lawns versus floral meadows. *Urban Forestry & Urban Greening*, vol. 84, p. 127932. DOI: 10.1016/j.ufug.2023.127932

Peskett, Leo M., and others (2021). Tracers reveal limited influence of plantation forests on surface runoff in a UK natural flood management catchment. *Journal of Hydrology: Regional Studies*, vol. 36, p. 100834. DOI: 10.1016/j.ejrh.2021.100834

Pinto, Luís V., and others (2022). Ecosystem services and well-being dimensions related to urban green spaces – A systematic review. *Sustainable Cities and Society*, vol. 85, p. 104072. DOI: 10.1016/j.scs.2022.104072

Qaiser, K., Y. Yuan, and R. D. Lopez (2012). Urbanization Impacts on Flooding in the Kansas River Basin and Evaluation of Wetlands as a Mitigation Measure. *Transactions of the ASABE*, vol. 55, No. 3, pp. 849–59. DOI: 10.13031/2013.41519

Quandt, Amy, Henry Neufeldt, and J. T. McCabe (2017). The role of agroforestry in building livelihood resilience to floods and drought in semiarid Kenya. *Ecology and Society*, vol. 22, No. 3, DOI: 10.5751/ES-09461-220310

Quijas, Sandra, and others (2019). Linking biodiversity, ecosystem services, and beneficiaries of tropical dry forests of Latin America: Review and new perspectives. *Ecosystem Services*, vol. 36, p. 100909. DOI: 10.1016/j.ecoser.2019.100909

Rahman, Khandkar-Siddikur, and others (2024). Nypa-based land uses and ecosystem services in the tropics: A review. *Ecological Indicators*, vol. 159, p. 111613. DOI: 10.1016/j.ecolind.2024.111613

Rankin, K., and J. Ball (2004). A review of the performance of permeable pavers. *Engineering, Environmental Science,*

Reinhardt-Imjela, Christian, and others (2018). The impact of late medieval deforestation and 20th century forest decline on extreme flood magnitudes in the Ore Mountains (Southeastern Germany). *Quaternary International*, vol. 475, pp. 42–53. DOI: 10.1016/j.quaint.2017.12.010

Reu Junqueira, Juliana, Silvia Serrao-Neumann, and Iain White (2022). Using green infrastructure as a social equity approach to reduce flood risks and address climate change impacts: A comparison of performance between cities and towns. *Cities*, vol. 131, p. 104051. DOI: 10.1016/j.cities.2022.104051

Rojas, Octavio, and others (2022). Assessment of the flood mitigation ecosystem service in a coastal wetland and potential impact of future urban development in Chile. *Habitat International*, vol. 123, p. 102554. DOI: 10.1016/j.habitatint.2022.102554

Rood, Stewart B., and others (2015). Biological bank protection: trees are more effective than grasses at resisting erosion from major river floods. *Ecohydrology*, vol. 8, No. 5, pp. 772–79. DOI: 10.1002/eco.1544

Ruiz-Sandoval, Daniela, and others (2018). Valoración económica de tres servicios ecosistémicos antes del establecimientode un cinturón verde alrededor de la ciudad de Quebec, Canadá. *Revista Chapingo Serie Ciencias Forestales y del Ambiente*, vol. 25, No. 1, pp. 3–15. DOI: 10.5154/r.rchscfa.2018.04.036

Russo, Alessio, and others (2017). Edible green infrastructure: An approach and review of provisioning ecosystem services and disservices in urban environments. *Agriculture, Ecosystems & Environment*, vol. 242, pp. 53–66. DOI: 10.1016/j.agee.2017.03.026

Sarı, Elif N., and Selim Bayraktar (2023). The role of park size on ecosystem services in urban environment: a review. *Environmental monitoring and assessment*, vol. 195, No. 9, p. 1072. DOI: 10.1007/s10661-023-11644-5

Sato, Tadamichi, and Yasuhiro Shuin (2023). Impact of national-scale changes in forest cover on floods and rainfall-induced sediment-related disasters in Japan. *Journal of Forest Research*, vol. 28, No. 2, pp. 106–10. DOI: 10.1080/13416979.2022.2131221

Sett, Dominic, and others (2024). Flood risks in Hue, Central Vietnam: An assessment of current flood hazard, exposures, vulnerabilities, root causes and impacts.

Sheergojri, Ishfaq A., Irfan Rashid, and Ishfaq u. Rehman (2024). Systematic review of wetland ecosystem services valuation in India: assessing economic approaches, knowledge gaps, and management implications. *Journal of Environmental Studies and Sciences*, vol. 14, No. 1, pp. 167–79. DOI: 10.1007/s13412-023-00866-1

Silva-Galicia, Ana, and others (2023). Weight-of-evidence approach for assessing agroforestry contributions to restore key ecosystem services in tropical dry forests. *Agroforestry Systems*, vol. 97, No. 2, pp. 151–61. DOI: 10.1007/s10457-022-00794-z

Singha, Pankaj, and Swades Pal (2023). Wetland transformation and its impact on the livelihood of the fishing community in a flood plain river basin of India. *The Science of the total environment*, vol. 858, Pt 1, p. 159547. DOI: 10.1016/j.scitotenv.2022.159547

Staccione, Andrea, and others (2024). Connected urban green spaces for pluvial flood risk reduction in the Metropolitan area of Milan. *Sustainable Cities and Society*, vol. 104, p. 105288. DOI: 10.1016/j.scs.2024.105288

Tang, Yun, Arturo S. Leon, and M. L. Kavvas (2020a). Impact of Dynamic Storage Management of Wetlands and Shallow Ponds on Watershed-scale Flood Control. *Water Resources Management*, vol. 34, No. 4, pp. 1305–18. DOI: 10.1007/s11269-020-02502-x

__________ (2020b). Impact of Size and Location of Wetlands on Watershed-Scale Flood Control. *Water Resources Management*, vol. 34, No. 5, pp. 1693–707. DOI: 10.1007/s11269-020-02518-3

Tomer, M. D., and J. D. van Horn (2018). Stream bank and sediment movement associated with 2008 flooding, South Fork Iowa River. *Journal of Soil and Water Conservation*, vol. 73, No. 2, pp. 97–106. DOI: 10.2489/jswc.73.2.97

Torralba, Mario, and others (2016). Do European agroforestry systems enhance biodiversity and ecosystem services? A meta-analysis. *Agriculture, Ecosystems & Environment*, vol. 230, pp. 150–61. DOI: 10.1016/j.agee.2016.06.002

Tyagi, Pallavi (2022). Flood Risks, Mangrove Ecosystem and Coastal Megacities: Assessing the Adaptation Benefits of Mangrove Ecosystem to Urban Flood Risk in the H/E Ward of Mumbai, vol. 42, No. 6, pp. 643–51.

Udawatta, Ranjith P. (2021). Flood Control and Air Cleaning Regulatory Ecosystem Services of Agroforestry. In *Agroforestry and Ecosystem Services.* Udawatta, Ranjith P. and Shibu Jose, eds. Cham: Springer International Publishing. DOI: 10.1007/978-3-030-80060-4_12

Udawatta, Ranjith P., and Shibu Jose, eds. (2021). *Agroforestry and Ecosystem Services.* Cham: Springer International Publishing

Utami, Westi, and others (2021). The impact of mangrove damage on tidal flooding in the subdistrict of Tugu, Semarang, Central Java. *Journal of Degraded and Mining Lands Management*, vol. 9, No. 1, pp. 3093–105. DOI: 10.15243/jdmlm.2021.091.3093

van Coppenolle, Rebecca, C. Schwarz, and S. Temmerman (2018). Contribution of Mangroves and Salt Marshes to Nature-Based Mitigation of Coastal Flood Risks in Major Deltas of the World. *Estuaries and Coasts*, vol. 41, No. 6, pp. 1699–711. DOI: 10.1007/s12237-018-0394-7 van Hespen, Rosanna, and others (2023). Mangrove forests as a nature-based solution for coastal flood protection: Biophysical and ecological considerations. *Water Science and Engineering*, vol. 16, No. 1, pp. 1–13. DOI: 10.1016/j.wse.2022.10.004

Vidal-Abarca Gutiérrez, María R., and others (2023). Ecosystem services provided by dry river socio-ecological systems and their drivers of change. *Hydrobiologia*, vol. 850, 12-13, pp. 2585–607. DOI: 10.1007/s10750-022-04915-8

Wang, Mao, and others (2010). Maintenance of estuarine water quality by mangroves occurs during flood periods: a case study of a subtropical mangrove wetland. *Marine pollution bulletin*, vol. 60, No. 11, pp. 2154–60. DOI: 10.1016/j.marpolbul.2010.07.025

Wang, Mo, and others (2023). Data-driven approach to spatiotemporal dynamic risk assessment of urban flooding based on shared socio-economic pathways. *Ecological Indicators*, vol. 154, p. 110764. DOI: 10.1016/j.ecolind.2023.110764

Wang, Xin, and others (2022). Flood mitigation effects of lake-reservoir group on the Poyang Lake watershed based on runoff-weighted model from multi-satellite weekly observation. *Journal of Hydrology: Regional Studies*, vol. 44, p. 101265. DOI: 10.1016/j.ejrh.2022.101265

Xiao, Jie, and Kangning Xiong (2022). A review of agroforestry ecosystem services and its enlightenment on the ecosystem improvement of rocky desertification control. *The Science of the total environment*, vol. 852, p. 158538. DOI: 10.1016/j.scitotenv.2022.158538

Xu, Xibao, and others (2018). Lake-wetland ecosystem services modeling and valuation: Progress, gaps and future directions. *Ecosystem Services*, vol. 33, pp. 19–28. DOI: 10.1016/j.ecoser.2018.08.001

Xu, Zhaoming, and others (2020). Flood control effect of the fluvial process in the middle and lower reaches of the Yangtze River. *Advances in Water Science*, vol. 31, No. 3, pp. 366–76.

Yang, Liu, and others (2016). River networks system changes and its impact on storage and flood control capacity under rapid urbanization. *Hydrological Processes*, vol. 30, No. 13, pp. 2401–12. DOI: 10.1002/hyp.10819

Yang, Yiling, Kangning Xiong, and Jie Xiao (2024). A review of agroforestry biodiversity-driven provision of ecosystem services and implications for karst desertification control. *Ecosystem Services*, vol. 67, p. 101634. DOI: 10.1016/j.ecoser.2024.101634

Yates, P., and J. M. Sheridan (1983). Estimating the effectiveness of vegetated floodplains/ wetlands as nitrate-nitrite and orthophosphorus filters. *Agriculture, Ecosystems & Environment*, vol. 9, No. 3, pp. 303–14. DOI: 10.1016/0167-8809(83)90104-4

Ye Klimenko, D., E. S. Cherepanova, and A. A. Khomyleva (2021). Influence of post-pyrogenic successions of the forests of the Urals on the formation of maximum rainfall flood discharges. *IOP Conference Series: Earth and Environmental Science*, vol. 834, No. 1, p. 12022. DOI: 10.1088/1755-1315/834/1/012022

Yoo, Chulsang, and others (2016). Simulation of infiltration facilities using the SEEP/W model and quantification of flood runoff reduction effect by the decrease in CN. *Water science and technology : a journal of the International Association on Water Pollution Research*, vol. 74, No. 1, pp. 118–29. DOI: 10.2166/wst.2016.189

Zell, Chris, Elliott Kellner, and Jason A. Hubbart (2015). Forested and agricultural land use impacts on subsurface floodplain storage capacity using coupled vadose zone-saturated zone modeling. *Environmental Earth Sciences*, vol. 74, No. 10, pp. 7215–28. DOI: 10.1007/s12665-015-4700-4

Zheng, Peng, and others (2019). Urban stormwater and flood control effect of green and grey infrastructures under extreme rainfall conditions. *China Environmental Science*, vol. 39, No. 5, pp. 2123–30.

Zia, Sahar, and others (2022). The Effect Of Urban Green Spaces In Reducing Urban Flooding In Lahore, Pakistan, Using Geospatial Techniques. *Geography, environment, sustainability*, vol. 15, No. 3, pp. 47–55. DOI: 10.24057/2071-9388-2021-135

Ziana, and others (2020). The effect of diameter and distance between vegetation in the riverbank to flood discharge by Eco-hydraulic in the Lawe Alas River, Southeast Aceh, Indonesia. *IOP Conference Series: Materials Science and Engineering*, vol. 933, No. 1, p. 12051. DOI: 10.1088/1757-899X/933/1/012051