Integrating Ecosystem-based Approaches into Flood Risk Management for Adaptive and Sustainable Urban Development in Central Viet Nam

- FloodAdaptVN -

Summary of the project

Central Viet Nam is characterized by rapid urbanization, particularly in small and medium-sized coastal cities. At the same time, the region is facing an increase in precipitation and heavy rainfall events caused by climate change, which, combined with land use changes upstream, results in more frequent and more intense flooding. The overall aim of FloodAdaptVN is to (1) understand and assess the drivers, spatial patterns (incl. hotspots), and dynamics of present-day and future flood risks (2030, 2050, 2100), (2) investigate entry points for and barriers towards the implementation of disaster risk reduction (DRR), risk transfer (i.e. insurance) and adaptation solutions (with a strong focus on ecosystem-based approaches), (3) co-develop a decision support tool for risk-informed (spatial) planning and prioritizing among different DRR, risk transfer and adaptation measures and, (4) foster capacity development. Focus area is the catchment of the Perfume River in the Thua Thien Hue Province, Viet Nam, which also includes the city of Hue.

Drawing on a participatory, transdisciplinary research design, FloodAdaptVN builds on a strong network that was established in the *Preparation* and *Definition Phases*. The network includes local to national stakeholders and (inter)national experts, which deliver on the above mentioned aims and ensure their mainstreaming into relevant local, national (e.g. National Adaptation Plans) and international policy processes (e.g. the Sendai Framework for DRR). During the *Definition Phase,* the modular FloodAdaptVN approach has been co-designed and pilot-tested successfully. A sophisticated and transferable modelling framework adapted to local conditions will assessment assess the present-day flood risks and possible future flood risk under Representative Concentration (RCP) and Shared Socioeconomic Pathways (SSP) scenarios. Existing and planned DRR, risk transfer and adaptation measures, as well as potential innovative measures will be identified and evaluated against a multi-criteria catalogue, including impact reduction, protection targets, social acceptance, cost-benefit, potential mal-adaptive consequences as well as synergies and trade-offs with Sustainable Development Goals (SDG) targets. The modular approach will be made available in a designated Flood Information System (FRAME).

To ensure that FloodAdaptVN produces policy-relevant outcomes, strengthens existing and builds new capacities in the region, the key research questions, the overall methodological approach as well as the type and format of the proposed outcomes and outputs will continue to be co-developed and co-produced in close collaboration with relevant local stakeholders and Vietnamese scientific partners. This process has been initiated during the *Preparation Phase* and successfully continued in the *Definition Phase*.

1 Description of the problem

1.1 Regional challenges and the need for action

Typhoons and associated floods repeatedly hit Central Viet Nam, predominantly in autumn. Within the last two decades, catastrophic events took place in 1997, 1998, 1999, 2007, 2008, 2009, 2013, 2016 and typhoon “Doksuri” in 2017. In 2016, typhoon "Sarika" and subsequent flood events left 134 people dead and missing (UN 2016). In Central Viet Nam, 10-30% of the population was affected, about one million people were in urgent need for support, and economic loss accounted for 460 million US$. In October 2019 and March 2020, extreme weather events resulted in four fatalities, over 5,000 damaged buildings and infrastructures, considerable loss of agri-/ aquacultural land and significant economic damage especially amongst small and mid-sized enterprises in cities/towns. As a result of climatic change, it is likely that extreme weather events will further intensify in magnitude and frequency (IPCC 2014, MONRE 2016, Bangalore et al. 2019). Coastal cities are particularly threatened by flooding – and with them the economic basis and sustainability of their urban regions (Kulp et al. 2019). Climate change and flooding will also intensify impacts on water quality or spreading pathogens through waterborne transmission, with knock-on effects on both natural and human systems (Tran & Shaw 2007, Rui *et al.* 2018). The situation in Central Viet Nam is characterized by rapid urbanization, particularly in small and mid-sized coastal cities (GSO 2016), which leads to (1) increased surface sealing and associated inundations following heavy rainfall, (2) loss of infiltration and retention areas generating higher runoff and flood depth, and (3) increased exposure through the expansion of settlements into flood-prone areas (Garschagen 2014, 2015, Sudmeier-Rieux et al. 2015, DiGregorio et al. 2016). In Central Viet Nam, high urbanization trends co-occur with land use changes in the upper catchment of the rivers (Truong et al. 2018, Tamura et al. 2020). The consequences are dramatic as the coastal area is squeezed between the mountainous upstream area and the sea, resulting in very short response times when heavy rainfall occurs. Due to changing settlement patterns, housing typologies and lifestyles (from rural to urban), combined with societal transformation, local vulnerabilities as well as adaptation practices are also changing and have to be considered (Garschagen & Kraas 2011, Pelling 2003, Carew-Reid 2008, Bloch et al. 2012). This dynamic and forward-looking perspective is not only relevant for preventive/adaptive planning, but particularly in a Covid-19 context, in which the virus and subsequent economic downturn have massive implications for future vulnerability and adaptive capacity. Local communities found ways to cope with recurring flood events by the construction of dams (e.g. upstream of city of Hue), flood-adapted housing, and channels for water drainage. Yet, as demonstrated by the severe impacts of past events, and as emphasized by local stakeholders in the *Definition Phase*, these efforts are not sufficient to prevent disasters in the future. Instead, the development of new industrial and residential areas is still given priority by local decision-makers intending to boost the economy, while little incentives for risk-informed planning are provided (Garschagen 2016). Additionally, in the city of Hue, which is the old capital and home to several of Viet Nam's most treasured national heritage sites, flood damages to these buildings and places are of concern that directly relates to sense of place, culture and income from tourism.

Considering these challenges, FloodAdaptVN co-designed objectives (section 2) and a work plan (section 3.1), which aims to better (1) understand and assess the drivers, spatial patterns (incl. hotspots), and dynamics of present-day and future (2030, 2050, 2100) flood risks, (2) investigate entry points for and barriers towards the implementation of DRR, risk transfer and adaptation solutions (with a strong focus on ecosystem-based approaches), (3) co-develop a (spatial) decision support tool for risk-informed planning and prioritizing among different DRR, risk transfer and adaptation measures and, (4) foster capacity development.

1.2 State of scientific and technological development

First, the city of Hue and its hinterland have seen a number of **initiatives** focusing on flood risk reduction (e.g. IHMEN & NCAP 2008; Nam & Udo 2011; Razafindrabe et al. 2014) **with varying scope, extent, effectiveness and sustainability**. An integrated assessment of current and future flood risks however is still lacking. FloodAdaptVN will engage with these initiatives to take stock and make use of existing data.

Second, **flood conditions in the study region are specific**, driven by an interplay of a mountainous upper catchment, short steep river(s), and densely populated areas at the coast. For the mapping and modelling of hydrologic conditions, flood events and scenarios, hydrologic and two-dimensional (2D) hydraulic models are widely used tools. For applications on larger scales, raster-based hydraulic models have proven to deliver realistic results (Tyrna et al. 2017).

Third, **remote sensing** provides information on flood extents, land-use changes and trends, existing ecosystems, imperviousness, as well as urban structures and buildings types, hence supporting flood modelling and exposure assessments (Bachofer & Rau 2016, Bachofer 2017, Palacios-Lopez et al. 2019).

Fourth, to fully grasp the complexity of risk, assessments should capture the diversity of impacts hazards might produce and their associated vulnerabilities – an approach described as multi-risk (Garcia-Aristizabal et al. 2015) or multi-vulnerability (Gallina et al., 2016) in the literature. However, to date flood risk assessments mostly assess generic flood risk for a specific territory instead of employing an **impact-specific perspective** where impact-specific drivers of vulnerability are considered.

Fifth, risk assessments in the context of climate change and associated hazards are often limited to future hazard scenarios (e.g. Carew-Reid 2008). Future dynamics of exposure and vulnerability are mostly not adequately accounted for (Garschagen & Kraas 2010; Birkmann et al. 2015). This presents a key gap given the dynamic societal transformation, urbanization and economic transition processes in Central Viet Nam, and the need for **future risk scenarios** as baselines for preventive/adaptive planning (Garschagen 2015; Sudmeier-Rieux et al. 2015).

Sixth, existing DRR and adaptation strategies still focus largely on structural (i.e. engineering-based) solutions, such as dams, dykes, reservoirs, etc., while the consideration of **ecosystem-based or hybrid approaches** is a comparably **new, dynamically evolving field** (Estrella & Saalismaa 2013, Hagenlocher et al. 2018). Unlike structural measures, ecosystem-based solutions can increase their risk reduction capacity over time (van Wesenbeeck et al. 2016), recover from extreme events (e.g. Long et al. 2016), have lower maintenance costs (Daigneault

et al. 2016), and provide additional co-benefits, such as esthetic value, food provision, or water purification (Almeida et al. 2018). A global review of Ecosystem-based adaptation (EbA) solutions in flood-prone urban catchments conducted in the *Definition Phase* revealed that few studies have evaluated the performance of EbA measures, and that criteria for the evaluation and monitoring of the multiple benefits of EbA measures are still lacking. Further, especially in small river catchments, **lack of space in upstream as well as in urban areas**, and conflicting policy goals (e.g. urban development), does **not offer easy solutions for ecosystem-based flood risk reduction (EcoDRR) and adaptation (EbA)**.

Seventh, in the context of flood risk management, adaptive planning and sustainable urban development, a wide range of stakeholders needs to be involved, and in countries like Viet Nam the **political economy of urban risk** (Garschagen 2014, 2015, DiGregorio et al. 2016) and the contested ways in which resilience-building in urban regions is interpreted and institutionally implemented by party-state actors (Garschagen 2013, 2016) need to be considered.

Eighth, responding to climate-related risks involves **decision making under uncertainty** (IPCC 2014). This calls for future risk scenarios and Decision Support Systems (DSS), currently not existing in urban regions of Central Viet Nam (Hertel & Rosch 2010, Nay et al. 2014). There is therefore a need to promote integrative decision-making tools, as proposed by FloodAdaptVN (Aznar-Siguan & Bresch 2019, Bresch & Mueller 2016, Souvignet et al. 2016).

Ninth, **climate risk insurance** offers ways to **transfer risks** and reduce the impacts of hazards on the most vulnerable (Paudel 2012). Several attempts have been made to introduce flood insurance in Viet Nam (GFDRR 2016, Hellmuth et al. 2009). To date, it is one of the few countries having introduced climate risk insurance as a national commitment to the Paris Agreement (Kreft et al. 2017). However, existing efforts are concentrated on flood risks for agriculture while total climate risk insurance coverage remains at only 5% (World Bank 2017).

Building on the complementary expertise of the partners (chapter 4.1), FloodAdaptVN will address these gaps in the *R&D Phase*. In contrast to other ongoing initiatives in Viet Nam, FloodAdaptVN has a distinctive focus on mid-sized cities, on assessing current multi-risk and simulating future risk scenarios, as well as and on evaluating the potentials of risk transfer, Eco-DRR and EbA as part of an overall DRR and adaptation strategy.

1.3 Own previous work

The FloodAdaptVN consortium is well experienced and networked in Viet Nam. **Several projects** related to urban planning, mid-sized cities, water management, risk assessment, resilience and adaptation (incl. ecosystem-based solutions) were coordinated and implemented in the last decade (Table 1). The **complimentary experience** of the consortium (chapter 4.1) enables tackling the above-mentioned challenges, while its **broad network** has allowed establishing trust-based relationships with relevant decision-makers, universities and practitioners on local to national level in the *Preparation* and *Definition Phases* already, which is a key asset for the transdisciplinary co-development approach of the *R&D Phase*. The most relevant **publications** of the consortium are included in the partners' short CVs in the attachment.

Table 1: Previous and ongoing cooperation experiences that are relevant for the envisaged activities.

Project name	Duration	Funding	Partners
UKRI Living Deltas Hub (**Mekong, Red River**, and Ganges-Brahmaputra delta)	2019-24	UKRI	UNU
DECIDER (FKZ: 01LZ1703F) Decisions for adaptive pathway design and the Integrative Development, Evaluation and Governance of Flood Risk Reduction Measures in Transforming Urban-Rural-Systems (**Ho Chi Minh City**)	2019-22	BMBF	TUE / LMU
ECA Studies in Honduras, Ethiopia and Viet Nam. **Quantification of risks and Adaptation** for flood and drought	2019-21	BMZ/ISF/ KfW	UNU/MCII
emplement! (FKZ: 01LE1902) Qualifizierung städtischer Regionen zur Umsetzung von Nachhaltigkeits- und Resilienzstrategien unter Berücksichtigung des urban-ruralen Nexus (**Da Nang and Quang Nam** province)	2019-20	BMBF	TUE / IZES
The Catch-Mekong project (02WM1338A) investigated the sustainable and transboundary management of the natural water resources in the **Mekong Delta**	2017-19	BMBF	DLR
Advancing Climate Risk Insurance (ACRI+). Application of the **ECA methodology** in China, Barbados and Morocco	2015-18	BMUB	MCII
RapidPlanning (FKZ: 01LG1301) Sustainable infrastructure, environmental and resource management for highly dynamic metropolises (Case city **Da Nang**)	2014-19	BMBF	TUE / IZES
The Political Economy of Urbanization and Climate Risk in Viet Nam (**Quy Nhon**, **Da Nang** and Can Tho)	2014-16	Rocke-feller F.	UNU / LMU
Development and implementation of **integrated insurance mechanisms (ICRM)** for disaster risk management in developing countries	2013-18	BMUB	MCII
Catalyzing action towards sustainability of deltaic systems with an integrated modelling framework for risk assessment-**Mekong**	2013-17	BELMONT (DFG)	UNU / DLR
Transformation and Resilience in the Urban Coasts (**TRUC**)	2013-17	BELMONT	UNU /LMU
Preservation of **coastal ecosystem and natural resources** under development activities	2012-2018	VLIR-IUC, Belgium	HUSC
Health risk assessment during **urban flooding in Hue**	2010-2011	Tokyo University	HUSC
Megacity Research Project TP. **Ho Chi Minh** – Integrative Urban and Environmental Planning Framework Adaptation to Climate Change (with BTU Cottbus-Senftenberg)	2008-13	BMBF	IZES
Indonesian-German Cooperation: Consultancy for the Project Mitigation of Georisks (Georisk III)	2008-09	BGR	GEOMER
Water-related information system of the sustainable development of the **Mekong Delta** (FKZ: WISDOM I 0330777 & WISDOM II 033L040)	2007-13	BMBF	UNU / DLR / LMU
Application of Water Quality Index (WQI) for assessment and classification of water quality of the Huong river in **Hue**, Viet Nam.	2007- 08	Hue University	HUSC
Integrated Water Resources management System (**IWRMS**) (with Uni Jena)	1999-03	EU FP4	TUE

1.4 Activities and results of the Definition Phase

The key research questions, the overall methodological approach, as well as the proposed outcomes and outputs have been **co-designed** with relevant local stakeholders and scientific partners during the *Preparation* and *Definition Phase*. A scoping mission to the study site was carried out in late 2019, relevant stakeholders (i.e. the provincial Departments of Planning and Investment [DPI], Construction [DOC], Agriculture and Rural Development [DARD], DONRE and the Committee for Flood and Storm Control [CFSC]) were interviewed and cooperation activities were initiated. Further key **achievements** of the *Definition Phase* include:

<u>Co-Design, networking and co-funding:</u>

- A **kick-off event** took place in November 2019 where the Vice-Chairman of the People's Committee Huê and relevant stakeholders emphasized the relevance of the project and confirmed their strong support (see attached LoIs).
- A **local project office** has been opened at Hue University, taking a central part in linking all involved participants since then.
- Contacts with other **BMBF** and **BMU IKI** (International Climate Initiative) projects, as well as **international projects** (e.g. NERC-funded: Past, Present and Future Flood Risk in South-Central Highlands in Viet Nam) were established to discuss potential collaborations.

- As the Vietnamese partners participated in the *Definition Phase* **at their own costs**, an application for **funding by HUIS** was submitted in parallel to **NAFOSTED**.

Outreach, capacity development and dissemination:

- A **project website** (www.floodadapt.eoc.dlr.de) has been set up and a **project flyer** designed.
- FloodAdaptVN was present at the **German Science Day** in Hanoi (10/2019), the **Zukunftsstadt Konferenz** in Muenster (12/2019) and a **networking event** of the VD-Office in Bonn (03/2020).
- Contents of FloodAdaptVN were integrated into ongoing **educational activities** of UNU, DLR and TUE, and a guest lecture has been delivered by UNU at Hue University (05/2020).

Literature reviews in preparation for the R&D Phase:

- **Two literature reviews** were conducted to (1) analyse the state of the art and persisting gaps regarding flood risk assessments and management in Viet Nam, and (2) reveal the status, potentials and limitations of EbA in small river catchments with short rivers, limited space and urban areas located downstream globally:
  - Nguyen. M.T., Sebesvari Z., Souvignet M., Bachofer F., Braun A., Garschagen M., Schinkel U., Yang L. E., Nguyen H. K. L., Hochschild V., Assmann A., Hagenlocher M. (**accepted**). Understanding and assessing flood risk in Viet Nam: current status, persisting gaps, and future directions. *Journal of Flood Risk Management*.
  - Nguyen. M.T., Hagenlocher M., Ortiz Vargas, A. & Sebesvari Z. (full paper in preparation). Integrating Ecosystem-based Adaptation (EbA) into flood risk management for coastal urban regions – current status, potentials and challenges. *Frontiers in Environmental Science* (invitation for full paper received in July 2020).

Data collection, interviews and analysis:

- An initial **review of the policy and planning framework** as well as a stakeholder mapping was conducted. The result is a visualisation of sectoral and spatial development targets as formulated in current strategies and plans at different levels, the identification of policy-related entry points and barriers for DRR, EbA and risk transfer solutions, as well as a Stakeholder Map, which provides an overview for the envisaged future stakeholder engagement and co-development process.
- A **data portal** for the storage/ exchange of spatial data was established. It currently contains 28 datasets and existing plans. Its transfer to a local server in Hue is currently under preparation.
- Ten **weather stations** have been acquired, of which three have already been installed in Hue and send temperature and precipitation data to our database every 5 minutes. The remaining stations will be positioned after consultation with the local partners towards the end of the *Definition Phase*.
- An initial remote sensing analysis identifying **land subsidence** in and around Hue was **published**:
  - Braun, A., Hochschild, V., Pham, T. G., Nguyen, L. H. K., & Bachofer, F. (2020). Linking land subsidence to soil types within Hue city in Central Viet Nam. *Journal of Vietnamese Environment*, 12(1), 1-6.
- **Annual settlement growth** (1985-2015) was derived from Landsat data and the approach for the **delineation of flood events** by Sentinel-1 data was successfully tested for flood event in December 2017. Further, **aquaculture ponds** were delineated for two test sites using Sentinel-1/2 data.
- We have applied for access to data from the Thailand Viet Nam Socio Economic Panel (**TVSEP**) **project,** a long-term panel project where data is available for Hue for the period 2007-2017.
- Despite the COVID-19 situation, **interviews** were conducted with authorities (n = 12), hamlet leaders (n = 4) and the local population (n = 9) to gain a better **understanding** of local concerns and adaptation needs related to flooding. **Household surveys** (n = 53) and a **water sampling campaign** (36 water samples) were conducted to identify the impacts of floods on water quality and livelihoods.
- An Economic Costs of Adaptation (**ECA-VN**) **prototype** has been developed and is currently pilot tested in An Dong ward. It will be linked to the FRAME information system in the *R&D Phase*.

2 Objectives, approach and expected impacts of the R&D Phase

2.1 Research framework of the project proposal

The **overall aim** of FloodAdaptVN is to address the above stated gaps in the rapidly urbanizing, flood-prone regions of central Viet Nam to assist local authorities in the development of adequate DRR, risk transfer and adaptation responses. To this end FloodAdaptVN will assess current patterns, impacts and future scenarios of flood risk, the potential of risk transfer and of ecosystem-based and hybrid DRR and adaptation options as complementary solutions to conventional, mostly structural, measures.

To ensure that FloodAdaptVN produces actionable and policy-relevant outcomes and enables strengthening of existing and the development of new capacities, FloodAdaptVN builds on a participatory **transdisciplinary co-development design** between Vietnamese and German partners. Following the consultative process of the co-design approach in the *Definition Phase*, **seven interrelated work packages (WPs,** Figure 1) were defined, in which we plan to co-develop, apply, validate and implement the FloodAdaptVN approach together with all project partners and stakeholders. **Current flood risks** and their associated **impacts** will be assessed, including an investigation of the impact-specific root causes/drivers of flood risk. Satellite imagery analysis, geospatial analysis and modelling will be used to map past and current flood events, and to assess the exposure and vulnerability of assets, systems and sectors towards these floods.

To enable preventive/adaptive planning, **future flood risk scenarios** (2030, 2050, and 2100) will be simulated under environmental, climatic and societal change. Here we will benefit from our preparatory work in the *Definition Phase*, for example by integrating data of installed climate stations or by applying simulation prototypes at larger regions and in greater detail.

Existing and planned flood risk reduction, risk transfer and adaptation solutions will be identified. This involves strategies and measures at national, regional, catchment, and city scale, and will serve as a starting point for more detailed analyses at the neighbourhood and household level. Thereby, a particular focus will be placed on risk transfer, hybrid and ecosystem-based solutions as part of an overall DRR and adaptation strategy.

Findings from above activities will contribute to the identification of **additional DRR, risk transfer and adaptation measures demands and solutions** as well as their **evaluation** against a set of criteria (e.g. protection targets, stakeholders' preferences, cost-benefit ratios, social acceptance, possible mal-adaptive consequences) co-developed with relevant stakeholders.

Further, FloodAdaptVN will focus on the integration of climate change concerns and DRR, risk transfer and adaptation measures, strategies and plans into the existing **legislative and policy framework** and administrative action/ planning culture. **Capacity development and knowledge exchange** (incl. practical training, E-Learning activities, etc.) accompany the entire process.

A framework of **data management and exchange**, as well as the utilization of cloud processing centres (e.g. Urban Thematic Exploitation Platform, DIAS) to ensure the sustainable processing capabilities of the local partners, completes our vision of the *R&D Phase*. The proposed system (FRAME) combines capabilities of existing portals, e.g. the WISDOM information system (Kuenzer et al. 2016) or the CATCH-MEKONG Knowledge Hub (DLR 2020).

2.2 Relevance of the project to the funding goals of the call

FloodAdaptVN with its distinct focus on urban regions in Central Viet Nam refers directly to the third FONA³ framework program, in particular to the flagship initiative "Zukunftsstadt" and the principle of future-oriented research. In addition, the project directly relates to the "New Urban Agenda" (NUA) (§ 65), the "Sendai Framework for Disaster Risk Reduction" (Priority 1), the "Sustainable Development Goals (SDGs)" (notably SDG 11, 13, 15 and 17), as well as the Paris Climate Agreement (Article 8). FloodAdaptVN focuses on the funding objective "Risk management in extreme weather conditions and natural disasters in rapidly growing cities and their surroundings as well as urban regions". In addition, the research foci of FloodAdaptVN meet multiple funding goals of the call (Table 2).

Table 2: Funding objectives of call and FloodAdaptVN activities

Call Objectives	Activities FloodAdaptVN
Integrated urban planning	Assessment of current and future flood risks and mainstreaming of results into policies and plans at different levels, such as the regional plan, the provincial-level Socio-Economic Development Plan, the provincial-level Masterplan, or the local-level action plans.
Risk management of natural disasters in rapidly growing cities and their surroundings as well as urban regions	Co-development of DRR, risk transfer and adaptation strategies in collaboration with local and regional stakeholders to support integrated flood risk management in rapidly changing urban regions of Central Viet Nam. Analysis of barriers and entry points for novel (ecosystem-based or hybrid) DRR, risk transfer or adaptation measures.
Governance structures and participation	Establishment of a local project office to facilitate co-development, co-production and co-dissemination of results. Fostering cooperation and collaboration between all relevant stakeholders to enable concerted action to adapt to climate change and to reduce flood risk at all levels. Consideration of existing governance structures when developing novel DRR and adaptation strategies and flood risk management solutions.
Training of specialist staff	Strengthening existing and building new capacities of staff of the project partners and stakeholders in terms of spatial data handling, flood modelling, risk assessment, scenario development, and integrated risk-informed planning approaches..
Management of data relevant to planning	Spatial data harmonization and communication of results and scenarios with a web-based interface. Balancing of science-based data with experiences gained by local stakeholders.
Integration into existing urban development and climate protection plans	Assessment of flood risks and mainstreaming of results into policies and plans at different levels: regional plan, provincial-level Socio-Economic Development Plan, provincial-level Masterplan, local-level action plans, National Adaptation Plan (NAP).
Impact of the planned measures on the surroundings (urban-hinterland relations)	Simulation of the effects of planned DRR and adaptation measures (e.g. embankments vs ecosystem-based solutions) on flood hazards and risk patterns in the city of Hue and its hinterland considering urban-rural interrelations. FloodAdaptVN will also evaluate co-benefits of ecosystem-based solutions (e.g. in terms of water quality, recreation, etc.).
Application and implementation by local decision-makers	All methods and measures will be co-developed, co-produced and co-disseminated with local stakeholders.

3 Description of the planned research activities

3.1 Work programme of the R&D Phase

The project structure is target oriented, and allows steady adaptations when necessary (Table 3, Figure 1). Core tasks include (1) the development of a comprehensive database, remote sensing and geospatial analysis, and a reliable and open information flow, (2) the assessment of current flood risks and impacts, (3) the development of future flood risk scenarios (2030, 2050, 2100), (4) the development and evaluation of flood risk management and adaptation measures, (5) a strong outreach, networking and capacity development component, as well as (6) mainstreaming into policy agendas and processes. To achieve this, FloodAdaptVN builds on seven closely interlinked work packages (WPs).

Milestones: M1.1 Project office operation continued**, M1.2** Co-Development workshops I-IV conducted; **M1.3** Mid-term report submitted; **M1.4** Four high-level publications submitted; **M1.5** Final report submitted + presentation held; **M1.6** *Implementation Phase* proposal submitted

Summary: *In this WP, the project coordination is administered, as well as the co-development strategy, the scientific excellence of the deliverables secured and the dissemination organized.*

Task-1.1: Project management (**M1-M48; Lead: DLR;** Contributor: German partners)
Beyond the standard responsibilities in project coordination, this task will ensure the effective preparation of all events and meetings, as well as of documentation material and reports. The timely delivery and distribution of work results and milestones will be supervised with this task. A thorough risk and opportunity plan (section 4.4) allows reacting to changing circumstances in a structured and well-organized manner. The proposal development and submission process for the *Implementation Phase* will be steered in this task (see T-7.5).

Task-1.2: Coordination of local stakeholders (**M1–M48; Lead: HUIS;** Contributor: DLR)
The local project office that was established in the *Definition Phase* will be maintained and continuously serve as a hub and steady exchange platform between the project partners, local stakeholders and third parties. The local coordinator (HUIS) will cooperate closely with the overall project coordination and is responsible for organization/preparation of local events and capacity development activities.

Task-1.3: Co-Development (**M1–M48; Lead: IZES**; Contributor: all)
A co-development approach (based on the co-design approach of the *Definition Phase*) will be designed and applied, in order to actively engage all relevant stakeholders. The intensive cooperation of the local stakeholders and the Vietnamese-German research team ensures that the research results of FloodAdaptVN (e.g. FRAME, ECA-VN) are shaped according to the requirements (e.g. required information for planning and decision-making) and technical conditions of the local 'end-users'. In order to facilitate the exchange and interaction between all parties, four Co-Development Workshops will be conducted and capacity development activities prepared (T-6.3).

Task-1.4: Quality control and quality assurance (**M1–M48; Lead: DLR;** Contributor: HUIS)
T-1.4 will ensure the adequacy, repeatability and reproducibility of the methods of WP2 to WP5, by a detailed documentation and control mechanisms, which ensure that the procedures are under statistical control by: (1) workflow documentation by reports, spreadsheets, scripts, etc., (2) identifying and documenting potential sources of error, (3) method validation ("fit for purpose") by state of the art review, (4) accuracy assessment, (5) evaluation of the uncertainty (method dependent statistical evaluation). All measures and outreach activities will be validated for their contribution to the aims of the project and the strategic alignment of the overall project. Findings will be documented in the mid-term and final reports.

Task-1.5: Dissemination (M1–M48; Lead: DLR; Contributor: German partners, HUIS, HUSC)
The project website (floodadapt.eoc.dlr.de) will be maintained to increase the project visibility and serve as information and contact platform. Outreach material, as well as social media contributions will be prepared and distributed through the channels of the participating partners. The project flyer developed in the *Definition Phase* will be updated and distributed at relevant conferences and events. A minimum of four high-level publications in scientific journals is envisaged in addition to the policy brief developed in T-7.4. The FloodAdaptVN objectives and outcomes will be channelled to Vietnamese local media, like the Official Gazette, to reach Vietnamese authorities. FloodAdaptVN will attend and contribute to BMBF events in Germany (networking events, etc.), in Viet Nam (e.g. German Science Day) and present the sector-specific results at dedicated scientific events (incl. conferences).

WP2: Data management, remote sensing and geospatial analysis							**Duration**: M1–M48, 71.5 (+7.5) PM | **Lead**: DLR				
PM	DLR 26	TUE 26	UNU 6.5	LMU 2	IZES 5	GEOMER 6	HUIS +5.5	HUSC +1	DONRE +1	CCNDPC -	MONRE -

Milestones: M2.1 Database is established and filled with datasets; **M2.2** Copernicus DEM available; **M2.3** Annual maps of urban development since 1985 (M2.3a) available; Building types for Hue (M2.3b); **M2.4** Flood extent maps for past events (M2.4a) Coastal dynamics (M2.4b) available; **M2.5** FRAME is available online and a manual is provided to all users; **M2.6** Status (M2.6a) and dynamics (M2.6b) of flood relevant land-use available

Summary: *This WP focuses on information and data gathering, remote sensing and geospatial analysis, as well as the development of an infrastructure for the collaborative collection, handling and analysis of information and geo-spatial data within the project.*

Task-2.1: Data gathering (**M01–M42; Lead: DLR**; Contributor: German partners, HUIS, HUSC, DONRE)
Geospatial data and spatial plans will be gathered from local stakeholders like DONRE and CFSC, as well as from previous and ongoing projects. The availability of data and willingness for data exchange was already explored in the *Definition Phase*. All datasets will be collected, harmonized and passed on to the database (T-2.2 & 2.5). Relevant satellite remote sensing data as well as time series of socio-economic data (census) will be identified, collected/ordered and stored for further processing. Reference data on building types and heights will be collected in the city of Hué. Existing legal texts, sector and spatial development plans for Thua Thien Hue Province (for the SEDP - Socio-Economic Development Plan period until 2030 (first phase: 2021-2025)) as well as other local development plans (climate action plans, detailed plans, construction master plans etc.) will be collected and examined. Further, empirical household surveys will be conducted in city of Hue and the catchment (HUIS, HUSC, UNU, LMU) to support the assessment of current risk awareness/perception, coping and adaptive capacities as well as past flood impacts (WP3) as well as the identification of entry points and barriers towards different risk transfer and adaptation options (WP5). Surveys will be designed to complement empirical data on Hue collected in the long-term panel project TVSEP. The Thua Thien Hue Province has currently only three meteorological stations and two additional rain gauges, limiting access to temporal high-resolution precipitation data. To overcome this obstacle and prepare an unproblematic and timely data access in the *R&D Phase*, ten additional rain gauges are currently being installed in the catchment. The gauges will be maintained by the local project office.

Task-2.2: Database and information flow (**M06–M48; Lead: TUE,** Contributor: GEOMER, DLR, HUIS)
This task ensures the safe, consistent and nonredundant storage and distribution of data within the project. As flood risk and adaptation measures are linked to a large variety of aspects (environmental, social, economic), a common database which is accessible by all project partners will be developed, filled and maintained on a server hosted by TUE. This involves collection, harmonization and distribution of spatial data, but also their long-term availability beyond the lifetime of the project. This is especially important because spatial data generated by the consortium and provided by the Vietnamese partners serve as inputs for the flood models and vulnerability estimates (WPs 3 and 4) and their resulting risks and impact. Furthermore, this task maps the contributions of all project partners, especially with respect to spatial information, and initiates a harmonized storage and exchange within the architecture of FRAME (T-2.5).

Task-2.3: Urban development, infrastructure and land-use (**M01–M36; Lead: DLR**; Contributor: TUE, LMU, IZES, HUIS)
For the assessment of past floods and flood risks, the urban growth and sprawl will be assessed on an annual base for the entire province from 1985 to today (using free and open Landsat images, 30 m resolution). This time series will also serve as an input for the land-use and urban growth modelling (T-4.3). To assess the current situation, a combined Sentinel-1 (S1) radar and Sentinel-2 (S2) multispectral approach will be utilized to derive built-up infrastructure with a 10 m resolution. Land-use and land-cover will be derived from S1/S2

for five-annual periods from 2000 to 2020. The classification scheme will be aligned with the Vietnamese planning code. For the classification, machine-learning approaches on time-series data will be utilized in a cloud environment that allows transferring the methods to stakeholders. To assess current risks (WP3) at higher detail, existing buildings and infrastructures will be classified based on object-based analysis of very high-resolution tri-stereoscopic images of the Pléiades satellite. It allows the retrieval of a digital surface model for the characterization of the buildings, which is an important prerequisite for the assessment of their exposure and vulnerability (WP 3 and 4).

Task-2.4: Flood mapping & assessment of current ecosystems and environment (**M01–M42; Lead: DLR**; Contributor: HUIS, TUE, UNU, GEOMER)

Flood maps are needed for the calibration of the flood model (T-3.2) and the exposure analysis (T-3.3). For the study area, the flood extent, flood depth and water volume will be determined by time-series analysis of S1 data (2014 to today). The availability of image acquisitions of other sensors on historic floods will be evaluated. The global Copernicus TanDEM-X DEM generated by DLR and enhanced for the European Commission will be utilized to derive flood depth estimations. In order to determine EbA potential for DRR and to contribute to the flood modelling and scenarios, following products will be derived (T-4.1, 4.3): In the low-lying areas close to the coast, aquaculture areas will be identified since the annual flood is important for the fertilization (using S1/S2). In addition, coastal dynamics (S2/Landsat), mangroves (S1/S2) and the Tam Giang Lagoon (DESIS & PRISMA hyperspectral data) will be investigated. The forest areas of the upstream area will be delineated (S1/S2),water bodies (ponds, lakes, reservoirs) identified (S2) and their dynamics mapped (MODIS/Sentinel-3). Using interferometric SAR analysis, land subsidence leading to increasing flood risk will be identified.

Task-2.5: Risk Information System (FRAME) (**M13–M48; Lead: TUE**; Contributor: DLR, UNU, GEOMER, HUIS, IZES)

FRAME (Flood Risk Adaptation Measures & Evaluation) is the system architecture which brings together the consortium's research findings with the existing planning framework (e.g. spatial and sectoral development plans) and proposed adaptation measures to visualize social, environmental and economic impacts under different scenarios. A server backend will be developed where all datasets converge in a modular but automated way, thus maintaining independence of datasets and potential extension of the system. These single modules are base data (e.g. buildings, ecosystems), hydrologic modelling (flood extents), current and future risks as well as the outcomes of the evaluation of risk reduction, risk transfer and adaptation options e.g. based on economic cost-benefit analyses (ECA-VN). A web-based portal (front-end) will be developed and can be accessed by all project partners and stakeholders. It supports planning and decision-making processes by interactive visualization and comparison of different planning options and their outcomes against (each other and) existing plans. Accordingly, FRAME is not designed to replace the deliberative planning processes in Viet Nam, but rather support it by data-driven estimates on planning options and a trans-sectoral view to develop a deeper understanding of the drivers and dynamics of flood risk in the province and to give the stakeholders enough flexibility to evolve their own decision-making process. FRAME will be co-developed in the first half of the *R&D Phase* and handed over to Vietnamese partners towards the end of the project to prepare its transition into local ownership incorporating a local company for the subsequent *Implementation Phase*. This is supported by its modular architecture, which allows the replacement or extension of single components by locally hosted solutions.

WP3: Current flood risks & impacts						**Duration**: M1–M31, 69 (+8.25) PM | **Lead**: UNU					
PM	DLR 5	TUE 4	UNU 41	LMU 6	IZES 5	GEOMER 8	HUIS +2.75	HUSC +4.25	DONRE +0.25	CCNDPC +0.75	MONRE +0.25

Milestones: M3.1 Impact chains developed; **M3.2** Flood hazard data available; **M3.3** Exposure analysis and asset valuation completed; **M3.4** Present-day vulnerability and risk of flood impacts assessed and database available; **M3.5** Historical damage data collected.

Summary: *This WP aims to identify and assess both the drivers and spatial patterns of present-day flood risk in all dimensions of flood hazard, exposure and vulnerability, as well as historical damages and impacts associated with floods for the city of Hue and Thua Thien Hue Province. In doing so, this WP also builds a strong foundation for WP4 where flood risk scenarios will be developed*.

Task-3.1: Drivers of risk and impact chains (**M1–M15; Lead: UNU,** Contributor: all)

Drawing on the systematic review of 77 publications on flood risk in Viet Nam conducted in the *Definition Phase* (Nguyen et al., accepted), the objective of this task is to identify relevant root causes/drivers of flood risk and to co-develop impact chains (cause-effect chains) that illustrate how the different drivers of flood risk

interact to co-produce risk of impacts for different assets, sectors or systems (e.g. on ecosystems and their services, loss of livelihoods, business disruption for MSMEs, damage to infrastructure, loss of life). Further, impact chains will enable better understanding how risk for one asset, sector or system might lead to knock-on effects on other assets, systems, and sectors (i.e. risk cascades). A particular emphasis will be placed on the role of ecosystem services as a key driver of risk. Impact chains will be co-developed with relevant stakeholders during a dedicated "Drivers of risk and impact chains workshop" (back-to-back with Co-Development workshop 1). Impact chains will inform the analysis of present-day risk (T-3.4), be used to identify possible DRR, risk transfer and adaptation options (WP5), and be revisited for potential changes when developing future risk scenarios (WP4).

Task-3.2: Flood hazard model set up and validation (**M1–M24; Lead: GEOMER,** Contributor: DONRE, CCNDPC)

Already the *Preparation Phase* has revealed that probabilistic flood maps (flood inundation model MIKE 11/21) exist for city of Hue and the main river stretch, with strong limitations regarding input data quality and the influence of urban structures. In the *Definition Phase* a part of the available data could be collected and evaluated; also a good overview on additional existing data has been achieved. Next to the river flooding topic, the discussion with users showed that some areas of the city also suffer from pluvial flooding revealing flash flood events as local problems. In order to cover both types of flooding and at the same time taking into account the different temporal and spatial scales two model settings are planned: For modelling river flood of Hue River the hydrological model HEC-HMS and the hydraulic 2D model HEC-RAS is intended and will be complemented by flash flood simulations via model chain of the models Hydro^{RAS} and FloodArea^{HPC} (developed by GEOMER). The assignment of these models allow a complete catchment modelling in high resolution and deliver information on the flood extent, the duration and depth of the inundation. In the *Definition Phase*, already first model runs have been conducted for the identified study area and validated against observed data from past flood events. The results show that the planned model combination has a high potential to fulfil the required tasks within the project and to be used by local institutions. As the region is directly affected from coastal impact, the sea level conditions are considered as lower border conditions in the hydraulic model.

Task-3.3: Exposure assessment and asset valuation (**M4–M27; Lead: UNU**; Contributor: DLR, TUE, LMU, IZES, HUIS, HUSC)

Drawing on flood hazard data developed in T-3.2, this task aims to assess which assets (e.g. houses, people, ecosystems, shop houses/SMEs, cultural heritage, and infrastructure) are exposed to flooding under present-day climate conditions. The assessment will largely build on existing land use maps, infrastructure data, and field survey data, complemented with stakeholder and household interviews and will also include water quality information of the floodwater. For the water quality analysis, a comprehensive sampling design will be developed with HUSC. Remote-sensing data will be used to spatially locate additional assets, such as ecosystems or agricultural areas. Next to identifying which assets are located in flood-prone areas, the monetary value (where feasible) of exposed assets will be quantified and evaluated.

Task-3.4: Vulnerability and flood risk assessment (**M10–M31; Lead: UNU**; Contributor: LMU, IZES, GEOMER, HUIS, HUSC)

Building on the impact chains developed in T-3.1, the objective of this task is to assess the present-day risk of flood impacts in a spatially explicit manner. This task integrates the outcomes of the flood hazard (T-3.2) and exposure analysis (T-3.3) with a vulnerability assessment. In order to allow for an impact-specific assessment, relevant drivers of vulnerability and risk (from T-3.1) will be weighted and (where feasible) associated vulnerability curves developed for each impact chain. This will be achieved by reviewing existing vulnerability curves and adapting them based on historical damage data (T-3.5) and expert consultation during a "Vulnerability indicators and curves" workshop (end of year 2). Present-day risk of flood risk impacts will be assessed (e.g. impacts on ecosystems and their services, loss of livelihoods, business disruption for SMEs, damage to infrastructure, loss of life) applying a multi-vulnerability/multi-risk perspective using a composite indicator (index)-based approach at the sub-province and sub-city scale. The catchment-wide analysis will be complemented with in-depth empirical surveys (T-2.1) aimed at understanding the risk awareness/perception, behaviour, and coping strategies of different actors (incl. citizens, SMEs, decision makers involved in urban planning, disaster risk management and adaptation).

Task-3.5: Historical damages and impacts (M01–M24; Lead: HUSC; Contributors: UNU, TUE, DLR, GEOMER)

Historical damages allow a better validation and calibration of the flood model but also inform on the relationship between hazard and expected impacts. In this task, historical damage information for different types of assets (housing, crops, infrastructure, ecosystems) will be gathered using a mix of methods (historical records, expert interviews, insurance records, desk research, and through empirical surveys conducted in T-2.1). Historical damages are subsequently aggregated and quality checked against other available databases

(e.g. EM-DAT for large scale validation, local databases for smaller scale validation). Information on reported health impacts due to flooding will be assessed including the impacts of water quality issues. The outputs of this task will be used for the construction and validation of vulnerability curves (WP3) and the validation of the ECA-VN model (WP5).

WP4: Future Flood Risk							**Duration**: M1–M48, 57 PM (+7) | **Lead**: LMU				
PM	DLR 5	TUE 2	UNU 13	LMU 27	IZES 1	GEOMER 9	HUIS +3	HUSC +3	DONRE +0.5	CCNDPC +0.25	MONRE +0.25

Milestones: M4.1 Framework of SSP and RCP scenarios finalized (incl. report); **M4.2** Flood hazard scenarios with RCPs calculated; **M4.3** Exposure scenarios with SSPs completed; **M4.4** Vulnerability scenarios with SSPs completed; **M4.5** Risk and impact scenarios completed

Summary: *This WP aims to develop and assess scenarios of possible future flood risk (2030, 2050, 2100) at the study area under identified SSP and RCP scenarios, which do not only consider future trends in the flood hazards but also in socio-economic vulnerability and exposure, as well as with and without adaptation measures.*

Task-4.1: Scenario framework (M1–M12); Lead: LMU, Contributors: UNU, DLR, GEOMER, TUE, IZES, HUIS, HUSC, DONRE, MONRE)

In a first step, a common scenario framework will be developed jointly with all project partners to allow for the later comparison and integration of the different modelling streams. The framework will build on the latest scenario techniques used in the IPCC, i.e. the so-called RCP-SSP framework, which integrates Representative Concentration Pathways (RCPs) for possible future climate change and impacts with Shared Socioeconomic Pathways (SSPs) regarding the regional urbanization, social and economic development (van Vuuren et al. 2012). Yet, the SSP framework has a global focus and uses storylines of global development trends. For the purpose of FloodAdaptVN, national and regional storylines (i.e. narrative assumptions of future developments to be used as a basis for later modelling) will be developed in close consultation with local stakeholders (scenario workshop, back-to-back with the second Co-Development workshop). Three time steps will be considered to capture short-term planning interests as well as long-term climate variations in 2030, 2050 and 2100. Existing other scenario approaches and planning documents will also be analysed as input to this process.

Task-4.2: Flood hazard scenarios (M12–M40; Lead: GEOMER, Contributors: LMU, DLR, TUE, DONRE, CCNDPC**)**

Considering future climate change, land use conditions (from T-4.3) and adaptation measures, flood hazard maps with future scenarios will be created using information about trends in precipitation (coming from RCPs) as well as land use changes or technical measures for flood adaptation. In this regard, the established hydrologic and hydraulic models will be used to display scenarios and therefore will be able to show probable prospective flood extents and inundation depth as well as the effectiveness of adaptation measures and can help as decision support for action planning. The underlying RCPs need to be analysed and the data processed to feed the models. The main challenge in this task will be to develop a methodology of integrating different types of measures into the different models (hydrology, hydraulics) as well as approaching different scales of measures. As each measure has a different impact on the water cycle and the flow process, the effects need to be implemented and parameterized for each of the models. As fluvial and pluvial floods have a quite different characteristic in response time and available water volume measures will have different efficiency too.

Task-4.3: Exposure scenarios (M7–M36; Lead: LMU; Contributor: DLR, UNU, HUIS, HUSC)

This task carries out an assessment of the relative effects of rate of climate change (four RCPs), and assumed future population and socioeconomic development (five local SSP-type development trends), on the regional exposure to flood hazards for 2030, 2050 and 2100. It is assumed that in different combinations of RCPs and SSPs, there are differences in the absolute numbers of people and properties exposed to floods. On the one hand, land-use change modelling (including urban growth) using SLEUTH will be applied to analyse different possible pathways of urban and socio-economic development in the study area. It will thus enable to assess where, what and how much population and infrastructures will be in the area for a given future period. The narratives of T4.1 will be used to drive the scenario development. One the other hand, the RCPs-based flood hazard analysis (T-4.2) will provide information on where and how serious future floods could be. A combination of both will allow to identify the exposed population and property and further evaluate the exposed values under different flood impacts. This task therefore has an iterative relationship with T-4.2 (flood hazard modelling) and incorporates past land use change analysis (T-2.3).

Task-4.4: Vulnerability scenarios (M13–M42; Lead: LMU, Contributor: UNU, HUIS, HUSC)
Building on the knowledge on past and current vulnerabilities to floods (WP3) this task will develop scenarios of future vulnerability trends of population, infrastructure and key sectors of highest importance. This will allow enriching the land use types used in the exposure scenarios (Task-4.3) with information on the vulnerability of exposed elements, hence adding the final piece to a full risk assessment, i.e. scenarios of risk (T-4.5). These tasks will operate within the framework and storylines developed in T-4.1. In a first step, it will develop qualitative vulnerability scenarios for the population, key infrastructure and key sectors. In a second step, these qualitative scenarios will be quantified as much as possible, using a combination of statistical modelling (using the results of WP3 as input), agent-based-modelling and Bayesian network modelling. A selected set of assumed adaptation measures (which will be identified in WP5) will also be integrated into this modelling exercise.

Task-4.5: Risk and impact scenarios (M31–M48; Lead: LMU, Contributor: UNU)
This task will integrate the findings from T-4.2-4.4 and assess the consequences once the various SSPs-based development and the RCPs-based flood occur. In order to facilitate policy dialogues, integrated risk scenarios (combining considerations of flood exposure, T-4.3, with vulnerability of the exposed elements, T-4.4) will not just be presented in abstract maps and statistics but in narrative formats as well, creating adhesive impressions of future risk conditions and narratives for cascading risks resulting from these. Also, flood adaptation strategies and measures (WP5) will be integrated into this analysis in the later phase of the project in order to juxtapose future risk trends with and without adaptation and hence facilitate policy dialogues even further.

WP5: Flood risk management and adaptation						**Duration**: M1–M48, 77 PM (+1.75) | **Lead**: UNU				
PM	DLR 2	TUE 4	UNU 56	LMU 6	IZES 9	GEOMER 0	HUIS +0.25	HUSC -	DONRE +0.75	CCNDPC -	MONRE +0.75

Milestones: M5.1 Criteria catalogue for evaluating adaptation co-developed; **M5.2** Evaluation of disaster preparedness and governance completed; **M5.3** List of existing and planned measures compiled and updated (M5.3a); **M5.4** Additional potential measures identified; **M5.5** Cost-benefit analysis of measures completed; **M5.6** Evaluation of already planned and potential new measures completed; **M5.7** Interactions with SDG targets assessed

Summary: *This WP aims to (1) compile existing and planned DRR, risk transfer and adaptation measures, (2) identify potential additional measures, and (3) evaluate planned and potential new measures against a multi-criteria catalogue co-developed with relevant stakeholders. Next to evaluation criteria co-developed with relevant stakeholders, the social acceptance, cost-benefit, possible mal-adaptive consequences as well as co-benefits and trade-offs with SDG targets of planned and potential measures will be evaluated.*

Task-5.1: Co-development of an evaluation criteria catalogue (M1–M14; Lead: UNU; Contributor: LMU, IZES, HUIS, DONRE, MONRE)
T-5.1 will develop a comprehensive multi-criteria catalogue for evaluating planned (T-5.3) and proposed (T-5.4) potentially competing DRR, risk transfer and adaptation options against protection targets and policy goals. A review of existing policy documents (provided by T-7.1) combined with expert consultation will be used to (1) identify existing and (2) co-develop additional protection targets and policy goals. Criteria for the evaluation of planned and proposed solutions will be compiled from a review of scientific literature and Vietnamese planning documents, ranked with key stakeholders and combined in an integrated evaluation framework. Particular attention will be paid not just to cost-benefit ratios, but also to social acceptance, stakeholders' preferences, equity implications, possible mal-adaptive consequences and (sustainability) co-benefits of adaptation measures. Particular consideration will be given to the coherency of the evaluation framework with national and global initiatives to evaluate adaptation.

Task-5.2: Evaluation of disaster preparedness and governance (M7–M36; Lead: LMU; Contributor: UNU, IZES, DONRE, MONRE)
Disaster risk governance has traditionally been fragmented between local, state, and national entities and between sectors, and compartmentalised in highly variable bureaucratic structures. The task will detect the presence and effectiveness of disaster preparedness and governance measures in the study area considering its administrative system and social networks. The evaluation design is a mixed method with a range of data collection activities, incl. literature and document review, in-depth interviews with key flood governance

stakeholders, focus group discussions, as well as quantitative surveys (conducted in T-2.1) at the provincial, city, community and household levels. Central is the collection of first hand data and the evaluation of existing disaster preparedness and governance measures and their effectiveness.

Task-5.3: Compilation of existing and planned risk reduction, risk transfer and adaptation strategies and measures (M1–M12, M24, M36; Lead: IZES; Contributor: UNU)
This task builds on initial stakeholder consultations conducted in the *Definition Phase* (which could only be done to a limited extent due to COVID-19 restrictions) as well as on a literature review of existing EcoDRR and EbA solutions in Viet Nam and for similar settings globally which was finalized in the *Definition Phase*. Activities in the *R&D Phase* will focus on the further compilation and update of existing and recently planned DRR and adaptation strategies and measures (incl. engineering-based, soft and ecosystem-based or hybrid solutions, risk transfer mechanisms) as listed in existing planning instruments (e.g. for the entire Thua Thien –Hue Province, for the catchment, for the city of Hue or other urban centres as well as for areas of particular interest). This review will add to initial efforts in the *Definition Phase*, and combine interviews, stakeholder workshops (back-to-back with Co-Development workshop 2), field visits and desk study. The result of this task will be a list of existing and planned strategies and measures, complemented with additional solutions (T-5.4) and in subsequent steps (T-5.4-5.5) evaluated against the criteria catalogue (T-5.1.)

Task-5.4: Identification of risk reduction, risk transfer and adaptation demands and solutions (M24–M40; Lead: UNU; Contributor: IZES)
T-5.4 focuses on risk management and adaptation goals by proposing innovative DRR, risk transfer and adaptation options (incl. engineering-based, soft and ecosystem-based or hybrid solutions, as well as risk transfer mechanisms). This will be achieved by drawing on the outcomes of the assessment and simulation of present-day (WP3) and future (WP4) risk, and complemented by an expert/stakeholder-based analysis of DRR, risk transfer and adaptation needs. Further desk research and detailed review of possible approaches will complement the analysis. A special focus will be placed on EbA measures and risk transfer solutions. Interviews and a first dedicated “Flood risk management, risk transfer and adaptation” workshop (back-to-back with Co-Development workshop 3) will be conducted with local insurance and reinsurance companies, local government, international development banks and local communities.

Task-5.5: Cost-benefit analysis of measures using the ECA-VN Tool (M12–M44; Lead: UNU; Contributor: TUE)
Building on the (EVA-VN) prototype developed in the *Definition Phase*, this task aims at evaluating planned and additional measures (from T-5.3. and T-5.4) based on their potential impact reduction, and their associated investment and maintenance costs. A cost-benefit analysis based on future risk scenarios (developed in WP5) will be performed for selected assets. An initial focus will be placed on infrastructure (e.g. buildings, roads, cultural assets, private sector) and ecosystems. Further research will evaluate the potential of transferring the ECA approach to other assets, sectors and systems at risk. The main outcome is a ranking of planned and proposed additional measures according to their technical and financial efficiency. ECA-VN will also provide a clear presentation of benefits of ecosystem-based, hybrid vs conventional DRR and adaptation and/or risk transfer solutions. Outputs generated by the ECA-VN platform will be embedded into the risk information system (FRAME) portal (T-2.5).

Task-5.6: Evaluation of planned and proposed risk reduction, risk transfer and adaptation options (M14–M46; Lead: UNU; Contributor: TUE, IZES, LMU, DONRE, MONRE)
The main objective of this task is to evaluate already planned (from T-5.3) and proposed additional (from T-5.4) DRR, risk transfer and adaptation measures against the multi-criteria catalogue developed in T-5.1. A second ““Flood risk management, risk transfer and adaptation” workshop (in year 4) will present, discuss and validate the outcomes of the evaluation with relevant stakeholders. All measures will be described qualitatively and quantitatively including their potential impact on flood reduction, delivery against defined protection targets, possible areas for implementation, their social acceptance, likely costs involved (from T-5.5), potential mal-adaptive consequences, likely trade-offs/conflicting interests with competing policy goals and additional criteria resulting from the consultations in T-5.1. The outcome will be a portfolio of innovative options for responding to adaptation needs and policy goals along with their evaluation results.

Task-5.7: Co-benefits and trade-offs with SDGs (M36–M48; Lead: UNU; Contributor: DLR, IZES)
Given the strong focus of FloodAdaptVN on EbA as part of an overall risk management and adaptation strategy, this task will identify and evaluate co-benefits as well as potential trade-offs (e.g. wetlands as habitats for vector/water-borne diseases) of proposed DRR and adaptation solutions. Relevant SDG targets linked to EbA such as improving water quality (target 6.3), sustainable management and efficient use of natural resources (target 12.2) or sustainable food production (target 2.4) will be identified in a participatory stakeholder consultation process. A network analysis will be performed to (1) determine priority targets, (2) identify interactions between targets, and (3) develop bi-directional EbA-SDG target networks. The network

analysis will explore the relationship between ecosystem-based measures and the identified targets to enhance the understanding of the impact of planned and proposed solutions (notably EbA) not only for addressing future risks, but also for making progress towards the SDGs.

WP6: Capacity development & knowledge exchange							**Duration**: M4–M48, 31.5 PM (+6.25) | **Lead: TUE**				
PM	DLR 4	TUE 5	UNU 12	LMU 3	IZES 6	GEOMER 1.5	HUIS +3	HUSC +1.5	DONRE +0.75	CCNDPC +0.75	MONRE +0.5

Milestones: M6.1 Two regional networking fora held and documented; **M6.2** DLR-DAAD fellowship filled; **M6.3** Online collection of training material, videos and documentation of capacity development activities; **M6.4** Capacity development events for academia (DE + VN) and local authorities held.

Summary: *This WP summarizes all activities, which aim at a sustainable exploitation and transfer of all project outcomes by intensive collaboration, collaborative learning, training, and exchange between all project partners and beyond the consortium.*

Task-6.1: Regional networking fora (M18-22 & M41-46; Lead: IZES; Contributor: all)
To support the dialogue and exchange of experiences between different provinces and levels of action and the transfer of research results of FloodAdaptVN to different contexts, two regional networking fora will be organised in year 2 and 4 of the *R&D Phase*. The events will address both, governments of neighbouring provinces in Central Viet Nam as well as relevant Ministries and national-level authorities. The forum will also integrate initiatives of local and international NGOs as well as other relevant BMBF funded research projects active in the region. Activities of this task include the identification of relevant stakeholders and initiatives within the region, the development of a suitable concept for the regional networking fora (e.g. discussion panels, excursions, site visits, mutual learning events) and the organisation and implementation.

Task-6.2: Scientists and expert exchange (M4–M48; Lead: LMU; Contributor: DLR, UNU, TUE, HUIS, HUSC, DONRE, CCNDPC)
Scientists exchange will be fostered between the research institutions in Germany and Viet Nam, which covers bilateral Ph.D. studies (short stay or degree program), third-party scholarship funded students (e.g. DAAD Ph.D. exchange), short visits of scientists and experts, as well as IHK (German Chamber of Commerce and Industry) seminars. In doing so, this task will support applicants in finding fitting funding opportunities and assisting them in their planning. One DLR-DAAD Ph.D. fellowship for a Vietnamese student is envisaged. Consortium partners commit to support and host visiting researchers for short stays.

Task-6.3: Capacity development (**M7–M48; Lead: TUE**; Contributor: all)
The *Definition Phase* has confirmed the needs to strengthen capacities to assess flood risk, develop future scenarios, evidence-based decision making for integrated DRR and adaptation, as well as the awareness of risk transfer and EbA potentials. These needs are collected from the stakeholders identified in T-7.2 via a digital questionnaire in order to assess existing capacities, gaps and needs in terms of awareness, skills, software, hardware, resources and groups of potential target audiences. Based on the findings, capacity development will be undertaken in various forms, including (1) technical training courses (as parts of the co-design workshops) on data generation and analysis, (2) online lectures and webinars which will be recorded and made available via the project homepage, (3) training materials, manuals and documentations on the different modules of the risk information system (FRAME) and its application to to strengthen the capacities of local authorities and the next generation of practitioners, academics and decision makers. Throughout all activities, emphasis will be placed on interaction and collaborative learning as central parts of our co-design strategy and a sustainable spatial planning (Elbakidsze et al. 2015).

WP7: Mainstreaming & Implementation							**Duration**: M1–M48, 43 PM (+12.25) | **Lead**: IZES				
PM	DLR 7	TUE 5	UNU 9.5	LMU 2	IZES 16	GEOMER 3.5	HUIS +7	HUSC +1.5	DONRE +2	CCNDPC +0.5	MONRE +1.25

Milestones: M7.1 Policy-related barriers and entry points identified; **M7.2** Stakeholder Map updated; **(M.7.2a final version); M7.3** FRAME transferred to VN servers; **M7.4** Recommendations for the mainstreaming of FloodAdaptVN results into the planning and policy framework developed; **M7.5** Thematic policy brief

developed; **M7.6** Report on implementation status finalized; **M7.7** Report on upscaling potential/strategy developed

Summary: *This WP focuses on the integration of the research results of FloodAdaptVN into the planning practice and into administrative action. The activities of this WP address the modification of the policy framework, foster the engagement and the cooperation of the local stakeholders and facilitate the implementation of FRAME. Moreover, this WP includes dissemination activities and the preparation of the Implementation Phase.*

Task-7.1: Assessment of the planning and policy framework, barriers & entry points (M1–M36; Lead: IZES; Contributor: UNU, LMU, HUIS, DONRE, MONRE)
T-7.1 focuses on the examination of the existing planning and policy frameworks and on the identification of policy-related barriers and entry points for the implementation of the strategies and measures for flood risk management and adaptation identified in WP5. Moreover, the (factual) enforcement of the legal texts and the implementation of strategies and plans will be studied. Intermediate results will be discussed in bilateral meetings and in a multi-stakeholder dialogue (linked to Co-development workshop 3). This task builds strongly on the results of the assessments done in the *Definition Phase*; however, as for the SEDP period until 2030 a new set of development plans for Thua Thien – Hue Province will be issued, the activity will be continued in the *R&D Phase*. Both, HUIS and DONRE will support the activities of this task.

Task-7.2: Stakeholder assessment and engagement (M1–M48; Lead: IZES; Contributor: DLR, UNU. GEOMER, HUIS, HUSC, DONRE, CCNDPC, MONRE)
To support the implementation of the co-development approach (T-1.3) and participatory activities of all project partners, the stakeholder assessment will be continued and the Stakeholder Map developed in the *Definition Phase* will be continuously updated. Based on the objectives and thematic foci of the engagement activities and on the requirements of the local stakeholders, suitable participatory formats will be developed and implemented (e.g. Co-development workshops, thematic workshops, multi-stakeholder dialogues). HUIS will support the communication with the local stakeholders as well as the organisation of the events.

Task-7.3: Implementation of FRAME (M25–M48; Lead: TUE; Contributor: GEOMER, HUIS, DONRE)
In anticipation of the *Implementation Phase*, the architecture of the risk information system (FRAME) is transferred to Vietnamese servers after its successful development and prototyping in Viet Nam. This not only allows the direct access and future data input from local authorities and universities, but also fosters the long-term establishment of this system as a planning instrument in Hue, and hopefully in Central Viet Nam. The partners from the University of Hue – International School will take an important role in the hosting of this system and its interlinkage to potential contributors and users.

Task-7.4: Mainstreaming of FloodAdaptVN results into the planning and policy framework "science to practice" (M25–M48; Lead: IZES, Contributor: UNU, DONRE, MONRE, DLR)
Based on the results of T-7.1, recommendations for the mainstreaming of FloodAdaptVN results into administrative action will be developed. The recommendations will focus on the integration of DRR, risk transfer and adaptation measures into development strategies and plans, on the modification of planning processes as well as on the improvement of the stakeholder cooperation. Intermediate results will be critically reflected within the framework of stakeholder meetings and dialogue events (see T-5.3) (linked to the Co-development workshops 3 and 4). DONRE, MONRE and the province-level Peoples' Committee will take on a prominent role in the discourse. Further, leveraging on the position of UNU at the science-policy interface, key outcomes of FloodAdaptVN will be mainstreamed into relevant international policy agendas (notably the Sendai framework, the SDGs, the New Urban Agenda) and associated processes. One thematic policy brief will be developed to facilitate the integration of the recommendations into the local planning practice.

Task-7.5: Exploring towards the *Implementation Phase* (M25–M48; Lead: DLR; Contributor: all)
In the second half of the *R&D Phase,* the progress and success, as well as the future opportunities of the implementation of FloodAdaptVN specific measures in the Thua Thien Hue Province will be evaluated and compiled in a report. If necessary, the implementation strategy and the utilization plan will be revised in order to create a sustainable impact (e.g. installation of a local advisory board to facilitate the implementation process). The need and the potential activities of a subsequent *Implementation Phase* will be explored. The modular approach of FRAME allows a flexible implementation and adaptation of local stakeholders, Vietnamese planning and engineering companies, as well as university start-ups. The development of an enabling strategy for these potential implementation partners is a key part of this task.

Task-7.6: Evaluating and defining the upscaling potential (M37–M48; Lead: DLR; Contributor: TUE, UNU, LMU, IZES, GEOMER, HUIS, HUSC, MONRE)
Flood risk is of increasing concern and a better understanding of present-day and future risk as well as of innovative solutions are needed for many urban regions of Viet Nam. Responding to that demand, this task aims at evaluating and defining the upscaling potential of the methods, approaches and solutions developed in the *R&D Phase* to other flood-prone urban regions of Viet Nam. To achieve this all partners will systematically evaluate the upscaling potential of their approaches, methods and tools in terms of usefulness, technical feasibility, likely costs involved, as well as potential challenges. The outcome will be a short report critically reflecting and demonstrating the upscaling potential of FloodAdaptVN activities and approaches to other flood-prone urban regions of Viet Nam.

3.2 Milestone Plan

Based on the work programme (section 3.1), the following milestones have been formulated:

Table 4: Milestone plan

Month	Task	Milestone	Responsibility
		M1.1 Project office operation continued	DLR/ HUIS
		M2.1 Database is established and filled with datasets	TUE
		M2.2 Copernicus DEM available and pre-processed	DLR
		M1.2 Co-development workshops I-IV conducted	DLR/ HUIS
		M4.1 Framework of SSP and RCP scenarios finalized	LMU
		M5.3 List of existing and planned measures compiled M5.3a List updated	IZES
		M2.3 Annual maps of urban development since 1985 (M2.3a) and building types for Hue (M2.3b) available	DLR/ TUE
		M7.2a Stakeholder Map updated; M7.2b Final version prepared	IZES
		M5.2 Criteria catalogue for evaluating adaptation completed	UNU
		M3.1 Impact chains developed	UNU
		M2.6a Status and M2.6b dynamics of flood relevant land-use available	DLR
		M6.2 DLR-DAAD fellowship filled	DLR
		M2.4a Flood extent maps for past events; M2.4b Coastal dynamics available	DLR
		M6.1 Two regional networking fora held and documented	IZES/ HUIS
		M3.2 Flood hazard data available (current climate, without measures)	GEOMER
		M3.5 Historical damage data collected	HUIS
		M1.3 Mid-term report submitted	DLR
		M3.3 Exposure analysis and asset valuation completed	UNU
		M3.4 Present-day vulnerability and risk of flood impacts assessed	UNU
		M2.5 FRAME is available online and a manual is provided to all users	TUE
		M4.3 Exposure scenarios with SSPs completed	LMU
		M5.1 Evaluation of disaster preparedness and governance completed	LMU
		M6.3 Online collection of training material, videos and documentation of capacity development activities	TUE
		M7.1 Policy-related barriers and entry points identified	IZES
		M5.4 Additional potential measures identified	UNU
		M4.2 Flood hazard scenarios with RCPs calculated	GEOMER
		M4.4 Vulnerability scenarios with SSPs completed	LMU
		M6.4 Capacity development events for academia (DE + VN) and local authorities held	TUE
		M5.5 Cost-benefit analysis of measures completed	UNU
		M7.4 Recommendations for the mainstreaming of FloodAdaptVN results into the planning and policy framework developed	IZES
		M5.5 Evaluation of already planned and potential new measures completed	UNU
		M1.4 Four high-level publications submitted	DLR
		M1.5 Final report submitted + presentation held	DLR
		M1.6 *Implementation Phase* proposal submitted	DLR
		M4.5 Risk and impact scenarios completed	LMU
		M5.7 Interactions with SDG targets assessed	UNU
		M7.3 FRAME transferred to VN servers	TUE
		M7.5 Thematic policy brief developed	IZES/ UNU
		M7.6 Report on implementation status finalized	DLR
		M7.7 Report on upscaling potential/strategy developed	DLR

4 Planned cooperation and work-sharing

4.1 Consortium structure and project management

The partners involved in this project have been selected in a way that the **expertise** required for essential analysis and development steps is **complementary** (i.e. remote sensing, GIS, flood modelling, vulnerability and risk assessment, scenario development, economic modelling, urban planning, insurance, ecosystem-based adaptation). In addition, following the transdisciplinary research approach of the project, there will be **close cooperation of scientific, economic and practical partners in Germany and Viet Nam**. On German side, the partners consist of a small enterprise (GEOMER), two research institutes (IZES, DLR) and three universities (UNU, LMU, TUE), including one institution at the science-policy interface (UNU). The scientific expertise of the university partners as well as the practical experience of the practical partners provide the prerequisites for a successful *R&D Phase* (see section 1.3 and attached CVs). The joint project is coordinated by **DLR-DFD** (German Remote Sensing Data Center), which has a long lasting experience in managing projects in Vietnam. In addition, the DLR-DFD has an outstanding expertise in the processing and data extraction of time-series satellite data. **GEOMER** is expert in flood modelling and simulations and intends to apply for the Perfume River catchment the software HEC-HMS and the hydraulic 2D model HEC-RAS, which will be complemented by flash flood simulations via model chain of the models Hydro^{RAS} and FloodArea^{HPC} (developed by GEOMER). **TUE** introduces experience in (geo-)data management, information systems and analysis of very high resolution satellite images in urban contexts. **IZES** has many years of research experience in Viet Nam focussing on the analysis of the legislative and policy framework and of the administrative system as well as on the initiation and facilitation of change management and stakeholder-based development processes. **UNU** is involved with three divisions (incl. MCII), and brings experience in flood risk assessment, scenario development, (ecosystem-based) DRR/adaptation, and risk transfer solutions. **LMU** has ample research expertise on risk, vulnerability, adaptation and transformation in the context of environmental hazards and climate change, particularly in cities of Southeast Asia. The Hydrology and Hydraulic Department of the Emschergenossenschaft/ Lippeverband) will provide **best practices** for DRR implementation measures (see LoI).

On the Vietnamese side, the partners consist of one national authority, two local authorities, as well as two local universities. **The Sub-Institute of Hydrometeorology and Climate Change (SIHYMECC)** is part of the Ministry of Natural Resources and Environment (MONRE), which is the leading ministry for climate action and the focal point to UNFCCC. SIHYMECC contributes to national-level climate change policy and coordinates the implementation of the respective activities. The integration of MONRE into FloodAdaptVN establishes the essential link between research activities at the provincial level and policy-making at the national level. The **Department of Natural Resources and Environment (DONRE)** is in charge of environmental resource management. This includes the management of land, water resources and issues related to hydro-meteorology. Due to DONRE's formal responsibilities and technical expertise, the department is one of the main important stakeholders for flood risk reduction and ecosystem-based solutions.

DONRE will significantly support the research and development activities of FloodAdaptVN. The **Provincial Commanding Committee of Natural Disaster Prevention and Control, Search and Rescue (CCNDPC)** is responsible for the development and implementation of plans for natural disaster prevention, control and response as well as for the integration of related contents into local socio-economic development and construction plans. The committee bundles competences of all relevant departments and other stakeholders and enables the mainstreaming of the results of FloodAdaptVN into the provincial planning framework and administrative action. **HUIS** is well networked in Hue and coordinates the Vietnamese partners and stakeholders. In addition, has experience with remote sensing, geodata management and organizes spatial plans (land management etc.) on a server infrastructure. **HUSC** is involved with the Department of Chemistry and have laboratory facilities, as well as expertise with water quality assessment and inundation. Multiple relevant stakeholders expressed their interest in an active contribution and cooperation and participated in the FloodAdaptVN workshops (e.g. Peoples Committee of the Thua Thien Hue province, Hydro-Meteorological Center, DPI, DARD, DOC and the Departments of Tourism, Health, Transport, etc.; see also attached LoIs).

Potential conflicts and opportunities have been identified and customized responses developed (see section 4.4). A data management plan that follows the **FAIR principles** (Findable, Accessible, Interoperable, and Re-usable) was developed already for the *Definition Phase* and will guide all parties involved in organizational, infrastructural, qualitative and legal aspects of data management in the *R&D Phase*.

4.2 Co-Development strategy

FloodAdaptVN aims at co-developing risk assessment and scenario approaches, as well as DRR, risk transfer and adaptation solutions and associated collaborative learning and capacity development activities in close cooperation with local stakeholders. The “co-design” approach (Sanders & Stappers 2008) of the *Definition Phase* has produced convincing results with regard to the shaping of the research design of FloodAdaptVN. For the *R&D Phase*, the approach will be further developed as a “co-development” approach focussing on the joint elaboration of FloodAdaptVN’s research results. As part of this “co-development” process, the developed tools will consider the needs and technical conditions as well as the resources and competences of the stakeholders (“end users”). Needs for capacity development will be jointly identified and adequate educational formats designed.

4.3 Strategy for pooling and integrating various bodies of knowledge

FloodAdaptVN aims at integrating climate change concerns and flood risk reduction (DRR), risk transfer and adaptation strategies, plans and measures into the legislative and policy framework as well as into the current planning practice. We acknowledge all earlier initiatives and aim at integrating their data, results and lessons learnt into the research work. Three groups of relevant stakeholders have been identified: (1) local stakeholders (decision-makers, local administration, universities, practitioners, private sector representatives, etc.), (2) national networks and other provinces with similar challenges, and (3) (international) research institutions, global

organisations, donors and development banks. Previous and ongoing initiatives have been identified in the *Definition Phase* and examined via desk research and stakeholders meetings. To support harmonization with these initiatives and to initiate future cooperation, a direct exchange (networking activities) with donors and inter-/national organisations and research institutions will be sought. The Association of Cities of Viet Nam will be approached to facilitate a transfer of our results to other cities and provinces of Viet Nam (contacts exist).

4.4 Dealing with potential conflicts and opportunities

Table 5: Risk and opportunity table.

Risk (R) & Opportunity (O) Identification		**Probability**	**Response & Responsibility**	
Id	Event (R/O) and consequence		Response	R/O Owner
1	**RISK**: No / limited field work by German partners possible due to Covid-19		HUIS, HUSC / subcontracts will engage in the collection of data	DLR / all
2	**RISK**: Subcontracts cannot be assigned to local stakeholders		Restructuring of subcontracted activities. Discussion with BMBF on alternative spending mechanisms	DLR
3	**RISK**: Personnel change with Vietnamese partner results in stop of activities		The project structure of FloodAdaptVN allows substituting the scientific expertise for specific domains. Regarding the local authorities: well established contacts to other stakeholders exist that can replace the functions	DLR / all
4	**RISK**: Cross section data cannot be used. Results in lower quality of hydraulic model results (fluvial flooding)		Considering river channel volume via 2-layer model approach	GEOMER
5	**RISK**: Technical implementation of FRAME in Viet Nam is prevented by Vietnamese laws		FRAME architecture will remain in Germany, but accessible by Vietnamese partners	TUE
6	**RISK**: Specific datasets not available		The modular FRAME approach allows to define alternative datasets.	DLR / all
7	**RISK**: The project results conflict with development goals of the province. This might affect the willingness of the local stakeholders to support the mainstreaming of results into the planning and policy framework		Continuous stakeholder involvement, sensitive handling of existing development goals, development of solutions that meet the development goals	IZES / all
8	**OPPORTUNITY**: The sector and spatial development strategies and plans for the period 2021-30 contain extensive specifications reg. flood risk reduction		Intensive stakeholder engagement; Stakeholders would have a strong interest in participating in the project to foster implementation	IZES / all
9	**OPPORTUNITY**: External funding / cooperating project enables the implementation of EbA measures		Networking and stakeholder engagement	DLR / all
10	**OPPORTUNITY**: HUIS and HUSC succeed with co-funding applications		With the additional funding, the existing research plan will be complemented	HUIS/ HUSC

5 Expected results, application potential and envisaged utilization

Due to the interplay of climate change and urbanization, a better understanding of the drivers, hotspots and dynamics of flood risk in urban regions and the evaluation of the potentials of EcoDRR/EbA and innovative risk transfer options are of increasing global relevance. Addressing these challenges, FloodAdaptVN provides extensive opportunities for economic and scientific utilization of its results, as well as for mainstreaming them into local, national (e.g. NAPs), and international policy processes.

5.1 Economic prospects

For the project's economic partners, FloodAdaptVN offers economic exploitation opportunities, in particular for the modelling techniques and the FRAME system, which are developed for the local context. These tools offer a potential for knowledge transfer to other cities or regions. In particular, GEOMER will have the opportunity to further develop and test the hydrologic and hydraulic model components in order to create a demonstration product for SE-Asian applications, while at the same time developing a potentially new market in Viet Nam over the longer term. Due to the fact that the city of Hue is trying to develop IT industry, it is planned to search for local cooperation partners and target the market in joint venture activities either concerning the IT-tools or consulting activities. A contact to German representations such as the German Chamber of Commerce Abroad (AHK) is envisaged. As university and non-profit research institutions and think tanks, the UNU, TUE, LMU, IZES and DLR do not strive for direct economic exploitation. Insights and developed products (ECA-VN, FRAME) are generally made available.

5.2 Scientific prospects

The scientific and technical chances of success as well as the innovation potential are considered very high. The project addresses existing and pressing knowledge gaps regarding the identification and adaptation approaches towards flood risks in urban regions of Central Viet Nam, which upscaling potential to neighbouring provinces but also in other similar urban and coastal areas worldwide. The methods and activities draw upon an extensive local expertise from both, network coordinators and German project partners. Particularly innovative aspects include (1) an impact-chain based approach to assessing multi-risk, reflecting local and regional complexities (2) development and simulation of future risk scenarios based on locally-adapted RCPs and SSPs (2030, 2050, 2100) with and without adaptation, (3) the identification and evaluation of a portfolio of adaptation options, including EbA and risk transfer-based approaches. The research results will be outlined and discussed within the context of regional networking events and scientific events. A strong stakeholder involvement via co-design and capacity development ensures collaborative learning and knowledge transfer, and increases the legitimacy and policy-relevance of envisaged outcomes for implementation in the next phase. A policy brief will document the modular FloodAdaptVN approach. In addition, a series of high-level publications to international journals is envisaged along with broader dissemination to larger international audiences and the private sector.

5.3 Potential for scientific and commercial follow-up and utilization

The scientific and commercial follow-up and utilization potentials of FloodAdaptVN are manifold. First, a high-level **scientific audience**, comprising international and local experts in Viet Nam will be created. Joint high-level publications (peer-reviewed) and conferences (e.g. AAG, EGU) will set the base for long-term collaboration, capacity development and knowledge transfer towards sustainable and adaptive flood risk management in urban regions. Due to the very high innovation potential, there is a high chance that the approaches developed in FloodAdaptVN will be picked up by other research institutes. Research results co-designed/developed with local authorities are

shared via the FRAME platform and facilitated through the dissemination strategy outlined in the work plan. The chances for an extensive **dissemination and further development of approaches, methods and decision support tools** developed in FloodAdaptVN in Germany, Viet Nam, but also internationally are therefore very high. Second, the strong commitment of relevant stakeholders will enable the **mainstreaming of FloodAdaptVN outputs into regional and national planning** (e.g. NAPs). New stakeholders, for instance from other provinces, can be included in the subsequent *Implementation Phase*. Third, the chances that the results of FloodAdaptVN attract a broader audience from **international financing institutions and the private sector** are very high. The strong scientific base of FloodAdaptVN and its natural relationship with the private sector (e.g. insurance solutions, modelling services, flood risk maps production) offer a solid ground for the creation of a spin-off in collaboration with the academic project partners. Such a research spin-off would work in close collaboration with German partners from the private sector in order to provide tailor-made solutions to local and national stakeholders in Viet Nam and other urban regions facing similar challenges worldwide. The development of an enabling strategy for these potential implementation partners is a key part of WP7. Drawing on the strategic position of UNU at the science-policy interface, the findings of FloodAdaptVN will be mainstreamed into ongoing **international policy processes and agendas**, such as the Sendai Framework for DRR, the SDGs (notably SDG 6, 11, 13), the NUA, and the Paris Agreement. Further, the results of FloodAdaptVN will be directly channelled into existing **education and capacity development programmes** of partners both in Viet Nam and Germany. Furthermore, the capacity development formats tested during the *R&D Phase* (e.g. E-Learning) are designed to be transferable to other provinces in the *Implementation Phase* to enable the next generation of risk scientists, practitioners and decision-makers. Lastly, FloodAdaptVN findings and outputs will be disseminated to the **wider public** using the wide array of communication channels available to the consortium, including the project website and flyer, the websites of the consortium partners, social media, and existing newsletters and networks (e.g. Partnership for Environment and Disaster Risk Reduction, Friends of EbA, UNDRR Global Risk Assessment Framework) of the consortium partners.

6 Time and funding schedule for the Research and Development Phase

The following Table 6 shows the financial plan for the *R&D Phase*. A detailed travel cost planning of the individual partners can be found in the respective partners' proposals.

Table 7 shows the chronological sequence of work packages and tasks. The project is structured in such a way that the exchange of content (incl. intermediate results) is enabled at regular intervals by joint workshops (W), co-development workshops (CD) regional networking fora (NF), regular meetings via video conference (not shown in the Table 7) and field surveys. A detailed (monthly) work schedule is provided with the proposal submission.

Table 7: Work schedule of the FloodAdaptVN R&D Phase with quarterly activities.

6.1 Own contribution of the international partners

All Vietnamese partners (HUIS, HUSC, MONRE, DONRE, CCNDPC) contribute with their own resources in the form of personnel hours (listed in work plan), data and equipment. This includes, for example, support in the organisation, alignment and implementation of the project workshops, interviews, bilateral meetings and the co-development of the implementation strategy. In addition, the partners are actively involved in field research, e.g. by supporting data collection, data provision and facilitating expert discussions with actors from relevant stakeholders. Direct costs for activities in Viet Nam caused by the German partners (e.g. field-work, workshop venue, translation, water sample analysis) will be covered via subcontracts. In addition, an application for funding on the Vietnamese side (HUIS) has been submitted to NAFOSTED (National Foundation for Science and Technology Development) in parallel to this application (envisaged start is spring 2021, duration 2 years). HUSC plans to apply for co-funding in 2021.

6.2 Budget estimation for potential Implementation Phase

A potential 2-year *Implementation Phase* strongly depends on the success and uptake of the developed methodology / approach by local stakeholders, as well as upscaling measures on other provinces. The personnel budget estimation is therefore a forward projection of the current partner structure to be able to accompany and supervise the implementation activities closely. With T-7.5 we facilitate the transfer towards the *Implementation Phase*, by considering the demands and needs of local stakeholders and the local business environment. T-7.6 assesses and prepares also the upscaling of the project results, methodology and technical implementation. Five implementation paths have been identified so far, which also can complement each other:

1) Uptake of the project results local to national policy frameworks and strategies and accompanying the implementation and realization (T-7.4)
2) Installation of the modular FloodAdaptVN tools (FRAME, ECA-VN, etc.) into the workflow of relevant stakeholders (CCNDPC, DONRE, etc.) (T-7.3)
3) Accompanying of a university spin-off or a local IT company and to enable them to offer the modular FloodAdaptVN tools as services to local stakeholders and to make GEOMER the long term partner of this enterprise (see utilization plan)
4) Upscaling and transferring the FloodAdaptVN approach to other Vietnamese provinces (see T-6.1 Regional Networking Fora & T-7.6 Upscaling)
5) The implementation of a specific ecosystem-based measure as a test case (greening, reforestation, detention reservoirs, etc.) with the support of a development funds (ADB, WorldBank, etc.)

To be able to support such activities in a sustainable way beyond providing expertise by the FloodAdaptVN partners, it might be necessary to support specific implementation paths with direct support, subcontracts or equipment. To this end, we reserved a lump sum of 250.000 Euro in the *Implementation Phase* budget.

6.3 Necessity of funding

The planned research of the alliance partners is a contribution to a joint initiative, which is not the subject of funding by another national or international programme. Third party funds or own resources are not available for the implementation of the project. The project cannot be implemented without the funding.