Final project report

GreenCityLabHuế: Nature-based Solutions to Strengthen Climate Resilience of Urban Regions in Central Vietnam

Final report for the definition phase of the joint research project

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Contents

I. Summary report

1 Description of the problem and state of the art of science

The project “Nature-based solutions to strengthen climate resilience of urban regions in Central Vietnam (GreenCityLabHuế)” aims to create a multi-level and multidisciplinary research and experimentation space, the Green City Lab Hue (GCLH), to develop, test, visualise, discuss, and implement ideas and concepts on the restoration and expansion of green-blue infrastructure (GBI) and thus the promotion of nature-based solutions (NBS) in the urban area of Hue, Central Vietnam. In cooperation with stakeholders from science, administration, politics, and civil society, the international extended project consortium will develop joint NBS-related knowledge for stakeholders and decision-makers. The integration of NBS and GBI approaches into the city development in Hue will protect a wide range of ecosystem services (ESS), while increasing and strengthening the social and ecological resilience to the increasing impacts of climate change. By applying approaches of co-learning and co-creation, the project not only enables the development of widely accepted, realistic and thought-out activities to improve socio-ecological conditions, climate-change mitigation, and resilience in Greater Hue – it also strengthens the capacities of Hue’s administrative-political decision-makers to translate general urban development guidelines into practical and suitable measures and outputs. In the successfully implemented definition phase, the project aimed to:

(i) acquire and provide detailed information on existing and potential GBIs,
(ii) develop stakeholder-based narratives and visions as well as subsequently derived land use scenarios,
(iii) support participation processes, capacity-building, co-learning- and co-creation-processes,
(iv) inspire other Vietnamese cities with the results and achievements to improve climate-resilience and
(v) create a basis for the following research and development project.

2 Course of research project and project activities

The joint project GreenCityLabHuế was funded within the call “Nachhaltige Entwicklung Urbaner Regionen” from 20.02.2017 and started its work on 01.07.2019. The regular duration of the project comprised 18 months and was extended by three further but cost-neutral months, so that the project ended on 31.03.2021. The research project was subdivided into seven work packages (WP), whereby all WP were in constant exchange and were closely interwoven in terms of content as well as operationally. Work in the WP contributed to the establishment of the GCLH and formed the basis for the subsequent research and development project. The individual WP focused on the following aspects:

WP 1: Analysis of the status quo of GBI in Hue by carrying out a literature research, conducting stakeholder interviews and an analysis of the spatial distribution of GBI in Hue using geospatial data.

WP 2: Development of stakeholder-based narratives and visions in a co-design- and co-learning-process and their subsequent translation into computational rules (codes) for modelling land use change in GIS.

WP 3: Modelling land use change scenarios based on the narratives by developing methodological approaches in the definition phase and, building on this, carrying out a test case scenario including feasibility test and evaluation.

WP 4: Creation of a public information and learning space (Green City Lab) and the GreenCityLabHuế project website that served as a virtual information and learning space

about NBS and GBI in Hue and as main tool for the external project communication, both in Germany and Vietnam.

WP 5: Preparation of the project application for the main research project (R&D phase) by identifying key research questions and developing an implementation plan for the main project.

WP 6: Presentation and reporting of project results at a closing event in Hue and by producing a final project report.

WP 7: Project management, administration and communication

In consequence of the SARS-CoV-2 coronavirus and the associated COVID-19 pandemic, changes to the initial work and time schedule of the work packages became necessary. The comprehensive adaptation and management measures within the project, as well as the approval of the cost-neutral extension, ensured a successful implementation of the tasks and an achievement of the goals as mentioned and set in the application.

3 Key findings of the project

Key findings of the definition phase include:

- Completion and publication of the status quo report "Nature-based solutions in Hue", including case study typology, status quo analysis based on geodata, stakeholder analysis and analysis of the legal and policy framework
- Compilation of relevant (geo)data and documents related to GBI-development and implementation of NBS in Hue, which will be continued in the R&D phase
- Implementation of a co-design and co-learning process
- Implementation of the webinar "Scenario Development and Modelling" as part of the method and knowledge transfer
- Development of four initial narratives and their revision according to the feedback of the stakeholder workshop and the urban planning 2030 dataset
- Development of the methodology for the pseudo-quantitative assessment of the effects of the proposed measures on selected ecosystem services (incl. feasibility test)
- Establishment of the virtual Green City Lab Hue in the form of a bilingual project website (www.greencitylabhue.com)
- Conception of the research design for the R&D phase and submission of the corresponding project proposal
- Presentation of the project results at the online closing workshop and in the form of a virtual exhibition on the project website
- Strengthening existing contacts and establishing new ones in Vietnam

4 Cooperation with project partners

The research project consists of the Humboldt-Universität zu Berlin (HUB), which was responsible for the project coordination in the definition phase, and the Independent Institute for Environmental Issues (UfU) from Berlin. Additionally, as part of the extended project consortium, the Mientrung Institute for Scientific Research (MISR), the Thua Thien Hue Institute for Development Studies (HueIDS) and the Faculty of Architecture of the University of Sciences, Hue University (HUSC), were involved in the implementation of the WP work and time schedule. The MISR acted as the main contact for the German project partners in the study area.

II. Detailed report

Global warming and urbanisation are closely interconnected. Cities are both drivers of global warming and especially affected by its impacts. The need for climate mitigation and adaptation as well as building resilience is therefore becoming essential for urban policy. In this context, nature-based solutions (NBS) in urban and regional planning are gaining increasing importance. NBS refer to the sustainable management and use of nature for tackling environmental and societal challenges such as climate change and the urban heat island effect, water supply security, water and air pollution, food security, human health, and disaster risk management. They include the enhancement and expansion of green-blue infrastructure (GBI), a strategically planned network of natural and semi-natural areas with other environmental features, designed and managed to deliver a wide range of ecosystem services. GBI planning also helps to reduce dependence on 'grey' (built) infrastructure that is often more expensive to build and maintain. It is therefore a smart investment for cities, especially in developing countries.

Against this background, the joint project “Nature-based solutions to strengthen climate resilience of urban regions in Central Vietnam” (GreenCityLabHuế) was dedicated to creating a trans- and multidisciplinary research and experimentation space, the Green City Lab Hue (GCLH), to develop, test, visualise, discuss, and implement ideas and concepts for the enhancement and expansion of GBI and thus the promotion of NBS in the urban area of Hue, and has generated joint NBS-related knowledge for stakeholders and decision-makers in cooperation with stakeholders from science, administration, politics, and civil society. In the definition phase, the two German project partners Humboldt-Universität zu Berlin (HUB) and the Independent Institute for Environmental Issues (UfU) were supported by the Vietnamese project partners, the Mientrung Institute for Scientific Research (MISR), the Thua Thien Hue Institute for Development Studies (HueIDS) and the Faculty of Architecture of the University of Sciences, Hue University (HUSC).

1 Objectives, approaches pursued, and indicators

The overall objective of the collaborative project GreenCityLabHuế is to strengthen the social and ecological resilience of Hue city and its surroundings by promoting NBS and maintaining and expanding GBI. Thereby, the project focuses on building a solid knowledge and idea base and a network between relevant stakeholders to be used for further research and on the integration of GBI approaches into urban planning processes, as well as on the active participation and integration of experiences and visions of local stakeholders, experts, and other knowledge holders such as citizens. To achieve abovementioned objective, the following sub-goals have been defined:

- ***Objective 1: Collect and provide detailed information on existing and potential GBI*** in Hue and its surroundings, including their distribution within the urban area and their benefits for the region.
- ***Objective 2: Development of visions and scenarios for the future potential of GBI and existing green and blue spaces in the urban area of Hue*** through the active involvement and participation of relevant stakeholders, experts and decision-makers to build capacity and enable them to take steps towards mainstreaming GBI in urban planning, governance and investment decisions.
- ***Objective 3: Capacity building, education, and the promotion of co-learning and co-creation processes*** to engage and activate different stakeholders to become aware of and participate in planning processes in their city and neighbourhood.
- ***Objective 4: To inspire other Vietnamese cities*** to integrate GBI approaches and co-learning and co-creation processes into their agenda and urban planning.

- ***Objective 5: Create the basis for the implementation of a research and development project***, including the identification of research questions, the development of a detailed concept and a project proposal.

To reach the abovementioned objectives the following approaches have been applied: Through ***qualitative research*** and ***GIS (Geographical Information System) mapping of urban green and blue spaces***, knowledge and a better understanding of the current distribution, abundance, trends and status of artificial as well as (semi-)natural GBI within the urban area of Hue and its current and future contribution to strengthening Hue's social and ecological resilience was generated. The ***Urban Learning Lab (ULL) approach*** is based on a systemic transformation methodology to provide research-based expertise to local stakeholders and to involve them and their local and professional knowledge actively in urban planning processes. Thus, the definition phase ensured that knowledge was exchanged and not only transferred in one direction, and enabled the co-creation and co-production of urban development measures. Furthermore, the ULL approach enables and promotes the exchange of experience and knowledge between Vietnamese cities. ***Backcasting scenarios*** were used as a tool towards targeted planning of future GBI development and learning multiple ways to go where (i) different GBIs can be involved according to the local settings and resources (including analysis of barriers for the implementation); and (ii) different constellations of stakeholders can be involved in setting/outlining the targets. All applied methods and approaches thus contributed to the creation of a solid information and knowledge base for the design of a research and development project and its subsequent implementation (R&D-phase), as well as to the achievement of the set objectives for the definition phase. The successful implementation of the definition phase can be assessed by the following indicators:

- ***Indicator objective 1:*** Completion of a comprehensive analysis of the status quo and possible future developments of GBI in the urban region of Hue.
- ***Indicator objective 2:*** Completion of narratives to illustrate different pathways of urban development for scenarios for GBI development and a test case scenario including feasibility test and evaluation.
- ***Indicator objectives 3 and 4:*** Number of stakeholders from Hue and representatives from other cities who participated in the workshop and events; number of visitors of Green City Lab Hue; number of visitors of the project website.
- ***Indicator objective 5:*** Submission of a complete application for the research and development project to the BMBF.

To what extent the indicators were achieved is addressed in the context of point 2 "Research activities and results".

2 Research activities and results

The definition phase of the collaborative project GreenCityLabHuế – Nature-based Solutions to Strengthen Climate Resilience of Urban Regions in Central Vietnam was funded within the call “Nachhaltige Entwicklung Urbaner Regionen” from 20.02.2017. The project started on 01.07.2019 with a project duration of 18 or 21 months (cost-neutral extension). In order to address the diverse challenges, such as the rapid population growth (The world Bank 2020) and ongoing urbanisation (Anh et al. 2013), climate change and its adverse effects, which Vietnamese cities and thus also the study area of Hue are facing (Eckstein et al. 2017, UNDP 2008), the research project was subdivided into seven work packages (WP) in the definition phase (Figure 1), whereby all WP were in constant exchange and were closely interwoven in terms of content as well as operationally. Work in the WP contributed to the generation of knowledge on GBI and NBS in Hue and Vietnam, as well as to the establishment of the GCLH, and formed the basis for the subsequent research and development

project. The activities carried out in each WP and the results achieved are presented in the following subsections.

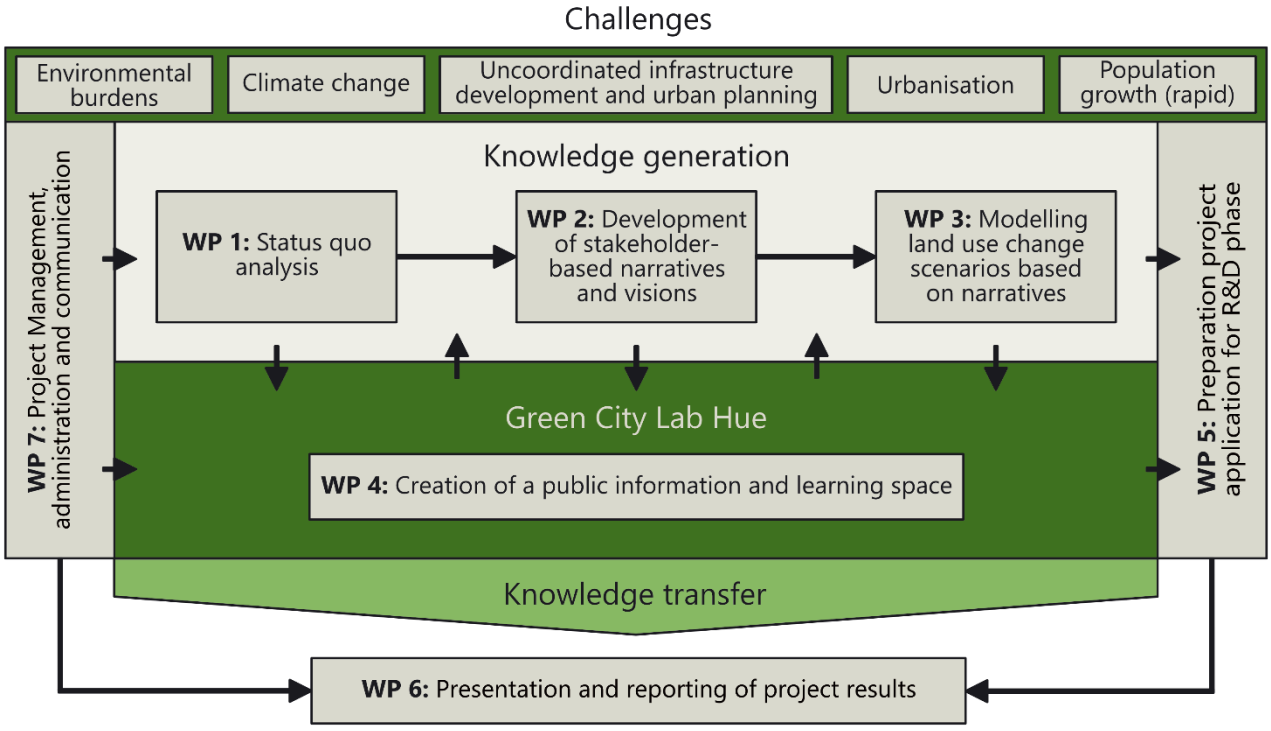


Figure 1. Structure of the research project and the associated work packages.

In addition to presenting the work done and the results, at the end of each WP, lessons learned are summarised in terms of content and methodology as well as organisational/administrative processes.

2.1 WP 1 Analysis of the status quo of green-blue infrastructure in Hue

One of the main objectives of the GreenCityLabHuế project in the definition phase was to analyse the status quo of GBI and its potential future development in Hue in order to, among other things, generate the knowledge base for the research project. Findings from the analysis were compiled in the status quo report and included not only detailed information on existing and potential GBI and NBS, but also on the study area itself, including societal challenges, climatic conditions and climate change, urban development, and the existing policy framework regarding the development and implementation of GBI and NBS. Overall, the status quo report intended to (i) collect and evaluate existing findings, documents and data related to GBI and NBS; (ii) analyse the future development of GBI and NBS in the study area; and (iii) identify key actors, opportunities, challenges, and barriers for GBI development. In doing so, the report is based on (i) information from 21 semi-structured interviews with 23 experts conducted by UfU in collaboration with MISR during the field research in October 2019; (ii) the assessment of climate change trends in Thua Thien Hue province; (iii) the case study typology developed in collaboration with HUSC as part of the co-learning and co-creation process; (iv) the status quo analysis based on geodata and remote sensing; and (v) the analysis of publications and grey literature including relevant manuals, public documents and laws. The most relevant results of the status quo analysis, which was carried out by the German project partners HUB and UfU in cooperation with MISR, are presented below.

Essential for the analysis of the status quo was the creation of a common comprehension with regards to different terminologies related to NBS and GBI in order to understand the various perceptions of both terms within the project partners, as well as the identification of relevant GBI in

the context of Hue city. In the following, NBS are understood as interventions or measures that are inspired by nature and the functions of ecosystems to tackle environmental and societal challenges. They comprise, among others, the enhancement and expansion of GBI, a planned network of green and blue spaces to protect biodiversity and provide multiple ecosystem services and associated benefits (European Commission 2013, Vinh and Huong 2017). To identify relevant GBI in the study area, the case study typology was developed in a co-creation and co-learning process, including feedback loops, between the Vietnamese partner HUSC and the German partner HUB. Two important documents on GBI, "A typology of urban green spaces, ecosystem services provisioning services and demands" by Cvejić et al. (2015) and "Reflections about blue ecosystem services in cities" by Haase (2015), form the basis for the typology. The typology itself illustrates important GBI elements as understood by the Vietnamese and German project partners (see Figure 2), and thus formed part of the knowledge base for the development of stakeholder-based narratives and the subsequent modelling of land use change scenarios.

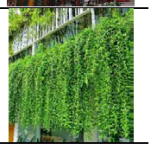
Term	Description (Europe)	Source	Example (Europe)	Description (Vietnam)	Source	Example (Vietnam)
Green Infrastructure on building structures						
Balcony green[1]	Plants in balcony and terraces, planted mostly in pots.	Cvejić et al. 2015: 18.		Plants in pots or movable boxes. Some buildings have unmovable tanks/containers on their balconies for the plants.	Architects from HUSC and local architecture offices, 2019	
Ground based green wall[2]	Ground based climbing plants intended for ornamental (and sometimes food production) purpose.	Cvejić et al. 2015: 18.		In Vietnam in general, and in the city of Hue in particular, this form is not preferred in building design due to water absorption and penetration into the house during the (long and heavy) rainy seasons. Instead, they prefer plants separated from wall surfaces when decorating buildings with (vertical) greenery.	Architects from HUSC and local architecture offices, 2019	
Façade-bound green wall[3]	Plants growing in façade bound substrate, e.g. containers or textile-systems.	Cvejić et al. 2015: 18.		Plants that grow not only on facades but also on interior ornamental walls to bring nature into the interior.	Architects from HUSC and local architecture offices, 2019	

Figure 2. Example of the case study typology developed in the co-learning and co-creation process.

The case study typology consists of 64 GBI elements grouped into ten categories: (i) Green Infrastructure on building structures; (ii) private, commercial, industrial and institutional GBI and GBI connected to grey infrastructure; (iii) allotment and community gardens; (iv) recreational parks and gardens; (v) agricultural GBI; (vi) other GBI; (vii) type of vegetation; (viii) blue infrastructure on building structure; (ix) natural or semi-natural water bodies and hydrographic networks; and (x) constructed wetlands/water bodies and built structures for water management. GBI listed in the typology include both single GBI elements, e.g., green roofs and green verge, as well as compositions of GBI elements, e.g., large urban park and botanical garden. Main findings of the co-created typology include: (i) Most of the key elements are common in both (Central) Vietnam and Europe; (ii) some types were identified that are unique to the city of Hue, including blue-green gardens (e.g., Tịnh Tam Lake), garden cafés and the traditional garden houses (e.g. in Kim Long); and (iii) the role of cemeteries as GBI offers potential for further investigation, particularly in terms of the provision of multiple ecosystem services, due to their abundance and distribution in Hue (cf. Figure 4, D).

Also, part of the status quo report was the actual analysis of the status quo of GBI in terms of spatial distribution based on the previously developed case study typology and, building on this, field studies by the Vietnamese project partner HUSC, land use data for the city of Hue from 2014 and remote sensing data. In general, the intended inventory of GBI in Hue, as part of the analysis of the status quo, was affected by issues related to the (partially belated or incomplete) delivery of data and (partially poor) data quality. The land use dataset available at the time of the status quo analysis was processed and supplemented with additional information from OpenStreetMap (OSM). As a result of

this procedure, the 36 original land use classes were transferred into ten or 16 land use types by systematically grouping similar classes under the aspect of applicability and finally mapped (cf. Figure 4, D). In addition, the grouped land use data was intersected with the ward boundaries to calculate the proportion of different GBI and built-up area in the city of Hue and in each ward (Figure 3). Looking at Figure 3 and Figure 4, it becomes clear that public green spaces and forests are not evenly distributed across the city and that there is an obvious concentration of GBI in the periphery.

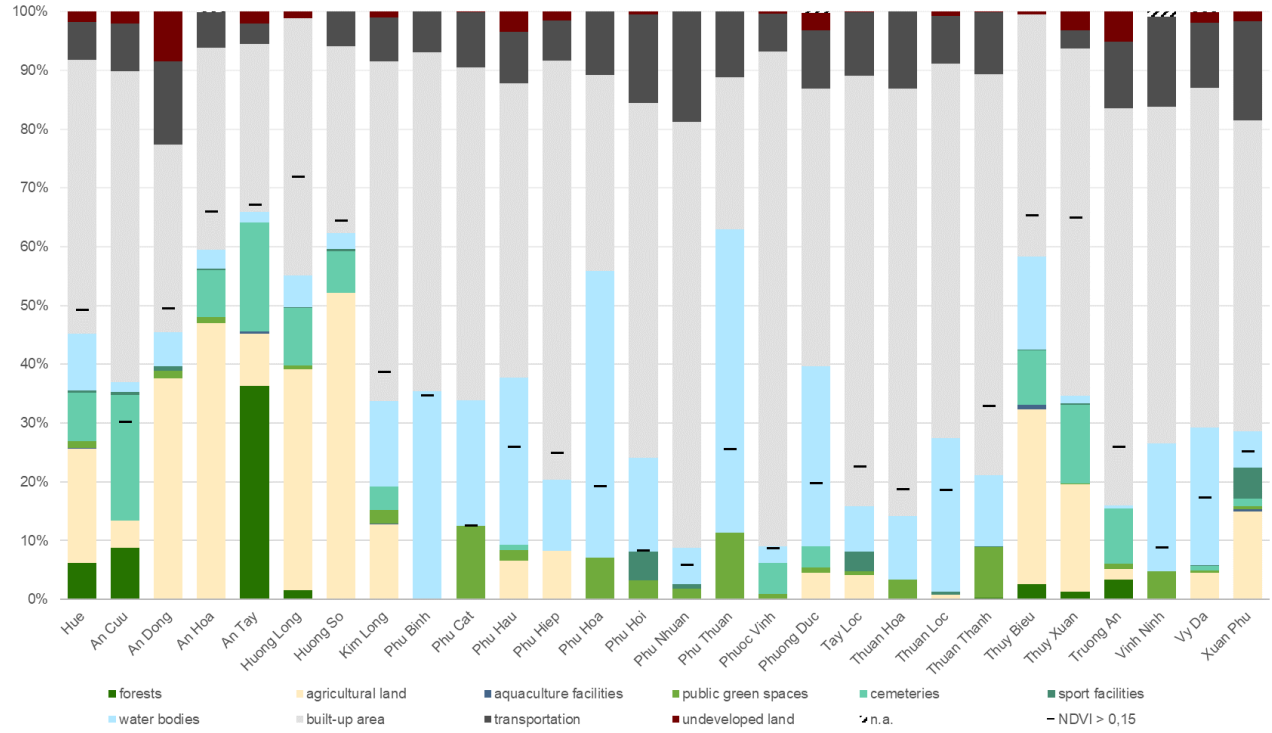


Figure 3. Share of green-blue infrastructure (based on land use data) and vegetation (based on vegetation classification using the normalised difference vegetation index - NDVI) in the city of Hue and in each ward.

In addition to the distribution of GBI based on land use data, a satellite image (Figure 4, A) was used to calculate the normalised difference vegetation index (NDVI) (Figure 4, B) and later to carry out an initial vegetation classification (Figure 4, C). The NDVI belongs to a group of vegetation indices and is used, among other things, to assess vegetation condition and cover and thus canopy greenness (Glenn et al. 2008). The threshold for the classification was set at 0.15, i.e., pixels with an NDVI value greater 0.15 were classified as vegetation. In most wards, the proportion of areas with a NDVI above 0.15 (= vegetated areas) correlates with the proportion of GBI (calculated based on land use data), i.e., wards with high a share of GBI often have large, vegetated areas (Figure 3). Whereby water bodies cannot be differentiated by means of vegetation classification and thus do not necessarily increase the proportion of areas classified as vegetation. Only water plants floating on the surface have an impact on the vegetation classification, as could be observed in the study area, e.g., lotus plants in Tịnh Tam Lake. But in general, wards with high shares of built-up area and water bodies, such as Phuong Duc and Thuan Loc, have only small areas with vegetation. As a result, the vegetation classification using NDVI revealed GBI that is not covered in the inventory of GBI based on land use data, e.g., vegetation such as trees and green verge along streets. It also uncovers the high amount of green of certain land uses, in particular historic and cultural monuments and urban residential areas with a high share of traditional garden houses or in the suburbs.

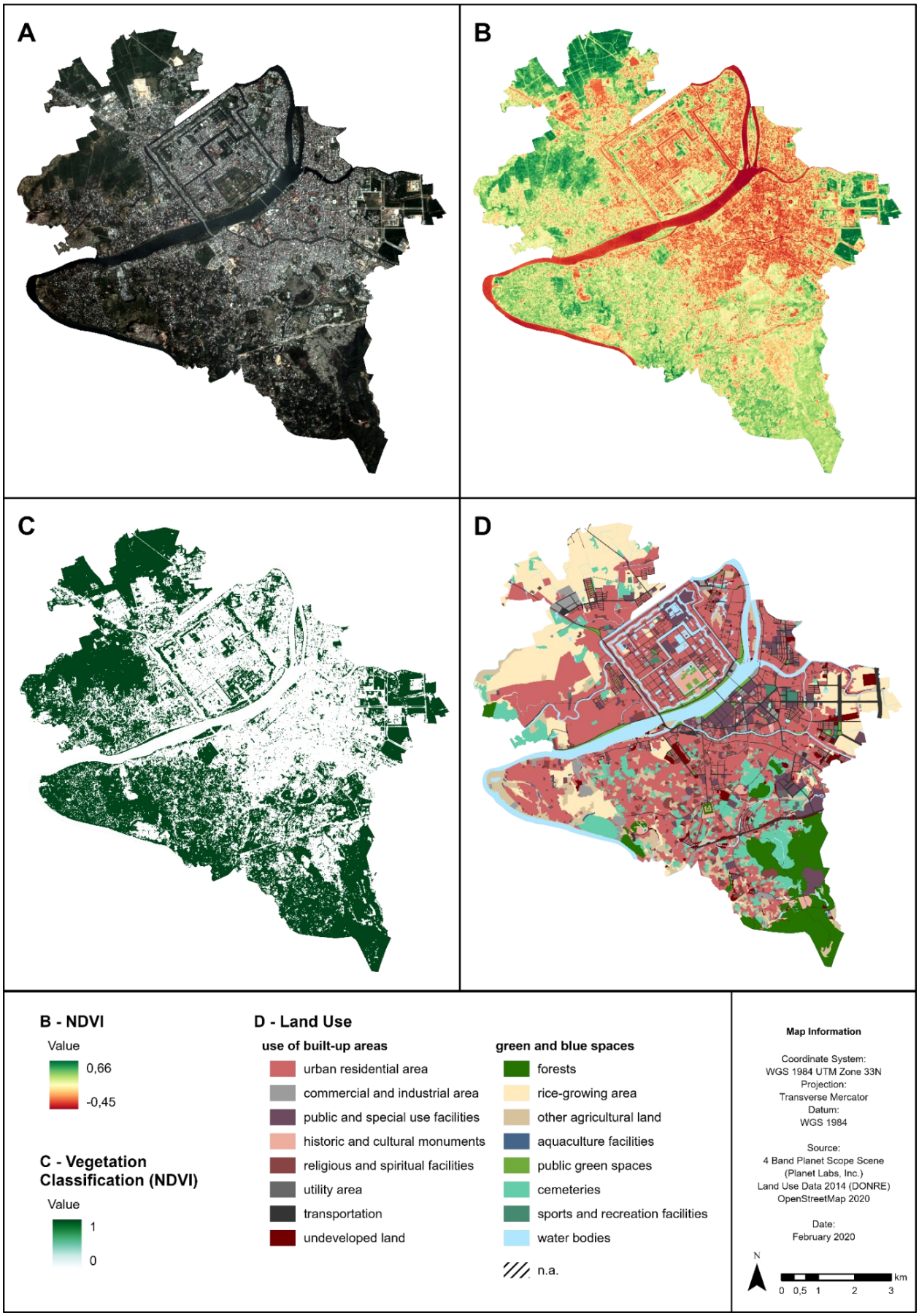


Figure 4. Different representations of the study area as part of the status quo analysis: PlanetScope satellite image of the city of Hue on 20th February 2020 (A), the normalised difference vegetation index (NDVI) calculated based on the PlanetScope image (B), vegetation classification based on the NDVI (C) and land use map (D).

Potential areas for the implementation of NBS or GBI-development in the city of Hue differ depending on whether GBI should be expanded or enhanced. The most suitable areas for expanding GBI are those marked as undeveloped land (cf. Figure 4, D) or the new and growing urban areas in the Huong So, An Hoa, Thuy Xuan and Huong Long wards[1]. In densely populated areas or in special zones (the possibilities for construction are limited here) such as the citadel, along the Huong River, the Vong Canh Hill and the Thien An Hill[2], priority should be given to enhancing GBI.

Another main focus of the status quo analysis was the examination of the political, legal and socio-economic framework conditions for a future extension of GBI in Hue. For this purpose, relevant official documents, recent plans and programs as well as political decisions of the city and provincial administration regarding GBI, climate protection and climate adaptation were analysed. Further, UfU in cooperation with the MISR conducted 21 interviews with relevant stakeholders. The interviews were based on a semi-structured interview guide. Interviewees had been carefully selected in order to represent different sectors (science, administration, civil society, etc.) and to avoid a gender bias. Subsequently, the interviews were transcribed and analysed with the data analysis program MAXQDA. Based on the document and interview analysis a summary of the political and socio-economic framework conditions and an actor analysis were included in the status quo report of the project.

Regarding the legal documents, plans and programs two main topics of major importance for the future GBI development of Hue and its surrounding provinces could be identified: (1) Decisions, plans and programs regarding city development as well as (2) decisions, plans and programs regarding climate protection and climate adaptation. In the following the most relevant findings of the document analysis will be summarised.

The urban policy direction of the province of Thua Thien is mainly characterised by the goal of transforming Hue into an important city directly under the central government of Vietnam, such as Hanoi, Ho Chi Minh City and Da Nang. The province strives to develop Hue into a national economic, cultural, and scientific centre with an impact visible beyond Vietnam's borders. Restoration, renovation, protection, and promotion of cultural heritage related to Hue's former significance as the imperial capital of Vietnam play a particularly important role and are stipulated in Decision 818/QD-TTg dated June 7th, 2010. The decision formed the basis for Hue's appointment as UNESCO World Cultural Heritage and stipulates that future urban developments should contribute to the protection of the historic architectural landscape and its surrounding natural landscape. Equally relevant for Hue's future urban development is decision 649/QD-TTg dated May 6th, 2014 which outlines the overall regional planning for Hue and its surroundings until 2030 with an outlook until 2050. The decision's scope encompasses Hue's urban area (70,67 km²) and the urban development area of the neighbouring towns of Huong Thuy, Huong Tra and part of the Phu Vang district (city of Thuan An and neighbouring communes), covering a total area of approximately 348,54 km². The development goals of the decision include:

- Preservation and promotion of the heritage of the former imperial capital Hue,
- Building a city with a modern organisational structure consisting of spatial planning, urban planning and architecture in harmony with nature, as well as the development of modern technical infrastructure
- Transforming Hue city and areas designated for development into a central metropolitan region of Thua Thien Hue province,

[1] Interview with Mr. Nguyen Van Trung, Deputy Director of Bac Trung Nam Company for Consultant and Investment Construction (18.10.2019)

[2] Interview with Dr. Hồ Thanh Hà, Director des Centre for Climate Change Study in Central Vietnam, University of Agriculture and Forestry, Hue University (14.10.2019)

- Transforming Thua Thien Hue metropolitan region into a city directly under the central government.

Also, in terms of climate protection and adaptation many urban policy decisions have been made which allow for an integration of future GBI planning. Already today negative consequences of climate change pose one of the biggest challenges for a successful socio-economic development of the city. In order to counteract these developments, the people's committee of the province of Thua Thien Hue passed several political decisions and plans for the adaptation and mitigation of climate change and for increasing the resilience of Hue City and its surrounding province with the following overarching goals relevant to GBI development:

- Promotion of awareness on the need for sustainable development by authorities and agencies at all political levels, as well as by companies,
- Promotion of sustainable development based on green growth, focusing on environmental protection and social security, as well as culture, tourism, health, education, science, and technology,
- Economic and efficient use of energy and natural resources to implement green growth,
- Transformation of economic and social activities towards greater sustainability and environmental protection,
- Promotion of green industry, sustainable agriculture, and green services,
- Improvement of the quality of life,
- Review and adaptation of urban planning in terms of sustainability.

Despite GBI and NBS development not being an explicit part of urban and provincial planning, a clear orientation towards the goals of sustainable urban planning, green growth and resilience enhancement can be identified, in which future GBI and NBS planning can be integrated and contribute to the achievement of goals. In the following project phases (R&D phase and implementation phase) it is necessary to specify and formulate them in cooperation with all relevant actors.

Within the actor analysis the following groups of actors have been identified for further GBI planning (Figure 5):

- Executive body - Thua Thien Hue Provincial People's Committee
- Provincial authorities
- City government
- Public agencies
- Scientific institutions
- Civil society groups
- Citizens

The **people's committee of the province of Thua Thien Hue** coordinates political decisions between the central government and municipal administrations and is responsible for implementing national decisions, plans and orders at the provincial and city level. As government of the province, it is also responsible for the provision and acquisition of national state resources for investments in urban areas. This makes the support of the People's Committee indispensable for the implementation of GBI projects in Hue City. The **provincial authorities** are specialised agencies that assist the provincial People's Committee in formulating projects, programs and plans. They are also responsible for their implementation at the provincial level. In terms of GBI planning in Hue, the Department of Planning and Investment (DPI), the Department of Construction, the Department of Natural Resources and Environment (DONRE), and the Department of Agriculture and Rural Development are of particular importance. In addition, depending on the type of GBI planning, other offices such as the Office of Tourism and the Office of Transportation may also be relevant. The **city**

government administers urban professional authorities to implement the plans at the city level according to the instructions of the People's Committee and the provincial authorities. It further collects and administers data on socio-economic urban planning. The urban planning office and the urban environmental office play a crucial role in the development of GBI in Hue. In addition, depending on the location and planning, the involvement of the relevant municipal district offices is relevant. **Public agencies** are state-owned enterprises that report directly to the provincial government and perform specific tasks. The Green Tree Company and the Hue City Environment and Water Improvement System Company (HEPCO) are relevant actors for GBI planning. **Scientific institutes** provide consulting support to the People's Committee. They examine planning projects and development guidelines of the province. The academic landscape of Hue is very diverse and covers several scientific directions. The scientific main actors in terms of GBI planning are the Faculty for Environment, Hue University of Sciences; the Faculty for Architecture, Hue University of Sciences; the Institute for Environmental and Occupational Health, Hue University; the Hue Institute for Development Studies (HueIDS), the Mientrung Institute for Scientific Research (MISR), the Institute of Resources and Environment (IREN) and the Institute of Construction and Planning**. Civil society organizations** in Hue relevant for GBI planning are in particular the Centre for Community Development and Social Work (CODES) and the Centre for Social Research and Development (CSRD). They can act as important interfaces in GBI planning between research and policy and the local population. Indeed, in addition to governmental scientific and organized civil society institutions, the participation of the **local population** in GBI planning and implementation is very important, as they are directly affected by the implementation of plans and projects. Achieving citizen acceptance and incorporating their needs into planning is central to the successful implementation of GBI measures.

The following chart (Figure 5) provides an overview of the key actors in Hue and its surrounding province identified within the project.

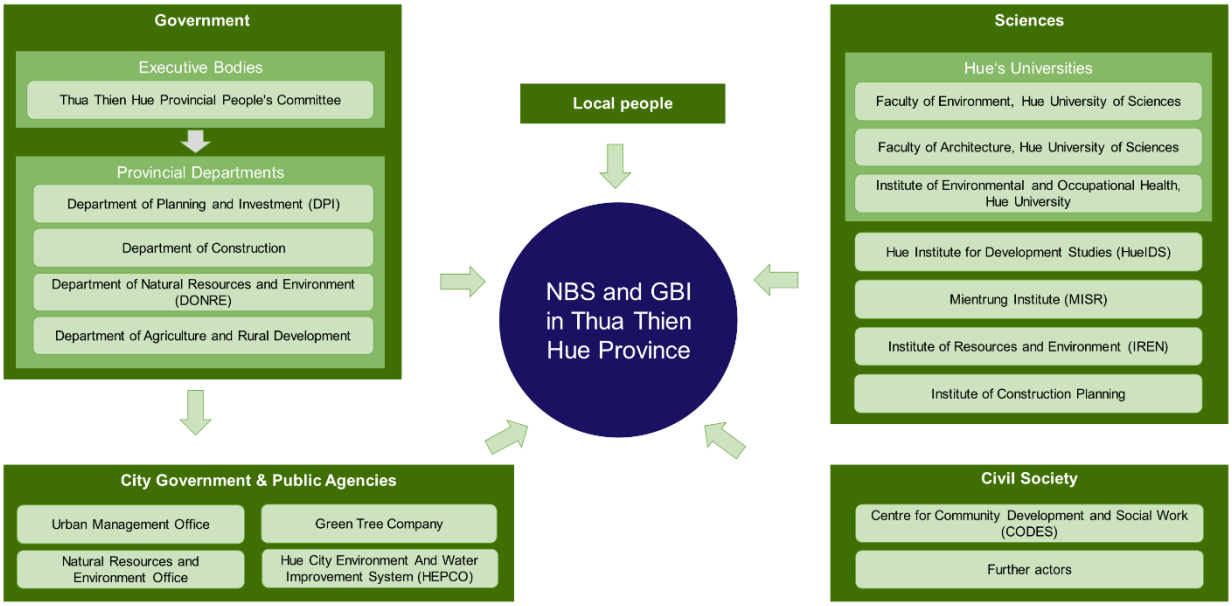


Figure 5. Stakeholder map of key actors for GBI development and implementation of NBS in Hue City, Vietnam.

In addition to the analysis of the status quo and the status quo report based on it, WP1 started with the compilation of (geo)data and documents relevant to the project, which will be continued in the R&D phase. Ideally, at the end of the research and development project, a database should be established that systematises and provides the collected (geo)data and documents. In the definition phase, the HUB specified the relevant (geo)data for this and communicated these to the Vietnamese

partners, in particular the MISR and HueIDS, who began the collection process. The compilation of relevant (geo)data proved to be more difficult and time-consuming than originally planned. This was due to issues related to the (partially belated or incomplete) delivery of data, (partially poor) data quality, (partial) lack of metadata, and different level of knowledge of the partners regarding the requirements for (geo)data. The latter point in particular is being considered more intensively in the R&D phase, among other things through knowledge and method transfer workshops Vietnamese project partners and other relevant local stakeholders.

- In cooperation with the Vietnamese partner HUSC, a case study typology was developed as part of the co-learning and co-creation process, which identifies relevant GBIs in the context of Hue city. Main findings include: (i) Many GBI elements are common in both (Central) Vietnam and Europe; (ii) types unique to Hue include green-blue gardens, garden cafés and the traditional garden houses; and (iii) the role of cemeteries offers potential for further research. The typology also formed part of the knowledge base for the development of stakeholder-based narratives (cf. WP2) and the subsequent modelling of land use change scenarios (cf. WP3).
- The status quo analysis based on land use and remote sensing data illustrates an uneven spatial distribution of green spaces and forests in the city, with a clear concentration of GBI in the less densely populated peripheral areas.
- An initial vegetation classification using NDVI revealed GBI such as trees and green verge along streets that were not covered by the status quo analysis using land use data. Additionally, the classification also uncovered the high amount of green of certain land uses, e.g., historic and cultural monuments and urban residential areas with a high share of traditional garden houses.
- The analysis of the legal and policy framework revealed that even though GBI and NBS development is currently not explicitly the subject of urban and provincial planning, a clear orientation towards sustainable urban development, green growth and strengthen resilience can be identified, into which future GBI and NBS planning can be integrated and contribute to the achievement of development objectives.
- For GBI planning in Hue, the involvement of stakeholders from science, administration, politics, and civil society at provincial and city level, as well as local population is crucial. The stakeholder analysis identified the most relevant stakeholders and described their areas of responsibility, thus forming the basis for cooperation with and involvement of key actors in the subsequent project phase.
- The compilation of relevant (geo)data and documents has been started and will be continued accordingly in the R&D phase; the aim here is to establish a database. Due to issues related to the (partially belated or incomplete) delivery of data, (partially poor) data quality, (partial) lack of metadata, and different level of knowledge of the partners regarding the requirements for (geo)data, the compilation proved to be more difficult and time-consuming than originally planned.
- Any complications that may arise due to different levels of knowledge regarding the requirements for (geo)data are to be addressed in the R&D phase by implementing workshops on knowledge and method transfer.

2.2 WP 2 Development of stakeholder-based narratives and visions

The focus of WP2, which was carried out by the HUB, was the development of stakeholder-based narratives and associated modelling of scenarios of land use change in Hue (cf. WP3). Of particular concern was the implementation and integration of the scenario modelling into a co-design and a co-learning process in order to involve experts from different disciplines, to take into account the

social context of the project by involving practitioners and other stakeholders (Aalbers 2013), and to obtain a first assessment of measures that are perceived as positive by the public (Seppelt et al. 2011). The schematic methodological approach is shown in Figure 6.

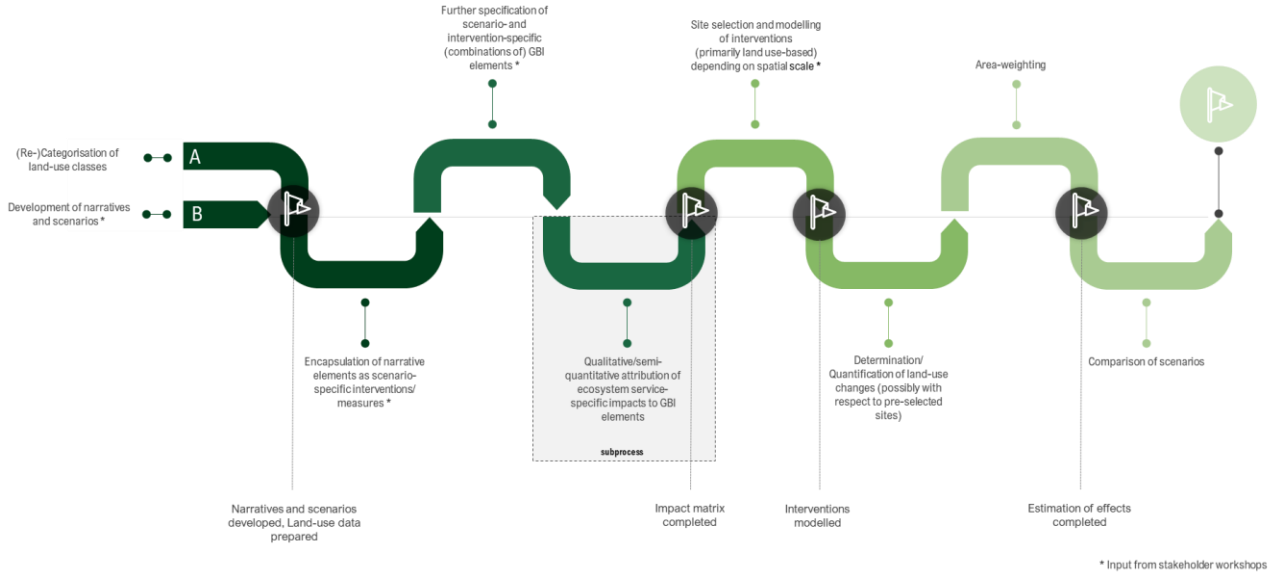


Figure 6. Schematic illustration of the development, modelling and evaluation process of land use change scenarios.

The approach to narrative-based modelling of land use scenarios as described in Figure 6 has two main "entry points": (A) the provision and processing of land use data; and (B) the formulation of "alternative futures" (narratives), each comprising differentiated interventions for greening, respectively establishing green infrastructure in Hue. The provision and processing of land use data is closely linked to WP1. The land use dataset pre-processed in WP1 (as of 2014[3]) was processed again for WP2, i.e. suitable land use categories for modelling were identified, described and the data accordingly re-categorised. As a result of this procedure, the 36 original land use classes were transferred into nine land use types by systematically grouping similar classes according to applicability. The second entry point comprises the actual development of narratives. The development of narratives was based on the interviews conducted in WP1, the case study typology and the findings of the status quo analysis (cf. status quo report). Four narratives were formulated, which are listed in Figure 7. The narratives include a baseline scenario (Business-as-usual, scenario A), two " intermediate" scenarios (scenarios B and C), and an "optimistic" narrative of a green utopia (the so-called "Biophilic city", scenario D). While the baseline scenario A does not formulate any interventions beyond those that have already been enacted in Hue (according to the plans surveyed in the status quo report), the extent of proposed interventions increases in the remaining narratives. The narratives, respectively the scenarios they represent, were thus designed in such a way that the degree of interventions for the greening of Hue, i.e., for the establishment of green-blue infrastructures, increases decidedly compared to the baseline.

[3] No more up-to-date land use datasets were available at the time, and attempts are still being made to obtain more up-to-date data.

Scenario A **Business-as-usual**	Scenario B **Small-scale improvements**
City growth and expansion result in **continuous encroachment into natural and agricultural land** that is converted into built-up land and **few urban green spaces**. **No measures** will be taken within the existing infrastructures.	City growth and expansion result in **continuous encroachment into natural and agricultural land**. However, to improve the sojourn quality and as aesthetical intervention, **trees are being planted in** the **newly built-up areas**. Still, only **few green spaces are created. Within the inner city and the citadel, additional trees are planted** to improve air quality.
Scenario C **Larger-scale improvements**	Scenario D **Biophilic city**
Encroachment into natural areas will be **limited**. Instead, most of the **expansion** of Hue is **accommodated by agricultural areas**. The **new built-up land** will be **greened** by planting of trees, **intensive greening** of, e.g., **courtyards, and rain gardens**. **Within** these **newly constructed areas, more green space per capita will be created** in the form of **woody public green spaces**. Several measures are applied across the city of Hue for the improvement of existing infrastructures, e.g., **greening by the planting of trees, intensive and extensive greening** of courtyards, or the addition of **green verges**. **Existing green spaces will be improved** in quality, e.g., **by** the **implementation of playgrounds**. These measures should help adapting the city to future extreme conditions (heat, flooding) and improve public health, e.g., by tackling air pollution.	**Natural areas will be protected**. As an additional climate change mitigation measure, forest areas will be increased by **afforestation**. Spatial **expansion** of the city will be **accommodated only through the conversion of agricultural areas and undeveloped land** into built-up land. Through the application of building codes for newly constructed buildings **to enable the greening of roofs and facades**, as well as the **high share of (woody) public green areas**, these newly constructed areas will be of very high environmental quality. Similarly, existing infrastructures will be improved, e.g., by **planting of trees, intensive and extensive greening**, adding **green verges, retention basins and bioswales. Public green spaces will be greened by adding of trees and woody elements**. Their quality is additionally increased by the **implementation of playgrounds**. These measures shall improve the resilience of Hue against future climate conditions, improve public health and well-being, and drastically improve sojourn quality and recreative potential across the city.

Figure 7. Initially developed narratives and scenarios for the subsequent modelling of land use change.

The business-as-usual scenario was contrasted by scenario D, the biophilic city, which envisions a very high degree of intervention and represents a form of green utopia. A full city-wide implementation of the measures proposed in this scenario is considered rather unrealistic, since the necessary land use changes and land use reallocations are of considerable scale. Rather, the scenario aims to over-emphasise the benefits of GBI in the context of a "green reality" and by doing so to inspire local actors in their thinking and decision-making regarding the further planning of GBI in Hue (Figure 8).

Figure 8. Inspiration for the GBI of a biophilic city: Gardens by the bay, Singapore (Sergio Sala, via Unsplash).

The entry points described above, i.e. (A) "land use data" and (B) "narratives", were merged methodologically and content-wise in the steps shown in Figure 6 and as described in the following. In a first step, elements of the case study typology were selected for each narrative and specified as specific individual interventions or bundles of measures. This could include, for example, "tree planting in streets" (single measure) or "tree planting combined with extensive greening and creation

of retention basins" (bundle of measures). Other types of GBI such as bioretention facilities (rain gardens) were also included as potential measures to improve the quality and capacity of land uses. Following the grading of the narratives, the interventions (also grouped as bundles, if applicable) were qualitatively ranked according to their depth and degree of intervention. This was realised by assigning an ordinal attribute, whereby values of +, ++, and +++ indicate increasingly comprehensive interventions (cf. Figure 9). Furthermore, the integration of both entry points took place by attributing those specified interventions to individual land uses. As can be seen in Figure 9, the assignment of measures to land uses and the targeted realisation of these measures were conceived as so-called "improved land uses".

	Scenario A **Business-as-usual**	Scenario B **Small-scale improvements**	Scenario C **Larger-scale improvements**	Scenario D **Biophilic city**
Improved residential land	n/a	Trees (+)	Trees (++) Intensive greening Rain gardens	Trees (+++) Intensive greening Rain gardens
Improved other developed land	n/a	Trees (+)	Trees (++) Extensive greening Retention basins	Trees (+++) Extensive greening Retention basins
Improved transportation	n/a	Trees (+)	Trees (++) Green verges	Trees (+++) Green verges Bioswales
Improved public green spaces	n/a	n/a	Playgrounds (+)	Trees (+++) Linear woody elements (+) Playgrounds (++)

Figure 9. Initially proposed interventions within existing land uses to improve their quality and capacity (note: +, ++ or +++ refer to an increasingly comprehensive level of intervention, e.g. planting more trees or focusing on a higher quality of improvement).

The previously described interventions - conceptualised as "improved land use" -include, in particular, interventions in existing urban spaces and infrastructures. The exception to this is Narrative or Scenario A. For this scenario, following its character as a baseline scenario, no further interventions were proposed. In contrast to interventions in existing urban structures, interventions were also conceived to be implemented in the context of planned urban expansions or in the context of urban redevelopment (cf. Figure 10). These interventions - internally referred to as "new land uses" in comparison to the previously mentioned "improved land uses" - comprise far-reaching interventions. We therefore anticipate the corresponding possibilities of implementation (e.g., with regard to freedom of design, land availability, etc.). The "new land uses" should be characterised by a special quality of design and a high amount or volume of green. They therefore correspond to a comparatively high level of intervention, and were therefore mainly assigned to Narratives or Scenarios C and D.

Woody public green space	Public green space with a very high density of trees (+++), linear woody elements (++) and playgrounds (++).
Eco-residential land	Residential land with construction codes to allow for the implementation of green roofs and green facades. Increased use of permeable materials for transportation land. Sealing should be minimised in these areas.
Eco-other developed land	Other developed land with construction codes to allow for the implementation of green roofs and green facades. Increased use of permeable materials for transportation land. Sealing should be minimised in these areas.
Afforestation	Afforestation of agricultural land.

Figure 10. Initial proposal for "novel" land uses within undeveloped areas that are converted into built-up areas.

In order to represent the heterogeneity of the study area and the associated different preconditions for the implementation of GBI and NBS in Hue as comprehensively as possible, the scenarios were in addition to the layer of land use also differentiated spatially. To achieve this, different spatial units were defined ("Citadel", "Inner City", and "Outer City"), and, in addition to the existing land uses (Figure 11), the interventions and bundles of measures - encapsulated as "improved" or "new" land uses - were in a further step assigned to the spatial units. These specified rule-based assignments form the basis for the actual modelling of the scenarios as well as the impact assessment in WP3.

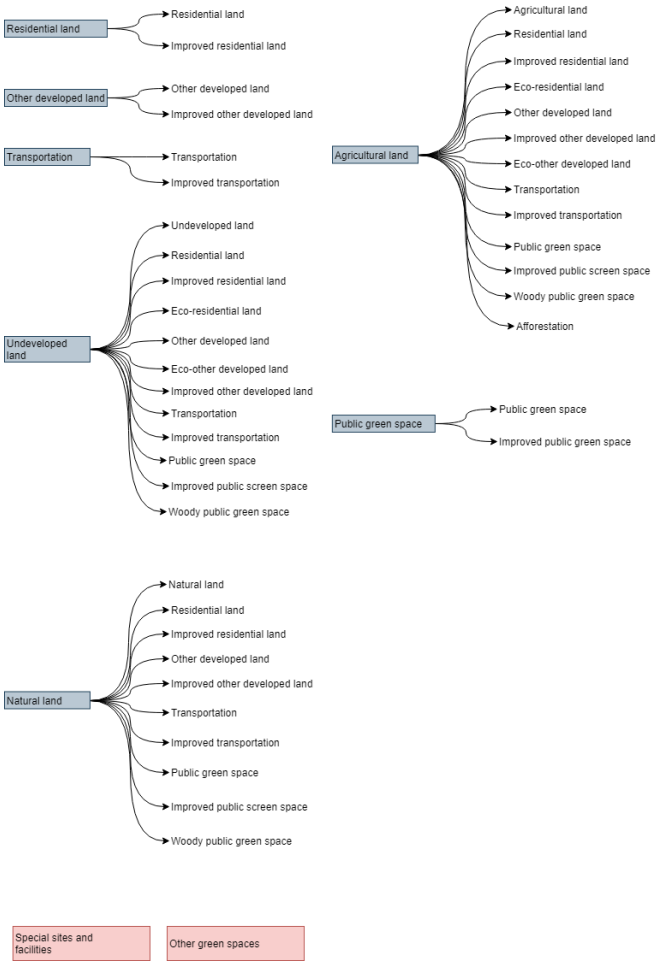


Figure 11. Rule-based assignment of interventions to land use types. The interventions, which include both, individual interventions and bundles of measures, are encapsulated here as land use types, i.e. "improved" land uses or new land use types such as "Eco-residential land".

As a result of the COVID 19 pandemic as well as issues related to the (partially belated or incomplete) delivery of data, (partially poor) data quality, and (partial) lack of metadata, the process in WP 2 was deviated from the original work and time schedule, so that methodological adjustments were necessary in the development and modelling of scenarios for land use change. In particular, this was due to the fact that the stakeholder workshop planned for March 2020 in Hue, which was originally supposed to discuss basic assumptions for scenario development and involve local stakeholders, could not take place. After the cancellation and postponement of the stakeholder workshop because of the COVID 19 pandemic, the work in WP2 was restructured in such a way that the HUB independently developed the methodology and the tentative narratives described above. In order to nevertheless ensure the involvement of local stakeholders in this process, the stakeholder workshop was further developed into a hybrid format (webinar, workshop, online feedback). The webinar, which was largely planned by the HUB, was held on 9 September 2020. The German and Vietnamese project partners participated. In this webinar, the methodology, including narratives,

scenarios, specified interventions and basic assumptions, e.g., in relation to the spatial units mentioned, was presented in detail to the Vietnamese partners by the HUB. Furthermore, relevant questions for further development, evaluation and improvement of these aspects were discussed during the webinar, and materials (e.g., maps, illustrations, summaries) as well as a discussion guide were provided by the HUB. Based on the information exchanged in the webinar, a local workshop was then organised in Hue under the responsibility of MISR, with UfU assisting in its design. The workshop was held on 31 October 2020 with the support of HueIDS and HUSC. During the workshop, the methodology, narratives, etc. were described to the participating actors by the Vietnamese project partners and discussed in detail with the help of the materials/guidelines provided. 20 people from the fields of politics, administration, science, and civil society took part. The knowledge and feedback gathered in the workshop was then reflected back to the German partners by the Vietnamese project partners in another online meeting (17 November 2020).

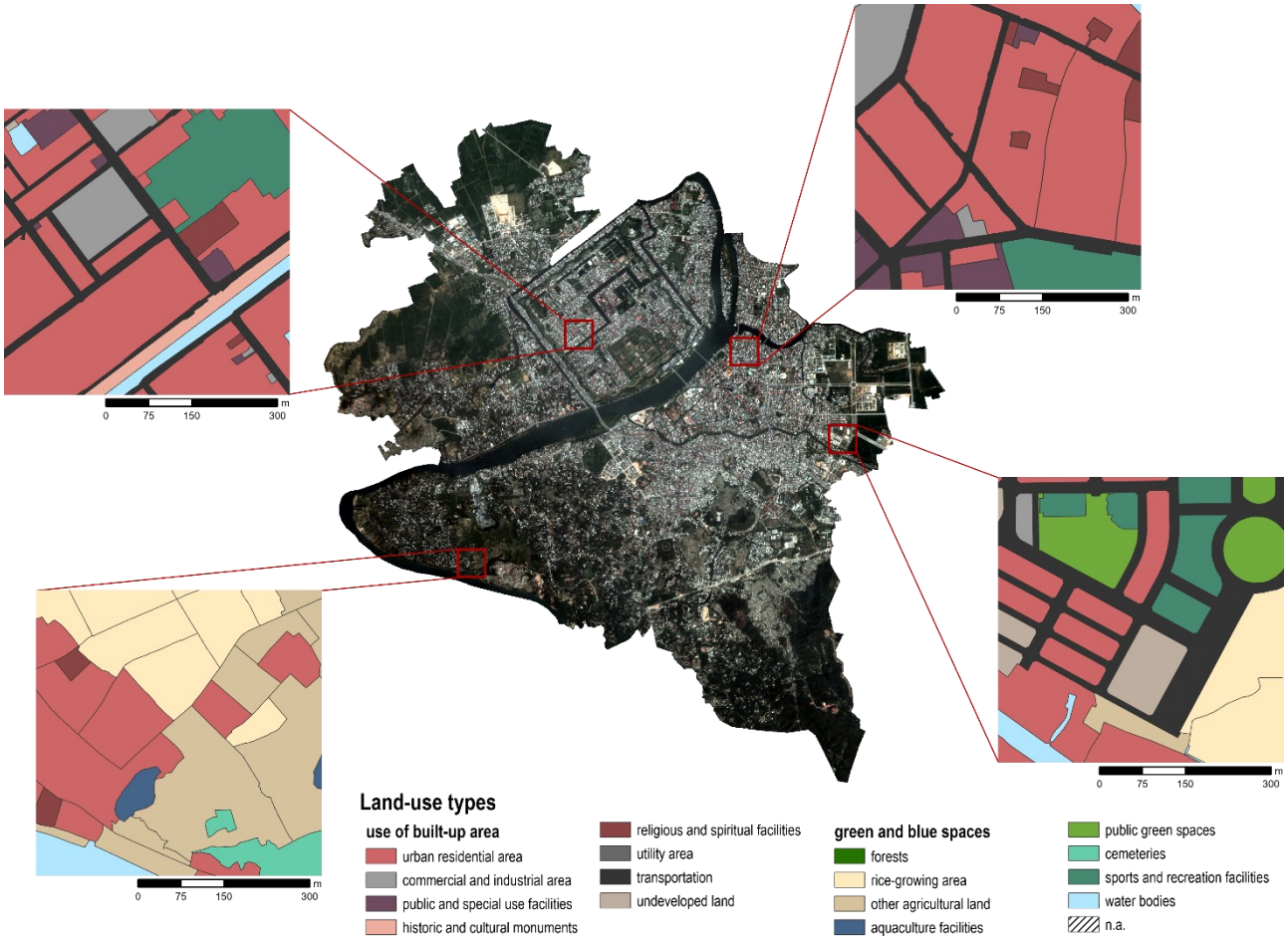


Figure 12. Illustration of the locations selected together with stakeholders. These locations form the basis for the detailed modelling of NBS interventions and implementation of practical examples as planned for the research and development project.

The stakeholders' feedback included certain revisions regarding the initially developed narratives/scenarios, the interventions, as well as the assumptions, e.g., regarding the spatial units. Specifically, this feedback included: (i) a stronger focus on 2030 urban planning, in contrast to the use of 2014 land use data (it should be noted that 2030 data was not yet available during the development of the methodology); (ii) a stronger focus of the interventions on more traditional elements of the GBI; and (iii) a stronger consideration of tourism in the process, in line with the ambitions of Hue City for a more focused ecotourism development. In accordance with the feedback from the stakeholders, first revision steps have already been initiated in the definition phase. With regard to the use of updated land use data, the (planning) database for the year 2030 is now

available and the processing and preparation of this data has begun - analogous to the methodology described above. In this context, four locations were determined in cooperation with the local actors within the framework of the co-design process, for which larger-scale observations, practical examples and modelling in comparison to the city as a whole are to be realised in the coming R&D phase (Figure 12). The concept of spatial units was also revised. It is now no longer differentiated according to urban location ("inner city", "outer city"), but is more strongly oriented towards real planning units or spaces. The revised spaces include (cf. Figure 13): (i) the Citadel; (ii) areas to be conserved; (iii) infill development areas; (iv) areas to be renovated; (v) redevelopment areas; (vi) new development areas; (vii) areas restricted from development; and (viii) reserve areas for development.

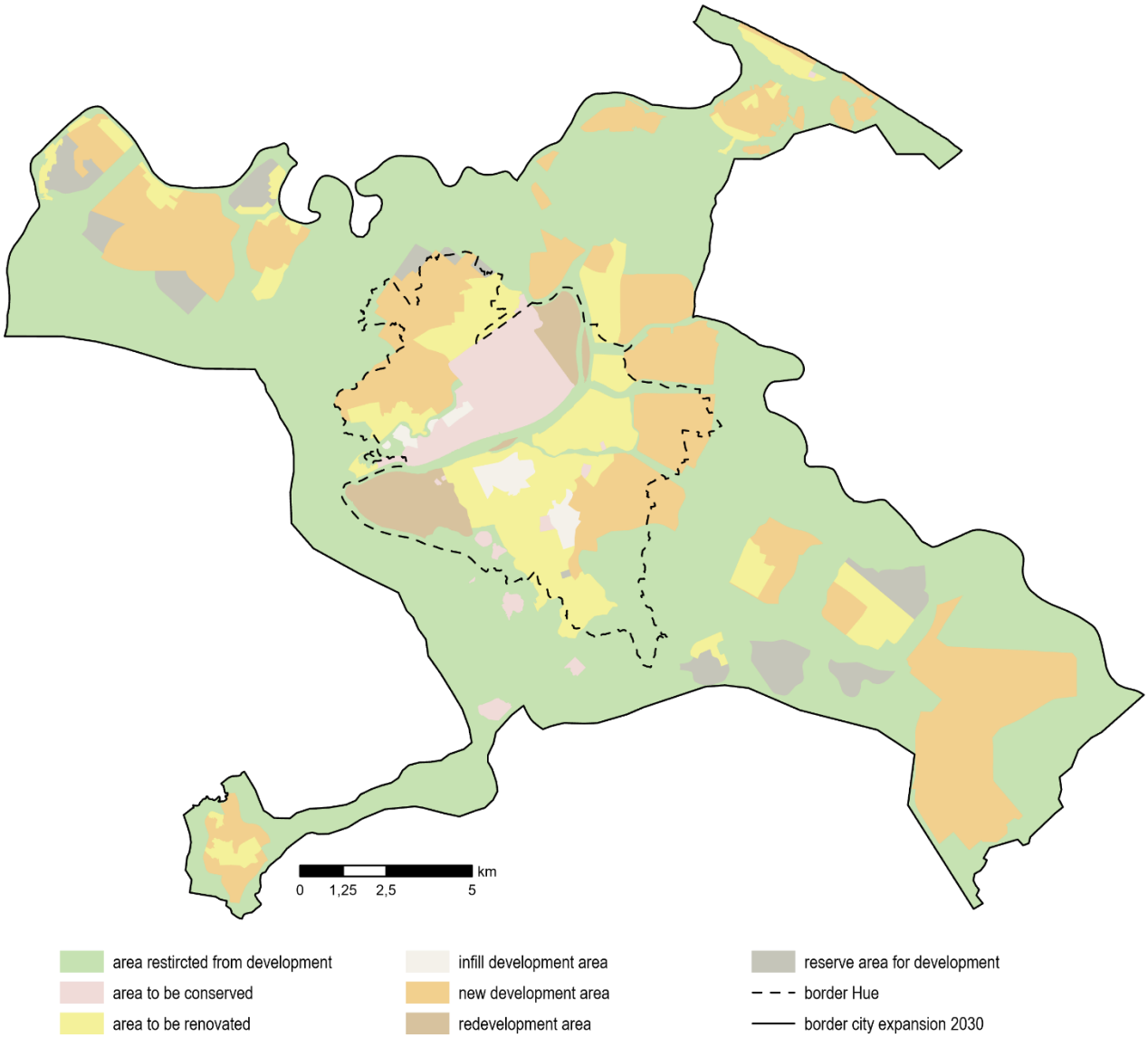


Figure 13. Refinement of spatial zones for interventions aligned with the 2030 urban planning of Hue city.

Regarding the selection of GBI elements and the conception of interventions, local stakeholders wanted a stronger orientation towards more traditional and locally popular GBI elements. Furthermore, stakeholders highlighted potential problems regarding the on-site implementation of individual types of greenery (e.g., green facades, blue roofs, cool roofs). This feedback was used to further differentiate the case study typology in terms of "popularity" and "feasibility" of GBI elements. As a result, a ranking of GBI elements was developed, with the categories: (i) Most-popular green elements; (ii) More-popular green elements; (iii) Other popular green elements; (4) Difficult to

implement but still favourable green elements; and (5) Undesirable or not implementable green elements (Figure 14). However, a classification was not possible in every case. For example, bioretention facilities or retention basins could not be assigned to any of the categories, because a characterisation of these with regard to popularity and feasibility cannot be estimated at this stage.

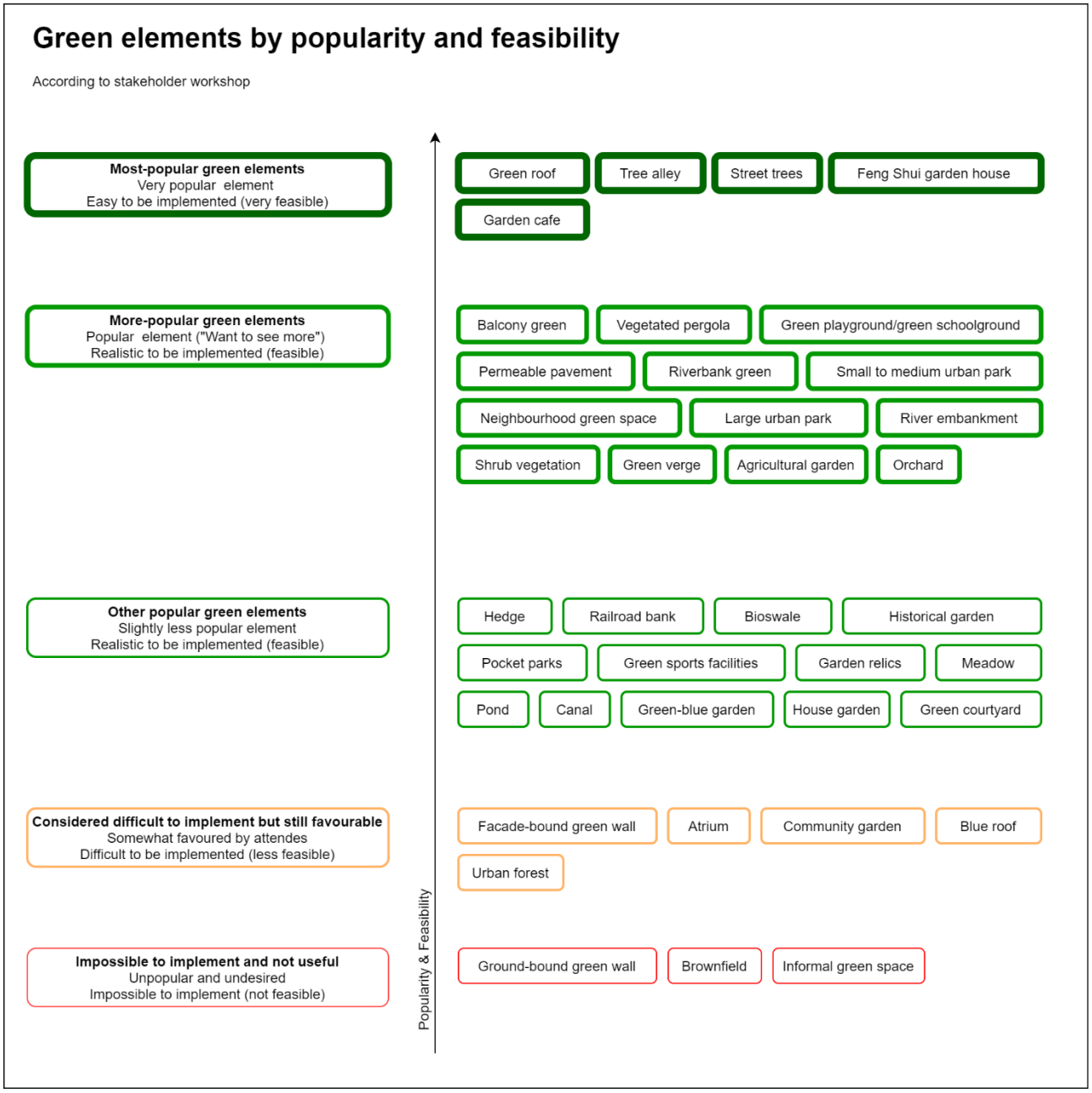


Figure 14. Categorisation of GBI elements by popularity/acceptance and feasibility according to the feedback and assessment of the participants of the stakeholder workshop.

The revision was accompanied by a re-conception of the narratives and scenarios (Figure 15). These continue to be graded according to the degree and depth of intervention. However, the depth of intervention is no longer based solely on the previous ordinal scale in the sense of a qualitative expression for an intended quantity, but also on the attempts to account for aspects of a "spatial footprint" of measures. This spatial dimension is intended to conceptualise the differentiated opportunities of urban development for the implementation of measures ("opportunities for intervention") within the spatial and planning units, e.g., within conservation areas compared to urban redevelopment areas. In the R&D phase, this concept will be fully developed. The narratives are now also more geared to the acceptance and feasibility of measures, so that narratives A to D are not

only graded in terms of the revised depth of intervention or the scope of proposed measures, but also in terms of the application of more traditional measures (narratives/scenarios A, B) and an increasing integration of currently not commonly used GBI elements (narratives/scenarios C, D). This assignment is also to be finalised in the R&D phase and will be harmonised with the Vietnamese partners and stakeholders.

Scenario A **Business-as-usual**	Scenario B **Smaller-scale improvements through traditional green elements**
In comparison to the 2030 planning, **no additional measures** will be taken. The business-as-usual scenario is characterised by the **2030 green space planning**. Planned green spaces include those in the citadel, where military land-uses are converted to urban green spaces. No particular interventions or actions are foreseen in other existing or planned land-uses.	This scenario **improves on the business-as-usual scenario through the implementation of additional actions/interventions**. Actions will be taken in both existing and planned land-uses (across all relevant types of areas). Mostly, **smaller-scale (selective and small-footprint) GBI elements/actions** will be considered that are **deemed traditional/popular**, and that are therefore also **(very) feasible for implementation**. These GBI elements/actions include the **planting of (street) trees, shrubs and hedges**, the creation of **tree alleys**, the construction of **green playgrounds** and the greening/improvement of existing playgrounds, or the construction of **small parks/pocket parks**. Selective actions in existing land-uses include the **greening of balconies** and the construction of **vegetated pergolas**.
Scenario C **Moderate to large-scale improvements**	Scenario D **Eco-city**
This scenario **improves on the small-scale interventions in scenario B through considering GBI elements/actions with larger spatial footprints (moderate- and large-footprint actions)**, as well as **less traditional/not yet popular GBI elements**. In existing land-uses, selective actions similar to B are anticipated; however, in addition to scenario B, also green courtyards, ponds, and house gardens will be considered, and **community gardens** will be proposed as well. Green spaces shall be improved, e.g., through the **planting of trees, shrubs, or hedges**, e.g., to construct **woody playgrounds**. **Existing infrastructures** may be **improved further through permeable pavements, bioswales and green verges**, especially in renovation and redevelopment areas. **Newly constructed areas**, represented by planned land-uses within in-fill areas, redevelopment areas and new development areas, provide the **opportunity to implement GBI elements/actions with moderate and/or large spatial footprints**, including, e.g., **neighbourhood green spaces, riverbank green, medium-sized and/or large urban parks, orchards, green sports facilities, historical gardens, and meadows**. It is anticipated that the 2030 urban planning may be revised if needed to spatially accommodate such larger-footprint actions. In so doing, the implementation of such actions/GBI elements, the **green space per capita in planned land-uses shall be increased in comparison to the business-as-usual**, or the smaller-scale improvements proposed in scenario B.	The eco-city narrative **builds upon narrative C**, and assumes that the **green space per capita ratio shall be increased further**. In addition to narrative C, it is proposed that **urban forests and/or orchards** may be planted, **or large urban parks and (historical) gardens** be constructed **within land reserved for future development**. Moreover, **additional property-related selective actions** are proposed, including **green roofs, façade-bound green walls**, and/or **blue roofs**. These actions should be implemented may be implemented where feasible within existing land-uses, and particularly in planned land-uses, their implementation may be increasingly accommodated through the adaptation of building codes.

Figure 15. Revision of the tentative narratives and scenarios in accordance with the feedback from the stakeholder workshop.

- The conducted stakeholder workshop with its rather interactive approach was new for some participants. It also enabled the moderators of the Vietnamese project partners to expand their methodological knowledge in the field of moderation. This may open up new possibilities, e.g., for more interaction and new impulses regarding discussions.
- The hybrid format of the stakeholder workshop has proven to be effective and practicable in order to implement the planned co-design and co-learning process as comprehensively as possible, despite the existing limitations. This is particularly relevant against the background of the follow-up workshop planned for the R&D phase and the most likely continuing restrictions due to the COVID 19 pandemic.
- Based on the stakeholders' feedback on the initially developed narratives/scenarios, interventions and assumptions, the revision process was initiated in the definition phase and is ongoing in the R&D phase. The revision of the narratives/scenarios will consider (i) a stronger focus on the 2030 urban planning; (ii) a stronger focus on more traditional elements of GBI within the interventions; and (iii) a stronger consideration of tourism in line with Hue City's ambitions for a more focused ecotourism development.
- There are partially diverging perceptions between the German and Vietnamese project partners and actors regarding the acceptance and feasibility of GBI elements. A comprehensively implemented co-design process reveals such, possibly interculturally induced differences regarding the acceptance of and preference for certain GBI element(s). These can be considered in further modelling.

2.3 WP 3 Modelling land use change scenarios based on the narratives

WP3 dealt with the implementation of the narratives formulated in WP2 and the resulting rule-based assignment of interventions to land uses. The main focus of WP3 was therefore on the one hand the GIS-based implementation of the interventions from WP2 and on the other hand the assessment of the effect of the proposed measures on selected ecosystem services. WP3 is primarily to be understood as a feasibility test. This means that the developed methodology was implemented on a trial basis. In this framework, the rules formulated in WP2 were evaluated with regard to their feasibility and deficits were identified. Based on this, improvements in terms of content and methodology will be enabled in the R&D phase.

In WP3, the GIS-based implementation of the narratives A to D was carried out. As a feasibility test, the rules formulated in WP2 were implemented for four selected urban areas ("sites") (cf. Figure 16). Area percentages with or without GBI interventions can be identified by the land use indicated in the figure. Conversion rates regarding the conversion of undeveloped land into developed land are based on the status quo (shares of certain land uses in the total area), which was determined for three selected urban structures (cf. Figure 17). In addition, the conversion rate, i.e., the area percentage in relation to specific land uses that is consulted or intended for the implementation of measures, is oriented towards the respective scenario. As a result, this percentage also increases going from the baseline scenario (Scenario A) to the "biophilic city" (Scenario D). Thus, for the feasibility study, it was assumed that in Scenario B interventions are implemented on an area percentage of approximately 10% per land use; for Scenario C this value is 25%, and for Scenario D 50%.

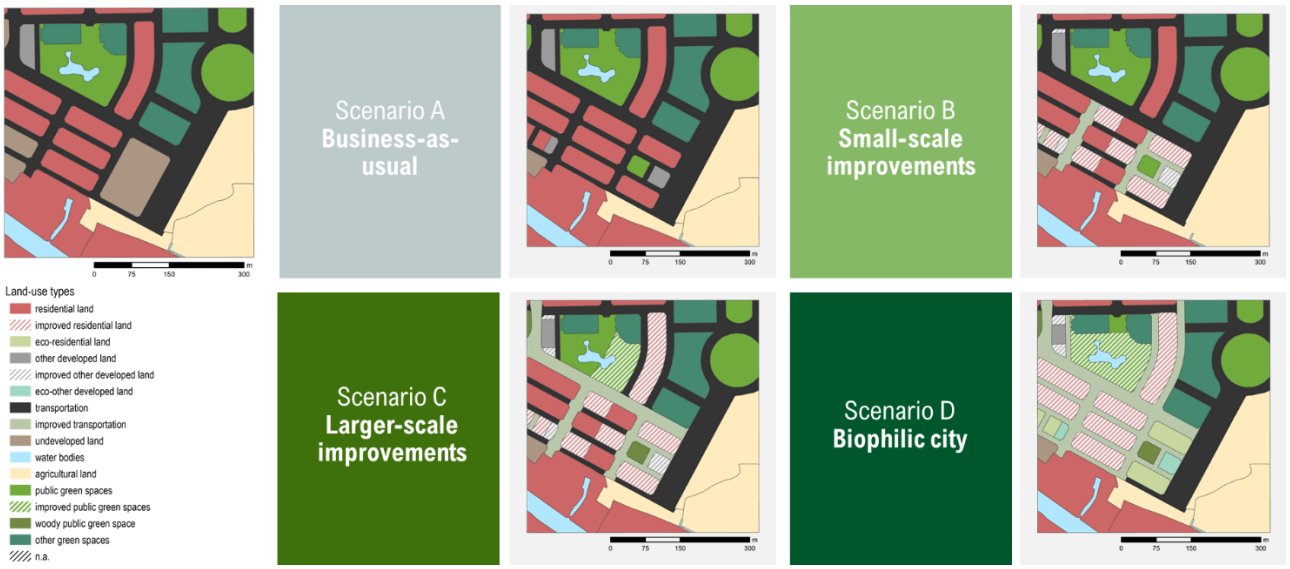


Figure 16. GIS-based implementation of Narratives A-D, taking the example of a site in the An Dong district (ward).

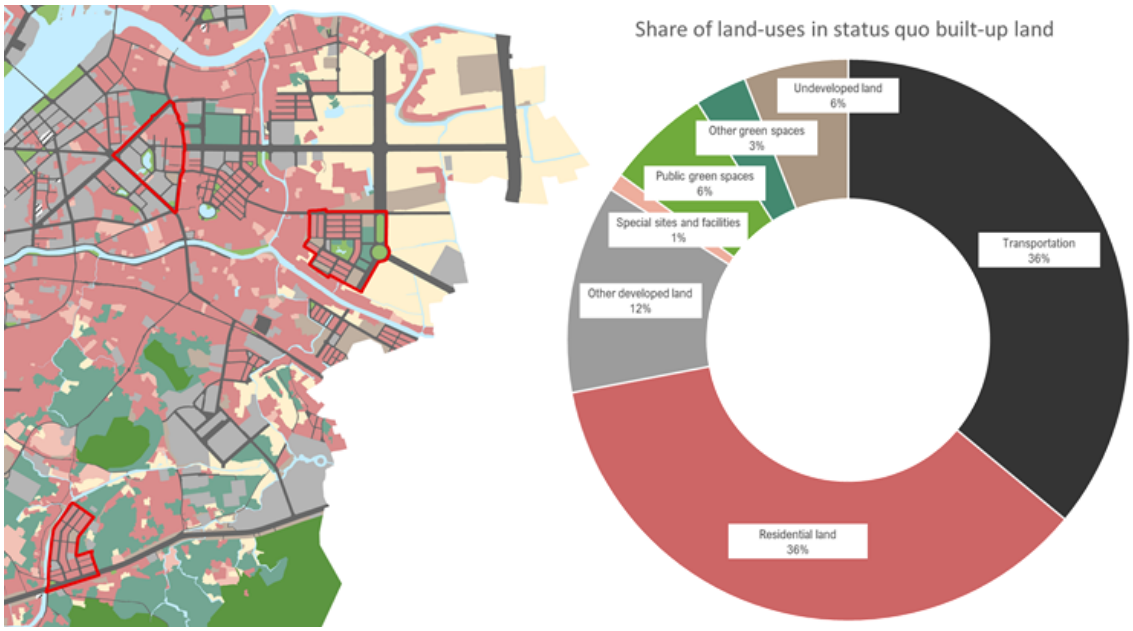


Figure 17. Area percentage of land uses collected for the status quo serve as a basis for estimating conversion rates of undeveloped to developed land.

In order to determine the effect of the GIS-modelled interventions on selected ecosystem services, WP3 continued to develop an impact matrix to assess the expected impacts of GBI interventions on a selected set of ecosystem services. The impact matrix is based on the case study typology developed in WP1. The selected ecosystem services include evapotranspiration (ET), shade (S), infiltration (WI), water retention (WR), air purification (AP), biodiversity conservation (B), and amenity value. For each GBI element of the typology, and for each ecosystem service, an assessment of the respective impact was carried out. This assessment is qualitative in nature and follows a ranking from "no impact" (no potential for improvement) to high potential for improvement, i.e., significant impact (see Figure 18). The assessment is based on expert knowledge and the typology developed in UNaLab by Eisenberg et al. (2019). Figure 19 shows the impact estimate for each individual intervention selected in WP2.

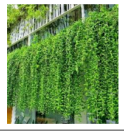
Term	Description (Europe)	Source	Example (Europe)	Description (Vietnam)	Source	Example (Vietnam)	ET	S	WI	WR	AR	B	AVF
Green Infrastructure on building structures													
Balcony green[1]	Plants in balcony and terraces, planted mostly in pots.	Cvejić et al. 2015: 18.		Plants in pots or movable boxes. Some buildings have unmovable tanks/containers on their balconies for the plants.	Architects from HUSC and local architecture offices, 2019		O	–	–	–	O	+	+
Ground based green wall[2]	Ground based climbing plants intended for ornamental (and sometimes food production) purpose.	Cvejić et al. 2015: 18.		In Vietnam in general, and in the city of Hue in particular, this form is not preferred in building design due to water absorption and penetration into the house during the (long and heavy) rainy seasons. Instead, they prefer plants separated from wall surfaces when decorating buildings with (vertical) greenery.	Architects from HUSC and local architecture offices, 2019		+	++	–	–	+	+	+
Façade-bound green wall[3]	Plants growing in façade bound substrate, e.g. containers or textile-systems.	Cvejić et al. 2015: 18.		Plants that grow not only on facades but also on interior ornamental walls to bring nature into the interior.	Architects from HUSC and local architecture offices, 2019		++	++	–	–	+	+	+

Figure 18. Qualitative impact assessment (- no function; O ... potential for function/unsure impact (depends on realisation); + ... good/positive impact; and ++ ... very good/very positive impact) for GBI elements on selected ecosystem services evapotranspiration (ET), shade (S), infiltration (WI), water retention (WR), air purification (AP), biodiversity conservation (B), and amenity value.

Implemented measures: Estimation of impacts

	Evapotranspiration	Shading	Water infiltration	Water retention	Air purification	Biodiversity	Amenity value function
Trees	++	++	0	0	+	+	++
Intensive green roof	++	+	-	++	0	+	++
Intensive greening (courtyard green)	+	+	+	+	0	+	+
Extensive greening (similar to meadow)	++	+	++	+	+	++	+
Extensive green roof	+	+	-	+	-	+	+
Rain garden	+	+	+	+	0	++	++
Facade-bound green wall	++	++	-	-	+	+	+
Retention basins	+	–	+	++	–	+	+
Permeable surfaces (pavement)	-	-	+	-	-	+	+
Green verges	+	–	+	+	+	+	+
Playgrounds	+	+	+	+	0	+	++
Bioswales	+	–	++	+	–	+	+
Linear woody elements: Hedges	+	0	+	0	+	+	+

Estimated impacts

- \- No impact
- o Unsure impact (depends on quality)
- \+ Positive impact
- ++ Very positive impact

Figure 19. Qualitative impact assessment (- no function; O ... potential for function/unsure impact (depends on realisation); + ... good/positive impact; and ++ ... very good/very positive impact) for all interventions selected in WP2 as impacts of GBI elements on selected ecosystem services evapotranspiration (ET), shade (S), infiltration (WI), water retention (WR), air purification (AP), biodiversity conservation (B), and amenity value.

In a further step, the qualitative impact assessment made for the individual GBI elements was numerically coded, and the numerically coded impacts were then scaled and normalised so that the degree of intervention depth or the extent of proposed interventions is represented as a pseudo-numerical score. This means that, for example, simple tree plantations (Trees, +) receive a score of 1 for the ecosystem service evapotranspiration, but very comprehensive tree plantations (Trees, +++) are assessed with a score of 3. The minimum and maximum scores are determined by the intended levels of intervention for the GBI element in question. An unpredictable effect on an ecosystem service is represented as a score of 0. In a next step, in accordance with the case study typology, the impact scores of individual measures were transferred to the proposed bundles of measures in WP2, sensu lato the conceptualised land uses. This was done by summing the impact scores of the interventions combined in a bundle of measures in order to make cumulative effects of individual measures on the selected ecosystem services numerically tangible. This is done specifically for each narrative or scenario A-D, as the type, number and degree of intervention of the measures, as described in WP2, differentiate (cf. Figure 20).

Improved residential land	Evapotranspiration	Shading	Water infiltration	Water retention	Air purification	Biodiversity	Amenity value function
Scenario A							
n/a	n/a	0,00	0,00	0,00	0,00	0,00	0,00
Scenario A score	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Scenario B							
Trees (+)	1,00	1,00	0,00	0,00	1,00	0,75	1,00
Scenario B score	1,00	1,00	0,00	0,00	1,00	0,75	1,00
Scenario C							
Trees (++)	2,00	2,00	0,00	0,00	2,00	1,50	2,00
Intensive greening (courtyard green	0,50	0,50	0,75	1,50	0,00	0,75	0,50
Rain garden	0,50	0,50	0,75	1,50	0,00	1,50	1,00
Scenario C score	3,00	3,00	1,50	3,00	2,00	3,75	3,50
Scenario D							
Trees (+++)	3,00	3,00	0,00	0,00	3,00	2,25	3,00
Intensive greening (courtyard green	0,50	0,50	0,75	1,50	0,00	0,75	0,50
Rain garden	0,50	0,50	0,75	1,50	0,00	1,50	1,00
Scenario D score	4,00	4,00	1,50	3,00	3,00	4,50	4,50

Figure 20. Development of scenario-specific impact scores for interventions or bundles of individual interventions using the example of residential areas (improved residential land). It is apparent how the type and number of proposed interventions increases from scenario A to D. Furthermore, also the depth of intervention is ranked, e.g. in terms of tree planting, with Trees (+) in Scenario B to Trees (+++) in Scenario D. The impact score increases accordingly. In scenario A, n/a indicates that no interventions are planned (baseline scenario).

In a final step, the GIS scenarios and the estimated impact on the selected ecosystem services were integrated. For this purpose, an area-weighted attribute was applied, i.e., the impact score and the relevant absolute area (in m²) were multiplied. This results in a factor which reflects the overall impact of a measure, assuming that the higher the impact of the GBI element (cf. Figure 18) and the more comprehensive the measure, the greater the effect of an intervention, e.g. on evapotranspiration or biodiversity: (i) number of interventions envisaged or clustered within a given land use type; (ii) degree of intervention of these measures; and (iii) size of the area on which the proposed measures are implemented. Assuming the above conditions, the so formed factor also allows for a comparison of the different narratives/scenarios (Figure 21).

Figure 21. Comparison of the effect of the interventions proposed in Narratives A-D and modelled as Scenario A-D on the selected ecosystem services using one of the selected urban areas as an example.

The feasibility test demonstrated that the tentative methodology is suitable for implementing the formulated narratives as GIS-supported scenarios. Also, the impact assessment of the effect on selected ecosystem services can be performed with this data. With regard to these methodological steps, the involvement of local actors, respectively their feedback on the content and methodology, is highly relevant. This concerns, for example, the evaluation and adjustment of the assumed conversion rates. Within the framework of the hybrid format (instead of the stakeholder workshop, cf. WP2), which became necessary due to the COVID 19 pandemic, it was not possible for the Vietnamese partners to obtain full methodological feedback from the local stakeholders regarding the GIS modelling/AP3. This was mainly due to time limitations in the context of the local workshop. In the R&D phase, further feedback on the content and methodology of WP3 should therefore be obtained and the methodology should be adjusted accordingly.

Another methodological deficit is the pseudo-quantitative approach to the impact assessment. In this case, it would be desirable to include actually measurable, i.e., quantitative indicators to characterise the performance of the proposed interventions with regard to the selected ecosystem services. To make this possible, the R&D phase should examine for which ecosystem services spatially adapted and thus transferable data on the performance of GBIs are available. In this regard, a screening and analysis of literature was already carried out in the definition phase. For example, with regard to the ecosystem service air purification, effects could be identified both at the level of plant species or genera, as well as at the level of different land uses in a regional context, including for Hanoi

(Vietnam) as well as Wuyishan and Luohe (both China) (Bertold et al., 2019; Zhu et al., 2019; Song et al., 2020). With regard to the ecosystem service cooling/regulation of air temperature, initial findings were also obtained at the level of tree genus and species – based on transpiration (Singapore, cf. Tan et al., 2020) or shade cast (Malaysia, cf. Tukiran et al., 2016). Also, with regard to the ecosystem service of biodiversity conservation, a study for Bangkok, Thailand, among others, could be evaluated (Chaiyarat et al., 2018). The findings from this review will be used to improve the impact assessment. For this purpose, a quantitative basis for determining performance is to be established, where possible, as part of the supply and demand modelling in the R&D phase. The detailed, quantitative assessment at the scale of the entire city, or conceptually on the basis of land use, is difficult because the actual design of measures is often decisive for the ecosystem service provided. This depends, for example, on the chosen species or genus for planting, which can potentially not be fully illustrated on a city-wide scale. Therefore, in the further process of the R&D phase, it should be examined and discussed with the Vietnamese stakeholders to what extent range estimates can make a contribution here.

The findings of the literature review (e.g., regarding the effects of specific genera/species) continue to be of great importance for the modelling of site-level interventions in the context of the R&D phase. As a preparatory step, an on-site visit by the Vietnamese partners has already been started in the context of WP3. The aim is to collect the data and characteristics necessary for the modelling at the individual sites that were selected as part of the co-design process.

- The impact of GBI interventions on selected ecosystem services was described pseudo-quantitatively in WP3. The basis is a qualitative assessment grounded in expert knowledge and existing typology.
- The more specific quantitative modelling of the performance of GBI interventions presupposes the examination of the transferability of existing models. A literature review provided initial evidence in a regional context. The integration of the findings is the goal for the R&D phase.
- With the help of the Vietnamese partners, an on-site visit was carried out for selected locations that are to be examined more closely in the R&D phase. The sites were selected jointly as part of the co-design process.
- Basic assumptions for the GIS-based implementation of the narratives developed in WP2 are to be evaluated in the R&D phase.

2.4 WP 4 Creation of a public information and learning space (Green City Lab Hue)

In order to promote the project and to make the generated knowledge accessible to the broader public, including experts, scientists, citizens and decision makers in Hue and other Vietnamese cities, relevant project results should be publicly communicated. This could also motivate the public to actively engage in the development and planning of GBIs. For this purpose, the Green City Lab will be established as a virtual, i.e., a website, as well as physical space, i.e., an information and event space located in the city of Hue. In the long-term, the Green City Lab will become a publicly accessible space providing information, exchange and learning on the topics of NBS and GBI in the city of Hue. It will host exhibitions, provide information material, and serve as a place for panels and workshops. During its definition phase the most important preparations for the setup of such a permanent space should be made and a provisional Green City Lab should be established in Hue. Also, the concept and content of the Green City Lab website will be developed during this phase. The website should contain information regarding GBI and NBS and it should serve as the main instrument of external project communication in Germany and Vietnam.

Due to the corona pandemic the setup of a provisional physical Green City Lab will not be possible during the definition phase. Thus, the establishment of the Green City Lab in the research and

development phase will not be preceded by a provisional Lab. Therefore, first conceptual discussions with the Vietnamese project partners were held during the definition phase and agreements regarding the postponement were made. However, the virtual part of the Green City Lab, the website, was successfully completed in the definition phase. The website is available at www.greencitylabhue.com in English and Vietnamese. The website's concept and content were developed by UfU which had been supported by the MISR in developing the Vietnamese part. A subcontractor designed and programmed the website. As of now the website contains the sections "home", "news", "nature-based solutions", "project" and "about us". The section "home" gives a short overview of the project and a preview of news and other sections. The "news" section provides up to date information about the project on a regular basis. A compilation of background information on NBS and GBI is available at the section "nature-based solutions". Additionally, after the completion of the definition phase this section will include a clear and easily understandable overview of relevant project results ("virtual exhibition of project results"). The section "project" contains a detailed project description and the section "about us" gives information on the project partners of the definition phase. It is planned to continuously develop the website during the main research project (R&D phase) so that in the medium term it can become a comprehensive virtual information and learning space on NBS and GBI in Hue and other Vietnamese cities.

- The project website of the Green City Lab is available at www.greencitylabhue.com in English and Vietnamese. It provides background information on the project as well as GBI and NBS. Also, news articles on project activities are published on a regular basis.
- After the completion of the definition phase relevant project results will be published at the website in a clear and easily understandable compilation.
- The website will be continuously improved during the main research project (R&D phase) in order to turn into a comprehensive virtual information and learning space on NBS and GBI in Hue and other Vietnamese cities in the medium term.
- Due to the corona pandemic the setup of a provisional physical Green City Lab was not possible during the definition phase. The full establishment of the Green City Lab is now scheduled for the research and development phase.

2.5 WP 5 Preparation of the project application for the main research project (R&D phase)

A central concern of the definition phase was to create the basis for a subsequent research and development project, including the identification of central research questions and the development of a detailed concept and project proposal. This was primarily based on the results and lessons learned from WP1 to 4 as well as on the feedback from the Vietnamese partners. Following the interviews conducted in October 2019 and their evaluation, initial research on the current situation and the prerequisites for the future development of GBI in Hue, as well as existing challenges in Hue regarding climate change, urban development, urban planning and the implementation of NBS, the status quo analysis of GBI and the feedback from the local project partners and stakeholders, the project design for the research and development phase (R&D phase) was jointly developed and adapted by the collaborative partners HUB and UfU. This included in particular the specification of the projects' focus on adaptation to the urban heat, and improvement of air quality, the integration of practical examples and the ascertainment of further Vietnamese partners and their involvement (cf. Figure 23). The reason for the focus of the R&D phase on adaptation to the urban heat and improvement of air quality was, on the one hand, that the status quo report identified flooding, heat stress and air pollution as major challenges in Hue and, on the other hand, that the FloodAdaptVN project, which is supported by the same BMBF funding, concentrates its research on the topic of flooding in the study area. By focusing on different research priorities, the two BMBF-funded projects

complement each other, and synergies can be used to provide the greatest possible benefit to the city of Hue. In coordination with the Vietnamese project partners, the following research hypothesis was established for the R&D phase: Strengthening climate resilience in the city of Hue by promoting co-creation and co-learning processes to implement nature-based solutions for improving air quality and adapting to urban heat. This hypothesis is the common thread of the research and development project, to which the work in the individual WP is oriented. Accordingly, also the objectives for the R&D phase were defined and the structure of the WP was conceptualised, which is briefly presented in the following.

The project has the overall objective to contribute to the increase and strengthening of social and ecological resilience in Hue and its surrounding province by promoting NBS and GBI approaches, including the promotion of protecting and enhancing existing urban ecosystems and the services they provide, as well as planning and implementing novel green spaces, and GBI. Thereby, the project especially focuses on active participation, and involvement of experiences and visions of local stakeholders, experts, and other knowledge holders such as citizens. To achieve the overall objective of the project, the following sub-objectives were set: ***To model the implementation of land-use changes and NBS (objective 1)*** at city-level, and in more detail at specific sites within the city, to illustrate different pathways of future urban development and desired futures, e.g., based on policy goals and visions. A further objective is the ***impact assessment of the modelled land-use changes and NBS interventions on the supply of selected ecosystem services (objective 2)*** for the identification of benefits and potential co-benefits of proposed NBS interventions. The project also aims at ***capacity building, education, and the promotion of co-learning opportunities and co-creation procedures of NBS interventions (objective 3)*** to engage and activate different interest groups to be aware of and participate in planning processes in their city and neighbourhoods. Furthermore, the project seeks to ***inspire other Vietnamese cities (objective 4)*** to integrate NBS approaches and co-learning and co-creation processes into their agendas. In addition, ***the basis for a subsequent implementation phase (objective 5)*** will be established, including a co-created and co-developed draft – the “Green City Vision Hue” - for an effective implementation of NBS in Hue and implementing a detailed concept and project plan for the implementation phase. Finally, the main objective of the R&D phase is the ***development of a city-wide vision document including proposals for a green and sustainable city in coordination with decision-makers, practitioners and the public (objective 6)***, to strengthen climate resilience and improve (micro)climatic conditions and air quality.

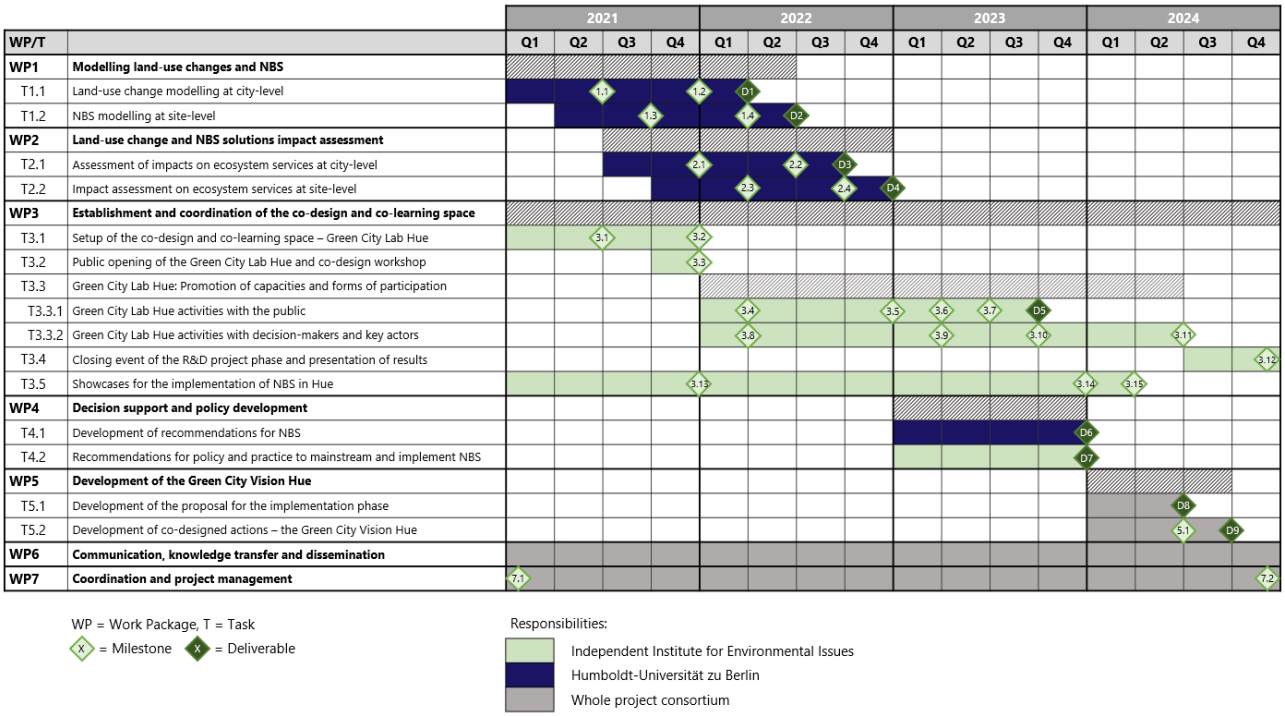


Figure 22. Timetable for project implementation.

To reach the abovementioned goals, the project was divided into seven WP (Figure 22), whereby WP 1 to 5 primarily generate the contents of the project and thus contribute essentially to the development of the "Green City Vision Hue". WP1 will provide the GreenCityLabHué project with a revised set of land-use and land-use change scenarios based on results of the definition phase. **WP1** "**Modelling the implementation of land-use changes and nature-based solutions"** will also extend and revise the proposed NBS interventions and scenarios following inputs of local stakeholders. In the R&D phase, two Tasks will streamline scenario development as described below: T1.1 will focus at the city-level, whereas T1.2 focuses at specific sites within the city, to model NBS interventions in more detail. To do so, a co-design approach is deemed crucial, to allow for a proper consideration of local conditions, e.g., regarding zoning restrictions or building codes. Therefore, WP1 is firmly embedded within the participatory co-design and co-learning process (cf. WP3). **WP2 "Land-use change and nature-based solutions impact assessment"** builds on the scenarios and models implemented in WP1 and uses these findings to assess the actual impacts of the modelled land-use changes and NBS interventions on ecosystem services. WP2 will therefore identify relevant ecosystem services, e.g., temperature regulation, air purification, or recreation, and estimate both baseline (status quo) conditions and the impacts (changes) in the provisioning of these services to account for ecosystem service supply. Here, potential co-benefits for other socio-environmental challenges identified for Hue, e.g., regarding flooding, water quality, or biodiversity, shall be identified. Similar to WP1, this assessment is two-fold, and conducted on the scale of the whole city of Hue (cf. T2.1), as well as on the level of the co-selected sites (cf. T2.2). A subsequent comparison of scenarios will then provide the basis for identifying best practice measures and for developing policy recommendations (cf. WP4). **WP3** "**Establishment and coordination of the participatory co-design and co-learning process – the Green City Lab Hue"** comprises the establishment and coordination of the GCLH. It is designed as an ULL and conceptualised as a publicly accessible venue for information, open exchange, and learning on NBS and GBI in Hue. The ULL approach is based on a systemic transformation methodology to offer local stakeholders research-based expertise and to actively involve them with their local and specialist knowledge in urban planning processes. This ensures that knowledge is exchanged and not only transferred in one direction, and that co-creation and co-production of urban development measures are made

possible (van der Jagt et al. 216). The GCLH will serve as a source of information and point of contact for NBS in Hue. It is geared towards the interested public and stakeholders in the field of NBS and GBI (decision-makers, business, practitioners, scientists, students, etc.). Its programme will include participatory events with citizens and relevant stakeholders, policy round tables with decision-makers, a regularly updated exhibition on potential NBS for Hue and specific project results, and practical showcases of small-scale NBS implementation at selected sites in the city. The activities at the GCLH will be accompanied and supplemented by the project website (cf. WP6). **WP4 "Decision support and policy development"** addresses the decision support and policy development in the form of a guideline on effective implementation and best practices along with policy recommendations to support decision-makers and practitioners in the implementation of NBS. While T4.1 focuses primarily on proposing specific best-practice measures to improve relevant ecosystem services, T4.2 aims to develop recommendations and guidelines for the mainstreaming of NBS into the policy framework of Hue and for the implementation of NBS in practice. The results of WP4, among others, are supposed to form the basis for the subsequent development of the Green City Vision Hue (cf. WP5). Following the experience from WP4 and the feedback from the participatory co-design and co-learning process **WP5 "Development of the Green City Vision Hue"** will develop a co-designed comprehensive strategical document - the "Green City Vision Hue". In addition, in WP5, the project application for the following implementation phase will be formulated accordingly. In this phase, parts of the co-designed Green City Vision Hue are to be put into practice with German and/or local Vietnamese support. The external communication, e.g., by means of the website, the transfer of methods and knowledge with Vietnamese project partners and stakeholders as well as the dissemination of the project results are covered by **WP6 "Communication, knowledge transfer and dissemination"**. Tasks related to project coordination and project management are bundled in **WP7 "Coordination and project management"**.

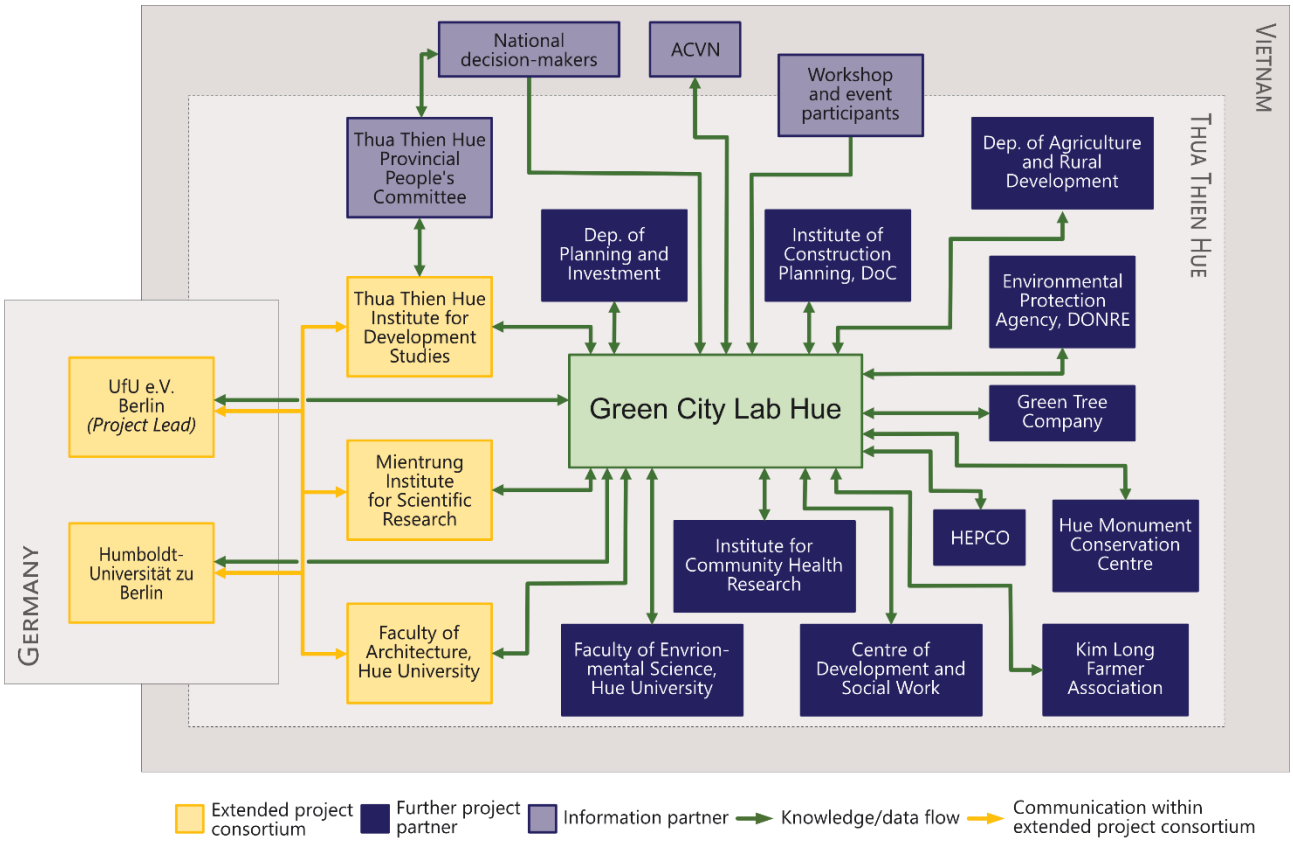


Figure 23. Structure of the GreenCityLabHué project network with the extended project consortium consisting of the German project partners UfU and HUB and the Vietnamese project partners MISR, HueIDS und the HUSC.

- To integrate the results of the interviews, the initial research on GBI-development and implementation of NBS, the status quo analysis of GBI and the feedback from local project partners and stakeholders, and also to differentiate from the BMBF-funded project FloodAdaptVN, the research focus for the R&D-phase was adjusted towards heat adaptation and air quality improvement.
- Further Vietnamese partners will be involved in the R&D-phase, e.g., through policy round tables and participatory events, in order to achieve a more coordinated planning with regard to urban development, implementation of NBS, and GBI-development. It will also help to promote the exchange of knowledge and ideas between stakeholders and obtain data and information as well as feedback for the project.
- The integration of practical showcases in the R&D phase is crucial to involve stakeholders and Hue's residents in the implementation of NBS at an early stage. Among other things, this can increase the acceptance of measures and demonstrate the effect of NBS on the surrounding area.
- In addition to focusing on the ecosystem services temperature regulation and air purification the consideration of co-benefits, e.g., biodiversity and water quality, was desired by Vietnamese stakeholders.

2.6 WP 6 Presentation and reporting of project results

On March 11th, 2021, the Closing Workshop of the Definition Phase of the Project "GreenCityLabHuế – Nature-based solutions to strengthen climate resilience of urban regions in Central Vietnam" was implemented. Due to the COVID-19 pandemic, the workshop was hosted virtually. During the 3-hours online workshop, the results of the Definition Phase and the plans for the next project phase, the Research and Development Phase were presented. Patrick Konopatzki (UfU) and Jessica Jache (HBU) presented results from the project's Status Quo Analysis, including current trends regarding Green-Blue Infrastructure and Nature-Based Solutions in Hue, that will form the basis for future research activities in the city. Prof. Dr. Dagmar Haase (HUB) presented concepts and methods of the scenario modelling process that her team implemented to demonstrate possible future developments regarding GBI-development. Hoang Thi Binh Minh (MISR) presented the results of the first stakeholder workshop that was implemented in 2020 to start the project's participatory co-creating process regarding GBI planning. Finally, Fabian Stolpe (UfU) closed the workshop with an outlook on future project activities that will follow in the next months and years during the R&D Phase. 34 stakeholders from different institutions from the sectors administration, science, civil society and the public from the Thua Thien Hue province and experts of the GreenCityLabHuế project team from Germany and Vietnam participated in the workshop, including the Department of Planning and Investment, the Thua Thien Hue Intelligent Operations Center; the Green Tree Center, the Institute of Resources and Environment, the Hue University, the Institute for Community Health Research, the Hue University of Pharmacy and Medicine, the Thua Thien Hue Bee Association, the organisation Peaceful Bamboo Family, and the People's Committees of An Dong ward, Phu Hoi ward, Tay Loc ward, Thuan Hoa ward, Thuy Bieu ward (Figure 24).

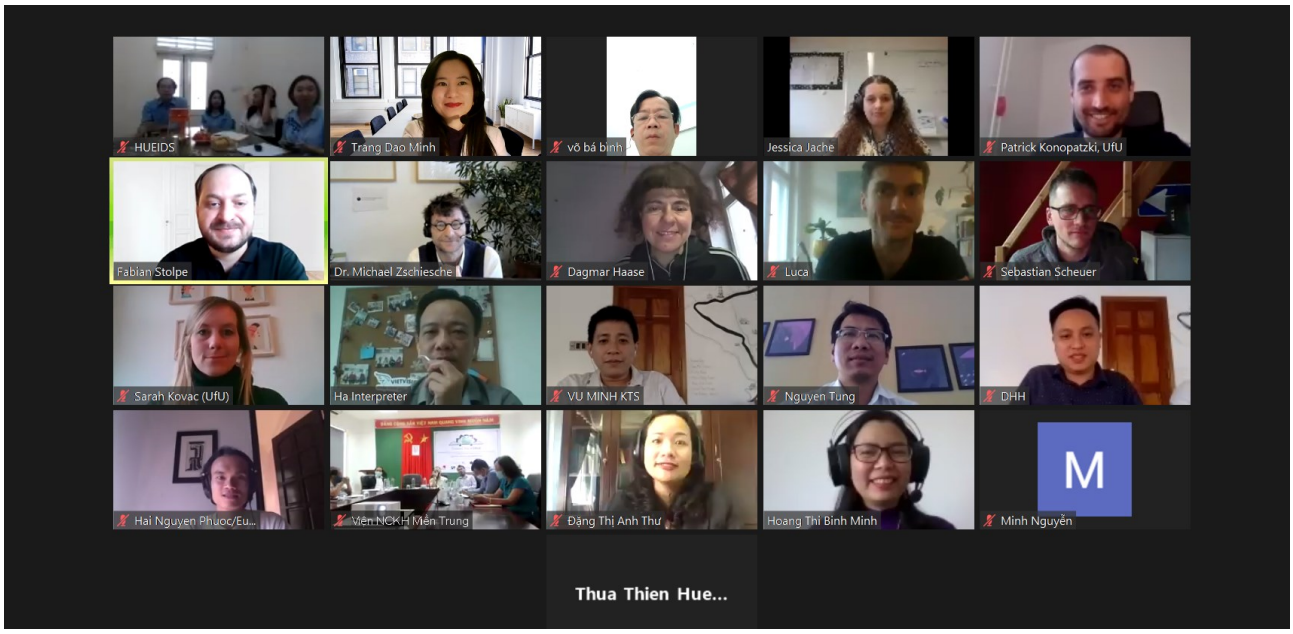


Figure 24. Participants of the Online Closing Event of the Definition Phase of the GreenCityLabHuế Project in March 2021.

- The final workshop took place on March 11th, 2021 as an online event
- The experts of the project consortium presented the most important results of the definition phase in a 3-hours workshop
- 34 stakeholders from various administrative, academic, civil society and public institutions from Thua Thien Hue Province attended the event

2.7 WP 7 Project management, administration, and communication

WP7 coordinated and managed the joint research project, including communicating with the German as well as the Vietnamese project partners and local stakeholders. Due to its role as project coordinator, HUB was the lead in charge of coordinating and steering the project as part of WP7. Here, HUB was supported by UfU. Moreover, UfU was the responsible body for the internal and external communication and dissemination. In addition to common project management and coordination tasks that include reporting to the funding agency, the organisation of internal project meetings, project supervision and the tracking of the project's progress, WP7 also encompassed approaching Vietnamese partners to initiate formal cooperation through memoranda of understanding and the subsequent tendering and awarding process, subcontracting, and administration. Due to Vietnam's legal framework that requires prior approvals by the provincial government and thus additional lead time as well as a formal termination of respective contracts, this contracting process was more elaborate and time-consuming for the project coordinator (HUB) than originally anticipated.

The kick-off meeting in Hue, Vietnam, was also part of WP7. Its planning, organisation and conduction was led by the German project partners that received support from the MISR. For the kick-off meeting, quotations free of cost were inquired, the respective contracts for catering and hosting of the meeting awarded, approvals for international events requested as needed, and participants and speakers invited accordingly. Vietnamese partners were provided with guidelines to describe the formal proceedings that need to be followed in regard to organisation (contracting) and the allocation of funds. At the kick-off meeting, the project was presented to selected guests and stakeholders. For UfU, M. Zschiesche and K. Rösler were present; for HUB, J. Jache was present at the kick-off, whereas D. Haase and S. Scheuer introduced themselves and presented their project responsibilities virtually in form of a video message. Feedback was provided by present Vietnamese

stakeholders and project partners in regard to the climate change-related challenges in the city of Hue and the province, the urban planning in Hue, on how to become role model cities for climate change adaptation, and the need for GBI in Hue. The German project partners shared their experiences from a local, European perspective, presented models and methods to be used in the project, and shared further details on the planned Green City Lab Hue. A total of 50 people attended the kick-off event in Hue.

As part of the external project communication, UfU has participated in the Federal Ministry of Education and Research's German Science Day and in the Match-Making-Workshop in Hanoi on October 30, 2019. The former facilitated an exchange between projects from the Federal Ministry of Education and Research's sustainability science funding measure, and from the International Climate Initiative (IKI) of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The joint research project was further presented by UfU at the networking event "Nachhaltige Regional- und Stadtentwicklung in Vietnam" (Sustainable regional and urban development in Vietnam) for Vietnam-based projects funded by the Federal Ministry of Education and Research. This event was held by the Ruhr-Universität Bochum and the Project Office for Sustainability Research in Vietnam on March 5, 2020 in Bonn, Germany. Another presentation of the project took place by UfU at a SURE event on December 18, 2020 in Bonn, Germany. SURE intents to support the R&D phase of projects funded through the funding priority "Nachhaltige Entwicklung urbaner Regionen" (Sustainable development of urban regions) by the Federal Ministry of Education and Research. These events represented valuable opportunities for the exchange of experiences and knowledge between Vietnam-based projects and could further aid in enabling future collaboration.

- When entering into subcontracts with Vietnamese project partners, a certain amount of lead time should be taken into account, as cooperation sometimes requires approval from the provincial government or a higher-level institution before a subcontract can even be concluded.
- In general, intercultural differences are noticeable in administrative and legal procedures, such as the administrative processing of subcontracts with Vietnamese project partners, which sometimes require additional steps, such as confirmation letters for tasks carried out, a contract liquidation at the end of the subcontract, etc., and should be calculated into the work plan and schedule.
- Project events must be planned with a certain amount of lead time, as due to the international composition of the project consortium and the legal regulations in Vietnam, approval must be obtained in advance from the appropriate office. For the approval procedure, the date, time, venue, agenda, and number of participants must be determined in advance.
- Events attended as part of external communication offer networking opportunities with other projects in the region (e.g., FloodAdaptVN, Rapid Planning) and thus promising starting points for future cooperation to exploit possible synergy effects.

3 Necessity and appropriateness of the work carried out

The necessity of the conducted work is becoming obvious in Hue's need for climate change adaptation measures. For the assessment of the status quo (cf. status quo report), one focus was put on likely climate change trends and climate change-related impacts, particularly regarding changes in air temperature and precipitation and associated natural hazards such as heat stress and flooding. The implementation of GBI provides means that help adapting to these challenges. In WP3, the focus on relevant ecosystem services, i.e., the regulation of air temperature/cooling potential through evapotranspiration and shading, as well as the regulation of the hydrological cycle through infiltration and retention, takes these challenges into account. Undoubtedly, GBI are also of

high relevance to improve and maintain public/human health and physical as well as psychological well-being. In this regard, GBI are means to improve air quality and reduce stress through their restorative potential. They are also valuable infrastructures for the improvement of amenity value and social cohesion. These aspects are considered in WP3 by addressing also those ecosystem services. Furthermore, through the employed co-design process, it could be highlighted that in addition to biophysical capacities of GBI elements to provide ecosystem services, also the (aesthetical) perception of GBI elements and thus stakeholder's preferences towards GBI have significant implications on the acceptance of interventions. Consequently, this needs to be considered in the implementation of green-blue infrastructures to obtain long-term sustainable solutions (see also Gavrilidis et al., 2019; Maya-Manzano et al., 2017). In this context, the co-design process allowed knowledge to be exchanged between the various project partners, and an intercultural understanding could be established, for example, in the form of the case study typology. This typology describes GBI elements from the perspective of both the European and the Vietnamese project partners. In so doing, the preferences towards and perception of differently viewed GBI elements, e.g., cemeteries, have been mutually informed.

The conducted work was appropriate as the previously described necessities could be addressed, in line with the project proposal and grant agreement. No additional funds were required, but instead, related to the COVID-19 pandemics, travel restrictions and the simultaneous cancellation of conferences and project-related events in 2020 and 2021 allowed corresponding planned costs to be saved. These saved costs were subsequently used for the reciprocal financing of staff to allow the project phase to be extended. This project extension allowed the project partners to compensate for delays caused by COVID-19, and address issues related to the (partially belated or incomplete) delivery of data, (partially poor) data quality, and (partial) lack of metadata. Despite these challenging circumstances, through adapting the proposed work including the development of hybrid stakeholder workshop formats and a virtual public information and learning space (Green City Lab Hue), the project objectives for the definition phase could nonetheless be achieved.

4 Expected benefit and usability of knowledge outcomes

Starting with the project's beginning, research findings were incorporated into devising a work plan and detailing the objectives of a follow-up research project, i.e., the research and development (R&D) phase. The corresponding project proposal was submitted by the project consortium on July 08, 2020. The positive evaluation of that proposal allows the project's continuation in the R&D phase, in which the methodologies and models developed at HUB that, in their current state, resemble the foreseen feasibility test, can be adapted further to local conditions and thus advanced fully. In the definition phase, first transfers and exchanges of knowledge were established, for example in form of the hybrid stakeholder workshop. Therefore, the co-design and co-learning process that is to be embedded in the project has been developed. In the R&D phase, these processes will be further stimulated and advanced. Findings from co-design and co-learning, including storylines, narratives, and methods, were adapted and prepared for an online exhibition of the Green City Lab Hue. In that project's website, also the various project reports are made available to the wider, interested public in both English and Vietnamese language. To enable the integration of project findings into the further provincial and municipal planning of GBI and NBS, HueIDS will provide the peoples committee of the Thia Thien Hue province and the Hue city administration with relevant key findings. Research results will further be disseminated for the advancement of the state of the art, and will thus provide the basis for discussing, proposing, and evaluating other follow-up projects that focus on the advancement of implementing GBI and NBS. For example, proposals for projects within the Federal Ministry of Education and Research's funding measure "Förderung von bürgerwissenschaftlichen Vorhaben" (Funding of citizen science) and the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety's funding measure "Förderaufruf für

innovative Klimaschutzprojekte im Rahmen der Nationalen Klimaschutzinitiative" (Funding of Innovative Climate Action within the National Climate Initiative) that seek the establishment of a public participation and co-design and co-learning process built on the findings of the GreenCityLabHuế project.

5 Progress in the field of the project by other bodies

The CLEARING HOUSE project develops a typology of urban forests as nature-based solutions, and evaluates the multiple impacts and benefits of such tree-based NBS. CLEARING HOUSE findings may be of particular interest due to the project's spatial focus on Europe on the one hand, and China on the other. Additional projects that aim at advancing the implementation of NBS in cities with potentially relevant findings include URBAN GreenUP (development, application and validation of methods to integrate NBS in urban planning for climate change adaptation), NATURVATION (building of applications and tools to realize the potential of NBS for sustainable urban development), and UNaLab (development of smart, inclusive, resilient and thus more sustainable cities through implementing NBS).

Based on the experiences of the front-runner cities of the EU-project URBAN GreenUP, five follower cities, including the Vietnamese city of Quy Nhon, will set up their own renaturation plans, i.e., implement NBS among others. In the case of the city of Quy Nhon, this includes the enhancement of local mangrove forests and the creation of new parks. In an exchange with the local project officer, Dr. Cuong, the following points were identified crucial regarding an effective implementation of NBS in Quy Nhon: (i) need for the development of a distinct NBS approach tailored to local conditions; (ii) the Climate Change Coordination Office as a coordination mechanism; (iii) focusing on a few specific NBS; (iv) applying different financing approaches; and (v) learning by doing. The collaborative project has already integrated these lessons learned into the design of the project proposal for the R&D phase and will take them into account when implementing the research project.

The "Flood Adapt" Project, which is funded in the same funding framework of the BMBF and is being carried out by DLR together with other project partners, will analyse ecosystem-based approaches to flood protection. The project is also located in Hue and the surrounding Thua Thien Hue Province. Many synergies are to be expected with this project due to the overlapping research topic of NBS for climate adaptation and due to the location in the same project region. With the GreenCityLabHuế project focussing on benefits of NBS for temperature regulation and air quality and the "Flood Adapt" Project focussing on the benefits of NBS for flood protection, the two projects together can provide a comprehensive basis for an effective integration of NBS in Hue's future urban and regional planning activities. The "Flood Adapt" project is also currently in its definition phase. Therefore, no final results are published at the moment. The UfU, however, is in contact with the project manager of the "Flood Adapt" project and it can be expected that the exchange in the R&D phase of both projects will be intensified. Based on the level of current knowledge, synergies will be possible in the fields of remote sensing, NBS in general, weather and wind data for the region, and urban and spatial planning.

On December 18, 2020, the first meeting with the SURE accompanying research project took place, in which representatives of the other projects of the BMBF funding framework attended. All these projects are implemented in the Southeast Asia region. Due to their research topics, further synergies with some of these projects could be identified, which should be used in the R&D phase.

Within the thematic scope of GreenCityLabHuế, and for the immediate case study area of the project, no further findings could be identified.

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7 Publication

Submitted or in preparation

von Döhren P, Haase D. (submitted) Geospatial assessment of urban ecosystem disservices: An example of poisonous urban trees in Berlin, Germany. Urban Forestry & Urban Greening.

Haase D, Drukewitz L, Wolff M (submitted) Enabling ecosystem services flows at neighbourhood scale while allowing for regrowth? The case of Halle, Germany. Ecology and Society.

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