UNIVERSITY OF WATERLOO

DEVELOPMENT OF AMPHIBIOUS HOMES FOR MARGINALIZED AND VULNERABLE POPULATIONS IN VIETNAM

WW216

FINAL REPORT – EXECUTIVE SUMMARY

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1.0 Introduction

Figure 1 *Aerial photo of Nguyen Van Nao's Home during the flood season in An Giang Province*

1.1. Main Objectives

The project "Development of Amphibious Homes for Marginalized and Vulnerable Populations in Vietnam" was initiated with the support of the Global Resilience Partnership (GRP) Water Window Challenge and the Z Zurich Foundation. This project was led by Dr. Elizabeth English at the School of Architecture, University of Waterloo, a global pioneer for providing amphibious architecture solutions for flood and climate change resilience. The joint Canadian-Vietnamese team consisted of Dr. Elizabeth English's non-profit organization, Buoyant Foundation Project, alongside students and faculty from Canadian and Vietnamese universities. Together they introduced amphibious retrofitting to residents of the Mekong Delta as a cost sensitive alternative to rebuilding on higher stilts as flooding worsens. This architectural innovation, pioneered through GRP Project WW216, involved the retrofitting of four existing homes to float temporarily during the Mekong Delta's seasonal flooding. This approach aimed to allow homeowners to safely remain within their homes during a flood, thus, building flood resilience and rapid recovery capacity within low income, flood-prone communities. The homes were retrofitted in the first half of 2018, and were monitored during that year's monsoon season to evaluate the success and performance of the amphibious concept to seek future scaling-up opportunities.

Figure 2 *Houses situated along the water in the Mekong Delta.*

1.2 Context: Flooding in the Mekong Delta

Vietnam's Mekong Delta is home to 17 million people (22% of the national population), most of whom are agricultural and aquacultural farmers. Although flooding is beneficial to the wet season's water-reliant agricultural and aquacultural production, increasingly severe storms and flood events have put millions of peoples' homes at risk of chronic flooding. These floods have resulted in loss of property and lengthy disruptions to community-based economic activities, impacting the livelihoods and resilience of families who own farms on the fertile land in the region. Mekong Delta communities have already employed numerous techniques to adapt to flooding. However, as the area anticipates increasingly severe floods, the current level of static elevation of these houses may no longer be adequate to protect residents and their belongings. Rebuilding or repairing homes after a flood event usually requires a significant period of time. During these repairs, residents are often displaced from their homes, increasing their economic burden and vulnerability.

1.3 The Buoyant Foundation Project

The Buoyant Foundation Project (BFP) was originally founded in 2006 to support the recovery of New Orleans' unique and endangered traditional cultures by providing a strategy for the safe and sustainable restoration of historic housing. Since then, the Buoyant Foundation's mission has broadened to apply buoyant (amphibious) foundations not only to post-Katrina New Orleans but also to numerous other flood-sensitive locations around the world. The Buoyant Foundation Project's team today consists largely of students, professors, alumni and friends of the University of Waterloo's School of Architecture.

Figure 3 *Retrofitting Team alongside homeowners in An Giang Province.*

Figure 4 *Carpenters retrofitting Nguyen Thi Dung's home in Long An Province.*

1.4 Response: Amphibious Retrofits

Amphibious architecture is an alternative flood mitigation strategy that allows an otherwise-ordinary structure to float on the surface of rising flood water rather than becoming inundated. An amphibious foundation retains a home's connection to the ground by resting firmly on the earth under usual circumstances, yet it allows a house to float as high as necessary when flooding occurs. A buoyancy system beneath the house displaces water to provide flotation as needed, and a vertical guidance system allows the rising and falling house to return to exactly the same place upon descent. Amphibious construction is a flood mitigation strategy that works in synchrony with a flood prone region's natural cycles of flooding, rather than attempting to control them.

Amphibious retrofits are an incremental adaptation that will further help these communities continue to cope with the nature and scale of flooding expected under climate change (English et al., 2018). In order to preserve residents' connection to their land and livelihoods, a passive climate change adaptation and flood mitigation technique can be implemented, allowing the land in the Delta to benefit from the seasonal flooding. Low-cost amphibious retrofits to existing houses can provide a solution to these vulnerable populations, allowing residents to remain on their farmland during flood events with little or no damage to their homes and possessions. Amphibious foundations make homes resilient; resilient homes lead to resilient communities.

2.0 Activity Reporting

2.1 Progress against work plan and activities

The following activities were completed over the course of the project. Activities agreed in the contract/revised work plan are listed below in the order in which they appear in the work plan. A description of work completed (including related quantitative progress) follows each activity.

Figure 5 *Homeowner Dang Van Nang indicating the water level of a flood inside his home.*

2.1.1 Site Selection (Completed)

- Site visits were conducted in various districts within both An Giang and Long An Provinces and all relevant permissions (Provincial People's Committee) were obtained.
- Numerous presentations were delivered to communities and officials within the Mekong Delta.
- Potential residents were interviewed and two houses were selected in each of the two separate villages for a total of four (4) houses with amphibious retrofits.

Figure 6 *Pham Duy Tien of An Giang University (right) in conversation with carpenters from Long An and An Giang Provinces.*

2.1.2 Design Process (Completed)

- Design collaboration with the Vietnamese team commenced in August 2017 and continued through January 2019.
- Local engineers were hired for collaboration.
- Site conditions were documented.
- Flood characteristic data and wind data specific to the sites were obtained.
- As-built drawings of the existing homes in each province were created.
- Amphibious designs were finalized and design drawings were completed.
- Permissions were obtained from local provincial officials.
- Agreements with owners of all homes to be retrofitted were obtained.

2.1.3 Production of Amphibious housing Prototypes (Phase 1)

(**Alternative Work Plan Completed):**

- Original Work Plan Consisted of sourcing materials and engaging local contractors.
- One new home was built in Vinh Chau A Commune during January 2018, then retrofitted in May 2018, in order to demonstrate proof of concept. An existing home in the same village also retrofitted in May 2018.
- Two additional houses retrofitted in Long An Province in June/July 2018.
- During retro-fittings all building materials were sourced and acquired and local master carpenters and crew were hired.
- Canadian and Vietnamese team members oversaw construction and retrofitting

Reasons for exceeding or not achieving activity

- Initially, the plan was to retrofit two houses as prototypes, then an additional 5-7 houses (Phase 2) were to be selected for retrofitting.
- A delay in technical deliverables (engineering data) resulted in fewer houses that could be retrofitted in an increasingly constricted schedule. Instead, [4] houses were retrofitted in total. Two in Vinh Loi Hamlet, Vinh Phuoc Commune, Tri Ton District, An Giang Province, and two in Vinh Nguyen Hamlet, Vinh Chau A Commune, Vinh Hung District, Long An Province.

Figure 7 *Monitoring equipment being installed on Dang Van Nang's home.*

2.1.4 Monitoring

(Activity was added in addition to the original work plan and Completed)

- The purpose was to monitor the technical performance and local perceptions of retrofitted homes.
- Monitoring instruments were developed and installed in all four houses and performance data collected and analysed.
- Recommendations for design modifications of retrofits were made based on performance.
- Site visits were conducted by team members during the flood period.
- Interviews were conducted with home owners and local authorities during the flood period.

Reasons for exceeding or not achieving activity

- This activity exceeded the original project scope. Because fewer houses were retrofitted than originally planned, that portion of the construction budget was instead used to monitor amphibious performance of retrofitted houses during peak flood period (Aug-Sept 2018).

2.1.5 Modification

- Design, construct and apply modifications as required.
- Completed (January 2019): Modified one project to include additional flotation devices in order to increase the freeboard height

3.0 Opportunities & Difficulties Experienced

3.1 Overview of Opportunities during the Seed Project

The following is a description of successful activities, challenges, and lessons learned.

Figure 8 Team site visit conducted in early October 2018 during peak flood period for first-hand experience of amphibious homes while floating.

3.1.1 Partner Engagement and Participation

Project commencement and Site Selection: Dr. Elizabeth English travelled to Vietnam in February 2017 to meet with Vietnamese partners and survey potential sites with houses that would be viable for amphibious retrofits.

Knowledge Exchange: Team members from Vietnam and Canada participated in the Second International Conference on Amphibious Architecture, Design and Engineering (ICAADE) as the first ever international policy symposium on amphibious architecture (First Global Amphibious Policy Symposium (GAPS 2017)), hosted by the University of Waterloo to return to Vietnam with information to enrich decision-making for the project.

Team Expansion: When Dr. English returned to Vietnam, in 2017 she collaborated with Mr. Pham Duy Tien of An Giang University who possessed extensive local knowledge of the sites and would effectively oversee the entire construction and retrofitting process. At this time, the prototype home was constructed to be retrofitted in the following visit.

Prototype Construction: In January 2018, the team returned to oversee the construction of the prototype. Mr. Pham Duy Tien then recruited Mr. Nguyen Van Truoc, a master carpenter based in Tri Ton, An Giang, who would actively lead in all construction and retrofitting activities for the remainder of the project. Local workers and students also participated in the process as they were hired to aid with the retrofitting process. The construction team learned the basics of amphibious architecture on a hands-on basis. One significant output of this activity, which holds promise for the upscaling of amphibious housing in Vietnam, is that Mr. Tam has expressed interest in continuing to retrofit other homes as a business venture and has mentioned many other carpenters can potentially learn this concept.

Wind Monitoring: Mr. Cao Hoang Tien of the Department of Rural Technology of Can Tho University joined the team, and was in charge of deploying wind monitoring equipment at the house sites in both Long An and An Giang Provinces. Mr. Tien was also extensively involved in overseeing the retrofits, as well as with designing, assembling, and installing instrumentation to monitor the movements of the houses as they floated during the flood season of 2018.

Figure 9 *Nguyen Van Nao's (Prototype) amphibiated home floating during peak flood season.*

Figure 10 *Nguyen Van Lac's amphibiated home floating during peak flood season.*

An Giang Retrofitting: The Canadian Team returned to Vietnam within An Giang province in May 2018, and installed the amphibious retrofit on Mr. Nguyen Van Nao's house that had been constructed the previous January. In addition to completing the retrofit on Mr. Nao's house, the team moved and rebuilt his younger brother Mr. Nguyen Van Lac's house prior to retrofitting it to become amphibious.

Long An Retrofitting: Shortly after this retrofit, the team returned to Long An province in June 2018, alongside master carpenter Chu Tam to complete the retrofitting projects of the two homes. While there, Mr. Douglas Varchol filmed a documentary on the construction process of the retrofitting projects. In addition to the filming of the documentary, Ms. Simone Verkaart from GRP/KPMG completed several days of site visits to check the team's progress on their goals.

Site Visit During Flood Season: The team returned to site in October 2019 to check on the prototypes during the flood season. During this visit the team learned that Lac's house was sitting lower in the water than was optimal. In January 2019, the team returned to make the necessary modifications to the buoyancy to increase the freeboard. The team also made post-flood evaluations of the centering devices to determine that they had all performed successfully. Also, in January, the final MEL interviews were completed with the local residents, as this was the Canadian team's last trip to Vietnam.

Partners for Future Efforts: It is anticipated that the Vietnamese partners will be involved in future efforts to scale up the use of amphibious architecture in Vietnam with the knowledge they are acquiring now to expand and implement amphibious architecture projects in the future. This will potentially engage new communities and grow the capacity of builders across the Mekong Delta to construct amphibious buildings.

Figure 11 *Chu Tam (Master Carpenter) working with Sy (Local Officer) and Cao Hoang Tien from Can Tho University*

3.1.2 Introduction of Amphibious Concept during Outreach

Opportunities to present the amphibious architecture concept and its applications to a wider range of Vietnamese audiences were pursued during February 2017 and August 2017, especially within the context of climate change adaptation. The variety of audiences contacted included villagers, commune leaders and representatives of various province-level government departments. After the retrofittings, a local news channel in An Giang Province featured the project – a form of encouragement for people who are interested in having their homes retrofitted to approach the local government and express their interest. Many people around the locality of the Vinh Phuoc Commune observed the houses and also expressed interest in having their homes retrofitted as well**.**

3.1.3 Leveraging Local Technical Expertise and Further Dissemination of Concept

As the project unfolded, new technical experts in Vietnam were recruited which provided an opportunity to further expand local knowledge of the amphibious architecture concept to the local institutions. The Canadian team collaborated with structural engineers in Vietnam to contribute to the development of as-built drawings, structural designs and buoyant stability calculations. Each of these experiences, both negative and positive, were opportunities to disseminate the amphibious concept to local technical experts in a practical way.

3.1.4 Identification of Other Potential Existing Homes for Future Scaling-up

During August 2017, the project team was made aware of a local road improvement plan which would modify an existing elevated bank beside a canal in An Giang Province which required the relocation of the existing homes to a lower elevation. One of the existing high bank homes was relocated at the request of the owner (Mr. Lac) and retrofitted as part of this project, proving that these homes ideal candidates for future amphibious retrofitting and could potentially be reinforced with government subsidy programs.

3.1.5 Engagement of Provincial Departments (Long An & An Giang)

In January 2018, Vietnamese and Canadian team members held introductory meetings with eight officials from four provincial departments. The intent of the meetings was to introduce and garner support for the amphibious concept, as well as the seed project, to the representatives. Another key goal was to engage the departments as part of our capacity building mandate. The meetings were crucial in that they involved relevant departments that would be instrumental in supporting any future scaling up of the concept.

Figure 12 Master Carpenter Chu Tam explaining the retrofitting process of Nguyen Van Nao's home

3.1.6 Successful Construction and Retrofitting

The effective collaborative efforts of the Canadian and Vietnamese team members resulted in four homes being successfully retrofitted, two each in An Giang and Long An Provinces. With the logistical support of Alternate Lead Lee Chan, the retrofitting construction schedule was planned, and a project management checklist employed, in order to ensure that the project moved forward as smoothly as possible (e.g. travel permissions, sourcing materials, coordinating travel schedules, hiring local workers, securing local travel and accommodations, etc.).

The Vietnamese team members demonstrated exceptional dedication to the project, notably Mr. Pham Duy Tien of An Giang University, whose participation was essential in organizing all materials acquisitions and hiring the local workers, and his extensive knowledge will help with identifying materials sources and local talent in future scale up projects, and Chu Tam, who contributed local knowledge of local construction practices during construction and retrofitting.

3.1.7 Performance and Public Exposure of Proof of Concept

All four retrofitted homes were complete and operational when the annual Mekong Delta monsoon floods arrived in August 2018, and all four performed very well, both throughout the peak flood period (in late September 2018) and afterwards as the floodwater subsided. All retrofitted homes demonstrated the proof of concept by floating during the flood.

From interviews conducted during that time, the residents were happily confident with the safety of their homes. By late October the flood waters had receded, and all four homes had successfully returned to the ground, precisely as designed.

Figure 13 *Community lifting Nguyen Thi Dung's house together in Long An Province.*

3.1.8 In-Line with Future Commune Development

Researchers, the local government and farmers plan to revitalize floating rice cultivation in the Delta, and to tie this in with eco-tourism development. Accordingly, the amphibious concept is well aligned with national plans to revitalize the cultural heritage of floating rice cultivation, allowing farmers to occupy their homes during the flood season, and showcasing of that culture through eco-tourism.

3.2 Difficulties Experienced

3.2.1 Retrofitting Challenges

Different areas of knowledge and language barriers between the Canadian and Vietnamese teams potentially posed difficulties in robust design and retrofit completion The Canadian team undertook very careful calculations to reduce the margins of errors associated with the engineering aspects, while the Vietnamese team, specifically the carpenters, contributed their extensive knowledge of local construction practices. These fruitful discussions eventually yielded newly invented design details that were true products of effective collaboration.

Figure 14 Different methods of construction for sleeves around the vertical guidance posts. On the left is a rope sleeve that loops around a vertical guidance post on Nao's house and on the right is a wood box sleeve with rope cushioning on Lac's house.

Figure 15 Different methods of construction for centering devices. Nguyen Van Nao's house is on the left and Nguyen Thi Dung's house on the right.

3.2.2 Acquisition of Local Flood and Wind Data

The delayed delivery of wind and flood data and data analysis, as well as related challenges with the technical calculations needed for reliable determination of the wind and water forces on the amphibious house while floating posed challenges for calculations to be met in a timely period. Nonetheless, Canadian and Vietnamese team members alike demonstrated exemplary commitment to the project and were able to find work-arounds to fulfill the overall project goals, which were to pilot and demonstrate the viability of amphibious housing and to build the capacity of local people to deploy the concept

3.2.3 Changes within the Team

During the course of the entire project, multiple changes occurred within the team on the both Canadian and Vietnamese side due to professional demands and availability.

3.2.4 Engineering Calculations and other delays

Delays in the delivery of acceptable engineering data and structural calculations resulted in design and retrofitting delays.

3.2.5 Challenges in scaling-up

Financial challenges limit the potential of the project as the cost of materials to complete amphibious retrofits is high relative to the incomes of impoverished farmers.

Project team members have already determined ways to reduce the costs of future retrofits while maintaining high levels of quality and safety

Financial support from the Ministry of Construction might be a more reliable path to the acquisition of materials within an established timeframe and budget than the District authorities in An Giang Province's suggestion of requesting donated or discounted materials from local suppliers.

4.0 Results

4.1 Data Collection strategy and methods

A combination of qualitative, quantitative and technical research tools were deployed to evaluate both the physical-technical and sociocultural performance of the project.

Figure 16 *Luu Thi Tang of Vietnam National University (right) interviews Le Thi Dao (left), resident of Vinh Nguyen Hamlet and aunt of homeowners Nang and Dung in Vinh Chau A Commune.*

4.1.1 Qualitative

Both semi-structured interviews and questionnaires were conducted to gather relevant data from owners/amphibious home recipients, and other persons trained in the amphibious concept. This qualitative data was used to evaluate the success of the project in the eyes of recipients and local communities, and local perspectives gleaned from these interviews informed decision-making in the project during all phases.

4.1.2 Quantitative & Technical Research Tools

Photography and videography were used to document the step-by-step construction and retrofitting activities. Specialised instruments were used to monitor amphibious performance when the retrofitted homes floated during the flood season of 2018 (August to October). The cost of retrofitting each house (i.e. materials, transportation and labour) were tracked and recorded to determine the overall per-house costs, and in order to help determine which components could be obtained more cost-effectively in order to benefit future recipients who are economically stressed.

4.2 GRP and project specific indicators

Progress to date against selected indicators were documented in the report included: People supported by GRP, net benefit per person, people more resilient, end-users satisfied with support, end-users engaged with project, People trained in amphibious construction and design, knowledge products generated, people accessing knowledge products, organizations receiving capacity building assistance, and partnerships formed.

Indicators agreed to in the MEL plan are also documented. The narratives documented for each indicator briefly detail changes that occurred as a result of project activities, and the project's contribution to these changes.

Figure 17 Our project team and visitors navigating a rice field during flood season.

4.3 Goals and Outcomes

Overall goals and outcomes the project set out to initially achieve in the project were documented for progress achieved against these goals and outcomes. These included: Number of amphibious retrofits, knowledge and learning, partnering with local specialists, engagement of local authorities. engagement of end-users, potential entrepreneurial opportunities, and potential lead up to scaling up.

Where relevant, amendments made to goals and outcomes were documented with brief reflection on the reasons for such changes.

4.4 Impact Pathway Narratives

Throughout its lifespan, the project experienced the following opportunities that would be beneficial for scaling up:

4.4.1 Support of homeowners, neighbours and surrounding communities

Throughout its lifecycle, from site selection stage to construction and retrofitting, the residents enthusiastically participated and supported the seed project. Successful performance during the flood season confirmed the proof of concept, and would have yielded numerous word-of-mouth testimonies to neighbours, relatives, co-workers and possibly members of other surrounding communities. These resident-to-resident communications can be leveraged to identify other potential owners for a scale-up project as the awareness of the concept expands.

4.4.2 Support of local authorities

Vietnamese team members were diligent in the engagement of DARD, DONRE and other relevant Vietnamese agencies. With Mr. Lee Chan, Alternate Project Lead, initial visits to the department heads were held during January 2018 (before the retrofitting stage) in order to introduce the concept, and department representatives were subsequently invited several times to the sites. All this engagement brought awareness to the technical authorities at the provincial level who would naturally assist in any future scaling up activities in other Vietnamese districts and communes.

Figure 18 Professor Kun from Can Tho University interviewing homeowner Nguyen Van Nao.

Figure 19 Centering devices and vertical guidance posts along Nguyen Van Lac'a home in An Giang.

4.4.3 Entrepreneurship

Chu Tam (the master carpenter and foreman of the construction retrofitting team), other carpenters and several farmers received hands-on training during retrofit construction. Chu Tam mentioned the possibility, with sufficient further training, of using his new skills to start an amphibious retrofitting business of his own. Establishing new retrofitting businesses would quickly help develop and bolster local capacity by training carpenters and construction workers, and by identifying and reserving needed material in the supply chain.

4.4.4 Vietnamese Team Members

Our Vietnamese Team Members provided invaluable support, engagement, knowledge and hard work, which culminated in the successful completion of the seed project. Accordingly, given the experience gained and transferable skills learned from the seed project, these partners would also be invaluable in any future scaling up activities.

4.4.5 Planned Engagement of Other Relevant Organizations

Other relevant organizations based in Vietnam have been identified as having the capacity to help scale up amphibious housing applications. As one example of this, the project has decided to partner with the Vietnamese Women's Union and the Fatherland Front. Both organizations are instrumental players in civil society in Vietnam and have a wide reach of influence.

Figure 20 *Dang Van Nang's retrofitted home floating in the flood season.*

4.5 Shocks and stresses

Flooding was the primary shock that occurred during the lifespan of this project and was the target shock against which this project sought to build community resilience. Had these homes not been retrofitted, numerous shock and stresses would have transpired based on the level of flooding:

During the yearly monsoon season of 2018, floodwater arrived early during August and inundated both sites where the four homes were retrofitted. All four houses successfully performed as per retrofit design by achieving buoyancy adequate to lift the houses above the ground and float above

This project undeniably enhanced the personal and household resilience of retrofit recipients, and hence the capacity of recipient communities to respond to the stresses associated with seasonal flooding.

5.0 Learning

5.1 Pathway to change

This project was an invaluable learning experience for both the Vietnamese and Canadian teams which has strengthened our current and future work on amphibious architecture. The following summary points describe a sample of the successful outputs of the project as described throughout this report, and they represent actions, practices, and activities that we would replicate or change for future projects.

5.1.1 Design

Four houses have been retrofitted and have successfully performed during the flood season as anticipated. This output means that our design process was technically successful, and it also engaged a wide array of project stakeholders. In the future, the process we used for this project will serve as a "best practice" for collaborative design during future projects.

5.1.2 Local Reception

- Two communities have been engaged and have been enthusiastic in embracing and supporting the implementation of the concept.
- Vinh Phuoc Commune officials have supported the seed implementation and as a result of this project have discussed the possibility of a subsidy program for vulnerable communities in potential scaling up efforts.
- Local carpenters and students who participated in the retrofits have gained valuable knowledge and skills in amphibious retrofits, and a master carpenter, Chu Tam, has expressed interest in the concept as a potential business start-up once he has received sufficient training.

Figure 21 Nguyen Thi Dung's house floating after amphibious retrofit.

5.1.3 Upscaling and Local Ownership

● A successful partnership with local Vietnamese academia, technical resources and those who can affect policy change has been formed.
● Interest and support of the provincial Department of Natural Resources and Environment (DONRE) and Department of Agriculture and Rural Development (DARD) of both An Giang and Long An Provinces have been generated.
● Interest in up-scaling voiced by the Chair of Vinh Phuoc Commune, Tri Ton District, An Giang Province.
● Interest in developing business enterprises based on amphibiation has been expressed by local carpenters

5.1.4 Increasing Resilience

In our theory of change, the associated activities (engaging local authorities, design, materials, contracting, construction) as well as the outcome of producing four retrofitted homes, and their subsequent positive performance in flooding, has enabled successful introduction of the concept through the GRP WW216 seed project. Most importantly, through planned scaling up activities, the future transfer of amphibious retrofit knowledge through outreach to other communities and the training of more local carpenters will increase the resilience of people vulnerable to severe flooding in the Mekong Delta.

As with the case in An Giang province, residents will no longer have to relocate to villages that are distant from their homes because of flooding. Rather, they will be poised to remain in their homes, serving as a testament to their increased resilience as a result of this project.

5.1.5 Assumptions

The project was initiated on the basis of internal, external and other assumptions to allow us to proceed. These included assumptions related to access to services during flooding, adequate flood levels in the region, coordination with engineering consultants, as well as the availability and cost of suitable construction/retrofit materials. Some of these assumptions proved to be true, and some false, but all of them resulted in critical learning experiences that can be applied to future retrofits to efficiently acquire data and reduce time spent as well as costs.

Figure 22 *Interview with a homeowner in Long An Province.*

5.1.6 Empowering women and Children

Women and children commonly comprise a substantial proportion of farming communities in the Mekong Delta. If their homes are not impacted from severe flooding due to amphibiation, women and children would benefit by not having to relocate or be put at-risk of physical harm thus nullify experiencing the shock or stress of being adversely impacted.

5.2 Areas of Transformation

Inclusive decision-making was practised from the beginning of the seed project. In fact, local partners within institutions were engaged in site selection even before formal announcement of the seed funding award. This not only demonstrated the team's understanding of the importance of including local partners in decision making, but the very fact that this process commenced before funding was formally announced attests to the team's commitment to having local team members take ownership of concept implementation during the seed project phase and into the scaling-up project phase.

Figure 23 *Nguyen Van Lac's home floating in the high flood season.*

5.2.1 Proven Concept

Four existing houses have been successfully retrofitted and have performed as expected during the peak flood period of the fall of 2018. Furthermore, the houses were of the local design indigenous to the Mekong Delta communities. While these houses would normally be inundated during the flood period, amphibiation prevented this from happening, and protected households from damage. As such, the structures are no longer at risk to annual floods.

5.2.2 Engagement of Local Knowledge

During the site selection stage, using local knowledge, the team identified areas that were at high risk to the adverse effects of severe flooding. Collaboration with Vietnamese team members proved invaluable in pinpointing specific areas within the Mekong Delta, and in identifying local partners and materials to employ in the amphibiation process. Technical solutions to potential retrofitting issues were developed collaboratively. The melding of the "new" amphibious concept with local construction skills and knowledge instilled practical amphibiation concepts in the minds of the Vietnamese crew.

5.2.3 Engagement of Local Commune Officials and Provincial Departments

Commune officials and representatives of the Department of Agriculture and Rural Development (DARD) and the Department of Natural Resources and Environment (DONRE) of both An Giang and Long An Provinces expressed much interest when introduced to the concept.

5.2.4 Identifying Entrepreneurial Opportunities

In line with our original Concept Note that identified the potential for entrepreneurial start-ups, during the retrofits, carpenter Chu Tam expressed an interest in continuing to retrofit other local houses potentially as a business endeavour. This, along with further efforts to reduce costs to allow low-income populations to access this service, would help catalyse scaling up.

5.2.5 Technical Data and Engineering

Several challenges were experienced in acquiring reliable site-specific data with respect to wind and flood conditions as well as delivery of robust engineering calculations from Vietnamese experts, both of which were crucial to design development of the retrofits. Ultimately it was explained that the necessary engineering skills required for a project of this scope are not covered in the typical Vietnamese Civil Engineering curriculum.

5.3 Lessons Learnt

5.3.1 Inclusive Decision-Making

Perhaps the most important lesson learned in this project was the importance of effectively engaging with our Vietnamese partners, homeowners/recipients, and carpenters throughout the project. It is crucially important not only to acquire the permission of the owners to retrofit their homes (and thus implement the project on their respective homes/property), but also to receive their input during the various stages of the project. As previously stated, we feel that the overwhelmingly positive reception of the retrofits among recipients and other community members serves as evidence that our approach to inclusive decision-making was successful.

Figure 24 *Retrofitting underneath Dang Van Nang's house in Long An.*

5.3.2 Partnerships in the project

Partnerships with the various Vietnamese team members were crucial to the success of the seed project. They facilitated the search for suitable sites, participation of the residents, presentations to various communities and officials, acquisition of permissions from local authorities, collection of materials, hiring of carpenters and students to undertake the physical retrofitting of homes, arrangements of accommodations and ground transportation, and conducting MEL interviews and post-retrofit instrumentation and monitoring.

5.3.3 How the project increases Resilience

We learned that project homeowners/recipients, and almost every individual who witnessed the amphibious home concept in action, quickly recognized the benefits of the homes for flood resilience: amphibiated homes were protected from inundation, meaning that families did not incur expensive and stressful property damages typically associated with seasonal flooding. This recognition was also shared by the Vietnamese partners, local officials, residents and carpenters who were involved throughout the length of the project. The same learning process would likely also occur during scaling up. As previously stated, this project also has the potential to enhance other dimensions of community resilience in the future, such as economic resilience and sustainable livelihoods, by providing opportunities for entrepreneurship related to amphibious construction.

Figure 25 *Mekong Delta rice farmers working in a field.*

6.0 Monitoring, Evaluation, and Learning (MEL) Plan

6.1 Overview

The purpose of the Monitoring, Evaluation and Learning (MEL) Plan was to evaluate how amphibious residential flood adaptation measures support livelihood outcomes and options. The objective was to report activities associated with the MEL Plan that were performed during the project including methods in data collection. This MEL report focuses on measures of beneficiary satisfaction and resilience enhancement, as compared to the GRP goals and relevant impact pathways emphasized in the Final Report. This MEL report also includes a brief discussion that summarizes the impact of the seed project on the homeowners (beneficiaries of amphibious retrofits) and their respective communities, as well as the impressions of local authorities.

6.2 Objectives/Methodology

Using GRP goals and suggested performance indicators, a MEL Plan was developed specifically for this project. Over the course of project implementation, data that would measure progress against the goals and indicators was collected. Generally, the following phases of MEL data collection were performed: i) before amphibiation, ii) post-construction prior to flooding iii) post-construction during flooding, and iv) post-construction, after flooding has receded.

6.3 Results/Discussion

Although the four houses had only 24 occupants, in each case, the entire community was made more resilient by the seed project. We are confident that the resulting benefits will expand beyond the project hamlets to other vulnerable communities, either due to word-of-mouth promotion or one or more formal government-led initiatives.

The seed project has proved to be an immense success in virtually every aspect: the participation and acceptance by local communities and authorities, the enthusiastic support of the Vietnamese partners, the willing participation of the homeowners and the support of their relatives and neighbours, the concerted efforts of the crews resulting in the completion of the retrofits, the fall 2018 monsoon flood conditions that allowed technical demonstration of proof-of-concept, discussions of a potential business stream by one of the master carpenters living in the Mekong Delta, and the initial proposal of the Vinh Phuoc Commune Chairman with respect to a potential scale-up amphibious house subsidy program.

Figure 26 *Floating rice field during the flood season in An Giang province.*

7.0 Conclusion

Following our demonstration of proof of concept with the first four amphibious retrofit prototypes, local commune officials have expressed considerable interest in scaling up the project.

Scaling up the project will enable us to continue knowledge transfer with local collaborators. Currently, human capacity for furthering this project is limited by the number of people who are able to teach other carpenters and homeowners within the community. We are the only research group in the world dedicated to developing amphibious retrofit technology for the world's most vulnerable populations; we aim to expand our scope by teaching local populations how to implement this technology themselves using affordable, locally available materials.

Everyone impacted by this project (home owners, carpenters, community members, and local and provincial authorities) believed that this concept should be scaled up. A policeman, Mr. Sy, who aided the project, discussed the concept with residents in the surrounding areas and many people expressed interest in having their homes retrofitted as well. Both Mr. Sy and Chu Tam, the master carpenter, believed that the amphibious concept offers convenience in that residents no longer need to relocate during the duration of a flood. With amphibiation, people can remain in their community during the flood and preserve their economic living.

If amphibious housing is successful and becomes popular in the region, an entirely new entrepreneurial opportunity will become available for those already trained in retrofitting techniques, further supporting their economies. It is our hope that this strategy will establish a self-sustaining, bottom-up approach to technology transfer and will demonstrate that amphibious architecture is a viable flood mitigation and climate change adaptation solution that will increase community resilience in the Mekong Delta region.