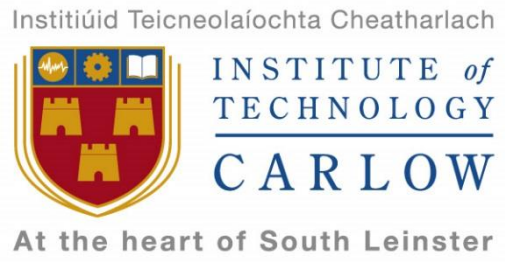

Enhancing Resilience within Vulnerable Communities Affected by Flooding

A Community Based Design Initiative for Open-Source User Centred Design

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Abstract

Global Warming is one of the largest challenges the world now faces. Validated by extreme weather patterns and re-occurring natural disasters, Climate Change threatens the world's population. Severe changes in climate causes rising sea levels, drought, floods, and storms etc. impacting communities physically, environmentally, socially and economically. With the occurrence of extreme events such as these, communities become vulnerable, disjointed and impaired.

Flooding is the most frequent natural disaster experienced by the Irish community. Over recent decades, Ireland has shown low capacity in anticipating, coping, resisting and recovering from flood events. This has resulted in the inundation of private property, commercial premises, agricultural land and transport routes. As a consequence, communities have been seriously affected with little or no protection from floodwater. The Irish community have displayed little compliance in introducing societal change and embracing community based initiatives, relying heavily on Governmental Bodies to implement flood defence measures. With a reduction in community engagement and a lack of adaptive resources, communities gradually become weaker and more exposed to the adverse effects of flooding.

This research has highlighted the need for increased alertness toward flooding and strengthened links between the affected community, responding professionals and responding community. The research aimed to define the elements necessary for increasing community vigilance and examined how these could be introduced into weakened community areas, focusing on the slow integration of knowledge, technology and skill transfer as a starting point for enhancing activity. This allows for shared experiences and gives communities the option for adopting successful initiatives. Further analysis highlights community complexity, the difficulty of introducing societal change and strengthening adaptive capacities.

The researcher utilized grounded theory to gain insight into how affected community members interact with flood events in collaboration with the Local County Council, The OPW, Local Authorities and the United Nation Framework Convention on Climate Change. Affected community members were involved throughout this study, participating in both interviews and field studies. This allowed participants to share local knowledge specific to the areas being examined, preparation measures taken for previous floods and their plans for newly anticipated flood events.

Key findings from initial enquiry stage conclude that; Communities are complex and comprised of economic, social, physical and institutional components. If an event such as a flood were to disrupt community networks, vulnerability is increased, and areas become more susceptible to damage. Another aspect to consider is that communities made up of different community culture, various existing groups, diverse attitudes and values, patterns of settlement etc., which makes it difficult to implement societal change. Increased knowledge, skill and technology transfer aims to provide communities with the tools required to implement change and slowly integrate adaptation methodologies and techniques for reducing flood related impacts.

To conclude, this investigation has highlighted that there is a major need for increased ability to endure flood events in Ireland. This research outlines how communities can be enhanced through the use of open-source product design supported by knowledge, skill and technology transfer, mending existing and forming new community links. A slow integration of initiatives aimed at alleviating the effects of flooding and adaptive measures, aims to strengthen community networks and boost engagement. The establishment of a flood sensor network supported by an online platform provides communities with an open-source, low-cost solution for allowing communities to prepare and respond better to flood related disasters.

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1.0 Introduction

1.1 Background Context

The original working title "Coastal Communities vs. Climate Change – a community-based design initiative for open-source, user-centred design solutions against severe weather conditions in waterside communities" provided the starting point for this research and framed the initial literature review. This research title was identified by DesignCORE and was validated by the Institute of Technology Carlow's Academic Council prior to commencement.

Research conducted prior to this investigation highlighted that providing preventative measures against flooding is more cost effective than dealing in a reactive way to extreme weather conditions that are predicted to become more frequent as time progresses. It was also emphasized that open-source software solutions have improved relief efforts and allow for the processing and collection of valuable information related to natural disasters.

It was proposed that an outcome with a social agenda will enhance flood awareness and promote engagement within communities. The objectives outlined prior to the researcher's engagement with this study suggest the following;

- To investigate and explore the possibilities of community-based, open-source product design in helping those people most affected by climate change in Ireland.
- To understand user and product design requirement of households and communities most vulnerable to the effects of climate change in Ireland.
- It was proposed that the research would be conducted in three stages, firstly 'enquiry', secondly 'exploration' and thirdly 'implementation'.
- The enquiry stage would include literature reviewing, field research and analysis whilst the implementation and testing stages would include practice-based research through design intervention, community engagement, testing and evaluation.

The initial research phase followed an explorative approach investigating both published and online information. This provided the researcher with an extensive body of knowledge required for guiding this study while also facilitating the literature review process.

Early findings from the literature review identified that in order to increase preparedness against flood events, links between responding professionals, responding community members and affected community members would need to be strengthened. Enhanced relationships between the three groups identified, aims to enable communities to increase flood resistance.

1.2 Gap in Existing Knowledge

It has been identified that open-source software solutions have proved to be effective for enhancing preventative measures related to natural disasters. Although open-source is common within the software industry, it remains elusive within product design. The development of an open-source, community-based, user-centred design initiative against flooding and other natural disasters has yet to be conducted in Ireland. It is hoped that the development of product solutions through open-source, user-centred design will be used to narrow the gap in existing knowledge and it is intended that this research study will be a unique contributor to this field. It is also envisaged that the outcome presents an opportunity for communities to establish and embrace the ability to endure the effects of natural disasters through a series of community-based initiatives.

2.0 Literature Review – Section 1

2.1 Introduction

The original working title "Waterside Communities vs. Climate Change – A community based design initiative for open-source, user centred design solutions against severe weather conditions on waterside communities", provided the researcher with the starting point from which an initial enquiry stage was conducted.

After primary investigation, through the exploration of available literature and field research, the researcher proposed the following research question:

'Investigation into the impacts of climate change suggests that re-occurring flood events make communities vulnerable to increased physical, social, economic and environmental damage.'

This literature review seeks to;

- Analyse existing data based on climate change and flooding, to investigate and explore the possibility of community-based, open source product design in helping people most affected by flooding in Ireland.
- Examine the impact of climate change issues and the effects on Irish climate and weather patterns.
- Gather data on how flooding has impacted communities, on a national level, to gain an insight into what community based initiatives have been implemented to deal with these issues and to highlight what strategies have been successful and, for those that were less successful, what lessons could be learnt to ensure that alternative strategies are investigated and proposed for the future.
- Investigate data relating to other communities across the world that are experiencing similar flood related issues, and provide the researcher with further insights into successful initiatives at global level.
- Identify the social, emotional and financial damages caused by flooding.

Global Warming, resulting in climate change, has become a critical issue for our planet and has contributed to significant changes in weather patterns globally. Over the last 200 years, concentrations of the main heat-trapping gases have increased dramatically. According to a report submitted by the Environmental Protection Agency, Ireland's greenhouse gas (GHG) emissions during 2015, resulted in a 3.7% increase as opposed to the previous year which showed a 0.3% decrease (EPA, 2016). Evidence form this report reveals that Ireland witnessed reduced economic activity resulting in low GHG emissions. Since 2016, Ireland has maintained its GHG outputs, represented in Figure 1, with the exceptions of 2012 and 2015. It is evident that we are currently exceeding our quota which falls in line with the growth of our economy and employment sectors, particularly transport. Emissions from transport alone saw a 5.5% increase from the Emissions Trading System (ETS) sector and a 3.0% increase from non-ETS emissions. (EPA, 2016).

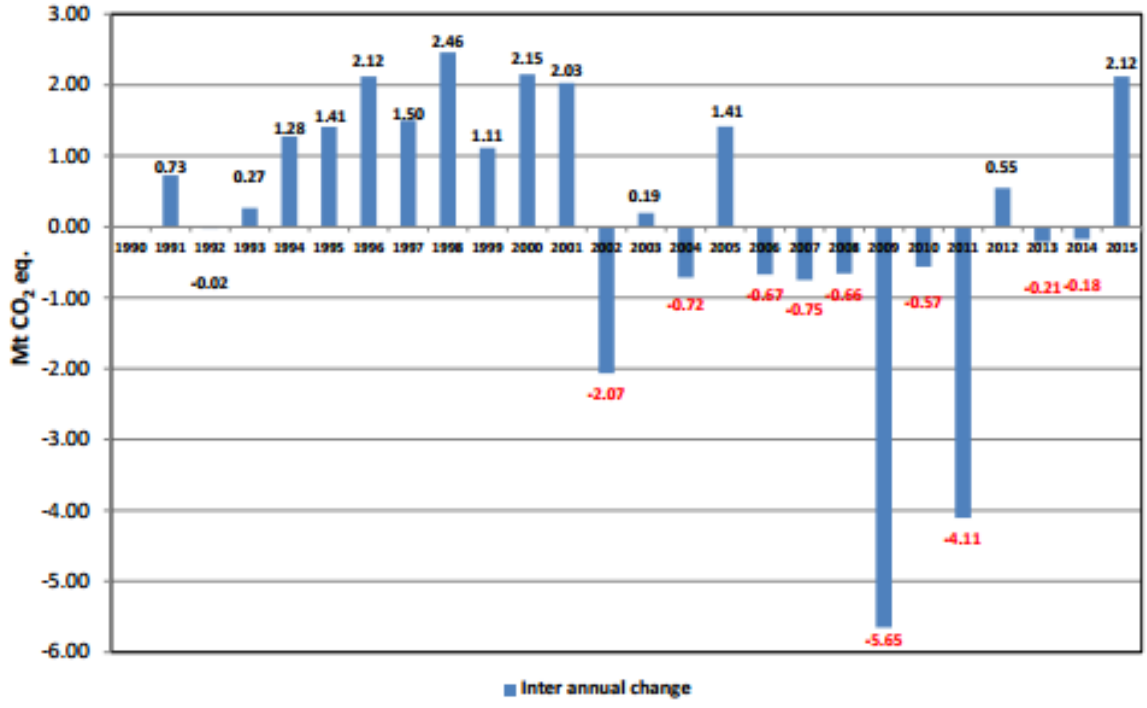


Figure 1. Inter annual changes in GHG emissions 1990-2015

Figure 1 Irelands GHG Emissions (EPA, 2016)

A report published by the Environmental Protection Agency in 2015, 'Ireland's Greenhouse Gas Emission Projections - 2014-2035', outlined a series of projections and estimations to demonstrate how climate change may impact on the Irish population. These projections offered valuable insights into both the best and worst case scenarios and with this data we are better placed to forecast or estimate the anticipated levels of Irish emissions in the immediate future.

The EPA report highlighted some important facts and had a significant role in the development and publication of the Climate Action and Low Carbon Development Bill that was published in the same year by The Department of Environment, Community and Local Government (2015). This Bill provides an outline of plans supporting relief efforts and preparation toward lower emission outputs. The Minister for Environment et al., published;

> *"An Act to provide for the approval of plans by the Government in relation to climate change for the purpose of pursuing the transition to a low carbon, climate resilient and environmentally sustainable economy;"* (Minister for Environment, 2015)

With the introduction of this bill Ireland can initiate and further enhance efforts in reducing emissions towards retaining current GHG emissions below the allocated quota.

Climate change in an issue that affects people all over the world. Extreme changes in weather patterns consist of heavy/prolonged precipitation, variations in temperature, severe storms, flooding and drought. In a book by Z. Zommers and A. Singh, the authors make reference to a report conducted in 2012 by The Intergovernmental Panel on Climate Change (IPCC). This indicates how extreme weather and climatic events can have large scale impacts on vulnerable people (Zommers & Singh, 2014).

> *"Extreme events will have greater impacts on sectors with closer links to climate, such as water, agriculture and food security, forestry, health, and tourism."* (IPCC, 2012).

Climate change significantly impacts people on a social, financial and emotional level, especially those who live in small isolated communities and do not have the capacity to prepare, resist, cope and recover from natural disasters. It is clear that climate change is not

just an issue for developing countries and has exhibited the vulnerability of towns and cities worldwide.

Much like climate change affects most countries, flooding too is an issue that has impacts across the globe. Flooding prompts conflicting issues on communities causing; damage to infrastructure, agriculture, economic loss, emotional strain etc. A combination of these issues results in weakened communities and have large implications for people who inhabit these areas. On a financial scale alone, the cost of preparing, coping with and recovering from a flood can be enormous. In a recent report by OECD (Organisation for Economic Co-Operation and Development), they emphasize that;

> *"Flooding is one of the most common, wide-reaching and destructive natural perils – causing average losses of USD 40 billion on an annual basis and increasing."* (Ministry of Labor, 2011).

This report validates how floods have resulted in huge economic losses and have become more frequent from around 1990 onwards, bringing the acceleration of climate change into perspective and highlighting the rapid increase over recent years.

2.2 Global Warming – Climate Change

Global warming, resulting in climate change, is one of the most severe challenges we currently face as a society, at a national and global level. Global warming is defined by the increase in planet temperatures that have ensued change in the world's climate. In a report conducted by The Royal Society focusing on the cause of accelerated climate temperatures over the past century much data has been evaluated. Research to date has shown that Green House Gases (GHG's) have made a major contribution to the rise in climate averages with Carbon Dioxide (CO_2) being the largest contributor.

> "*GREENHOUSE GASES such as carbon dioxide (CO_2) absorb heat (infrared radiation) emitted from Earth's surface. Increases in the atmospheric concentrations of these gases cause Earth to warm by trapping more of this heat."* (Wolff et al., 2014)

According to Ingvaldsen & Gulla (2015), World Meteorological Organization (WMO) – A summary of current climate change findings and figures, GHG's constitute less than one percent of the earth's atmosphere. Combined they form a blanket and cause the earth to become warmer than it would usually be. Furthermore, GHG levels reached a reported high in 2011 with the average global temperature over the 20th century, reported to have risen by approximately 0.6℃ (1.1°F).

Evidently, GHG's are the main driver behind climate change. In order to slow down the damages caused, we need to significantly reduce our GHG emissions across the globe at individual and community levels. Many countries have already become more sustainable through the use of renewable energies (solar, geothermal, wind, hydroelectric energy), reducing car use, reforestation etc. The challenge now is to prompt countries, who have not implemented flood relief strategies, to adopt these or similar approaches to lessen GHG outputs.

2.2.1 Contributors to Climate Change

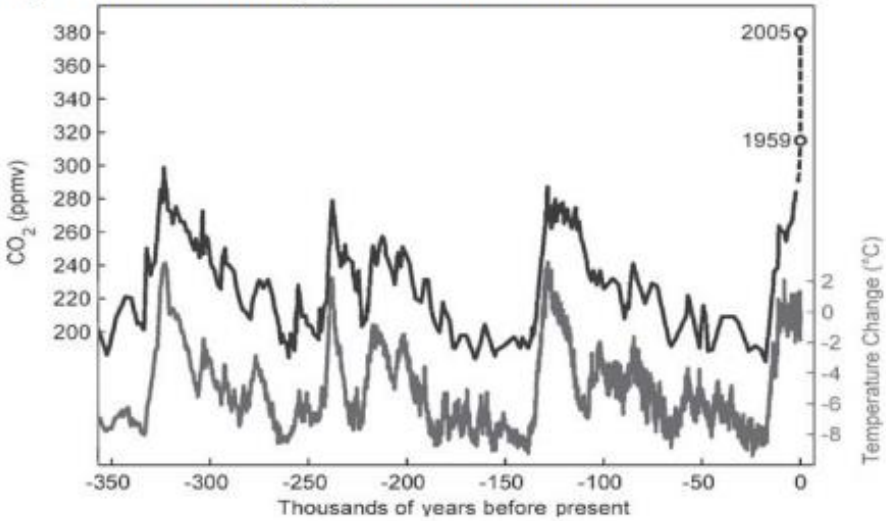
Numerous studies have provided evidence to demonstrate that human activity has been the largest contributor to Climate change. With emphasis on the burning of fossil fuels which are reported to *"—have increased atmospheric CO_2 concentrations by about 40%, with more than half the increase occurring since 1970."* (Wolff et al., 2014). This view is supported by the IPCC 2014 climate change synthesis report, stating that;

> *"Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. The period from 1983 to 2012 was likely the warmest 30-year period of the last 1400 years in the Northern Hemisphere, where such assessment is possible"* (IPCC, 2014).

Several studies have acknowledged that human activity has largely affected the acceleration of climate change, however, it is true that natural processes have also made an impact, but to a lesser extent. The evidence that human activity is having the greatest effect on our climate is supported by Mr. Stefan Rahmstorf, a German oceanographer and climatologist. In a publication by Rahmstorf (2005), he explains that for at least 650,000 years, carbon dioxide levels in the atmosphere were never as high as they are at present. This can be

validated by reports of increasing industrial activity, particularly in developed countries. Evidence of the sudden rise in CO_2 levels can be seen in Figure 2 below. In a report on estimating global impacts from climate change, carried out by S.Hitz, J.Smith et al. (2004), nine sectors are examined that are expected to suffer from global warming. The conclusion is that they are confident that the damages caused tend to be adverse and increasing.

Figure 3-1. *Climate History of the Past 350,000 Years*[a]



Source: J. R. Petit and others, "Climate and Atmospheric History of the Past 420,000 Years from the Vostok Ice Core, Antarctica," *Nature* 399 (June 1999): 429–36.

a. Based on Vostok ice core in Antarctica. These ice core data end before the onset of anthropogenic changes. Anthropogenic emissions have now increased the CO_2 concentration to 380 ppm (as of 2005).

Figure 2 Climate History (Stefan, 2005)

In light of this information, it raises the question of, how did the world allow atmospheric concentrations of greenhouse gases increase to levels that have resulted in the acceleration of global warming and reoccurring natural disasters, when we have been aware of this issue for decades? Perhaps the earth is unable to withstand the rapid advancements of our industrialised society and now we are only coming to terms with the consequences of not protecting our planet.

2.2.2 Climate Change Impacts

Data derived from several studies has identified that as a result of global warming, we are now experiencing more extreme weather patterns resulting in more frequent natural disasters.

> *"The increase in the number of reported natural disasters in 2015, was mostly due to a higher number of climatological disasters: 45 compared with the 2005-2014 annual average of 32, an increase of 41%."* (Guha-sapir, Hoyois, & Below, 2015).

Natural disasters are classified as extreme and usually sudden events that cause physical, economic, environmental, social implications, and in some cases, loss of life. A substantial amount of evidence has been published on how natural disasters such as storms, floods, droughts etc. have previously impacted and are predicted to impact people across the globe. In a report IMPACTS OF NATURAL DISASTERS ON ENVIRONMENTAL AND SOCIO - ECONOMIC SYSTEMS: WHAT MAKES THE DIFFERENCE? ', by Mata-lima et al., it states that;

> *"In the last two decades, many studies have consistently presented forecasts and demonstrations of an increase in the frequency and intensity of natural disasters (e.g. hurricanes, floods, droughts and associated forest fires, earthquakes, tornadoes, among others) …"* (Mata-lima et al., 2013)

In light of this statement it is accurate to say that natural disasters are becoming more of threat to people worldwide leaving vulnerable communities devastated by their impacts.

Much of the recent literature has revealed that people inhabiting low-income countries, who contribute the least to our overall global emissions, are most exposed to its effects. This suggests that the more economically developed countries need to make significant changes to reduce their GHG outputs in order to reduce the acceleration of climate change in order to aid people residing in both developed and developing countries.

2.3 Climate Change effects in Ireland

The effects of climate change have become more and more apparent in Ireland over recent years. The latter months of 2015 and early 2016, saw many parts of the country devastated by heavy rainfall resulting in extensive flooding. As a nation, it is indisputable that we are highly vulnerable to the effects of flooding and that the majority of communities within Ireland do not have the capacity to anticipate, cope, resist and recover from such intense rainfall patterns.

> *"Effective actions are needed to reduce vulnerabilities to the negative impacts, take advantages of opportunities that may arise and increase social, economic and environmental resilience."* (Peptides, 2016).

In addition, community capacities need to be strengthened throughout. Improvements in knowledge transfer through information, communication, adaptation and alleviation technologies will enhance community engagement, resulting in communities more prepared for withstanding the effects of flooding.

In a report published by the Environmental Protection Agency (EPA), Ensemble of Regional Climate Model Projections for Ireland, it outlines how global climate change is anticipated to affect Ireland's mid-21st-century climate. The report focuses on providing an outline of expected temperature, rainfall, storm track, mean sea level and wind energy projections.

The report concludes that by the middle of this century;

- Mean annual temperatures will increase by 1–1.6°C, with the largest increases seen in the east of the country.
- Hot days will get warmer by 0.7–2.6°C compared with the baseline period.
- Cold nights will get warmer by 1.1–3.1°C.
- Averaged over the whole country, the number of frost days is projected to decrease by over 50%.
- The average length of the growing season will increase by over 35 days per year.
- Significant decreases in rainfall during the spring and summer months are likely.

- Heavy rainfall events will increase in winter and autumn.

- The energy content of the wind is projected to decrease during spring, summer and autumn. The projected decreases are largest for summer, with values ranging from 3% to 15%.

- Storms affecting Ireland will decrease in frequency, but increase in intensity, with increased risk of damage. (Nolan, 2015)

Many of the changes outlined above have already begun to appear with Ireland recently experiencing extensive and widespread rainfall which led to the flooding of many commercial and residential properties along with the inundation of agricultural land. A combination of heavy periods of rainfall and the occurrence of six storms, impacted the harsh weather patterns Ireland experienced during the winter months of 2015/2016. An evaluation of this extreme flood event highlighted just how unprepared Ireland is, to deal with the deluge endured during this period. There is a clear need for the reassessment of solutions currently in place for dealing with severe weather conditions and we need to implement new strategies for anticipating, coping, resisting and recovering from the effects of these newly intensified weather patterns.

2.3.1 Agricultural Impacts

Climate change and particularly flooding has had devastating impacts on the Irish community. Research has revealed that climate change greatly affects the Irish population environmentally, agriculturally, socially, economically and physically. The agricultural sector in Ireland produces a far bigger return than any other traded sectors. There are approximately 167,500 people employed in the agri-food sector, and is our most important indigenous manufacturing sector.

A report from Teagasc, *The impact of climate change on Irish farming,* Dr.Thia Hennesy (2010) expresses the threats and opportunities associated with the changing climate and how it is predicted to affect farming in Ireland. This report is primarily based around the economic benefits of increased temperatures on agriculture, however, the report does not outline the importance of reducing our GHG outputs in the fight to mitigate climate change.

It has been conclusively shown that the growth of grass in particular is an asset to livestock farmers, resulting in larger quantities of fodder for their herds and a reduced need for manufactured agricultural feeds. In light of this, it is possible that livestock farming may significantly increase with the huge economic gain associated with the cattle rearing industry. Previous studies have revealed that, *"The livestock sector contributes between 25 and 40 per cent of all anthropogenic methane emissions – the biggest single source."* (Grasslands, 2005), this suggests that a rise in livestock populations could increase Ireland's production of GHG's.

In another report carried out in The Irish Climate Analysis and Research Units (ICARUS), NUIM, it is highlighted that the acceleration of global warming will have adverse effects on tillage farming and has the potential to impact negatively;

> *"…in relation to pests and diseases, crop yields, flooding, plant and animal stress factors, drought effects and the ability to provide sufficient resources for animals during extreme events"* (Flood, 2013).

Flood concludes that all aspects related to climate change should be carefully considered and we need to plan accordingly. Some of the methods for adaptation recommended in this report include;

> *"increasing crop diversity and varieties, altering planting and harvest dates, planning for and implementing water supply management strategies, and supporting research that focuses on identifying crops that can grow more successfully in the next 10 or 20 years, taking into account the expected continuing changes in climate and growing seasons."* (Flood, 2013).

To conclude, climate change is expected to have both positive and negative effects on the Irish agricultural industry. This information provided in these reports is of great value with the provision of knowledge on improved methods for adaptation in relation to agriculture. However, both authors offer very little information emphasising methods for delaying advancements in global warming, alternatively highlighting that livestock farming could prosper. Advancement in this area could result in increased production of methane, boosting Ireland's GHG emission outputs and assisting in the acceleration of climate change.

2.3.2 Social Impacts on Ireland

There is little information published on the societal issues associated with climate change in Ireland, particularly in relation to flooding and its impacts on communities. Based on news articles and various reports, flood related events impact negatively on several aspects of human life "*Climate change affects human health, livelihoods, safety, and society"* (Global Humanitarian Forum, 2009), with some cases being more severe than others depending on an areas environment, societal issues, financial position etc. It is clear that Ireland needs to strengthen its capacity for reducing the issues associated with flood events.

The flooding that occurred during the winter of 2015 and early 2016 has triggered some much-needed action, in the hope of increasing preparation for the future. In the recent, OPW RESPONSE TO THE WINTER 2015/2016 FLOODING IN IRELAND, written by Oliver Nicholson and Dr. Fasil Gebre, they evaluate the response from The Office of Public Works (OPW) during the last major flood events. This report describes the intensity of the floods and outlines work carried out by the OPW in collaboration with various national and international Governmental Bodies. The key findings from this report conclude that;

- *On 5 January 2016, the government decided to establish a National Flood Forecasting and Warning Service. This decision has provided the opportunity to proceed with a first stage of implementation of the service that will involve the following elements:*
- *Establishment of a National Flood Forecasting Service as a new operational unit within Met Éireann, and*
- *Establishment of an independent Oversight Unit within the Office of Public Works (OPW).* (Nicholson & Gebre, 2016)

They also draw attention to the evidence that many places were not capable of anticipating these extreme weather conditions and one of their principal means of receiving important data was through the European Flood Awareness System (EFAS). Even though EFAS is a very useful tool for publicising the potential of a flood, there is a need for "*more accurate and site specific flood forecasts"* (Nicholson & Gebre, 2016)

2.4 Flooding

Over the past 50 years the world has witnessed an increase in extreme weather conditions such as drought, storms, flash floods etc. There are records of events of similar severity in history, however they have become more and more frequent in recent years.

In a recent report by the United Nations, it is revealed that flooding is the most common natural disaster experienced worldwide. It is estimated that 2.3 billion people have been affected by flood related events from the year 1995 to 2015.

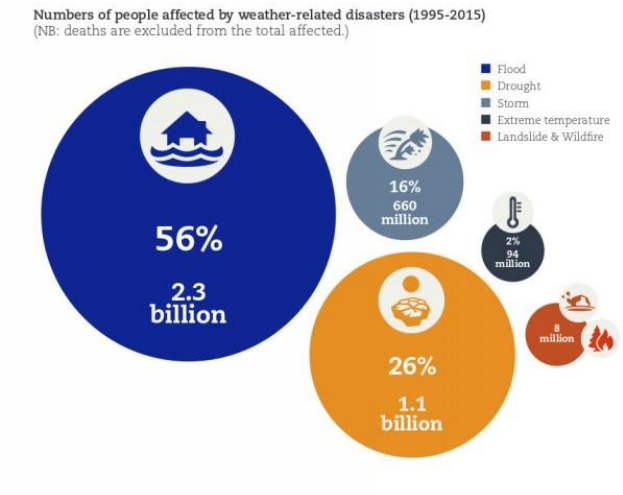


Figure 3 Number of people affected by weather related disasters (1995-2015) Source: (UNISDR)

The focus area for this research project is flooding, the impact of floods on communities, how community resistance can be increased and the design and implementation of effective solutions and systems for communities that are identified as being less prepared for flood events. In a recent publication produced by the UN (United Nations), "The Human Cost of Weather Related Disasters", it states that;

> *"Since 1995, floods have accounted for 47% of all weather-related disasters, affecting 2.3 billion people. The number of floods per year rose to an average of 171 in the period 2005-2014, up from an annual average of 127 in the previous decade."*
> (Center for Research on the Epidemiology of Disasters (CRED) & The United Nations Office for Disaster Risk Reduction (UNISDR), 2015)

In the same report an example is provided, showcasing the increase in the number of people affected by floods in South America in the two periods between 1995-2004 and 2005-2014. In the first decade 560,000 people were affected on average each year, the second decade shows a serious increase to 2.2 million people, nearly four times larger than the statistics for the previous decade.

This is a massive and rapid increase over a short period of time and proves that flooding is becoming more of an issue across the globe. To address this effectively, countries need solutions tailored to suit their own needs and their nation's capacity.

FloodList, an online forum that provides information to people worldwide concerning floods, issued an article based on a report published by The European Environment Agency (EEA). This report, 'Floodplain Management: reducing flood risks and restoring healthy ecosystems', by the EEA has outlined how flooding is anticipated to continue accelerating over the coming years.

> *"Annual flood losses can be expected to increase fivefold by 2050 and up to 17 -fold by 2080. The major share of this increase (70–90%) is estimated to be attributable to socio -economic development as the economic value of the assets in floodplains increases, and the remainder (10–30%) to climate change."* (Vanneuville & Environment, 2016)

While climate change is considered the main contributor to the cause of extreme weather patterns, there are other factors such as urbanization, human interference with waterways, social and economic development etc. all of which play a part in the impact a natural disaster has on our society.

Previously, frequent flooding has occurred in many areas in Ireland, however, few methods for prevention or protection have been implemented since. Bandon is just one example of an area that had been flooded before but were unprepared for the extreme weather events that took place during the end of 2015 and early 2016;

> *"Despite the provision of sandbags and the overnight work of the fire brigade pumping thousands of gallons of water off the streets, businesses were flooded. With no insurance, damage to property and loss of trading, retailers on South Main St*

> *were counting the substantial cost of the second major flood in six years."* (Examiner, 2015)

Another major issue for the country is the poor planning decisions and permission that had been granted for building residential and commercial properties on areas that had been marked as floodplains. In a report from The Irish Times, published on the 16th of December 2016, Chairman of the Oireachtas Joint Committee Michael McCarthy spoke about property and flood insurance after the launch of the Oireachtas Report on Flooding and Property Insurance 2015, at Leinster House, Dublin.

> *"Asked about homes built in floodplains Mr McCarthy said the report was in favour of a complete ban on development in these areas. But he said the recurring problem of flooding across the country was having a devastating impact on those already in high-risk areas."* (O'Brien, 2015)

As a result, the Government are beginning to consider a ban on building in the areas subjected to floods, however, many residents who were granted permission to build in the past, currently own properties on or near floodplains. These affected community members have very few options left to protect and preserve their homes and businesses as the issue of flooding worsens.

The country now looks to the Government to implement strategies and flood defences to reduce the impact of severe flooding and lessen the extent of the damage caused.

Since the last major flood, the OPW have assessed some of the worst affected areas in the country and have made plans to erect hard defences to minimise risk. The majority of these flood relief schemes could take up to 5 years to complete depending on how long it takes to carry out the five stages of the flood relief scheme. These five stages include:

Stage 1: Feasibility & Preferred Option Selection

Stage 2: Environmental Assessment & Planning

Stage 3: Detailed design, tender process & award of construction contract

Stage 4 & 5: Construction & Handover (Cork County Council, 2014)

With such a long process to construct these flood defences, and with many of these being unable to reach all persons affected, it leaves community members, usually inhabiting rural areas, exposed to the effects of a flood disaster. This information has highlighted that there is an opportunity for an advancement in community awareness and a chance for people to develop their own strategies for protecting themselves and other affected communities within Ireland.

2.5 Adaptation – Section 2

Adaptation to the acceleration of our changing weather patterns is vital in the fight against climate change. Adaptation is defined as;

> *"The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects."* (Mach, Planton, & von Stechow, 2014)

Adaptation Technologies refer to new methods of carrying out certain activities in response to global warming and extreme weather conditions. These technologies are used in order to;

> *"reduce the negative effects of climate change (or exploit the positive ones) by making the appropriate adjustments and changes."*(UNFCCC, 2007).

The UNFCCC implement adaptation action through National Adaptation Plans (NAPs) and National Adaptation Programmes of Action (NAPAs). Adaptation Technologies are crucial in assisting countries inadequately prepared for the effects of global warming. These include activities such as farming, fishing, irrigation, water purification, sea defences etc.

As a result of our increased global temperature, it is important that vulnerability is reduced and that proper adaptation measures are introduced. The United Nations Framework Convention on Climate Change (UNFCCC) was established in 1994 and now has 191 member countries. The aim of the UNFCCC is to provide the basis for united action on an international level to mitigate climate change and improve adaptive capacities. (UNFCCC, 2007). The Organisation for Economic Co-operation and Development (OECD) report, 'adaptation to climate change: Key Terms (2006)', distinguishes several different types of adaptation; Anticipatory, Autonomous, Planned, Private, Public and Reactive.

- Anticipatory Adaptation—Adaptation that takes place before impacts of climate change are observed. Also referred to as proactive adaptation.
- Autonomous Adaptation—Adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural

systems and by market or welfare changes in human systems. Also referred to as spontaneous adaptation.

- Planned Adaptation—Adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, maintain, or achieve a desired state.
- Private Adaptation—Adaptation that is initiated and implemented by individuals, households or private companies. Private adaptation is usually in the adaptor's rational self-interest.
- Public Adaptation—Adaptation that is initiated and implemented by governments at all levels. Public adaptation is usually directed at collective needs.
- Reactive Adaptation—Adaptation that takes place after impacts of climate change have been observed. (Levina & Tirpak, 2006)

Many countries at national and international levels have already began to adopt adaptation policies, however, studies on post development approaches to climate change adaptation have revealed that community efforts at local level rarely have impact externally. The aim of this post development perspective is to evaluate how local actions can aid communities globally. (Philip & Katharine, 2013)

Philip et al., provide a strong proposal for aiding adaptation on a global scale using the success of local initiatives which can also be extremely beneficial for communities at national levels.

In the Climate Change Research Programme (CCRP) 2007-2013, Report Series No.9 by the EPA (2013), it is highlighted that in order to aid planning for climate change effects, accurate information is required on anticipated impacts, capacity for adaptation, vulnerable communities, economic implications and options for adaptation. These methods could allow Irish governmental and non-governmental bodies to assess the vulnerability of communities nationwide and adjust plans accordingly to their specific needs. This approach is crucial in minimising the effects of unstable weather patterns and the;

> *"assessment of Ireland's adaptive capacity adds an important dimension to understanding how to plan for adaptation."* (Shine & Desmond, 2013)

Assessment of community capacity to adapt to climate change will help target areas within Ireland that are most vulnerable. It acts as the groundwork for informing decision makers on methods most appropriate for increasing community vigilance.

2.6 Knowledge and Skill Transfer

Knowledge transfer (KT) consists of the transmission of influential data from one entity to another. This provides people with targeted information on specific issues and various methods on how similar areas have adjusted to the effects of natural disasters. It allows other countries to adopt these ideas and tailor them to their own community.

> *"This knowledge transfer is needed to address issues like compatibility of spatial and temporal scales, multidisciplinary and integrated approaches, language used by researchers and users of study results, treatment and integration of uncertainties, etc."* (Vescovi, Bourque, Simonet, & Musy, 2007)

The transfer of knowledge is already being carried out within a variety of national and international organisations such as the United Nations Volunteers (UNV) who are constantly trying to increase information sharing to help improve their voluntary actions. Knowledge transfer can be achieved on different scales, for example, between community members in small localised areas or between developed and developing countries. Vescovi et al. (2007) stresses that effective communication and knowledge transfer between researchers and decision makers will be an essential element to ensuring that the correct action is taken.

User-driven knowledge transfer is fundamental in obtaining valuable data related to efforts for reducing the effects of flooding from people in localised areas. This can be shared with other community groups that are affected by similar issues.

Similar to KT, Skill Transfer (ST) offers solutions to areas of low capacity. Skill Transfer can be defined by acquiring skills that can be adapted to new situations and transferred between populations. Skill Transfer is an important tool in reinforcing adaptation and is of great benefit to areas that are less equipped for tackling disaster related issues.

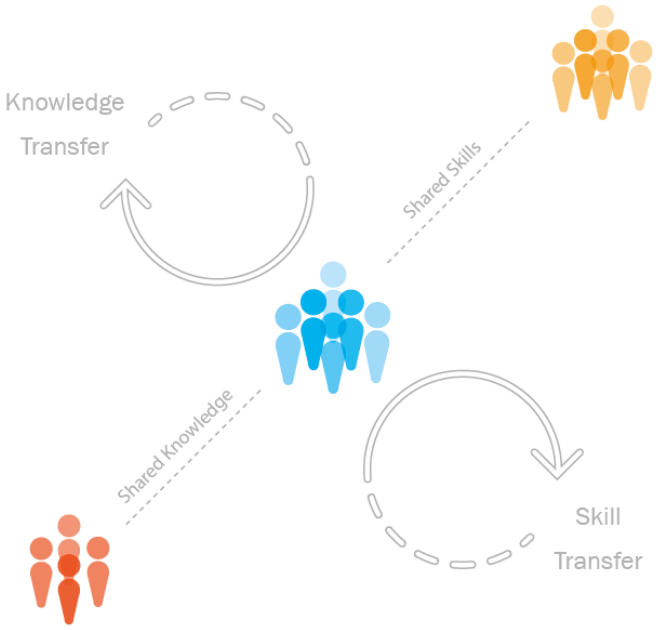


Figure 4 Knowledge and Skill Transfer – Source: (Self-generated)

Information from primary sources, such as active community members, can be a large asset to policy/decision makers. Community members are experts in their area with direct knowledge on flood related events that affect their own communities. The transfer of relevant knowledge and skills is key for communities affected by flooding. It allows for the sharing of information and techniques resulting in enhanced preparation and alleviation methods associated with predicted and unpredicted weather events.

2.6.1 Technology Transfer

Much like knowledge and skill transfer, technology transfer fulfils a similar objective by transferring technology from one entity to another. While Technology Transfer (TT) has many definitions, the Intergovernmental Panel on Climate Change (IPCC) defines knowledge transfer as;

> *"…a broad set of processes covering the flows of know-how, experience and equipment for mitigating and adapting to climate change amongst different*

stakeholders such as governments, private sector entities, financial institutions, non-governmental organizations (NGOs) and research/education institutions" (Fox, 2002).

Furthermore the IPCC use the term "transfer" in a broad sense, encompassing the dispersal of technologies and technology co-operation between and within countries. Technology information is an important link to technology transfer. It comprises of;

> *"…hardware, software and networking, to facilitate the flow of information between the different stakeholders to enhance the development and transfer of technologie*s."(Nations United Framework Convention Climate Change, 2007).

Both these components are fundamental to ensure a clear understanding, use and replication of technology as well as the capacity to choose appropriate technologies and adapt them to local conditions. The UNFCCC launched TT: CLEAR, the technology transfer information clearing house, in September 2001. TT: CLEAR operates as a gateway for information on technology transfer issues at global level.

To date, there is very little published work on the benefits of Technology Transfer in relation to climate change in Ireland. The availability of information on adaptation and mitigation technologies would have huge benefits for vulnerable communities across the country. The OPW highlight the European Flood Awareness System (EFAS) as a means for people at local levels to obtain important data on flooding, however, Ireland has no specific platform where individuals can gather information on all aspects of adaptation, alleviation, knowledge, skill and technology transfer, mechanisms to anticipate, cope, resist and recover etc. tailored specific to communities nationally. (Nicholson & Gebre, 2016)

2.7 Social Vulnerability

According to Singh et al., (2014) the characteristics that define vulnerability consist of *"… a person or group and their situation that influence their capacity to anticipate, to cope with, resist and recover from the impact of a natural hazard."* Vulnerability can be measured in terms of physical, social, environmental and economic factors or processes along with factors that enhance social vulnerability. (Singh et al., 2014). Oliver Smith states;

> *"Like few other phenomena the internal complexity of disasters forces us to confront the many and shifting faces of socially constructed reality (ies). The complexity is embodied in the multiplicity of perspectives as varied as the individuals and groups impacted or participating in the event and process"* (Oliver-Smith, 1999).

Smith highlights that social vulnerability is tailored to specific populations and is determined by a variety of participant's mind-sets and views along with various other factors. In a report by the International Journal of Interdisciplinary and Multidisciplinary Studies – The Concept of Social Vulnerability: A Review from Disasters Perspectives (Singh et al., 2014), underlines that disaster is perceived as being a collaboration of two conflicting issues, these being natural hazards and a vulnerable society. Disasters have huge impacts globally, and those who are ill-prepared and do not possess the capacity to withstand major flood events, fail to combat these issues effectively.

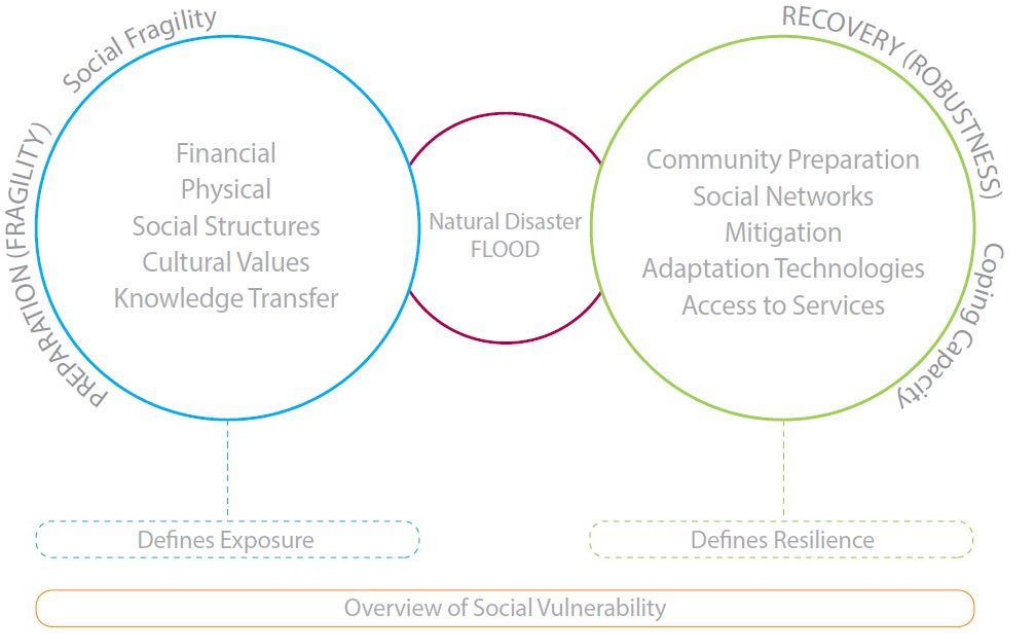


Figure 5 Mapping Social Vulnerability – Source (Self-generated)

In a report carried out within the United Nations University, Dr. Ingenieur assesses the Social Vulnerability for River-Floods in Germany. In his introduction he outlines the importance of mapping social vulnerability as a valuable tool;

> *"The assessment of social vulnerability unveils hidden weaknesses and strengths of the human society towards a certain stressor or hazard."* (Fekete, 2009)

Some advancements have been made in relation to mapping in Ireland. CFRAM have recently developed an online interactive map, to aid preparation for flood risk assessment. These detailed sources of information need to be combined to give a greater understanding, at local level, of the repercussions of the occurrence of a natural disaster on an overall social scale with the potential of being used to assess future trends.

2.8 Social and Behaviour Change Communication

During the early stages of this research project, through the study of relevant literature and engagement with community members affected by flooding, the researcher has become aware of some behavioural obstacles that need to be overcome to ensure that the outcome of this research is of benefit to the Irish community. Social and Behaviour Change Communication (SBCC);

> "*…is the use of communication to change behaviours, including service utilization, by positively influencing knowledge, attitudes and social norms. More than just an advertisement or website, SBCC coordinates messaging across a variety of communication channels to reach multiple levels of society…"* (The Health Communication Capacity Collaborative HC3, 2016)

In an increasing material world, we have become consumers in regards to all aspects of life. The possibility of convincing individuals or groups of people to invest in something that they cannot see immediate or long-term benefits from is, therefore, very small. With the development of the UNFCCC's redesigned website TT: CLEAR, one of the most critical elements included was the addition of success stories. These success stories include natural disaster reduction and adaptation efforts achieved by countries worldwide. The incorporation of these aims to allow practitioners and private sector users to familiarise themselves with procedures that have been successfully undertaken by countries that suffer from climatic issues.

This example illustrates how similar activities can be carried out for those areas who are vulnerable to the effects of climate change. Success stories act as a benefit statement for those in search of ways to improve their efforts toward delaying the effects of global warming. For Ireland a similar approach must be taken in order to motivate members of the community to invest in assisting themselves and their community.

2.9 Community Resilience

The primary objective of this research study is to inspire communities and increase resistance against the effects of flooding. Community resilience has no commonly accepted definition, however, for this study the researcher focused on community social resilience.

The International Federation of Red Cross and Red Crescent Societies defines resilience as;

> *"the ability of individuals, communities, organizations or countries exposed to disasters, crises and underlying vulnerabilities to anticipate, prepare for, reduce the impact of, cope with and recover from the effects of shocks and stresses without compromising their long-term prospects."* (IFRC, 2014)

When an event such as a flood strikes a community, it can cause great strain and, in time, leads to increased exposure and vulnerability in the future.

> "*A local community is considered as a complex adaptive system, composed of closely linked social, economic, physical and institutional components. In case of disruption, the interrelationship between the components makes the local community vulnerable for cascade effects that can seriously affect its functioning."* (Ivanis, Babić, & Komazec, 2016).

This view is backed up by Norris et al., (2008), expressing that that community resilience cannot be *"measured or monitored simply".*

A recent publication on Enhancing Community Resilience (2016), has provided the researcher with significant insight on theories associated with adaptive systems and ways of enhancing the ability to endure certain strains. The document highlights how a community is a complex system, comprised of linked components such as society, economy, physical

characteristics and institutions. One of the most important key points to take from this publication is the importance of bridging the collaborative gap *"…between the affected community, the responding community and the responding professionals."* (Ivanis et al., 2016). In response to these findings COBACORE, a collaborative research project for Community Based Comprehensive Recovery, was set up and funded by the European Commission with partners in Holland, the UK, Germany, Ireland, Spain and Slovakia. The project seeks to assist communities during post-crisis recovery periods and aims to close or reduce any collaboration gaps between stakeholders within and beyond the affected community (See Figure 6). COBACORE is a valuable and effective tool for enhancing community vigilance, however, anticipatory, endurance and prevention methods also need to be taken into consideration.

Figure 6 COBACORE - Approach for disaster recovery - Source (COBACORE, 2017)

In a paper on 'Community Resilience as a Metaphor, Theory, Set of Capacities and Strategy for Disaster Readiness' (Norris et al., 2008), a variation of components that influence a community's adaptive capacities are examined. Key findings from this paper conclude that community wellbeing and endurance materialises from a range of diversified adaptation capacities i.e. *"robustness, redundancy, and rapidity."* (Norris et al., 2008). Secondly, if communities are to make improvements regarding awareness, then it is important that they work together as a unit, engaging decision makers with local people and creating new links and stronger relationships to enhance and preserve naturally occurring social support systems. The third key point emphasises 'place attachment' as a stimulus. This is the driving force behind many community based initiatives comprised of individuals that live in communities who feel a strong attachment to their area. This increases the likelihood of the community to rebound and recover from issues that threaten their vulnerability.

To conclude, communities are complex, which often makes it difficult to encourage societal change. However, data from several studies outline various methods of tackling these obstacles, many of which focus on bridging gaps between community members, responding community members (volunteers) and responding professional community (governing bodies, local authorities etc.), which can significantly reduce vulnerability.

2.10 Open Source

The research brief outlines that the outcome of this study is to provide a community-based design initiative for open-source, used centred design. Currently there is a large body of literature published on open-source software (OSS) design and open-source technology, however, little information has been published on open-source product design. According to opensource.com;

> *"The term "open source" refers to something people can modify and share because its design is publicly accessible"* and open-source software is *"Open source software is software with source code that anyone can inspect, modify, and enhance."* (RedHat, 2016).

Essentially, open-source in relation to user-centred design describes an artefact, or range of artefacts, that are available for the consumer to modify its use to suit a variety of needs. For example, rubber bands have the primary function of holding multiple items together, however they now have several uses like; hanging objects, a hair band, an eraser, an electrical insulator etc.

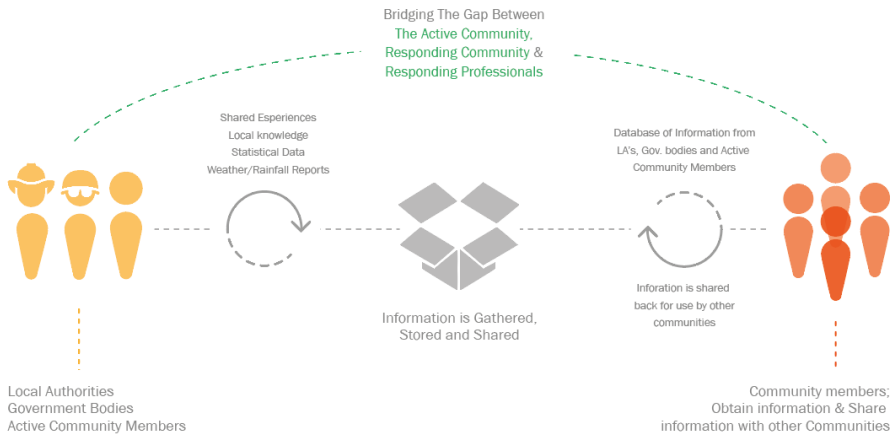


Figure 7 Bridging the Gap between Information and Community Members – Source: (Self-generated)

The objective of this research is to increase community resilience through a community based initiative linked to a product or range of products that can aid communities vulnerable to flood related events. To achieve this through product design, User Experience (UX) and User Interface (UI) were explored to gain a greater understanding how people interact with open-source technology and products available at present.

In the report, Innovation by User Communities – Learning from Open-Source Software, Eric von Hippel compares two methods of distributing user innovations. He states that;

> *"For information products, general distribution within and beyond the user community is carried out by the community itself – no manufacturer is required. For physical products, general distribution typically requires manufacturers."* (Hippel, 2001).

He argues that open-source software is more advantageous because it can be distributed for free as it is just information, whereas the production of a physical product requires economies of scale. In light of his argument, it is true that OSS is an efficient tool and requires less processes than that of a physical artefact, however, research findings suggested that a combination of the two could provide a more integrated a more advantageous solution.

2.11 User Experience (UX)

User Experience (UX) is represented as being;

> *"Every aspect of the user's interaction with a product, service, or company that make up the user's perceptions of the whole. User experience design as a discipline is concerned with all the elements that together make up that interface, including layout, visual design, text, brand, sound, and interaction. UE works to coordinate these elements to allow for the best possible interaction by users."* (Usability Professionals Association, 2010)

UX is linked to almost every aspect of our daily lives, especially in relation to products and services. Open-Source Software (OSS) is a tool that is widely available to users where they

can inspect, modify and enhance this operating system, therefore it needs to be user-friendly and have a well-designed User Interface (UI). When designing a physical product for human use, the designer must consider the enhancement of user satisfaction throughout.

UX is a crucial element in human to product interaction but can also benefit human to human communication, by enhanced information sharing and product usability through the transfer of data using OSS. In a report on the use of social media as an information source for rapid flood inundation mapping, the advantages of using social media in gathering qualitative information, and the benefits of retrieving primary data on flood related issues are outlined.

> *"…social media as an information source for rapid inundation mapping provide the opportunity to close the information gap when traditional data sources are lacking or are sparse."* (Fohringer, Dransch, Kreibich, & Schroter, 2015)

To conclude, OSS greatly serves the enhancement of knowledge transfer. The aim of this research project is to combine Open Source Software and Product Design, both of which will incorporate User Experience and User Interface to allow individuals and groups to operate these products easily. A combination of methods for improving flood resistance will aid shared knowledge and skills between communities with the aim of increasing community engagement and, in turn, result in strengthened capacities.

2.12 Conclusion – Expected Impacts

Throughout this literature review a foundation of knowledge was gathered on areas related to global warming which provided insight into three key areas; Global Warming, Natural Disaster Impacts on Communities and Community Resilience. Information was then collected on factors that impact these three key areas, such as; Knowledge and Skill Transfer, Social Vulnerability, Open Source Technology.

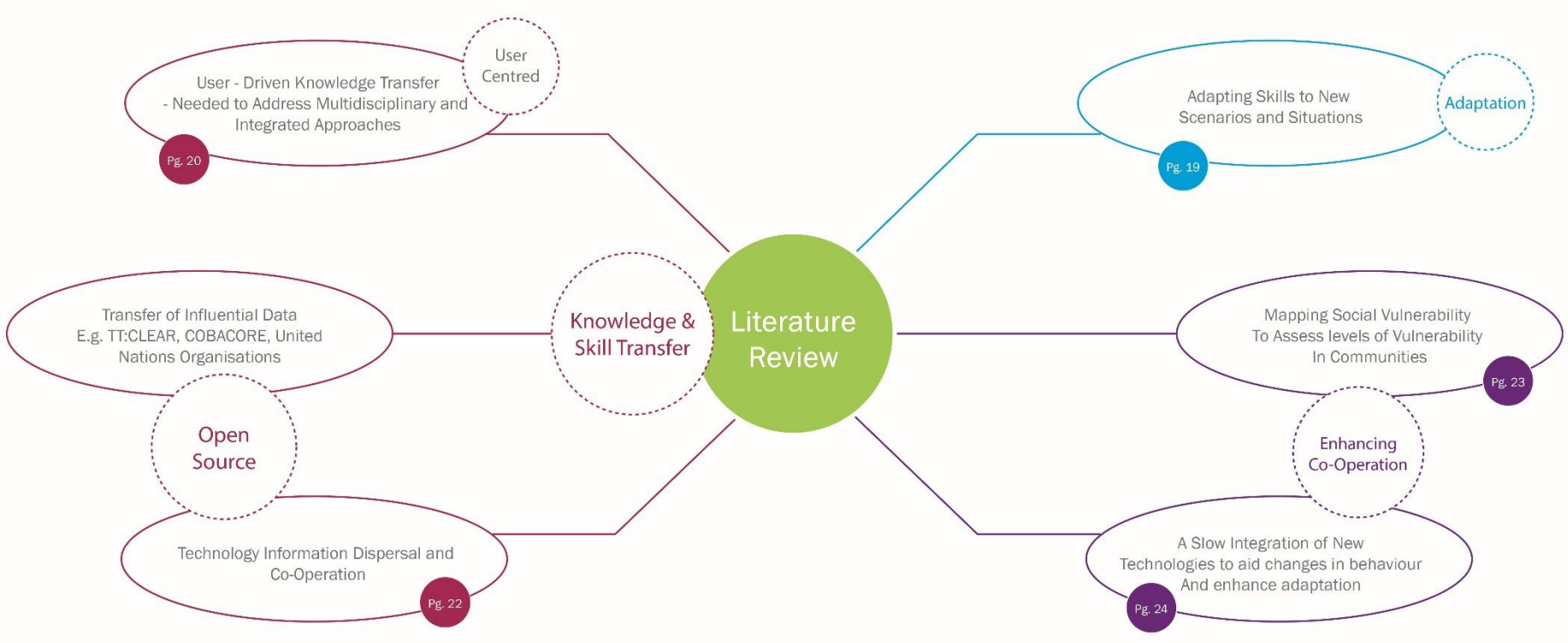


Figure 8 Literature Review Outcomes

Conclusions that have been drawn from this research include;
Communities are extremely complex units comprised of economic, social, physical and institutional components. If the relationship between these units is disrupted by an event such as a flood, the community becomes vulnerable and susceptible to damage. In order to maintain and strengthen relationships within the affected community, then the collaboration, integration and cooperation of the responding community and the responding professional needs to be established, developed and perfected. This can be accomplished by focusing on enhancing information exchange through open-source technology and software, establishing links between the responding professionals, responding community members and affected community, transferring methods for adaptation, decreasing social vulnerability and using user-driven knowledge to address multidisciplinary and integrated approaches (See Figure 8). This infographic outlines the gaps in existing knowledge, particularly at national level.

As communities are classed as being extremely complex, it makes it difficult to implement societal change, however, research suggests that the appliance of adaptation technologies can provide long term benefits for vulnerable groups and progressively influence changes into society. Using social mapping as starting point, it aims to create awareness on the areas that are most susceptible to flooding. The introduction of advanced methods for knowledge and skill transfer will enhance community capacities within areas prone to flooding and allow information to be adopted and integrated into other communities. By creating a stronger connection within communities and extending links across at national level, a larger archive of knowledge is generated. The addition of success stories, communicated through an online platform, provides communities with a benefit statement, enticing individuals to engage in new and existing successful community group based initiatives.

The evidence from this literature review suggests that there are many factors that must be taken into consideration when enhancing community endurance. The complexity of different community groups highlights the difficulties associated with the introduction of a new community based initiative. A slow integration of knowledge, skills and technology, can over time, alter behavioural patterns and entice community groups to engage in community led initiatives geared towards minimising the effects of flood related events.

Global warming resulting in climate change has been identified as not being universally accepted by people across the globe. There is a huge emphasis on the effects of climate change at global level but little has been seen at national level. It has been identified, through secondary research that the link between Global Warming resulting in Climate Change and new extreme flood events at national level is missing.

The original working title outlined the development of a community-based design initiative for open-source user-centred design solutions. This, along with existing gaps in knowledge identified in the literature, such as the need for transferring old and new flood related data through open-source technology and software, assisted in the development of the following research questions;

- What are the necessary elements needed to assist in empowering a vulnerable person or group of people?
- How can societal change be enhanced through open-source, user-centred design solutions?
- Could the integration of skills and technology along with existing and new knowledge enhance community preparation against flood related events?

3.0 Methodology

3.1 Introduction

This chapter outlines the appropriate research methodologies selected to establish the structure for the development of this research project. Methodologies selected include;

- Grounded Theory
- Narratives

Each methodology was chosen based on;

- **Suitability** to the research area
- **Ethical Considerations** ensuring selected methods work in compliance with IT Carlow's Ethics in Research Policy
- **Timeframe** controlling each phase of the project
- **Expected Outcomes** and how each method could facilitate the best result
- **Feasibility** for grounding the research
- **Limitations** impacting the breadth of research carried out

The original working title *"A community-based design initiative for open-source, user-centred design solutions against flood events affecting communities"* provided the researcher with a starting point for exploration, highlighting the themes; community-based, open-source, user-centred design and flood events. These themes were analysed in an initial research period through the investigation of secondary sources as highlighted in Chapter 2 – The Literature Review.

Conclusions extracted from the literature review highlighted that the introduction of enhanced knowledge, skill and technology transfer could provide communities with the tools for implementing change and inspiring affected communities. This, combined with open-source product design, may provide the framework necessary to prepare, cope, resist and recover from flood events. These findings provided the researcher with the groundwork for the formulation of a hypothesis.

'It is possible to increase community capacities for mitigating the effects of flooding by facilitating the transfer of knowledge, technology and skills through open-source, user-centred design'.

The hypothesis highlights that in order to create community empowerment, links between responding professionals, responding community and affected community members need to be strengthened through enhanced knowledge, technology and skill transfer.

Figure 9 Responding Professionals, Responding Community and Affected Community Members - Source: (Self-generated)

This, in turn, may provide the foundation needed to increase community capacities for minimising the effects of flooding by:

- Financially – Increasing preparation before a flood event occurs,
- Socially – Reducing the feeling of isolation between community members and within communities,
- Environmentally - Providing protection for property, land, livestock etc. and
- Economically – disrupting employment, transport, tourism etc.

This research aimed to explore how communities are affected by flooding and what elements within communities structures need to be strengthened to increase empowerment.

3.2 Establishing Appropriate Methodology

3.2.1 Epistemology

For this research study, the researcher followed a constructivist and transformative paradigm. The constructivist paradigm allowed the researcher to construct their own subjective representations of objective reality. The transformative paradigm facilitated the use of qualitative methods for data collection involving key stakeholders throughout the research project. These approaches used research methods such as unstructured interviews, participant observations, focus groups etc. and ensured an empathetic approach to the research undertaken. These qualitative methods helped to develop an understanding of the *"values, opinions, behaviours and social contexts of particular populations."* (Family Health International, 2005)

Qualitative research enhanced the researcher's knowledge surrounding issues related to flooding from the perspective of affected community members impacted by weather related events. Qualitative research methods facilitated a flexible approach toward the interactions between the researcher and each participant involved in this study. Open-ended interviews resulted in a conversational approach allowing the participants to respond in their own words rather than a simple "yes" or "no" answer.

3.2.2 The Approach

The constructivist and transformative paradigms followed an inductive approach for qualitative data analysis. Inductive reasoning as a "bottom up" approach is an efficient method for analysing qualitative data. Observing specific patterns offered clear direction and provided a tentative hypothesis for further investigation.

According to Thomas, the three primary purposes for using a general inductive approach are;

"1. To condense extensive and varied raw text data into a brief, summary format,

2. To establish clear links between the research objectives and the summary findings derived from the raw data and

3. To develop of model or theory about the underlying structure of experiences or processes which are evident in the raw data." (Thomas, 2003)

Thomas claims that an inductive research approach allows for findings to emerge from dominant themes within raw data as opposed to structured methodologies which can impose restrictions on the research outcome. This allowed for the investigation into community-based, open-source, user-centred design solutions against flooding to be unconstrained. By following an inductive approach the researcher could identify gaps in existing knowledge and extract common strengths and weaknesses within each area being examined.

3.2.3 Action Research

Action Research or Active Research (AR) allows the researcher to identify a question or questions, test a strategy, gather data and determine if the chosen strategy works. Bridget Somekh (2017) outlines that AR is differentiated from other forms of research by how it is an integration of both research and action. AR bridges the gap between research and practice. Jack M. Pernecky (Press & Education, 2017) expresses that the most important aspect of AR is that it grows the researcher's understanding of the research area. AR is a fundamental element to any research project. One round AR was used to assist in the development of a hypothesis from data collected during this study.

3.2.4 Grounded Theory

Theory that is established using an inductive research approach to the collection of data is referred to as Grounded Theory. The 1967 publication by Barney G. Glaser and Anselm L. Strauss, *The Discovery of Grounded Theory: Strategies for Qualitative Research*, provides the foundations for how theory developed from data can be furthered. Grounded Theory *'provides relevant predictions, explanations, interpretations, and applications'*. (Glaser & Strauss, 1967) Glaser and Strauss highlight that prior to being confined to the

method of coding, the researcher must constantly redesign and reiterate theoretical notions as the material is reviewed. Joint collection, coding and analysis of data follow an iterative process throughout research to establish and justify newly generated theories.

Theoretical Sampling involves the collecting, coding and analysis of data. The emerging theory helps define the data that needs to be collected next. This is a key component for developing grounded theories.

> *"Theoretical sampling necessitates building interpretative theories from the emerging data and selecting a new sample to examine and elaborate on this theory."* (Glaser & Strauss, 1967)

Theoretical Saturation is one of the main components within this sampling strategy. The researcher carried out theoretical sampling until saturation was reached. In the 2006 publication, Constructing Grounded Theory, by Kathy Charmaz (2006), Theoretical Saturation is described:

> *"Categories are 'saturated' when gathering fresh data no longer sparks new theoretical insights, nor reveals new properties of your core theoretical categories."* (Charmaz, 2006)

Grounded Theory, similar to the design process, follows constant iterative development and, therefore, was selected as an appropriate method for data collection and analysis. This methodology allowed the researcher to develop questions based on findings from the literature review. These questions were then carried through the project and addressed in the field research and design phases.

3.4 Data Collection

The researcher followed an interpretivist approach using qualitative methods for collecting data. Open-ended and semi-structured interviews with representatives from various Governmental Bodies and stakeholders provided insight into the research area. This allowed for the generation of a loose framework that facilitated a flexible design approach.

The researcher utilised field research, narratives and an internship experience to gather experiential data relevant to the research area. Data related to stakeholder experiences concerning flood events was gathered through open-ended interviews.

Narratives allowed the researcher to assess individual community levels of flood risk management and identify key elements needed within communities to allow for self-empowerment.

An internship undertaken by the researcher provided valuable insights into the work of communities at global level and to observe the execution of strategies designed to help mitigate the effects of climate change.

The majority of methods utilized, resulted in the collection of knowledge through stakeholder experiences, leaving the emerging data open to researcher interpretation. Data collected provided the researcher with sufficient knowledge for achieving a balanced understanding the effects of flood events on communities at national and international levels.

3.5 Data Analysis

Qualitative data analysis was carried out after information was gathered through interviews, focus groups, observation and document analysis. Qualitative data analysis, involving labelling and coding, was carried out in order to form a clear understanding of factors related to each scenarios being investigated. Participant samples consisted of 20+ individuals. This allowed for the development of a large database of information based on individual and collaborative experiences relevant to each case study area. The data collected was coded and analysed to identify contrasting themes and reoccurring patterns within and between communities. This helped the researcher establish gaps in existing knowledge and highlighted key elements required for engaging community members.

3.6 Research Design

The research was broken into phases to facilitate the collection of theoretical knowledge. The mixed methods approach allowed both primary and secondary research methods to be utilised throughout. Results from primary and secondary research informed and guided each phase of this study. In order to develop a clear understanding of how the research was carried out, each phase will be discussed in isolation.

3.6.1 Research Phase One: Literature Review

The literature review acted as an initial investigation into existing knowledge and aimed to expand the researcher's understanding of the specified area. The majority of literature sourced stemmed from online articles and published documents. The review of current literature granted the researcher the opportunity to identify gaps in existing knowledge. This initial enquiry formed the foundations for generating research questions that provided direction for this study.

Research Questions:

1. What are the necessary elements needed to assist in the preparation and empowerment of a vulnerable person or group of people?
2. How can societal change be enhanced through open-source, user-centred design solutions?
3. Could the integration of skills and technology along with existing and new knowledge enhance community preparation against flood related events?

The investigation into current literature allowed the researcher to conduct primary research whilst having a strong understanding and awareness of existing knowledge related to the research area. The selection of appropriate methodologies for conducting primary research was influenced by the analysis of this secondary data.

3.6.2 Research Phase Two: Field Research

Field research in the form of participant interviews were conducted during the initial stage of the research project and throughout. The research area became highly topical within the first four months of the project. Ireland, amongst several other countries, were impacted by extreme flood events that saw many communities severely damaged. Due to a limited amount of published literature on flood events prior to the flood of 2015/16, it was important to make contact with individuals who possess first-hand knowledge in the research area.

Initial interviews were conducted with representatives from Local Authorities and Governmental Bodies. Ethical considerations indicated that contact made with members of the community would be initiated by a gatekeeper who would open up channels of communication with potential participants. This approach facilitated the use of semi-structured interviews with gatekeepers and unstructured interviews with individuals. Interviews with participants were informal and unstructured to allow the interviewee to respond freely and express their own opinions. This qualitative approach helps emphasise the researchers concerns and facilitates the extraction of information that the participant feels to be relevant or important.

3.6.3 Interviews with Local Authorities and representatives from Government Bodies

Initial interviews were carried out to achieve a clear understanding of the roles played by members of local authorities and people employed by the Government during a flood event. This allowed the researcher to assess the dependence of community members on these organisations and the interdependence of these organisations on each other. Interviews were semi-structured and guided by questions specific to flood related issues, however if the participant felt the need to express an opinion that may not have been brought up during questioning, they were permitted to do so. Each interview was conducted in a public location as to allow both the researcher and the participant to feel at ease. Some participants were interviewed on several occasions as the research project progressed.

3.6.4 Interviews with community members

Interviews with community members followed a similar approach. Each interview, organised through a gatekeeper, was conducted in a public location chosen by either the gatekeeper or the participant. Each participant was issued with a 'Participants Information Sheet' that provided a background to the research area along with its aims and objectives. A full version of the 'Participants Information Sheet' can be found in Appendix B. Questions were open-ended and were used only to guide the participant through the conversation. The researcher used short hand note taking and/or voice recording equipment to document each interview which were later transcribed and stored accordingly.

The research analysed each interview and extracted key themes within the data. These key themes were compared with secondary research findings. From this a hypothesis was formed.

> Hypothesis: *It is possible to increase community capacities for mitigating the effects of flooding by facilitating the transfer of knowledge, technology and skills through open-source, user-centred design.*

3.6.5 Research Phase Three: Narratives

This phase of the project offered the researcher the opportunity to gain a broad knowledge and understanding of a particular scenario or a collection of related scenarios. Secondary research highlighted that the majority of communities across Ireland are poorly prepared to cope, resist and recover from flood events. However, a small number communities exhibited positive levels of community engagement resulting in increased community empowerment against floods. In order to validate these initial findings and explore the key factors that have led to particular communities being more resilient than others, two primary case studies were carried out.

Narrative one involved Skibbereen in County Cork a town that demonstrated a high level of community resilience and case study two involved Thomastown in County Kilkenny who were less resilient as a community. This research aimed to extract key factors within Skibbereen for enhancing community capacities. From this, a flood model and social resilience model were generated.

With each narrative, the researcher was assisted by a gatekeeper or multiple gatekeepers linked to that community. The primary objective was to obtain a clear understanding of each area and how previous floods have impacted these areas. Conducting narrative studies allowed the researcher to analyse and assess these areas from on an observer's perspective whilst being guided by feedback provided by the stakeholders it involves.

Methods utilised for data collection included investigation into existing publications and participant interviews. The researcher gained a general understanding of the areas through online research and documents published on relevant flood related incidents. Once a sufficient body of knowledge was developed, the researcher organised interviews with members of the community through gatekeepers. Unstructured interviews allowed each participant to provide a general overview of the community response during a natural disaster. This information facilitated the mapping of key engagement points within communities and how effectively they work in relation to flood events. Three community resilience status infographics were generated. These can be seen in Chapter 4.

3.7 Reliability and Validity of the Research

Qualitative research is used to explore social phenomena experienced by individuals in their natural context. It is often criticised as being 'subjective', however, it is clear that no research project can be purely 'objective'. It is important to understand how and where qualitative research is integrated in the research process. Richards highlights that this challenge is "*captured by Angrosino and de Pérez (2000: 689) writing from the perspective of ethnography:"*

> *"[T]he ethnographer may need to realize that what he or she observes is conditioned by who he or she is, and that different ethnographers — equally well trained and well versed in theory and method but of different gender, race or age — might well stimulate a very different set of interactions, and hence a different set of observations leading to a different set of conclusions."* (Angrosino & de Perez, 2000)

In order to demonstrate the reliability and validity of the research undertaken the researcher implemented strategies to verify findings. Some of these strategies include;

- Being aware of personal prejudice related to the research area that may impact on findings
- Constant evaluation and reflection of methods utilised to ensure the collection of data and analysis was of sufficient depth and relevance
- Ensuring all data was collected and stored to demonstrate how findings steered the project in a particular direction
- Conducting case studies to identify differences and similarities between communities ensuring that a collection of contrasting perspectives and opinions were represented
- Presenting in-depth descriptions of participant reports to support research findings
- Engagement with other researchers to minimize research bias
- Interaction with participants throughout the research project in order to gain stakeholder opinions on the research direction being proposed for further exploration
- Utilizing data triangulation techniques to verify the accuracy of research findings achieved through the use of multiple methods of data collection

Validity within quantitative research is said to be somewhat easier to evaluate than that of qualitative research. This is due to the scientific rigour related to quantitative data analysis. Noble and Smith outline that;

> *"Unlike quantitative researchers, who apply statistical methods for establishing validity and reliability of research findings, qualitative researchers aim to design and incorporate methodological strategies to ensure the 'trustworthiness' of the findings"* (Noble & Smith, 2015)

Interviews involving members of Government Bodies and community members, case studies and an internship experience with the UNFCCC were triangulated to provide validation for this study. The researcher presented the outcomes of this research to a

number of community members involved in the study, which provided verbal validation for the proposed solution for increasing community resilience against flood related events.

3.8 Ethical Considerations

Ethics in research, also known as moral philosophy, *"focuses on providing guidelines for researchers, reviewing and evaluating research, and establishing enforcement mechanisms to ensure ethical research."* (Aguinis & Henle, 2004). The research project complied with ethical guidelines outlined in The Institute of Technology Carlow's Ethics in Research Policy. This policy represents a clear articulation of the research project, its methods, aims, objectives and outputs. Guidelines covered in this document include;

- An outline of the size and composition of participant samples
- Methods for participant and selection, approach and recruitment
- Procedures for maintaining participant confidentiality
- A description of how data is gathered, stored, handled and anonymized
- Locations proposed for conducting research

3.8.1 Participant Information Sheet

In compliance with the Ethics in Research policy and highlighted in the Application for Ethical Clearance (AEC), contact with participants was facilitated by a gatekeeper. Prior to any interview being conducted, participants were issued with a 'Participant Information Sheet' outlining the following;

- Objectives of the research project
- Research methods expected to be utilized
- An outline of the participants involvement in the project
- Why their involvement is necessary
- Any possible risks associated with conducting research and how they will be addressed
- Expected benefits of the research
- The participant's right to withdraw at any time

- How the research findings will be stored and used
- To whom it will be reported
- Confidentiality and anonymity of the participant

3.8.2 Ethical Issues

With any research project, the researcher must be aware of any ethical issues that may arise when conducting field research involving stakeholders. It important that the researcher recognizes how to deal with any concerns that may emerge. Ethical issues considered for this research project are as follows;

- Be sensitive to the needs of vulnerable populations
- Identify a research problem that will benefit participants
- Treat all participants equally
- Avoid collecting harmful information
- Respect the privacy and anonymity of participants
- Avoid siding with participants
- Disclose the purpose of the study
- Avoid putting any pressure on participants

Ethical clearance was achieved by the researcher before any primary research involving community members was carried out.

3.9 Limitations of the Research

Due to the 24 month period allocated to this research study, time dedicated to each phase was limited. This imposed restrictions on the extent of work carried out during each phase of the project. A 3-month internship at the United Nations Framework Convention on Climate Change (UNFCCC), from August to November 2016, proved to be very beneficial, however, the internship impacted on the overall duration dedicated to this study.

Action research was applied to this study as an appropriate methodology, however, only one round of action research was carried out. It is suggested that action research be carried through to a deployment and testing phase to assist in further developing the project.

Ethical considerations outlined that communication with participants must be achieved through a gatekeeper. This was a lengthy process when organising interviews that accommodated both the gatekeeper and the participant. Due to the difficulty and time consumption in organising one on one interviews it became almost impossible to set up workshops comprised of more than one community member. This prevented the researcher from obtaining feedback from group sessions which may have highlighted additional issues.

For future research, is it suggested that workshops should be utilised as a method of collecting collaborative data from community members. This approach allows for a more holistic approach for gathering information specific to each community involved in the research study.

3.10 Conclusion

The methodologies highlighted in this chapter frame the approach employed by the researcher. The interpretivist paradigm is complimentary to the researcher's educational background and follows an iterative approach to the collection of data. Mixed methodologies were utilised, in the form of qualitative methods, throughout the research project. The mixed methods approach allowed the researcher to frame the study among philosophical and theoretical positions.

The inductive research approach followed throughout this project is consistent with the design process. This process focuses on user experiences and user-centred design, ensuing a 'bottom-up' approach to the study. Steps associated with the 'bottom-up' approach include; Observation of the user/s associated with the specified issue, identification of emerging patterns between thematic areas, generation of a tentative hypothesis and development of a theory based on these findings. This chapter highlights the role of the design process within academia and the benefits of utilising a design led approach when conducting research.

Findings generated from both primary and secondary research phases resulted in the development of an infographic (See Figure 10) that highlights the key outcomes from the Literature review (Figure 8), Field Research (Figure 11) and the Internship (Figure 12).

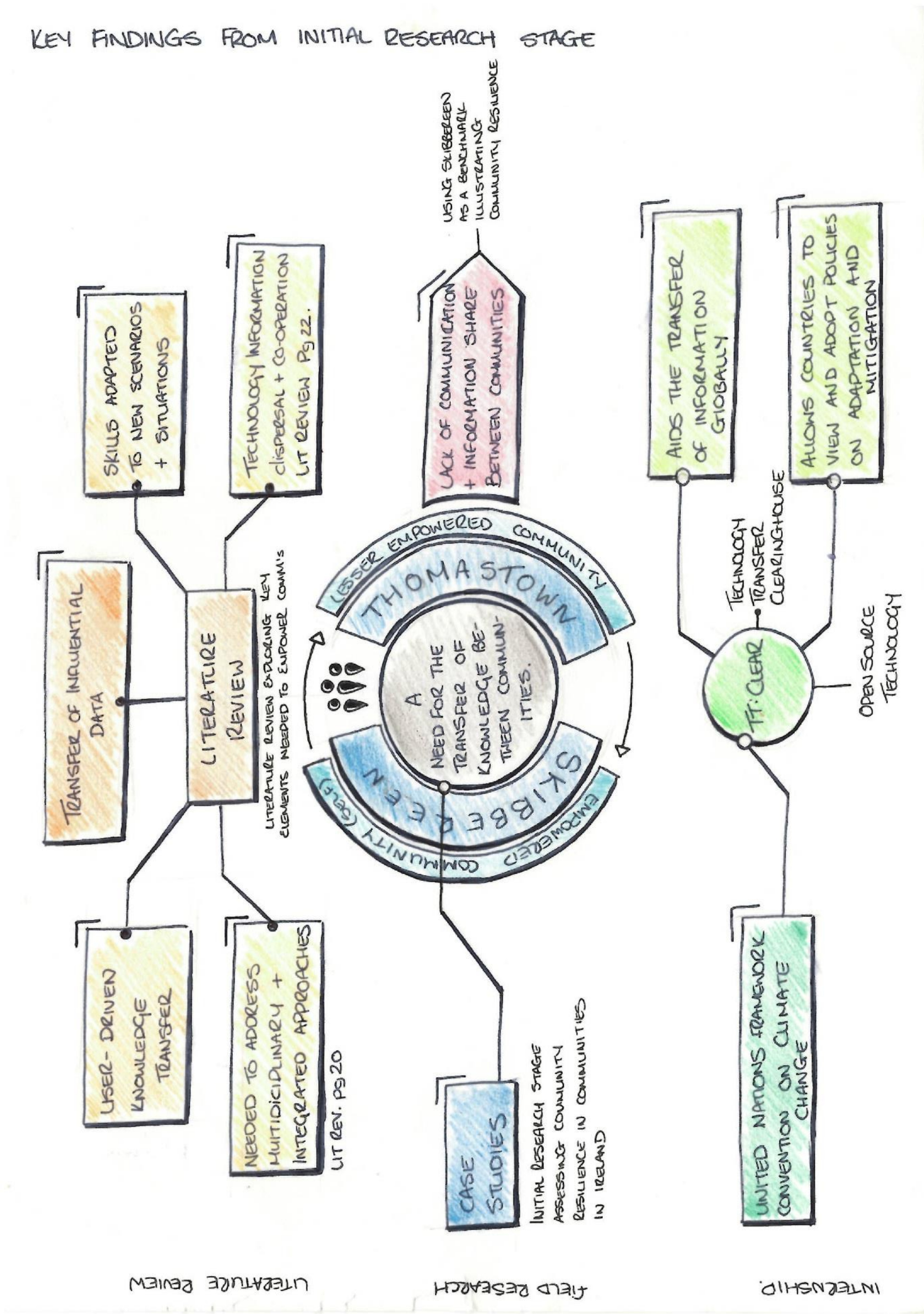


Figure 10 Key Outcomes (Self-Generated)

3.11 Field Research

3.11.1 Interviews

The initial phase of field research conducted comprised of interviews. Conducting interviews aims to achieve a greater understanding of the research area from the opinions and perspectives of its stakeholders. *"At the root of in-depth interviewing is an interest in understanding the lived experience of other people and the meaning they make of that experience."* (Seidman, 2006) Findings generated from initial interviews were compared with secondary research findings to identify contrasting and complimentary themes. Transcripts and shorthand notes on each interview carried out can be found in Appendix B.

Initial interviews were conducted involving members from Government Bodies and Organisations including;

- Carlow County Council
- Carlow Fire Department
- Carlow Weather
- Waterford Civil Defence
- Centre for Marine and Research Energy (MaREI)
- Skibbereen County Council
- Office of Public Works (OPW)
- United Nations Framework Convention on Climate Change (UNFCCC) Adaptation

Introductory interviews aimed to contribute to the researcher's knowledge on the area from a Government Representative and Emergency Services point of view. Interviews involving Carlow County Council, Carlow Fire Department and Waterford Civil Defence offered insight into the emergency support offered, at county level, to community members affected by flooding. This approach also assisted the researcher in opening up various channels of communication with community members.

Participant interviews were conducted involving community members from areas including;

- Skibbereen, Co. Cork
- Thomastown, Co. Kilkenny
- Inistioge, Co. Kilkenny
- Graiguenamanagh, Co. Kilkenny

Participant interviews aimed to provide the researcher with valuable insights into flood events experienced by affected community members. Interviews in Skibbereen, Co. Cork were conducted with active community members who assist the Skibbereen community during flood events. Thomastown, Inistioge and Graiguenamanagh interviews involving affected community members provided the research with information related to their personal experiences associated with flooding. This approach facilitated an inductive approach toward the development of an effective solution for enhancing community empowerment.

3.11.2 Approach and Method

Interviews with Government Bodies and affected community members were generally one-on-one followed a semi-structured approach. Semi-structured interviews allowed the researcher to extract information that they felt to be relevant based on knowledge achieved through secondary research. Open-ended interviews with community members allowed the participants to speak freely based on their own perspectives and opinions and raise issues that they felt to be important. *"Researchers encourage participants to talk about issues pertinent to the research question by asking open-ended questions, usually in one-to-one interviews."* (Tong, Sainsbury, & Craig, 2007) Data gathered from the literature review guided the selection of appropriate methods for conducting field research.

Voice recorded interviews were transcribed and interviews documented through shorthand note taking were recorded and stored accordingly. Key findings related to the research project was extracted from these interviews and used to inform the next stage of research. Transcripts of these interviews can be found in Appendix B.

3.11.3 Carlow County Council

Interview one involved a representative from the Local Civil Defence. Several interviews with this participant were held in the County Buildings, Athy Road, Carlow. The Civil Defence is a voluntary organisation that offers support to front line emergency services and assists communities in dealing with events such as extreme weather, flooding, accidents and searching for missing people. There are currently 4,500 volunteers nationally within the Civil Defence. The aim of this interview was to gain insight into the role of the Civil Defence during flood related incidents at local level. It provided the researcher with insight into how floods are dealt with at local level and how emergency services respond to extreme weather events. The participant expressed extensive knowledge on flood events in Carlow and provided info on what has been done to mitigate local flooding. The interviews were recorded through shorthand note taking.

Key findings from these interviews include;

- There are “little community based activities” in Carlow in relation to flooding.
- Waterways Ireland monitor water levels and alert Carlow 24 hours before a flood is expected to hit.
- Community members are notified of flooding through the media e.g. KCLR – fastest method for distributing information.
- The civil defence do not have a general protocol for flooding – they just “react to the situation at hand”.

3.11.4 Carlow Fire Department

Interview two involved a member of Carlow’s fire department. The participant had previously spent eight years working with the Civil Defence. Carlow Fire and Rescue Service is set up to respond rapidly and efficiently to fires and other emergencies throughout the county. Fire Services in Ireland are funded by the Government, annual rates collected from commercial premises, charges for attending fire related incidents and fire service inspections. Full-time professional fire fighters occupy cities and large urban areas while

retained part-time staff service rural areas and are available for emergencies at all times. All fire stations provide a 24-hour on call service.

This interview aimed to provide an outline of the work carried out by Carlow Fire Department during flood related events.

The Interview was recorded using short hand notes. Key findings from this interview conclude that Carlow Fire Services;

- Provide initial emergency response.
- Are responsible for providing assistance for rescuing people, deploying sandbags, directing staff, closing roads, diverting people, deploying road signs etc.
- Provide assistance in the 'clean-up' period.

3.11.5 Centre for Marine and Renewable Energy (MaREI)

The MaREI is the marine and renewable energy research, development and innovation centre. It incorporates the expertise of various research groups and industry partners aiming to solve challenges related to marine and renewable energy sectors. This interview aimed to achieve a greater understanding of the work that MaREI do and explore the possibility of a collaboration between MaREI and this research project. The participant provided a brief outline of what they do including working with local authorities, hosting workshops, analysis of past flooding events, mapping out areas affected and assessment of impacts on social and economic levels. This brief interview was conducted via telephone and recorded using shorthand notes.

Some key points extracted from this interview include;

- Working with the community – community members possess the best knowledge about their own areas.
- Assisting in guiding members of the public toward the information that they need.
- Working with active community groups.

3.11.6 Office of Public Works (OPW)

The Office of Public Works is a client focused service organisation aimed at ensuring a prompt delivery of services and value for money. Their two main areas of responsibility include Estate Portfolio Management - Heritage Services and Flood Risk Management. The OPW aims to minimise the impacts of flooding through sustainable planning. The objective of the interview was to achieve a broader understanding of the levels of engagement between the OPW and affected communities, what areas do the OPW focus their works on and whether flood defences being proposed and implemented are capable of withstanding accelerated climate change/flooding. Communication with the participant via email determined the method utilised for collecting data. A short questionnaire was provided to the participant.

Key points extracted from this questionnaire include;

- *"We engage heavily with the public and stakeholders in communities…"*
- *"….we have held nearly 400 Public Consultation Days (PCDs) to consult on the flood maps and the options for resolving the flood problems for that community."*
- *"…we give members of the community the opportunity to come in to see the maps or options, and have face-to-face discussions with the team…"*
- *"…structural flood protection works remain and will remain one of the corner-stones of our work."*
- *"…we have assessed and mapped the flood risk for two future scenarios that take into account the potential impacts of climate change."*

A complete version of the questionnaire can be found in Appendix B.

3.12 Interviews with Community Members

3.12.1 Skibbereen, Co. Cork

Interviews with community members in Skibbereen were conducted as part of a case study. Participants included members of the Civil Defence, Cork County Council and Skibbereen Fire Department. The purpose was to gain a deeper understanding of the key elements that have been successful for increasing their capacity for minimising the effects of flooding.

> Responding Professional; *"When a flood event is predicted, we hold a meeting in the Civil Defence Headquarters between members of the Fire Department, Gardaí, Civil Defence, Local Authorities and members of the local flood committee"*

3.12.2 Thomastown, Co. Kilkenny

Initial interviews in Thomastown involved active community members. Interviews involved residents of the Thomastown community. The interviews provided insight on Thomastown's fight toward mitigating flooding and their intentions for future adaptation. These meetings highlighted the level of community engagement in Thomastown and their willingness to generate a higher level of community vigilance within the town.

> Responding Community Member; *So the idea is, attenuation, slowing up, taking the energy out of the water, leaky dams, slowing it down, next stage, next stage, so the slow release and that has to be, that could account for, you know, a huge amount of, if we got that into our, how would you say, Modus Operandi"*

3.12.3 Inistioge, Co. Kilkenny

Interviews in Inistioge involved members of the community who experienced flooding. Majority of interviewees were of an older demographic and are long term residents in the town. Some of these participants had been affected by flooding on more than one occasion. Interviews were conducted alongside Councillor Michael Doyle who is heavily involved in the community. The purpose of conducting these interviews was to gain knowledge on the flood status of Inistioge, to obtain insights into the existing level of

community engagement and to establish how future engagement might be improved. Each participant provided the researcher with information on their own personal flood experiences and voiced their opinions on how the problem may be alleviated.

> Affected Community Member; *"In 2016 my home flooded. It was a combination of the rain, non-dredged river and change of winds."*
>
> *"I looked out on the Friday evening and the water was being swept by the winds. I said to myself, oh God, I'm definitely going to get it now"*
>
> *"Coming down the stairs was the most frightening thing."*

3.12.4 Graiguenamanagh, Co. Kilkenny

A single interview was conducted in Graiguenamanagh involving one participant. This interview provided insight on the current flood status in Graiguenamanagh, highlighting the participants experience with flooding, methods for protection currently in place and their plan for the future.

Affected Community member; *"In 2016, the water, in the middle of the night, about three in the morning, got over the flood doors. We thought it would stop, obviously, before it got to that height. It got over my flood doors and that hit the electricity then, so my pumps cut out etc. So the whole place filled up and we had quite a lot of damage in 2016."*

Full descriptions of these case studies can be found in Chapter 4 – Narratives.

3.13 Ethical Considerations

As mentioned in Chapter 3 - Methodology, Ethical Considerations, affected community members were selected by a gatekeeper who opened up channels of communication between the researcher and the participant. Interviews were conducted in public settings and followed an open-ended approach.

3.14 Outcome / Findings

Findings from initial interviews highlighted that the majority of communities are poorly prepared for dealing with flood events. Communities have a high level of dependency on local authorities and government bodies to provide assistance on preparing for extreme weather conditions. The majority of communities are unaware of how to implement measures for preparing, coping, resisting and recovering from extreme weather events.

Communities like Skibbereen in County Cork have a high capacity for dealing with flooding and over the years have implemented measures for mitigating flood events. These measures have proved extremely beneficial for the Skibbereen community. It was evident that the knowledge, skills and technology witnessed within the Skibbereen community could be beneficial to and be transferred to other less prepared communities.

3.15 Narratives

3.15.1 Approach and Method

Narratives provide an in-depth and holistic investigation into areas that experience flooding. This method was selected in order to thoroughly explore community based issues. The narratives generated for this project aimed to map out the key activities that occur within specific communities before, during and after a flood event. This process also facilitated the mapping of key community engagement points within each area to assess levels of community engagement. Detailed descriptions of the research carried out in these specific areas affected by flooding can be found in chapter 4.

3.15.2 Skibbereen, Co. Cork

Research carried out in Skibbereen, Co. Cork aimed to highlight how they have generated a high level of self-empowerment. This area was used as a benchmark for generating a flood resilience model aimed at creating awareness for other communities to reduce the effects of flood related events. Information gathered on Skibbereen's flood resilience status was achieved through interviews with community members and local

authorities. The researcher carried out a field study alongside a member of the local Civil Defence. Here, the researcher was taken through each step carried out by both community members and local authorities before, during and after a flood event. This information was then synthesized and from this an infographic was developed to communicate findings.

3.15.3 Thomastown, Co. Kilkenny

A similar process was carried out in Thomastown alongside a member of the community. The researcher was provided with in-depth knowledge on the processes carried out by the community during a flood. The Thomastown narrative was used an example of a less resilient community in Ireland. An infographic was generated displaying Thomastown's flood resilience level.

3.15.4 Inistioge, Co. Kilkenny

Similar to Thomastown, field research was conducted to generate a clear understanding of the flood awareness levels in Inistioge. Interviews involved a member or the Tidy towns and the local Councillor who supervised interviews with affected community members.

3.15.5 Outcome / Findings

Findings generated from conducting research in these locations showed that there is a need for increased knowledge, skill and technology transfer between communities. (See Figure 11) Through investigation into published documents on Ireland's current position on flooding combined with these narratives showed that the majority of communities lack preparedness. Fostering the transfer of local knowledge, skills and technology between affected communities was identified as a key building block to promote and enhance links between members, responding community and responding professionals in these communities.

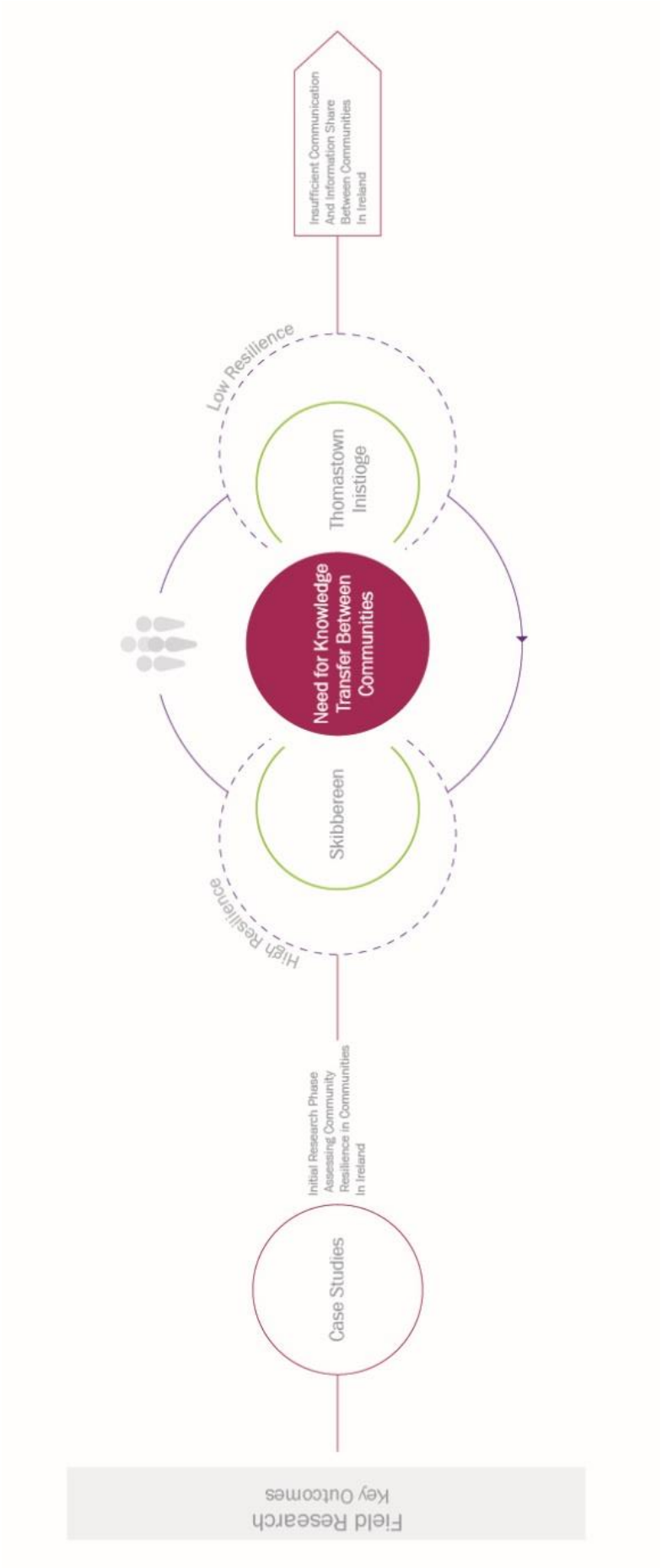


Figure 11 Field Research Key Outcomes – Source: (Self-generated)

3.16 Internship

The researcher completed an internship with the United Nations Framework Convention on Climate Change from late August to early November 2016. The principle task was to collaborate with the technology team to ensure the delivery of the redesigned TT: CLEAR website in time for the Conference of the Parties (COP 22) in Marrakesh, Morocco. Other activities of this internship position included;

- Support in Developing Publications
- Implement Social Media Campaign for TEC 13
- Reading
- Updating Technology Portal
- Undertake Maintenance to TT:CLEAR to ensure that it remains up-to-date and error free

3.16.1 Outcome / Findings

The internship position highlighted the importance of technology for the transfer of information within and between countries. (See Figure 12) Information on successful Mitigation and Adaptation strategies currently in place, can be sourced through the TT: CLEAR website, allowing countries to adopt appropriate strategies. These success stories are also used as a benefit statement to entice countries to invest in climate technologies. Climate technologies help reduce Green House Gas (GHG) emissions. Knowledge, skill and technology transfer through an online portal could lead to the distribution of important information on minimising the effects of flooding at national level.

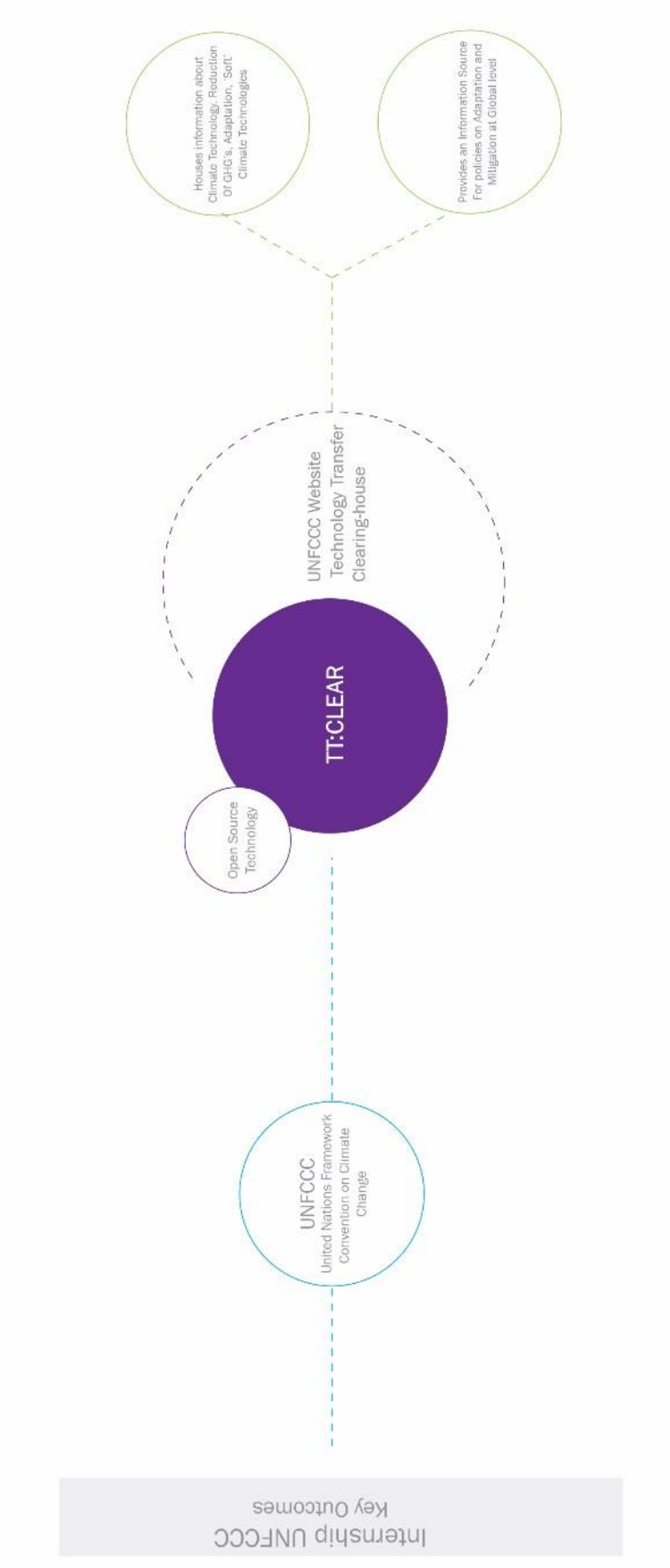


Figure 12 Internship Key Outcomes - Source (Self-generated)

4.0 Narratives

Preliminary investigation of the research area highlighted that a small number of communities across Ireland are more advanced in preparing, coping, resisting and recovering from flood events. This chapter outlines the investigation into three separate communities in Ireland, Skibbereen in County Cork, Thomastown and Inistioge in County Kilkenny. As previously mentioned in the literature review, the research aimed to facilitate a community-based, open-source, user centred design initiative against severe weather conditions in waterside communities. Each investigation was conducted through liaison with responding professionals, responding community members and affected community members. This aimed to discover, record and analyse existing knowledge banks within community structures, ascertain their strengths and weaknesses, understand how flooding impacts these vulnerable communities and to identify existing and possible methods for decreasing vulnerability.

4.1 Approach and Method

Data was collected through information search, field research and participant interviews. As outlined in the methodology chapter, each participant was approached and selected by a gatekeeper. The gatekeeper was the researcher's first point of contact and provided an initial overview of the flooding experienced by their community. Field research was carried out with a gatekeeper related to the area being investigated. The gatekeeper took the researcher through each stage of a flood event, highlighting activities undertaken before, during and after a flood occurs. The researcher was shown where flood water breaches the community, the type/s of floods that occur in these areas and how flooding has accelerated over the years. This comparative study aimed to develop an understanding of key components and key players within the Skibbereen community that have led to a greater level of vigilance and how these key factors could be adopted by Thomastown, Inistioge and other less organised communities. Data collection methods included shorthand note taking, photographs and voice recorded interviews. These three methods of data collection were combined to develop a narrative for each community. The information

gathered allowed the researcher to analyse and measure each area based on stakeholder knowledge and experiences.

4.1.1 Un-Weighted Data Analysis – Percentage Analysis Chart

Data extracted from the three areas examined in this chapter was synthesised using a percentage analysis chart. This chart was separated into three stages (before, during and after) and within each stage, key activities necessary for dealing with flood related issues were identified. These charts were developed early in the interview stage and revised throughout the study to ensure findings were as accurate as possible. Each area was evaluated and simplified to generate pie charts displaying their levels of both preparedness and unpreparedness. A full version of the percentage analysis charts can be found in Appendix B.

4.2 Narrative One – Skibbereen Co. Cork

Skibbereen is a small town in County Cork, and home to more than 2,500 people (according to the 2011 census). The River Ilen that runs through the town is tidal and meets the sea roughly 12 kilometres away at Baltimore. Skibbereen has experienced approximately 22 significant floods between the years 1943 and 2016. The most recent floods occurred during the end of 2015 and early 2016.

After Initial enquiry into flooding in Skibbereen, the researcher visited the town to see first-hand how they deal with flood events. The researcher was assisted by a paramedic who is heavily involved in flood relief work around the town.

Over the years, Skibbereen have developed methods for dealing with floods. This was achieved through the collaboration between affected community members, the responding community and responding professionals. The majority of work is carried out by the responding community and responding professionals and supported by affected community members. This can be seen in Figure 13.

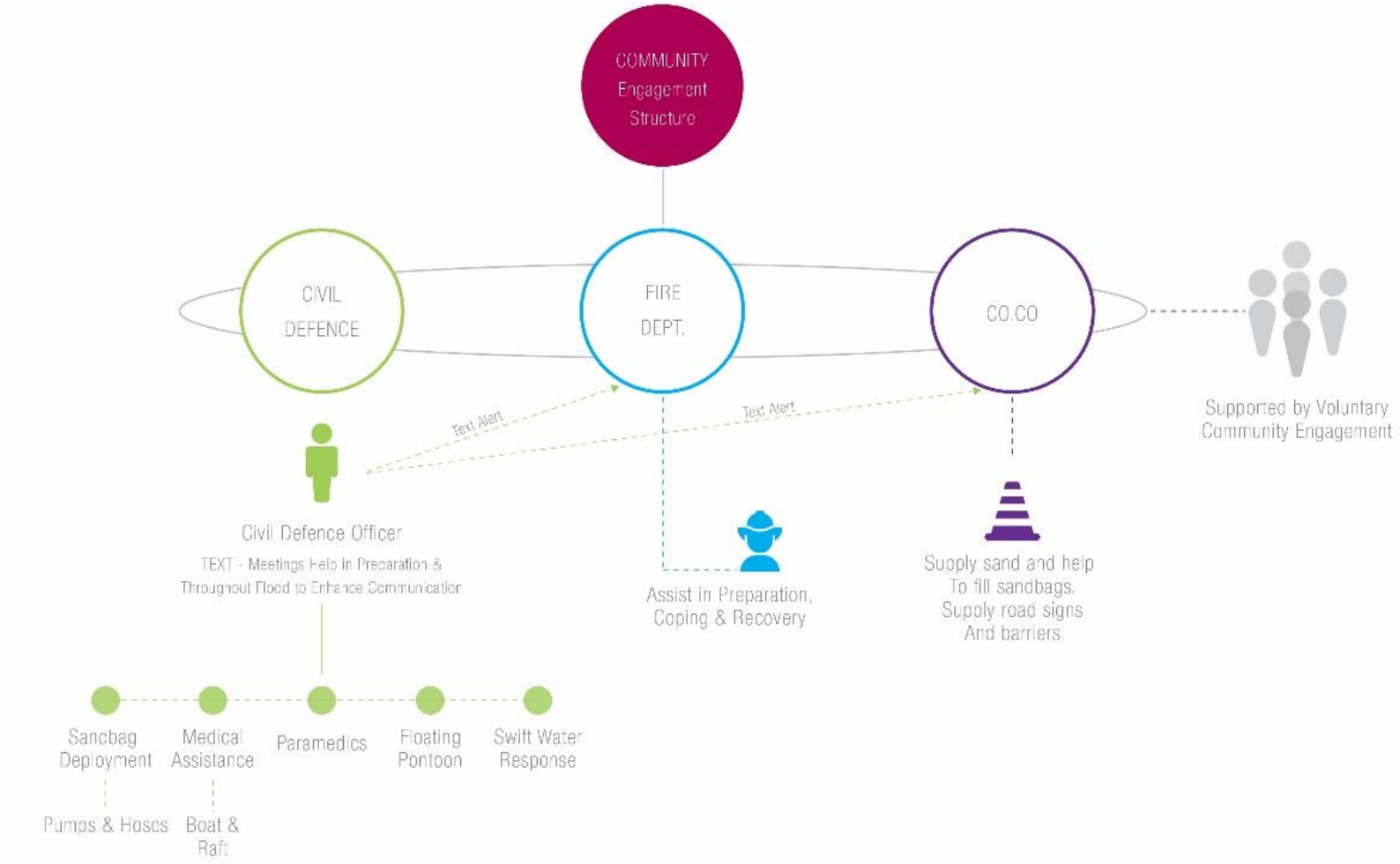


Figure 13 Skibbereen Engagement Structure (Self-generated)

Standard procedure for dealing with a major flood event in Skibbereen is as follows;

1. Early warning system – an infrared gauge 5 kilometres up stream takes readings of the river levels, allowing the community to determine the possibility of a flood occurring.
2. A meeting is called between the Fire Department, Gardaí, Civil Defence and the Local Flood Committee in the Civil Defence Head Quarters.
3. The Civil Defence HQ set up boards for recording information on their:
    - Recognised current situation
    - Key issues
    - Strategic aims and priorities
    - Actions
4. Prior to any flood event, containers are placed strategically around the town holding signs, barriers, sandbags, tools and wires for opening storm drains.
5. Flood defence measures are put in place, sandbags, road signs etc.
6. A text alert system is activated, notifying community members.
7. These community members inform the rest of the community increasing awareness.
8. Depending on the severity the flood, meetings are held regularly to plan and react accordingly to a flood event.
9. Flood sensors are situated along the river at critical locations. The sensors collect data on river levels. This data can be retrieved by SMS.
10. Residents are assisted by responding professionals (distribution of sandbags, evacuation etc.)
11. Hotels provide emergency accommodation, food, water, clothing etc.
12. After the flood subsides community members and responding professionals assist in the clean-up and removal of damaged property.

These methods for dealing with flood events have been developed in response to the frequent flooding experienced by the Skibbereen community. This iterative process has led to effective strategic planning, enhanced community engagement and increased preparation for flood events. The information gathered was synthesised and an infographic was generated displaying the key activities carried out by responding professionals and responding community members. This can be seen in Figure 14.

Figure 14 Skibbereen Flood Response (Self-Generated)

A second infographic was generated (See Figure 15) mapping out key community engagement points. This displays the interaction of responding professionals with the affected community. The Majority of these interactions involve providing information and assistance to community members. These engagement points represent knowledge transfer and assistance support provided by responding professionals to community members.

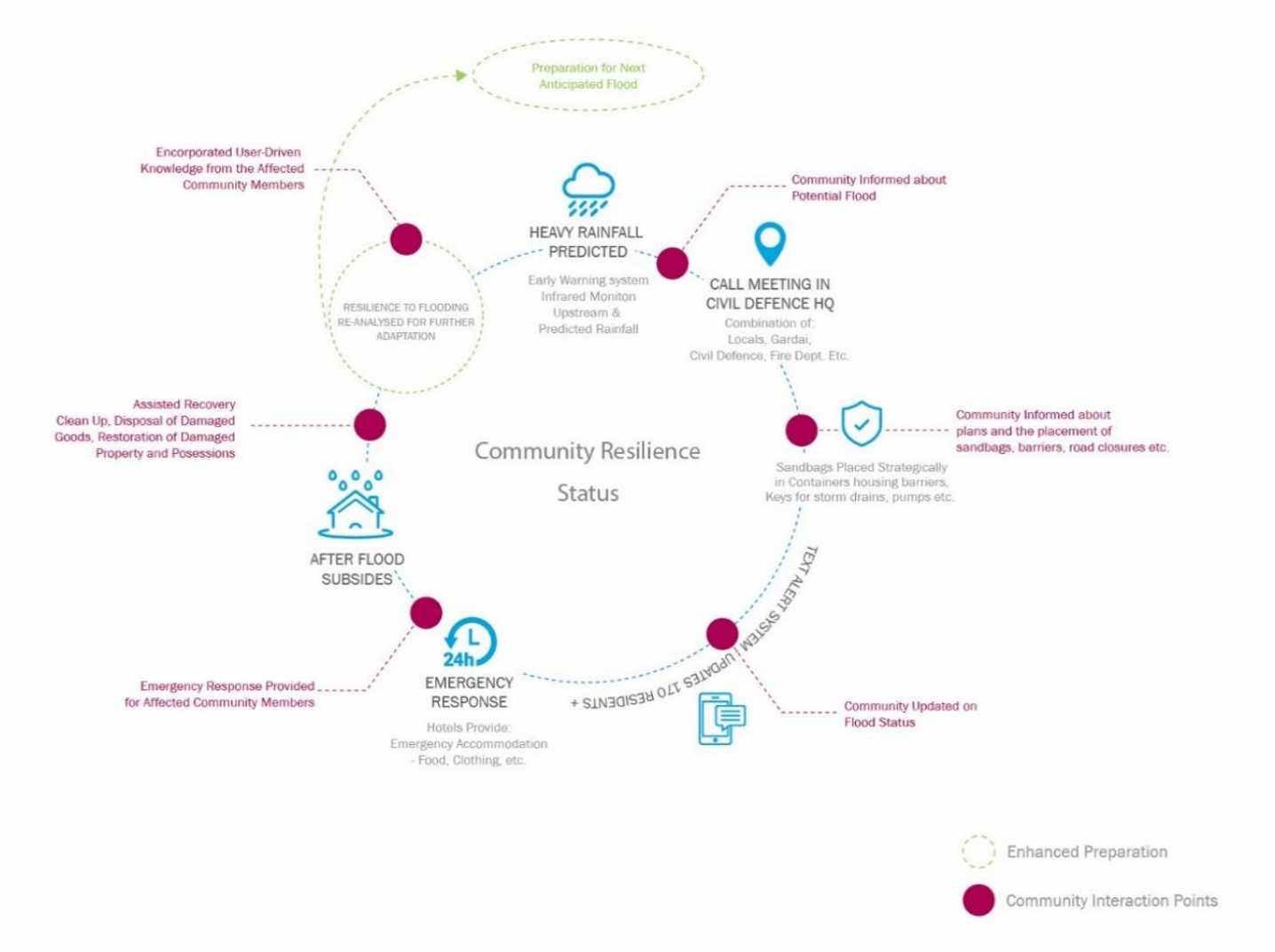


Figure 15 – Skibbereen Community Engagement Points (Self-Generated)

A percentage analysis chart was developed by the researcher. The data gathered during each phase was recorded in this chart and formed a statistical database of knowledge on Skibbereen displaying levels of preparedness before, during and after a flood. This chart was created after initial engagement with community members and reiterated throughout. A pie chart representing this data was developed and can be seen in Figure 16. The original percentage analysis chart on Skibbereen can be found in Appendix B.

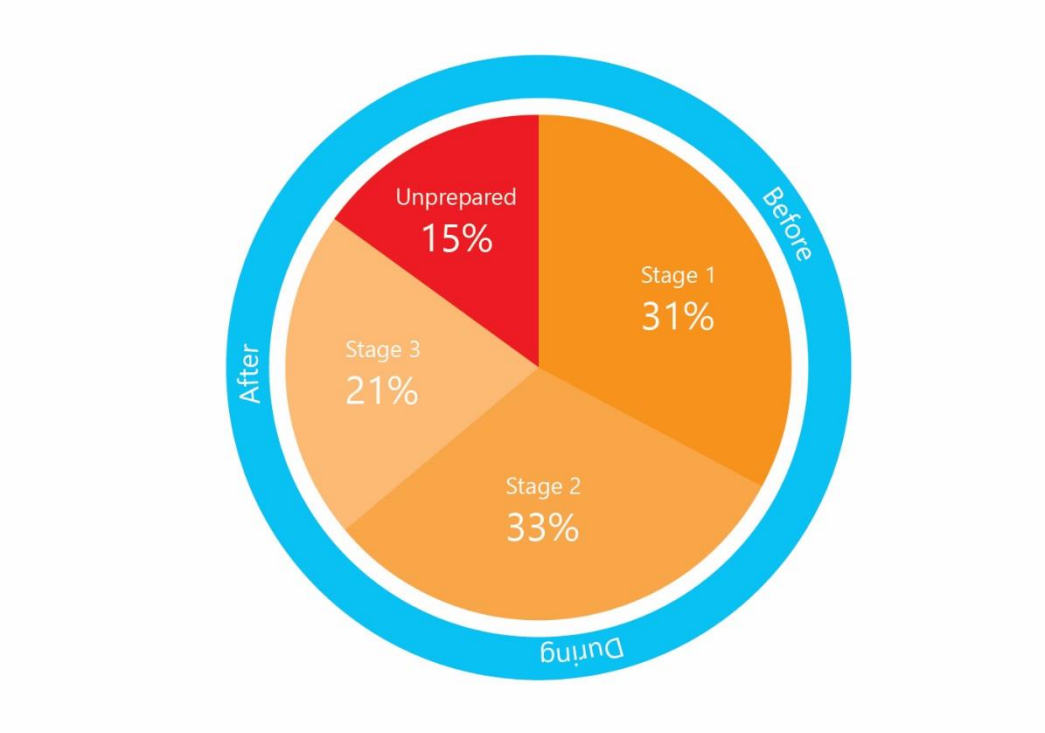


Figure 15 Pie Chart representing levels of preparedness at each stage of a flood (Self-generated)

4.2.1 Outcome/Findings

Findings generated from this case study concluded that;

- Skibbereen have a high level of cooperation between responding professionals, responding community and affected community members.

- Each component of Skibbereen's community structure is supported by the other, enhancing engagement.
- Enhanced engagement has resulted in increased community resilience.
- The transfer of knowledge, technology and skills has demonstrated fundamental for moderating flood events.

4.3 Narrative Two: Thomastown

Thomastown is a town in County Kilkenny and home to just over 2,250 people (according to the 2011 census). The tidal River Nore runs through the town and enters the sea at Waterford Harbour. Thomastown does not flood on a regular basis, however, flooding is becoming more frequent and intensified. The most recent and severe floods occurred in late 2015 through to early 2016.

After initial enquiry into the area the researcher visited Thomastown to examine their protocol related to flooding. The researcher was assisted by a local artist who is heavily involved in the community. The participants house is always first and sometimes the only home to be impacted by a flood.

As a result of the town not experiencing severe flooding since 1947 until 2009 and 2015/16, little preparation for a flood related event had been accomplished. This case study aimed to gain a greater understanding of the current level of preparedness in Thomastown and how it could be enhanced. Based on the last flood experienced by Thomastown, the following infographic (Figure 17) was generated to communicate how they are assisted during a flood.

Figure 16 Thomastown Engagement Structure (Self-generated)

Standard procedure related to the last flood in Thomastown was as follows;

1. The Civil Defence and Local Engineer were the first to gain knowledge on a possible flood event.
2. The Engineer informed the community of weather predictions and the possibility of a flood event occurring.
3. Army and County Council assisted with supplying sandbags, signs and road barriers to areas needed.
4. Assistance was provided by the Civil Defence, Army and County Council for emergency response and recovery.

This response to flooding is a result of the new intensified flood pattern as opposed to the old attenuated flood. This data reveals that the Thomastown community is less prepared for a flood event. Knowledge derived from these findings was synthesised to form an infographic that can be seen in Figure 18.

Figure 17 Thomastown Flood Response (Self-generated)

From the infographic displaying the key activities carried out by responding professionals and community members, a second infographic (See Figure 19) was generated mapping key community engagement points. These engagement points represent knowledge transfer and assistance provided by responding professionals to community members.

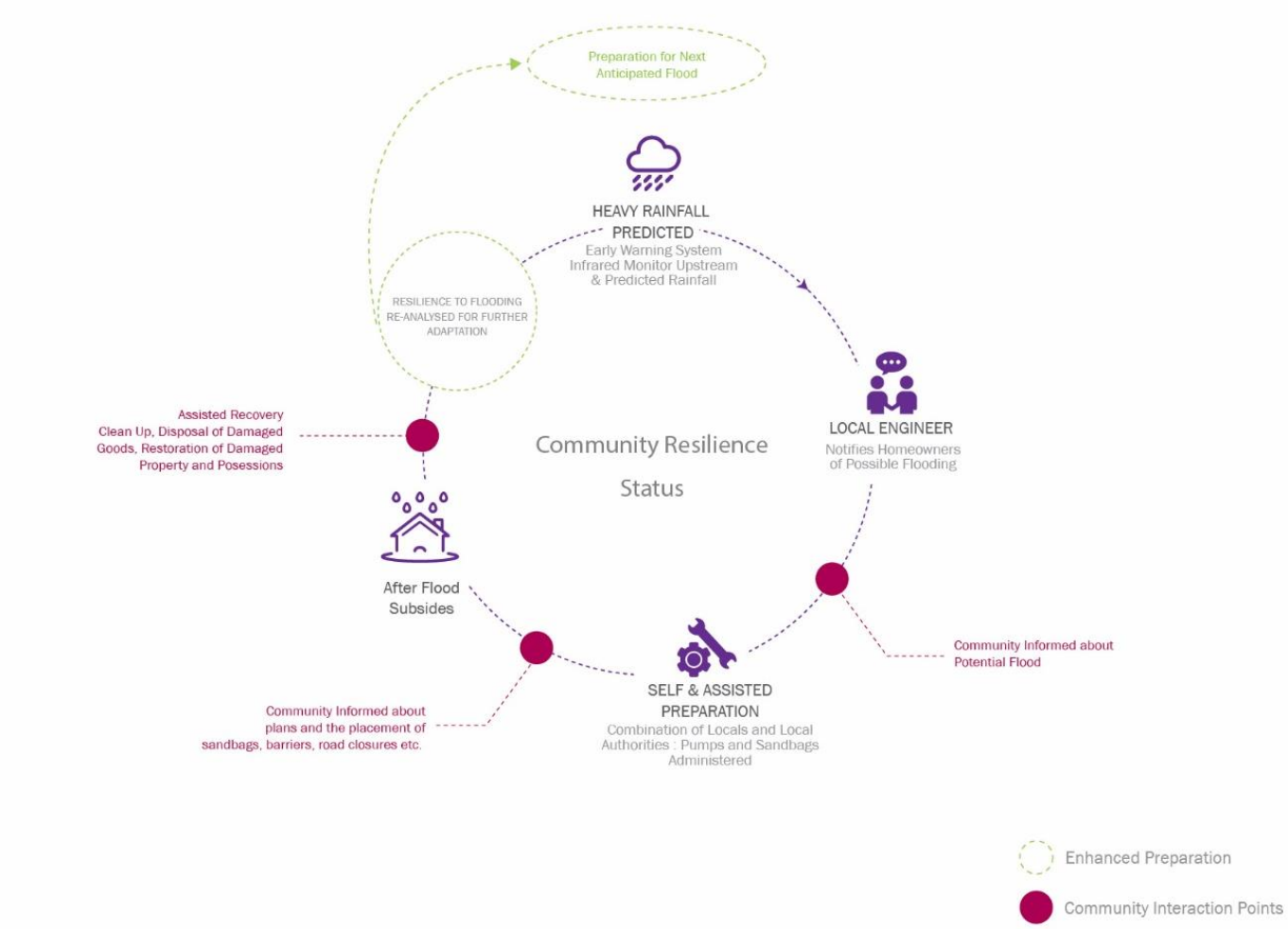


Figure 18 Thomastown Community Engagement Points (Self-generated)

A percentage analysis chart generated by the researcher based on data gathered formed a statistical database of knowledge on Thomastown showing levels of preparedness before, during and after a flood. This chart was iterated throughout the research project based on findings. A pie chart representing this data was generated and can be seen in Figure 20. The original percentage analysis chart can be found in Appendix B.

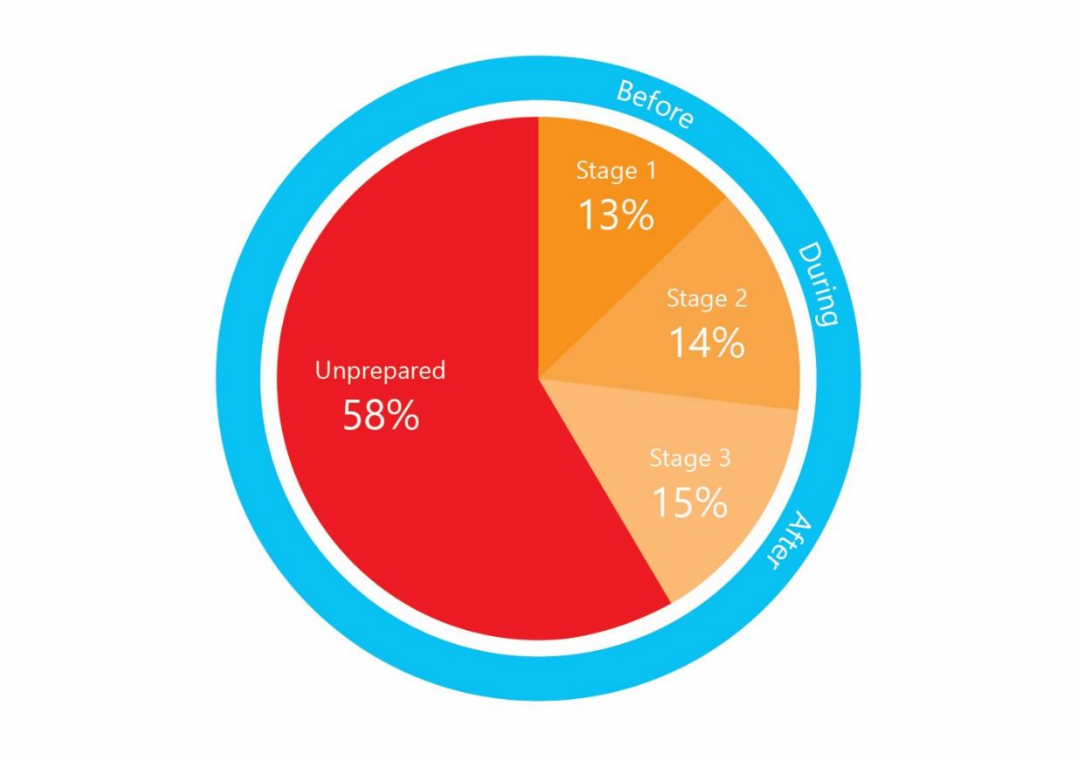


Figure 19 Pie Chart representing levels of preparedness at each stage of a flood (Self-generated)

4.3.1 Outcomes/ Findings

Findings generated form this study concluded that;

- Thomastown has a lower level of cooperation between responding professionals, responding community and affected community members.
- There is a need for enhanced collaboration between responding professionals.
- There is a lack of community engagement during each phase of a flood event.
- The before, during and after stages of a flood event need to be strengthened.
- Communication between responding professionals and community members needs to be enhanced and continuous.

4.4 Narrative Three: Inistioge

Inistioge is a small village in County Kilkenny situated along the River Nore and home to approximately 260 people (according to the 2011 census). During the end of 2015 and early 2016, Inistioge was hit with the worst flood in approximately 50 years. Roughly 20 homes were inundated by floodwater causing severe damage. Flooding occurred due to a combination of prolonged, heavy rainfall and a high tide. Much like Thomastown, Inistioge would not flood regularly, leaving them poorly prepared for a serious flood event. However, during the last flood, they showed a high level of community resilience. The majority of work carried out during this flood was achieved by responding professionals and responding community members. After initial enquiry on the last flood affecting the Inistioge community, the following infographic (Figure 21) was developed.

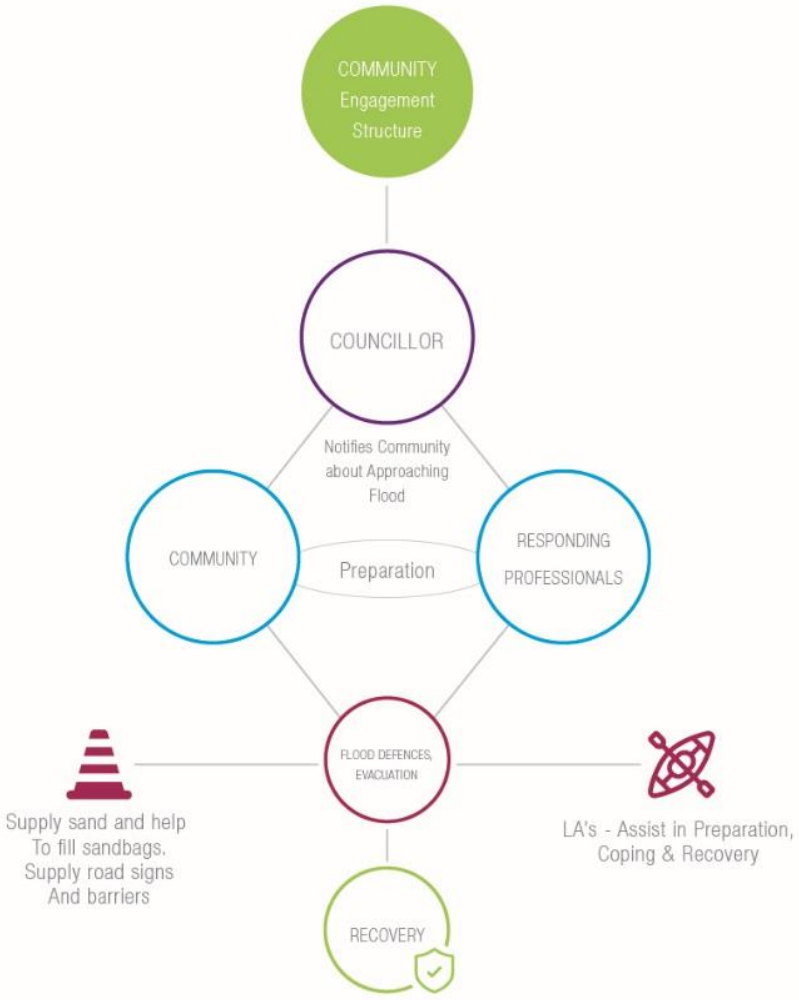


Figure 20 Inistioge Community Engagement Structure (Self-generated)

Standard procedure as of the last flood in Inistioge was as follows;

1. Based on local knowledge and weather predictions, responding professionals notify the community of the possibility of a flood.
2. Community deploy flood defence mechanisms e.g. door barriers, road signs etc.
3. LA's assist the distribution of sandbags.
4. Civil defence assist the evacuation of affected community members.
5. The community joined together to assist and speed up the recovery process.

The following infographic (Figure 22) was generated highlighting the activities carried out in response to the most recent flood event in Inistioge.

Figure 21 Inistioge Flood Response (Self-Generated)

From the infographic displaying activities carried out by responding professionals and community members, a second infographic (Figure 23) was generated mapping key community engagement points. These engagement points represent knowledge transfer and assistance provided by responding professionals to affected community members.

Figure 22 Inistioge Community Engagement Points (Self-generated)

A percentage analysis chart generated by the researcher based on data gathered during each phase and observations formed a statistical dataset for Inistioge exhibiting levels of preparedness before, during and after a flood. A pie chart representing this data was generated and can be seen in Figure 24. The original percentage analysis chart can be found in Appendix B.

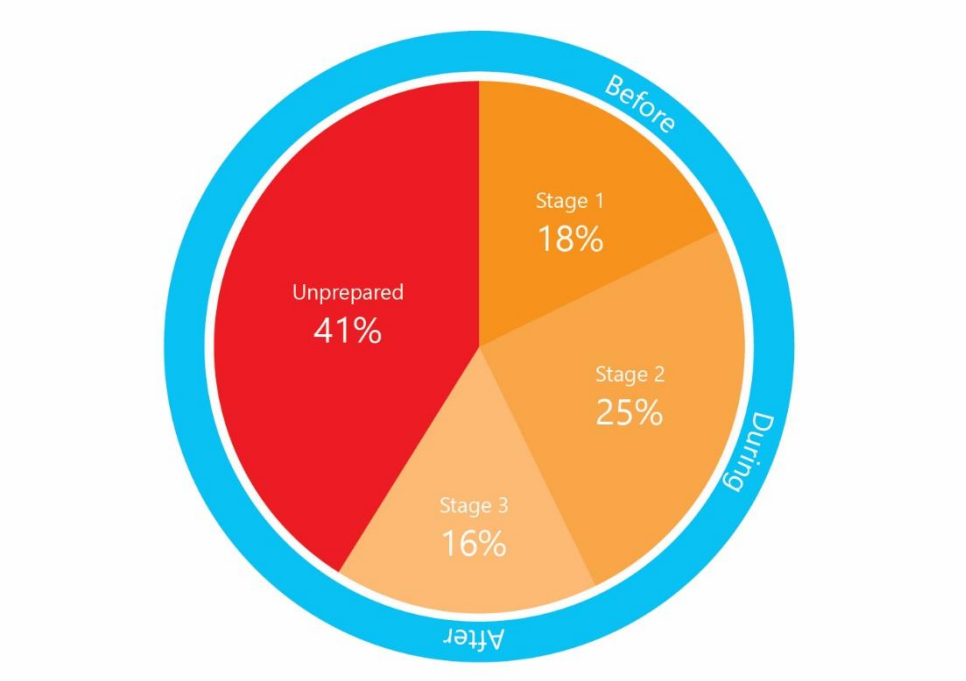


Figure 23 Pie Chart representing levels of preparedness at each stage of a flood (Self-generated)

4.4.1 Outcome/Findings

Findings derived from this case study concluded that;

- The response to the last flood event was positive.
- There was a satisfactory level of engagement between responding professionals, active community member and affected community members.
- There is a need for a more advanced early warning system to allow the community to enhance preparation.
- Improvements need to be made in relation to knowledge transfer and providing community members with necessary flood related information.

4.5 Conclusion

Upon completion of these case studies it was recognised that there are areas within both communities that need to be enhanced. All communities were analysed and compared to assess the areas that need to be strengthened. Skibbereen proved to have a higher level of community resilience, however, Thomastown and Inistioge are beginning to make advances in the area. A comparative chart (See Figure 25) generated from these findings displays the activities that need to be enhanced in preparation for a flood event.

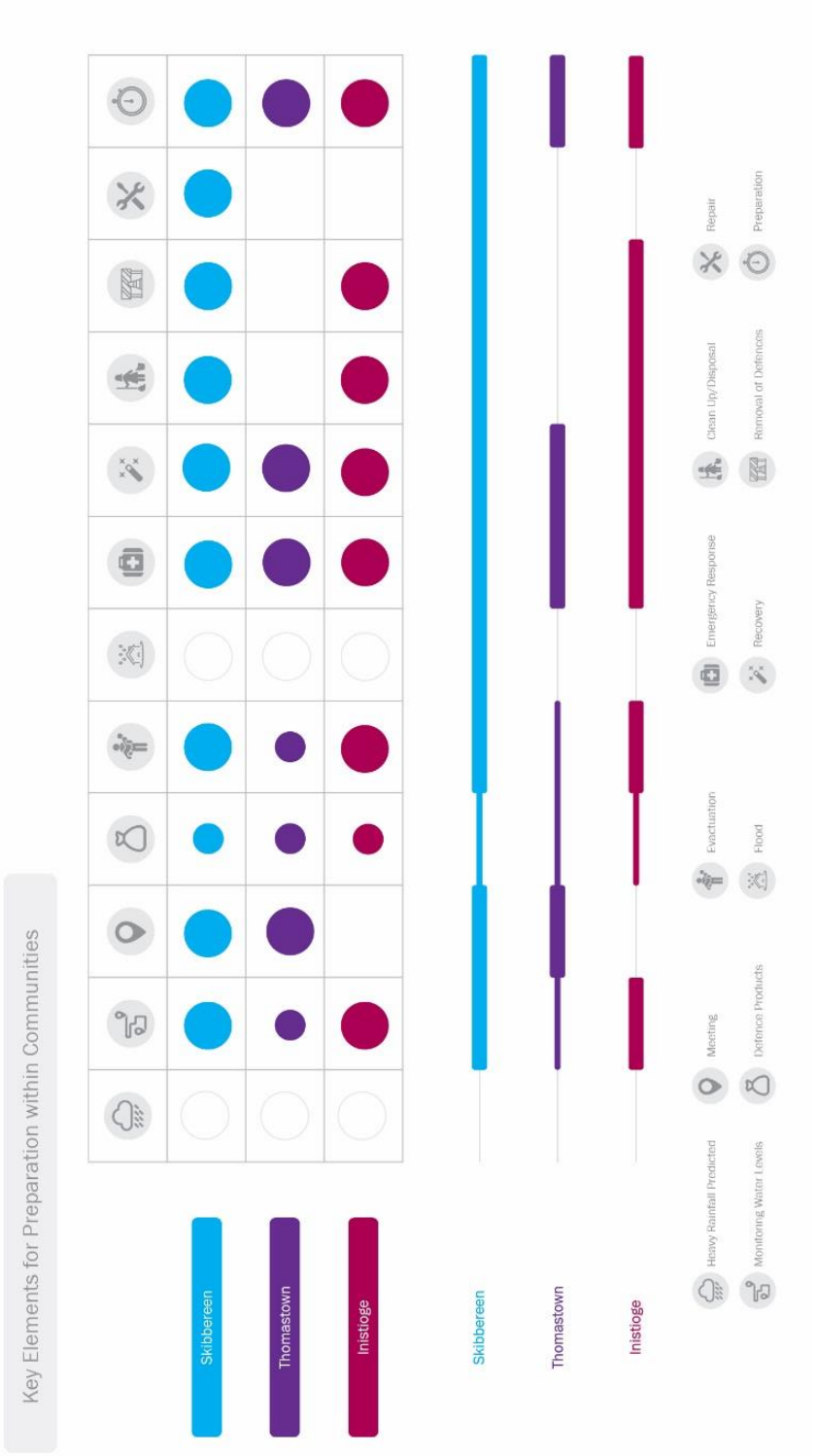


Figure 24 Comparative Chart (Self-generated)

Key findings concluded that communities are complex structures. Through the initial research phase and participant interviews it was highlighted that there is a strong dependency in government bodies to provide assistance to communities that suffer from flood events, resulting in weakened links between key players. In order to strengthen communities, social resilience must be increased. Social resilience represents the ability of communities to prepare, cope, resist, recover and adjust to threats. From this, a model (Figure 26) was created to assist communities in increasing Social Resilience and creating community empowerment.

4.6 Social Resilience Model

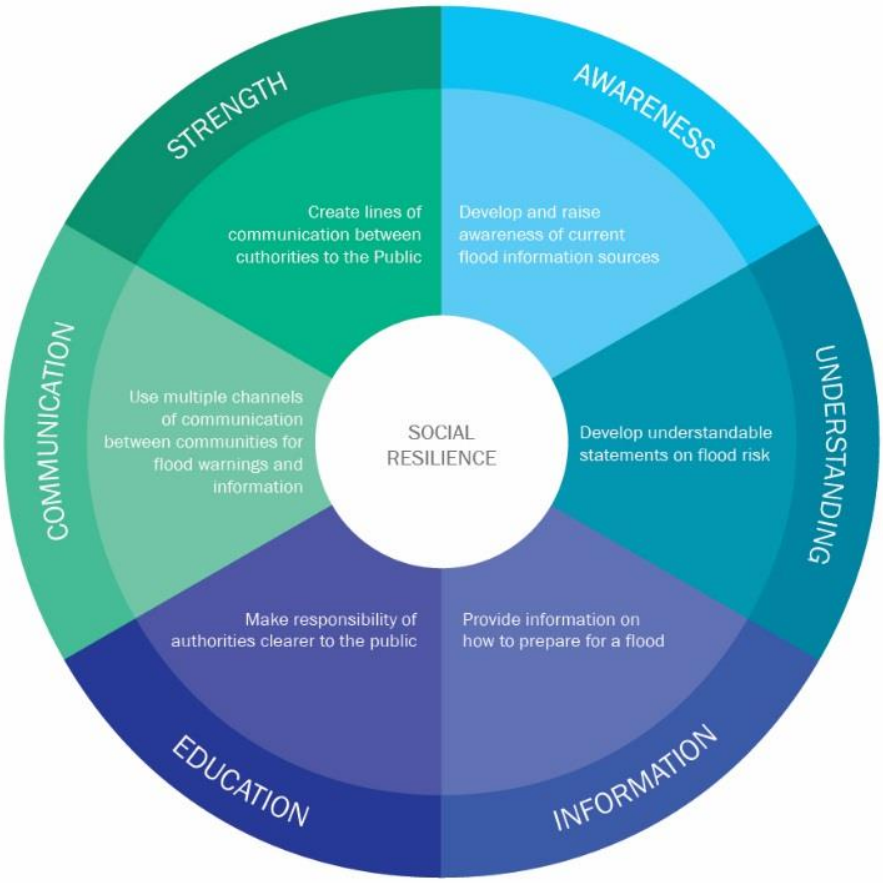


Figure 25 Social Resilience Model (Self-generated)

The model focuses on 6 steps that aim to enhance Social Resilience.

Step 1 – Awareness

To develop and raise awareness on current flood solutions and information sources to allow communities to explore options for abating or moderating flooding.

Step 2 – Understanding

To develop a widespread understanding on flood risks.

Step 3 – Information

Provide communities with information on different methods for dealing with flood events.

Step 4 – Education

Educate the public on the roles and responsibilities of Local Authorities and responding professionals.

Step 5 – Communication

Use multiple channels of communication between communities to facilitate the transfer of knowledge on flood events.

Step 6 – Strength

Strengthen knowledge transfer by creating lines of communication between responding professionals, responding community members and affected community members.

To support the Social Resilience Model, a Flood Model (Figure 27) was generated. This flood model represents six stages before, during and after a flood, to aid communities affected by flood related events. The model was developed using Skibbereen as a benchmark for increasing flood vigilance. This Flood model aims to identify arrangements and actions crucial for obtaining a consensus within the community against possible natural disasters.

4.7 Flood Model

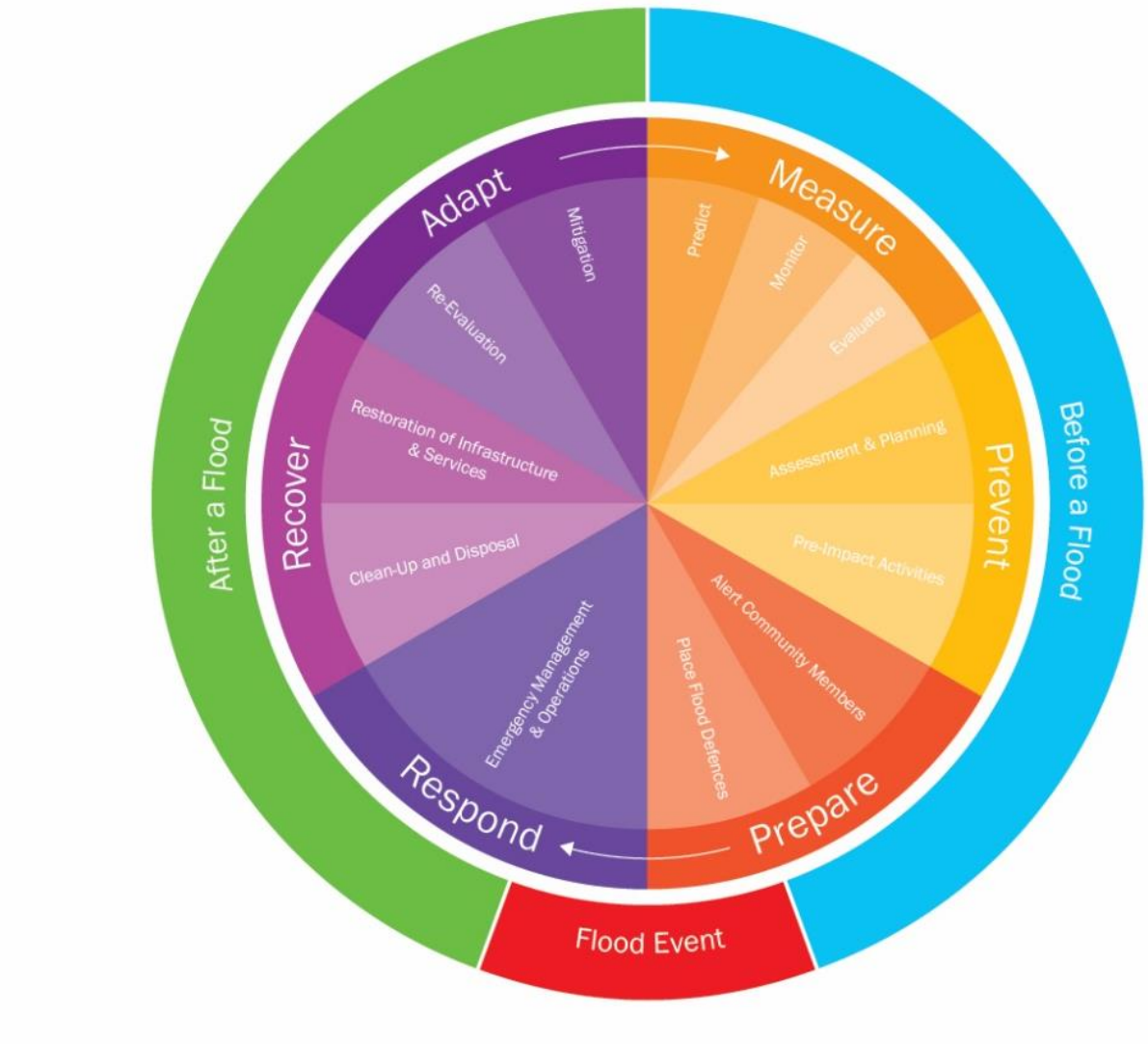


Figure 26 Flood Model (Self-generated)

The model focuses on six main steps before, during and after phases of a flood.

1. **Measure**

   Step one focuses on preparation related to predicting the potential of a flood occurring, constant monitoring of the situation and evaluation of this data to determine how to react.

2. **Prevent**

   Step two aims to help prevent damage by better assessment and planning and the execution of pre-impact activities.

3. **Prepare**

   Step three involves alerting community members of important data related to a possible flood event and the deployment of flood defences to areas needed.

4. **Respond**

   Step four outlines support from responding professionals and responding community members.

5. **Recover**

   Step five focuses on the clean-up and disposal of damaged possessions and the restoration of infrastructure and services post flood event.

6. **Adapt**

   Step six highlights the re-evaluation of a community's level of preparedness based on previous floods and mitigation efforts for adapting and increasing resistance.

The provision of both the Social Resilience Model and the Flood Model aims to equip community members with the basic tools and knowledge necessary for preparing, coping, resisting and recovering from a flood event.

5.0 Design Phase

5.1 Design Hypothesis

Ensuing the research phase of this project, the researcher aimed to propose appropriate solutions to the issues and opportunities identified. These included;

- Social Resilience
- Knowledge, Skill and Technology Transfer
- Open Source Design

These key findings were combined to generate a hypothesis that helped lead and influence the design phase of the project. The Hypothesis provided an explanation for conclusions derived from the Literature Review that needed to be validated through the design phase. It allowed the researcher to generate solutions while being led by the findings obtained from the research stage.

Hypothesis;

"It is possible to increase community capacities for mitigating the effects of flooding by facilitating the transfer of knowledge, technology and skills through open-source, user-centred design."

5.2 The Interaction Framework

Outcomes and findings generated from field research, Chapter 3, helped inform the researcher of the key interaction points between community members and flood prediction. The design of the interaction framework was user focused, incorporating design demographics to ensure that a range of stakeholders were considered throughout the design phase. This resulted in the design of a community–based initiative aimed at a wide range of individuals within community groups.

This approach led to the development of a visual displaying the interactions and activities associated with each persona. (See Figure 28) The process captured community interactions with current sensor technology, from delivery to installation and monitoring. This visual shows current community interaction with sensor driven initiatives and highlights that there is little interaction from the affected community. The infographic assisted the researcher throughout the design phase to ensure a community led approach for developing concepts.

The interaction framework facilitated the identification of interactions between three sets of demographics within communities and early warning systems. This allowed the researcher to create a design led initiative aimed at enhancing engagement between community members and early warning systems and to ensure a community led approach throughout.

Outcomes generated from the initial research phase led by the interaction framework, resulted in three directions for further exploration.

- **Intervention 1** – Open-source product design – flood sensor
- **Intervention 2** – Social Resilience Model and Flood Model (Chapter 5)
- **Intervention 3** – Online platform – Community Network

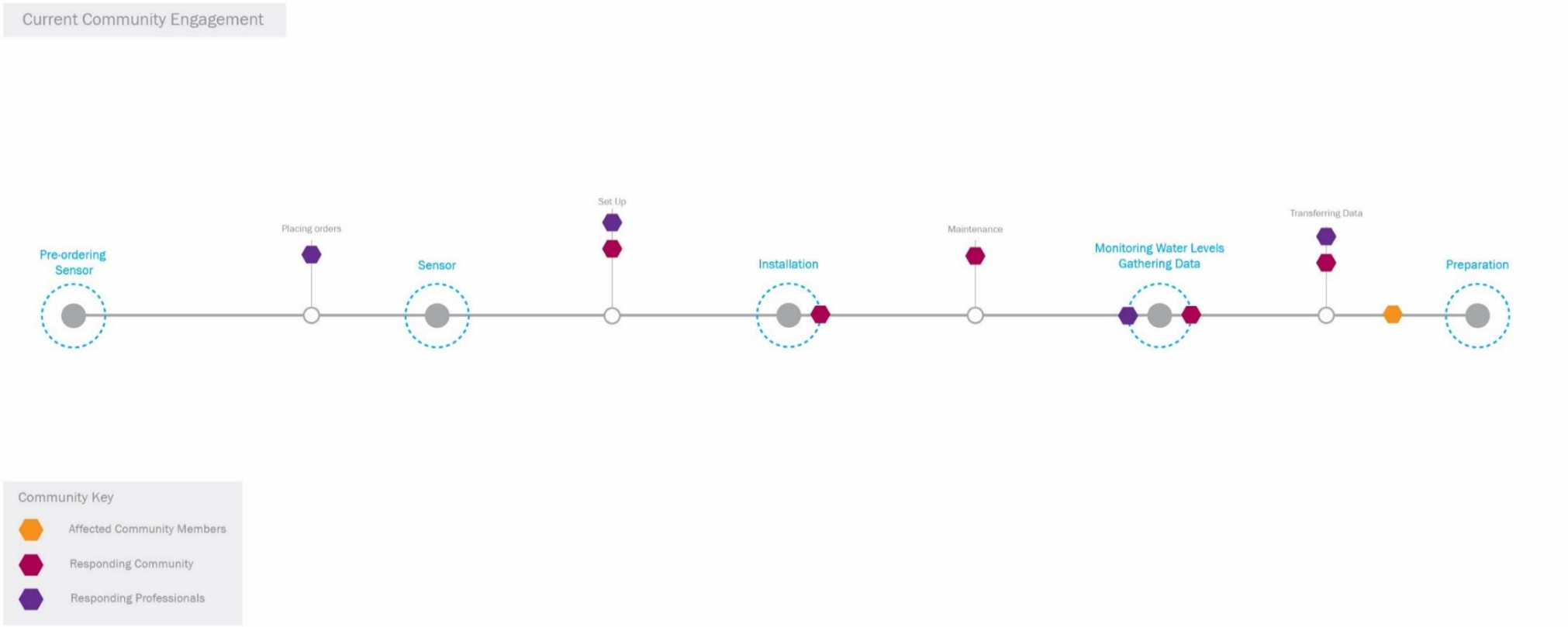


Figure 27 Current Community Engagement - Source: (Self-generated)

5.2.1 Intervention One

The first intervention was formed by combining conclusions derived from the Literature Review, Case Studies and the Internship. (See Figure 29)

This concept focuses on using sensors to predict weather patterns and water levels. The results of gathering new data aims to result in a more advanced early warning system for predicting flood events.

It is proposed that communities would be provided with the information necessary for developing a system that would be set up and run by community members. The concept aims to facilitate the establishment of a database of new knowledge.

Combined with existing knowledge within communities, this database forms the groundwork necessary for enhanced prediction of flood events and increased preparation.

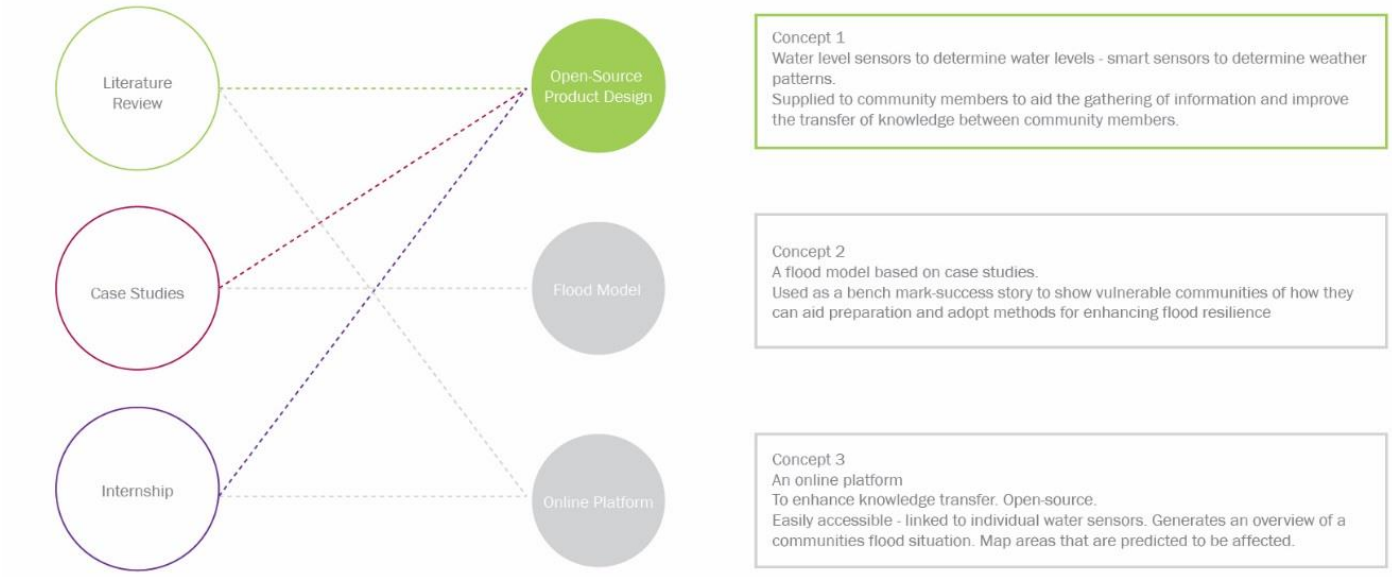


Figure 28 Open-Source Product Design - Source: (Self-generated)

5.2.2 Intervention Two

The second intervention, the Flood Model, was developed based on findings generated from the narratives discussed in chapter 4. (See Figure 30)

The idea focuses on using successful elements identified within communities with a high level of flood resistance and providing this information to vulnerable communities. This aims to allow susceptible communities to adopt suitable methods for dealing with flood events before, during and after they occur. The Flood Model acts as a universal benchmark for displaying successful procedures for enhancing flood resistance that can be tailored to any community that experiences flooding.

A full description of this flood model can be found in Chapter 4.6.

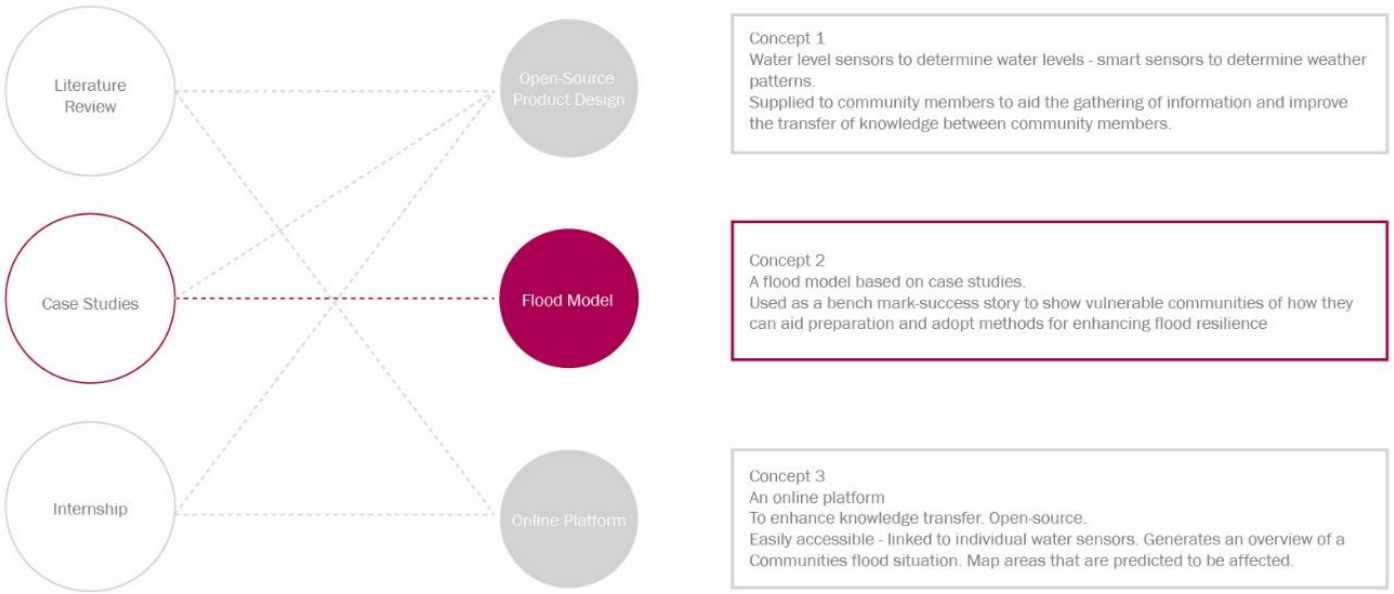


Figure 29 Flood Model - Source: (Self-generated)

5.2.3 Intervention Three

The third intervention was formed as a result of the outcomes generated in the Literature Review, Narratives and the Internship. (See Figure 31)

This idea is aimed at providing a method for transferring new and existing knowledge within and between communities. The idea focuses on developing an online network allowing communities to upload and retrieve data specific to flood related events.

The platform acts as a support system for intervention 1 and intervention 2 and facilitates the establishment of a community driven network for enabling communities to increase flood awareness.

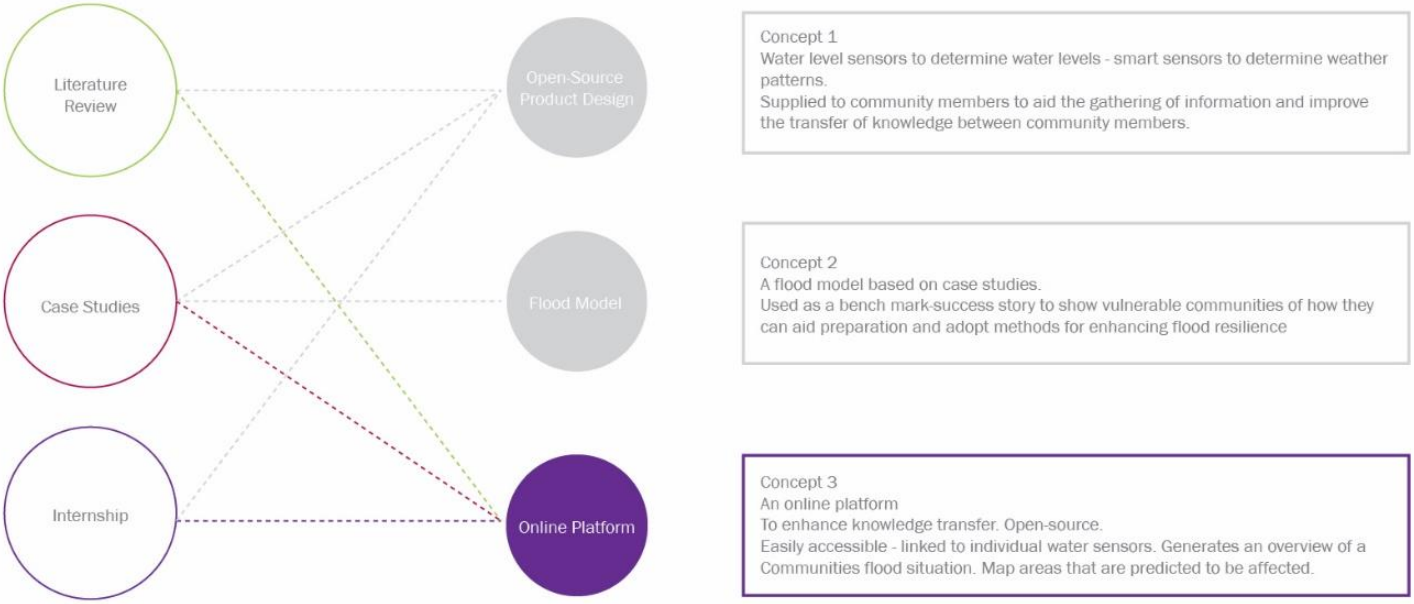


Figure 30 Online Platform - Source: (Self-generated)

5.3 Conclusion

All three interventions (See Figure 32) were brought forward for further development and combined to generate an outcome that facilitates the establishment of an open-source community-based initiative against flooding. This aims to facilitate the slow integration of knowledge, skills and technology needed for enhancing community Awareness.

A full description of Intervention two can be found in chapter 4 - Narratives. Intervention one and three will be described in detail in this chapter.

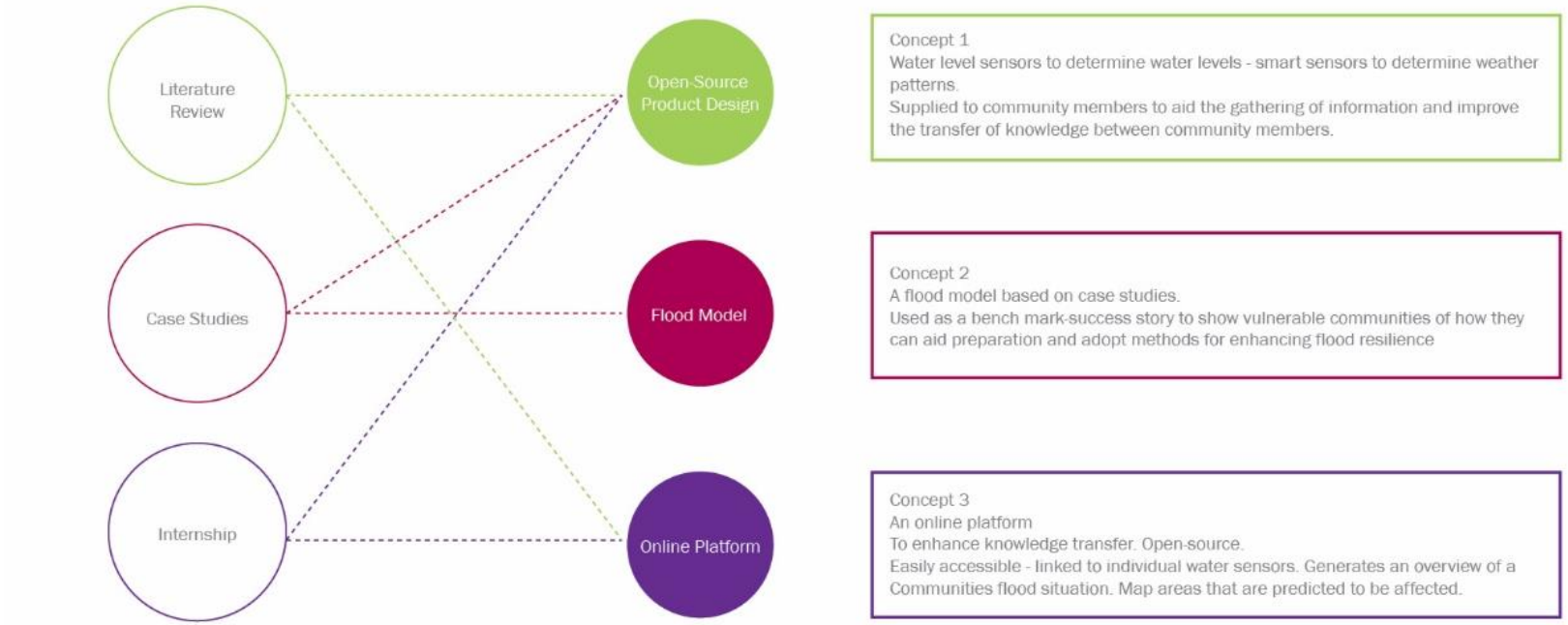


Figure 31 Three Interventions - Source: (Self-generated)

5.4 Design Interventions – Open Source Product Design

5.4.1 Intervention One

Approach and Method

From the first intervention, three product design concepts were developed based on using open-source product design as part of an early warning system. The researcher conducted further investigation into the area around early warning systems before entering the design phase. This allowed the researcher to build further knowledge in the area and assisted in the identification of existing methods that have been both successful and unsuccessful. This section provides a description of the three design concepts considered for further development.

Concept One: Probe Sensor

Concept One focused on using probes for immediate water detection. The concept incorporated an Alarm and Bluetooth feature to allow the user to receive alerts when the flood sensor is triggered. (See Figure 33) The sensor facilitates the use of one or more probes to allow the user to tailor fit the sensor to the area being monitored. The probes are attached to the sensor by a wire that can be extended and placed in an area most suited to the user's needs. This concept focuses on the installation of flood sensor near residential and commercial properties.

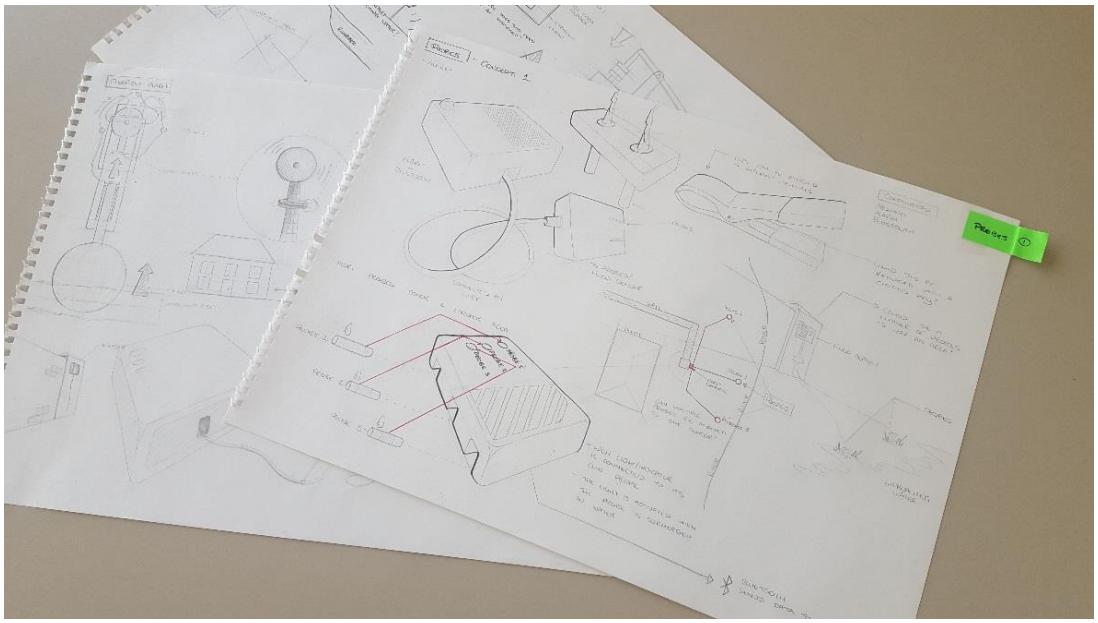


Figure 32 Design Concept One Sketching

Concept Two: Level Sensor

Concept Two involved using a level sensor for detecting water and taking measurement of the water from the river bed to the water's surface. (See Figure 34) Like the probe sensor, an alarm is triggered when water is detected and a notification is sent out to the user. As the water rises the sensor measures the water level and sends updates via SMS. The sensor could be mounted on self-made or fixed structures near flood zones to facilitate the early prediction of approaching water.

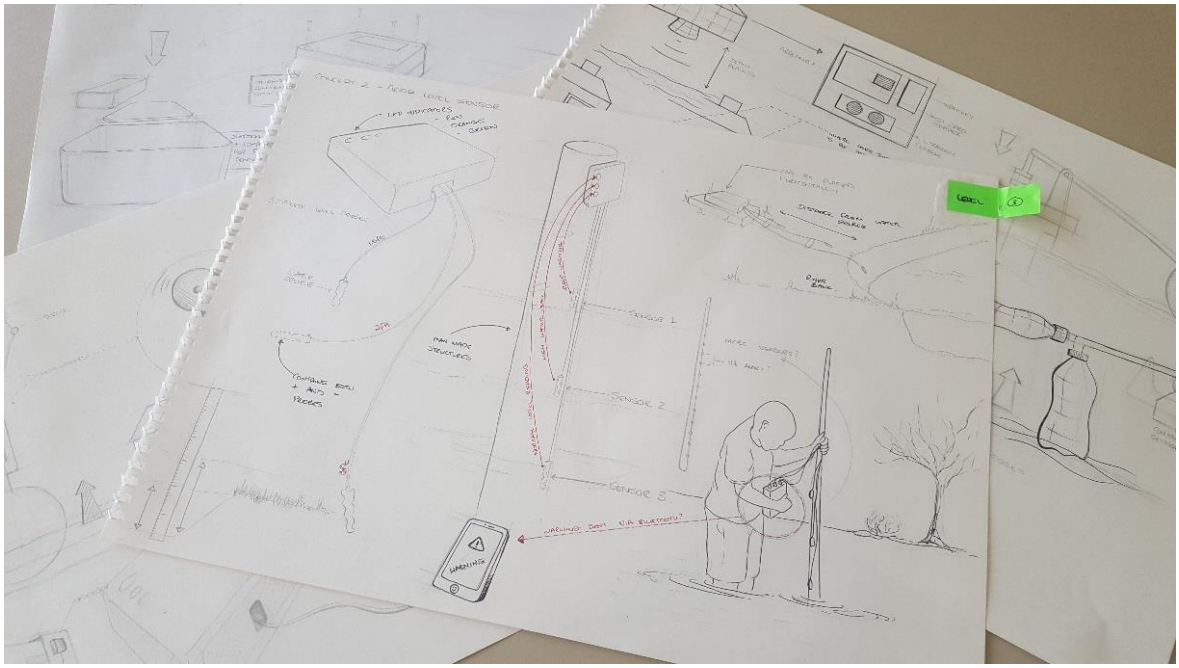


Figure 33 Design Concept Two Sketching

Concept 3: Ultrasonic Sensor

Concept 3 incorporated an ultrasonic sensor for measuring the distance from the sensor to the water surface. (See Figure 35) The sensor would need to operate constantly and incorporate a SMS function allowing the user to send a text to the sensor and retrieve data on real time water levels. The sensor included a micro SD card integrated into the design that would form a log of the water levels detected. This information could potentially be used for predicting future flood events.

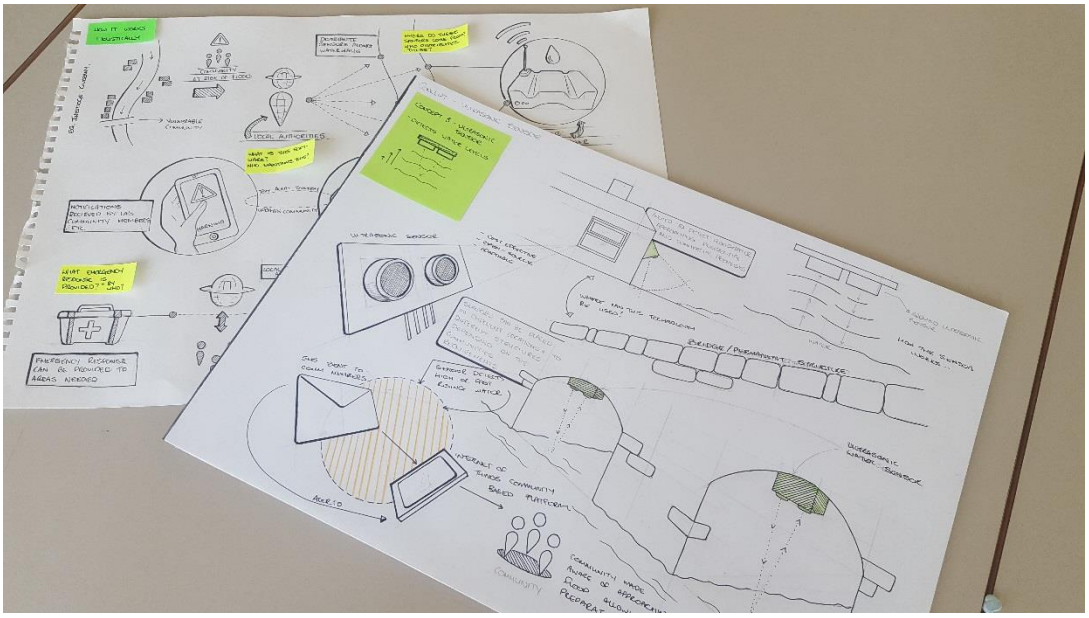


Figure 34 Design Concept Three Sketching

5.4.2 Selecting a Concept

To select a concept for development, a suitability matrix was generated (See Figure 36) highlighting the elements necessary for identifying the concept most suitable to fulfilling the criteria set out in the hypothesis.

Hypothesis – Criteria

- Open-source product design
- Enhanced community engagement
- Knowledge, skill and technology transfer

Suitability Matrix

The suitability matrix was split into two sections, User/Product and Product. This allowed the researcher to compare all three concepts and select one or a combination of more than one to achieve the best product outcome.

From this chart, it was concluded that concept three would be brought forward for further exploration and development. As concept three was the most complex, none of the elements from concept one or concept two were integrated into its development.

	Concept 1	Concept 2	Concept 3
Product/User			
Ease of Use	High	High	High
Set Up	Moderate	Moderate	High
Assembly	High	High	High
Enhances Community Engagement	Moderate	Moderate	High
Facilitates Knowledge Transfer	Moderate	Moderate	High
Strengthens Skill Sets	High	High	High
Promotes Roles within the Community	Low	Low	Moderate
Safety	Moderate	Moderate	High
Product			
Low Cost	High	High	High
Durability	Low	Low	Moderate
Captures Data	Low	Low	High

Figure 35 Suitability Matrix - Source: (Self-generated)

5.4.3 Chosen Concept

Concept Three – Ultrasonic Sensor

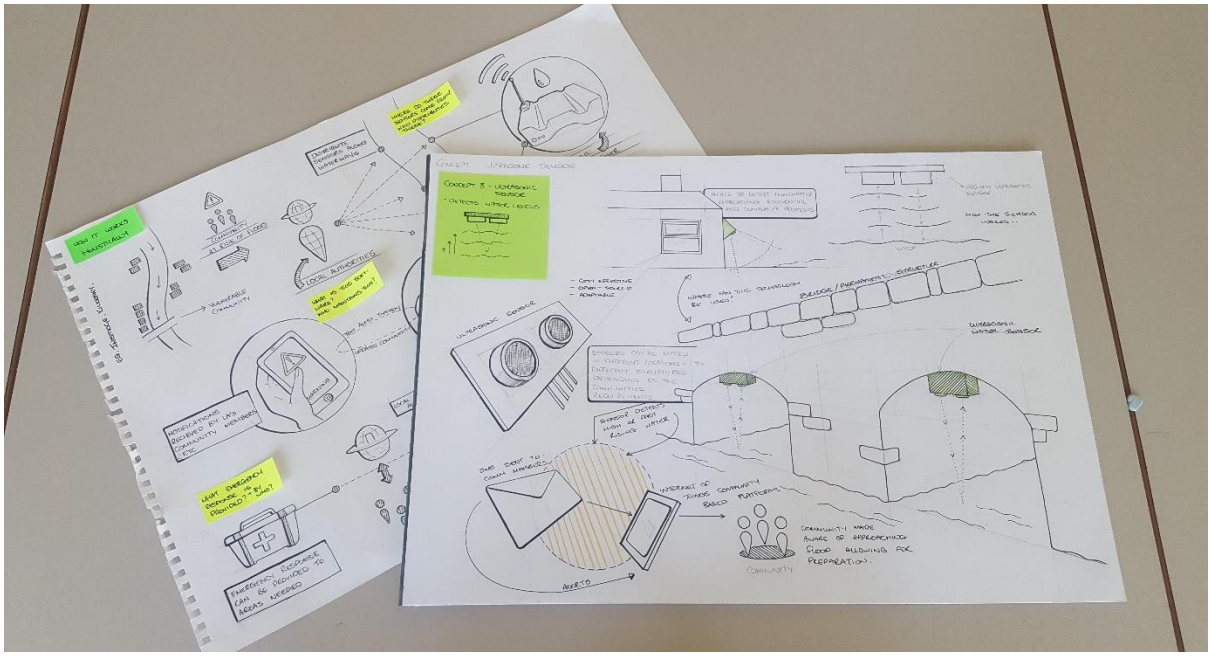


Figure 36 Selected Concept Sketching

5.5 Concept Development

The concept was mapped out as part of a network using the water sensor to facilitate knowledge transfer specific to flood events. The holistic mapping allowed the researcher to ensure a community led approach was followed throughout the design phase. This map grounded the concept and assisted its development through design, sketch modelling and prototyping.

The Ultrasonic Sensor Concept aims to enhance the transfer of knowledge, skill and technology as part of a community-based network. This network proposes to provide a platform where information specific to flood related events can be gathered and shared by community members to create empowerment and enhance awareness. The concept act as a starting point for the integration of a community-based initiative, led by affected and responding community members and supported by responding professionals. (See Figure 38 and Figure 39)

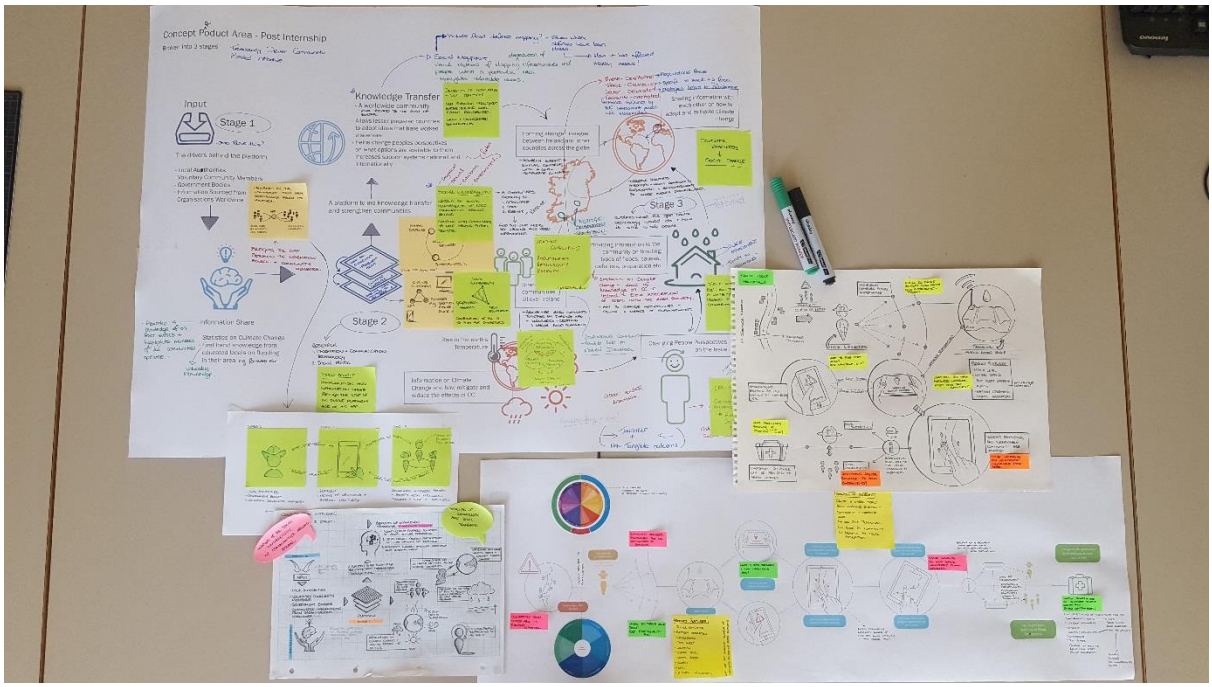


Figure 37 Mapping Holistic Approach for Further Development

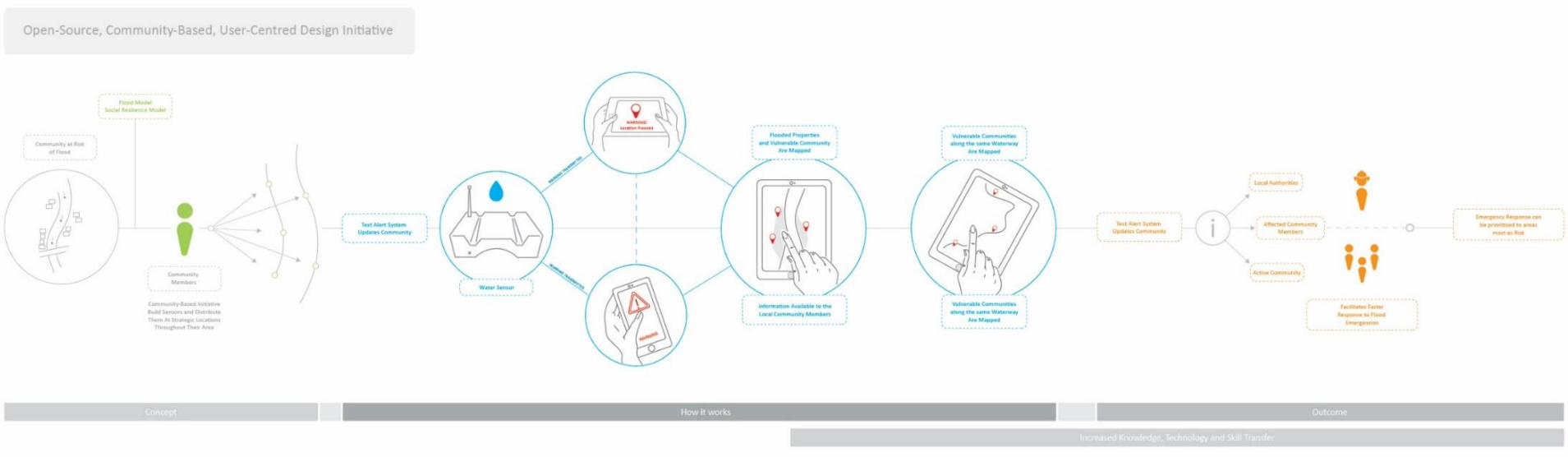


Figure 38 Holistic Mapping of Concept

5.5.1 Current Engagement with Water Sensor Technology

Initial research highlighted community engagement points with current flood sensor networks in Ireland. The research emphasised that there is a relatively low number of communities utilising water sensor technology. The areas that use water sensors for flood predication are predominantly run by responding community members and responding professionals, leaving affected community members disconnected from early warning systems. The researcher mapped out the main interaction points (See Figure 28, Page 84), to identify areas that could be strengthened by initiating a community based flood network engaging affected community members.

This visual allowed the researcher to ensure that the outcome of a new community based initiative using water sensor technology would further engage affected community members and result in enhanced levels of community vigilance.

5.5.2 Concept Development

Prior to any design work being carried out, further research was conducted to enhance the researcher's knowledge on sensor technology. This phase allowed the researcher to gain an insight into existing technologies and how they are currently being used to deliver early flood warning systems. The research displayed huge advancements in technology and highlighted areas across the globe using flood sensors for predicting natural disasters. This investigation grounded the concept further and allowed for a more informed and educated approach toward the design phase of the project.

5.5.3 Outcomes/Findings

Findings from this research phase included;

- Rapid advancements in technology is resulting in a more technology driven society i.e.; smart cities integrating information and communication technologies for education and development.
- Technology driven community-based initiatives are being developed across the globe highlighting a newly identified passion for community engagement.

As mentioned previously in the literature review, knowledge transfer is a key element for ensuring that communities are more vigilant toward flooding. Further research showed that existing initiatives using sensor technology proved positive for enhancing knowledge transfer.

5.6 Sketch Modelling

Before the researcher began prototyping, three sketch models were developed as physical representations of both the concept and the system supported by the concept. The sketch models allowed the researcher to clearly communicate the concept using 3D versions of previously generated visuals and sketches.

5.6.1 Reverse Engineering

The researcher undertook a preliminary reverse engineering phase prior to engaging in the construction of the ultrasonic sensor. The aim of this phase was to allow the researcher to deconstruct a simple contact sensor to understand its components and how it works. The process involved dismantling the contact sensor and reworking its internal components to form a water sensor.

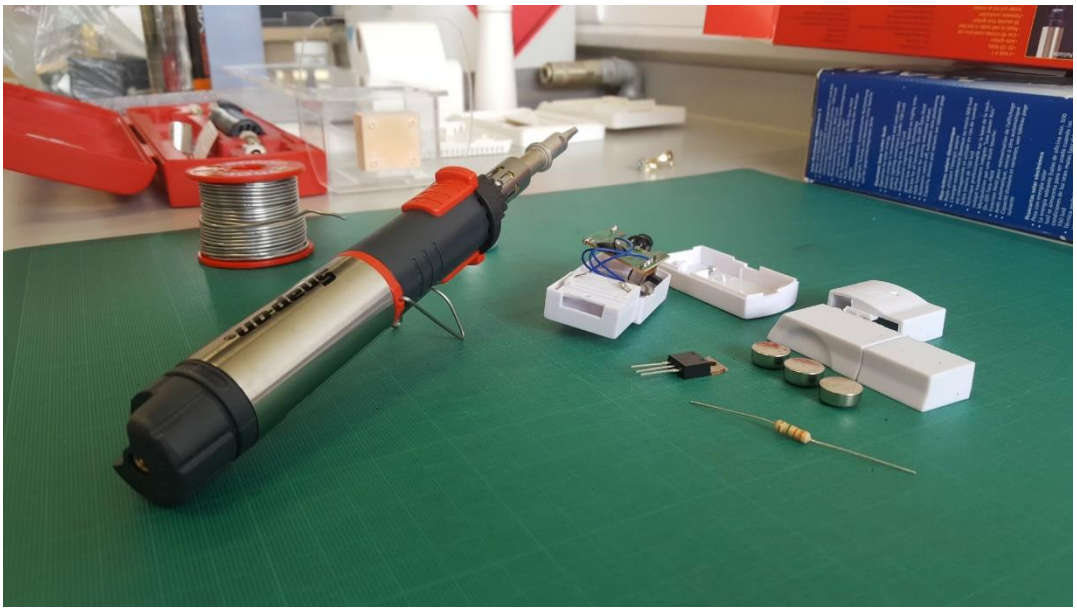


Figure 39 Reverse Engineering

This process resulted in a prototype that detected water using two exposed wires that formed a connection when placed in a body of liquid. As water is a conductor it joined the circuit between the two exposed wires to trigger an alarm.

This prototype acted as a good starting point for the researcher to explore electronic engineering and develop knowledge and skills necessary for further development of the concept

Ensuing the reverse engineering phase, the researcher explored different methods of connecting wires to form a circuit without using the soldering iron. (See Figure 41) This aimed to facilitate use by communities that may not have access to soldering equipment and required an alternative solution.

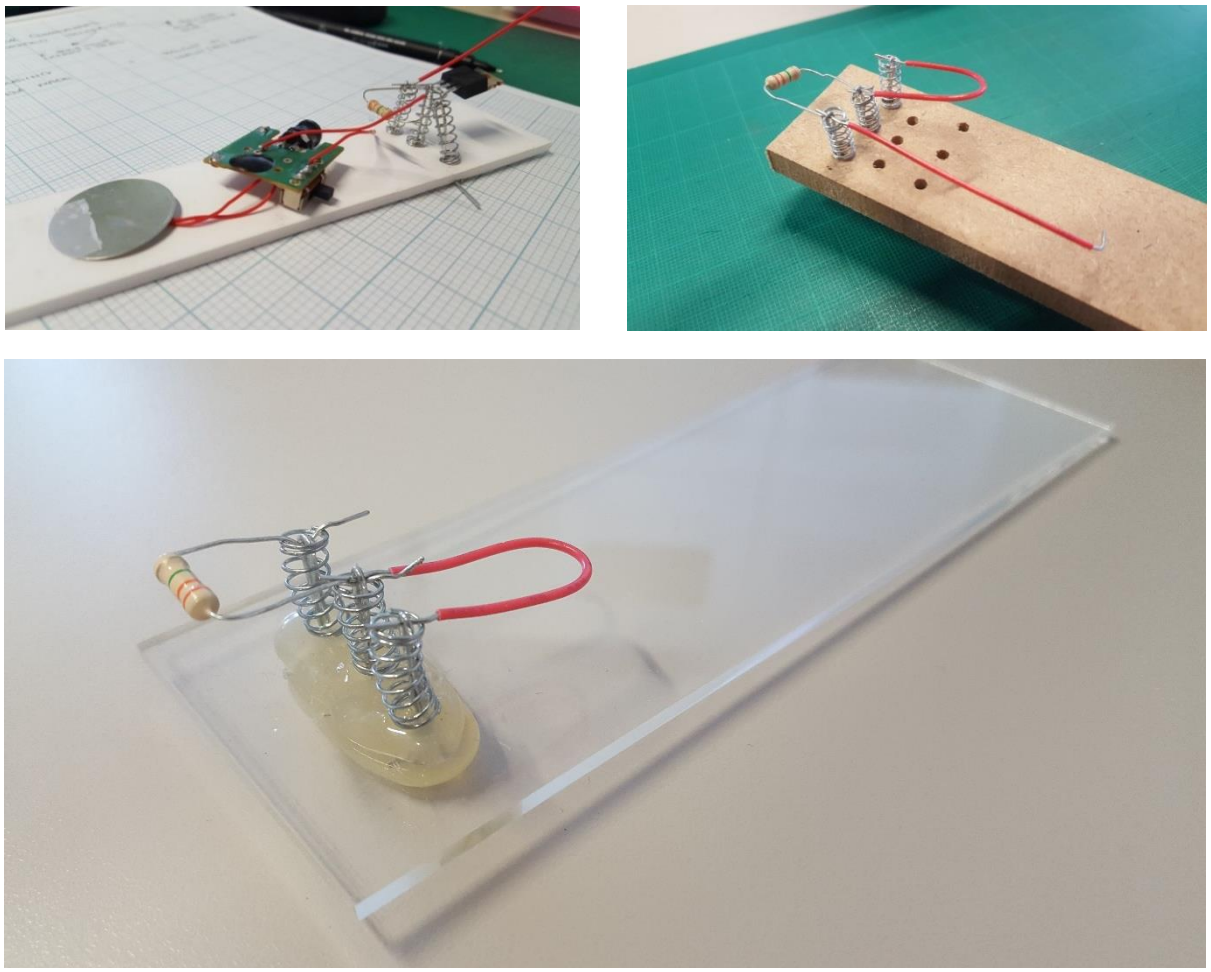


Figure 40 Exploring Methods for Connecting Components

5.6.2 Outcomes/Findings

Finding generated from the reverse engineering phase concluded that it is relatively easy to manufacture a low-cost flood sensor. All materials used in this phase were open-source and tutorials on how to make your own water sensor could be found online.

In order to fulfil the criteria, set out in the hypothesis, this concept needed to be developed further but still remain open-source and relatively low in cost.

5.7 Arduino

The researcher began building a sensor using an Arduino starter kit. Arduino is an open-source electronics platform that is aimed at users with little knowledge on electronics or programming. This open-source technology is aimed at encouraging users to adapt and tailor these microcontrollers to their specific wants and needs. Arduino was selected as the most appropriate method for building a sensor as it is;

- Cost effective
- Compatible with Windows, Macintosh OSX, and Linux operating systems
- Simple, clear and flexible – Arduino can be used by both beginners and advanced users
- Open-source

Arduino is aimed at a worldwide community and facilitates fast learning and prototyping. This microcontroller uses C/C++ programming language which is efficient, portable and available on all platforms. The Arduino software can be sourced online through the Arduino website and provides code samples for use by the public domain.

In order to build a sensor that corresponded with the criteria set out in the brief, the researcher had to source extra components online. These components included;

- An ultrasonic sensor
- A piezo buzzer

Once all the components necessary for building a sensor to detect water levels were sourced, the researcher began the prototyping phase of the project. Initial prototyping involved the testing of different methods for detecting water.

5.7.1 Prototype 1

The first prototype was developed using a contact sensor. Contact sensors are usually installed or doors and windows in residential or commercial properties. An alarm is triggered when a window or door is opened and the current is disturbed.

The prototype was built using a low-cost contact senor attached to a small bottle using a straw. (See Figure 42) The bottle acted as a float that rose with the water level, separating the sensor and triggering an alarm. This concept was validated through testing, however, this type of sensor proved unsuitable for rapid and fast-moving water associated with flooding.

Figure 41 Prototype One - Testing

5.7.2 Prototype 2

The second prototype was created using LED's as a method for communicating water levels. This was created using;

- A 9V Battery and 9V battery connector
- Three wires measured at three different distances
- Three LED's – different colours
- One wire for creating a current to activate the LED's
- A length of 2"x1" pine

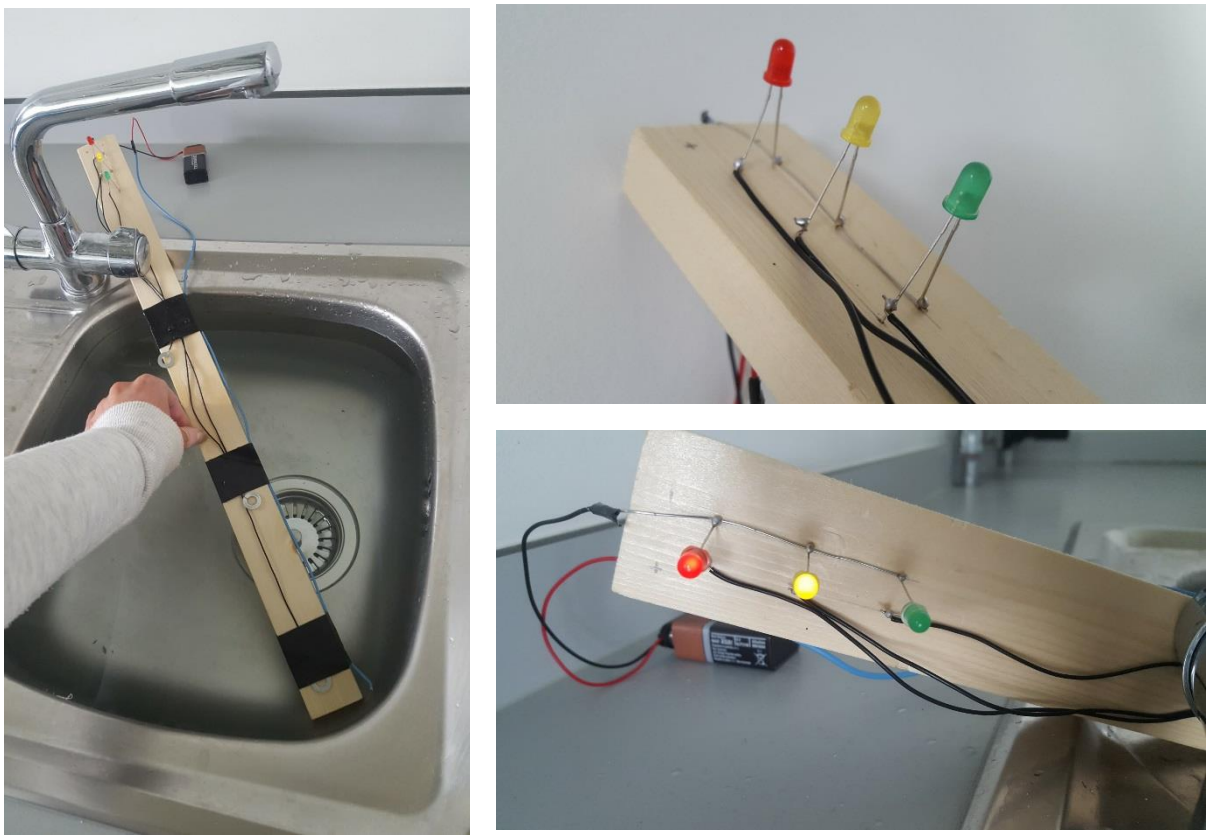


Figure 42 Prototype Two - Testing

The prototype was developed and tested to explore the use of LED's for detecting water levels. This concept was validated through testing but proved too simple for providing a satisfactory method for predicting flood events.

5.7.3 Prototype 3

The third prototype incorporated Arduino Uno. Research previously conducted in this area highlighted the capabilities of Arduino and how it can be used to measure water levels. This concept was further developed through prototyping, allowing the researcher to generate a high-quality working model to validate research findings.

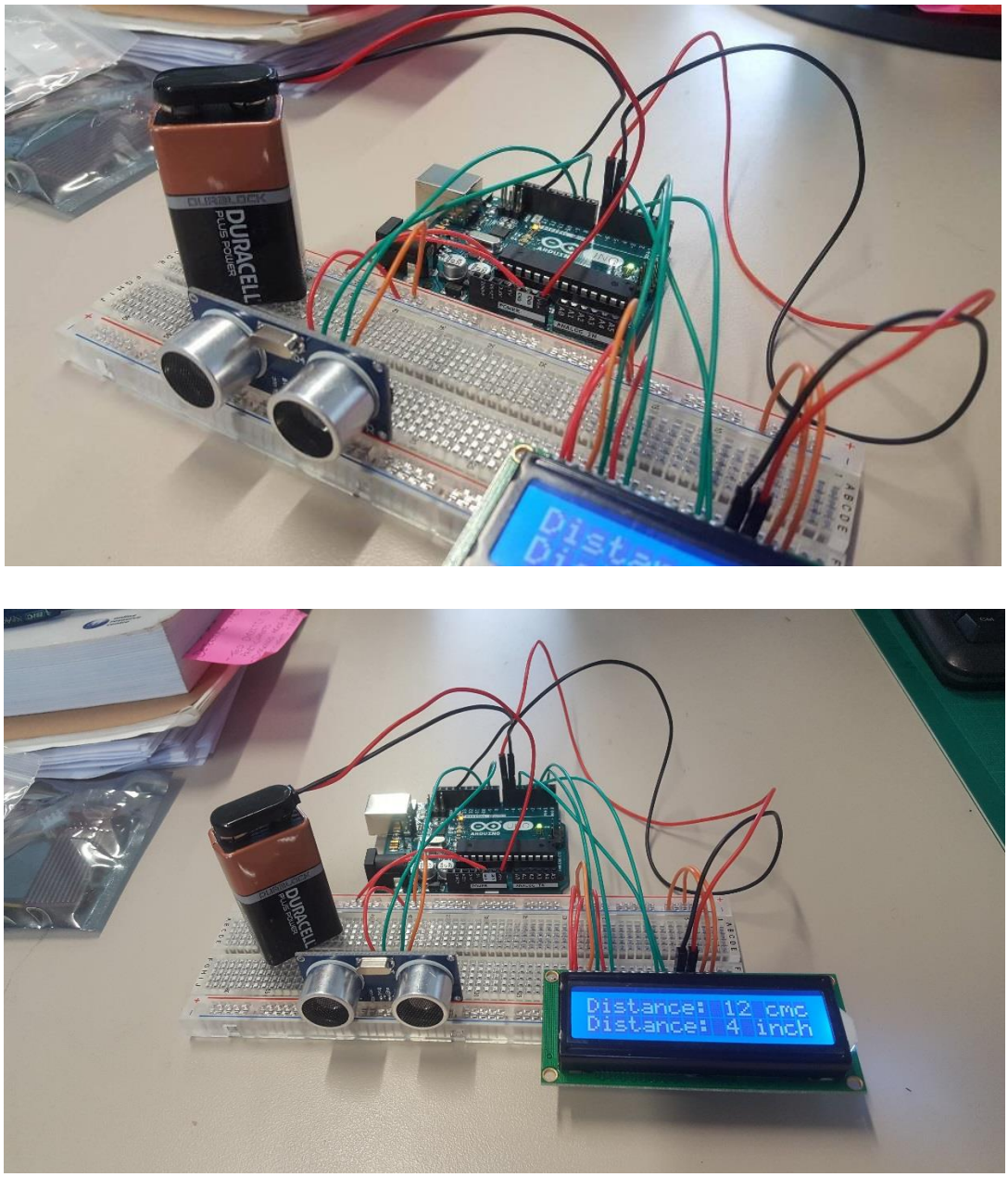


Figure 43 Prototype Three - Testing

The researcher built an ultrasonic sensor using components included in the Arduino Uno starter kit and extra components sourced online. These items necessary for building this sensor included;

- 1 x Ultrasonic Sensor
- 1 x LCD Screen
- 1 x 830-point breadboard
- 22 x M/M Jumper Wires
- 1 x Piezo Buzzer
- 1 x Arduino Uno
- 1 x 100-ohm resistor

The Arduino was constructed in 5 stages. At each stage, the researcher added an extra component to the board and tested it to ensure that all elements were working properly. This process facilitated the development of an accurate, low-cost working prototype for reading water levels.

5.8 Coding

Throughout the development stages that Arduino was coded in order for it to complete a specific set of functions. The Arduino needed to;

- Measure the distance from the sensor to the water level to assist the user in identifying real time water levels.
- Display distances in 'cm' on the LCD screen.
- Display "WATER HIGH", "WATER NORMAL" and "WATER LOW" for variables set by the researcher.
- Trigger a buzzer when the sensor detects high water levels.
- Be battery powered.

Code specific to ensuring that the sensor performed the tasks set out by the researcher was sourced online through the Arduino website and online tutorials. The researcher was assisted by an electronic engineer who helped tailor the code to the researcher's requirements and ensure the prototype was of a high standard. A copy of this code can be found in Appendix C.

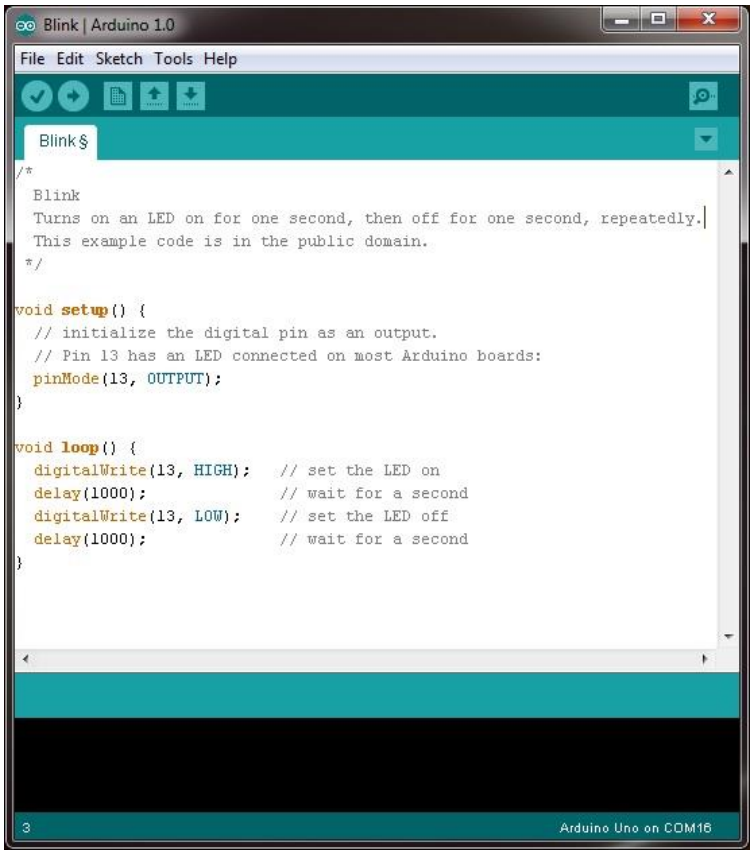


Figure 44 Coding Arduino (Example) - Source: (Online)

5.9 Housing

After the sensor was refined the researcher began designing the housing for the water sensor. During the research stage the researcher identified skills and expertise within participating communities. This was carried out for the development of housing solutions for different communities with different skills and expertise.

5.9.1 Kappa Board Model

The housing designed by the researcher needed to be simple allowing community members to be able to manufacture the housing easily themselves. The design also needed to be durable and waterproof. A low fidelity sketch model (See Figure 46) assisted the researcher with further development and ideation. The sketch model allowed for quick and easy manipulation of the concept and facilitated a more informed approach toward the next stage of model making.

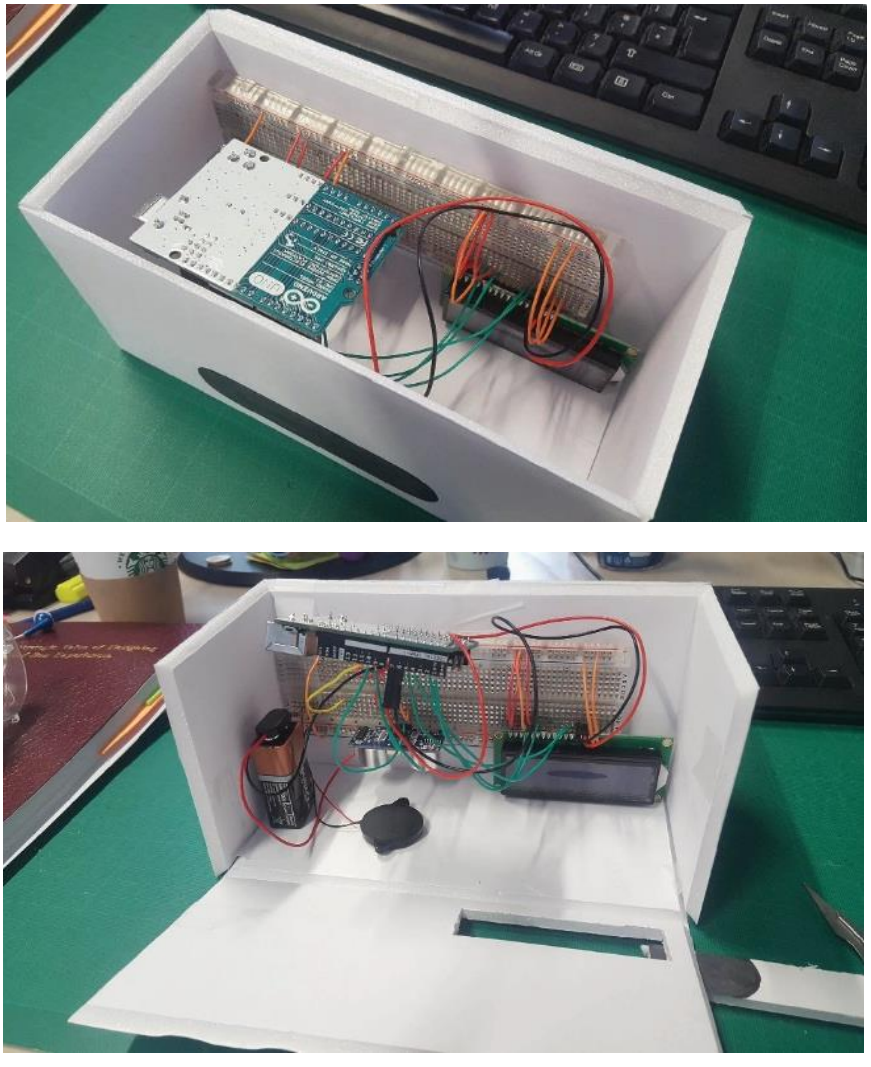


Figure 45 Kappa Board Model

5.9.2 Acrylic Model

A second model was developed using acrylic. (See Figure 47) This enclosure was created for testing purposes to ensure that the Arduino and all its components were protected from liquids. Files for this model were generated using Adobe Illustrator which were then converted to EPS (Encapsulated PostScript) files compatible with the laser cutter.

The design incorporated etchings that illustrated where each component would be positioned. Sections cut out in the model allowed for the ultrasonic sensor to extend past the surface of the model to ensure that the sound waves were not interfered with.

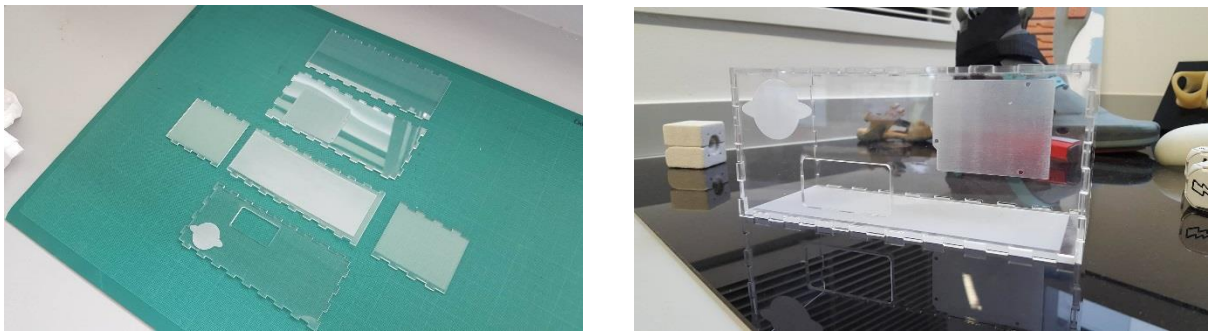


Figure 46 Acrylic Model

The Arduino was then placed inside the model and secured with double sided sticky tape to ensure that no component fell out of the housing during testing.

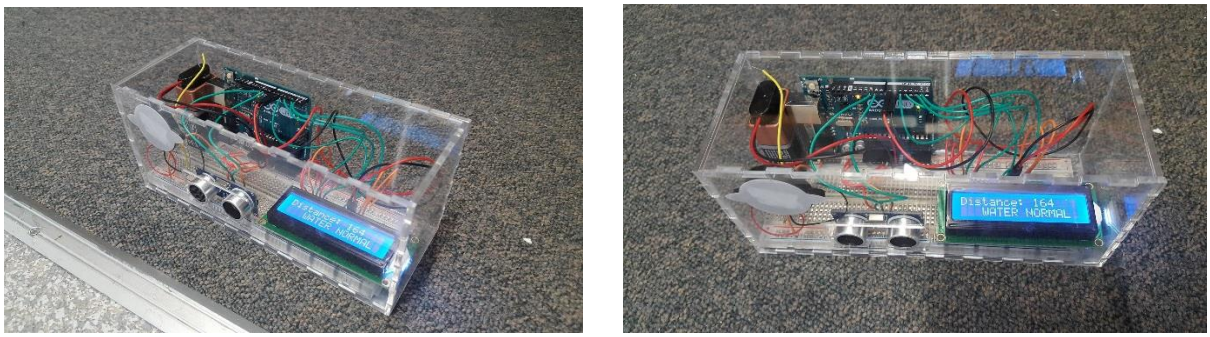


Figure 47 Acrylic Model with Arduino

5.10 Testing

The working prototype was then tested for accuracy to ensure that the acrylic housing caused no interference with the sensor. The Arduino was tested using three sets of variables;

1. 100 – 150 centimetres: WATER HIGH
2. 150 – 200 centimetres: WATER NORMAL
3. 200 + centimetres: WATER LOW

These variables were tested against a flat surface i.e. walls, floors etc. Once it was verified that the sensor was functioning correctly, the researcher pursued to the next stage of testing the sensor for measuring the distance from the sensor to the water's surface.

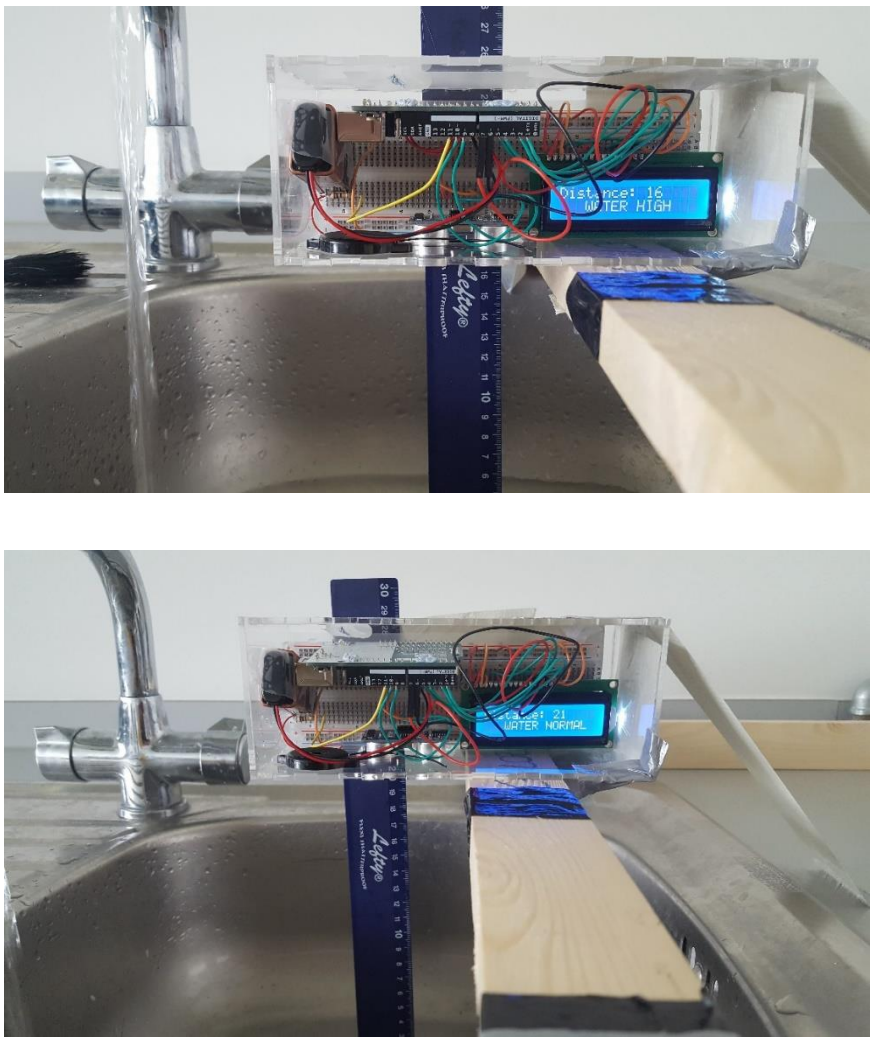


Figure 48 Working Model - Testing Variables

This phase of testing was carried out to ensure that the sensor was capable of detecting liquid surfaces. Initial research carried out showed that ultrasonic sensors have been previously used for this purpose, however, it was important for the researcher to carry out further testing to validate these research findings.

For this phase, the variables within the code were changed slightly due to the space envelope of the testing area. The variables set for testing were as follows;

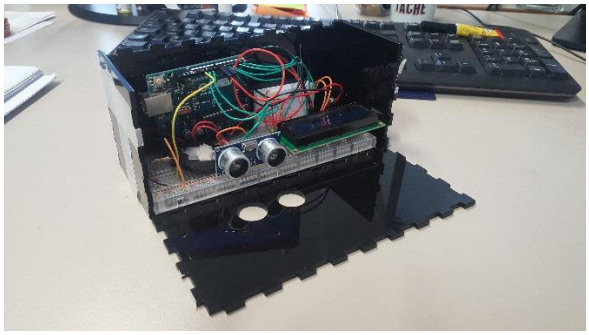
1. 10 – 20 centimetres: WATER HIGH
2. 20 – 30 centimetres: WATER NORMAL
3. 30 + centimetres: WATER LOW

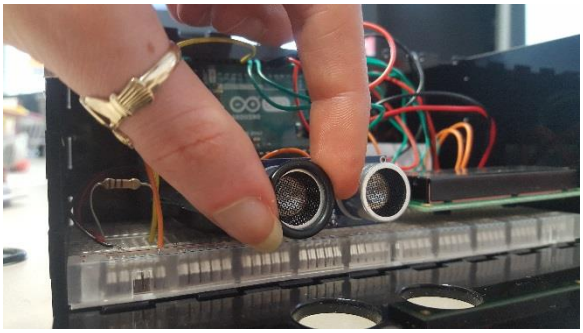
5.10.1 Findings/Outcomes

The testing phase concluded that;

- The Arduino Ultrasonic Sensor detects water levels
- The Sensor provided accurate readings of the distance from the sensor to the water surface
- The LCD screen displayed the correct variables set by the researcher

Once it was verified that the sensor detected water and measured that distance from the sensor itself and the water surface, the initial housing was reiterated to increase water resistance. Two circular sections were removed from the acrylic to allow the sensor to project through the surface allowing for minimal exposure. O-rings were placed on the sensor, both inside and outside the model, to further reduce the possibility of water ingress and damaging electronic components.





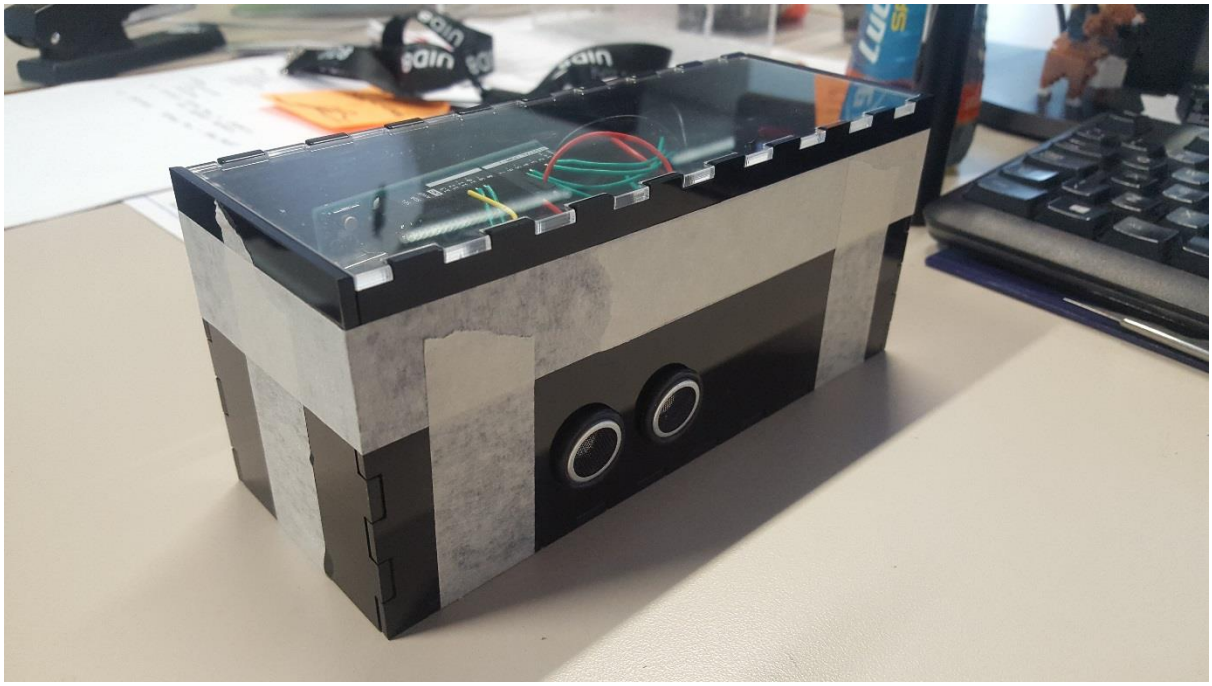


Figure 49 Final Working Prototype

5.10.2 Conclusion

In conclusion, the working prototype proved to be fundamental in validating the concept outlined at the beginning of this chapter. The construction of this model also justified the capabilities of Arduino and acted as a starting point for communities to develop their own flood sensors, with the possibility of redesigning and constructing more advanced flood sensors further down the line.

5.11 The Internet of Things (IoT) – Theoretical Concept Three

To facilitate the effective transfer of data collected through this community based initiative, it is proposed that the Internet of Things (IoT) be used to facilitate the collection and exchange of data.

The IoT is *"the concept of basically connecting any device with an on and off switch to the Internet (and/or to each other)"* (Morgan, 2014) These physical devices, also known as connected devices or smart devices, are defined as being anything comprised of the following;

- electronic components
- sensors
- software
- network connectivity
- actuators

IoT allows information technology (IT) administrators to use this system for anything related to their physical environment, if they require information about it.

> *"In one case, IoT is being used to stymie deforestation in the Amazon rainforest. A Brazilian location-services company called Cargo Tracck places M2M sensors from security company Gemalto in trees in protected areas. When a tree is cut or moved, law enforcement receives a message with its GPS location, allowing authorities to track down the illegally removed tree."* (Botelho, 2013)

The researcher concluded that IoT can assist communities throughout Ireland to increase the transfer of data for increasing preparation toward flood events.

5.11.1 The Things Network

The Things Network is a global community comprised of over 20,000 people in just under 90 countries. This network uses a long range and low power radio frequency called LoRaWAN which facilitates the connectivity of devices to the internet without using 3G or WIFI.

The benefits of using this network include;

- Is it open-source, which is consistent with guidelines set out in the hypothesis
- It is low cost
- Is does not require 3G or WIFI for connecting devices to the internet

It is proposed that the community based initiative outlined in this chapter would be linked to this network, facilitating the creation of a larger community database both nationally and internationally.

5.12 Concept Definition

To fully define the design hypothesis, the concept of a community-based initiative was further developed. Sketches and visuals aimed to help communicate the links between sensor technology, the flood model and an online platform and how they are supported by one and other. The final concept was defined as A Community-Based Initiative for Predicting Flood Events Using Ultrasonic Sensor technology.

The concept is a combination of all three theoretical concepts outlined at the beginning of this chapter. The concept proposes to enhance community engagement by increasing knowledge, skills and technology transfer using ultrasonic sensor technology. The transfer of knowledge, skills and technology aims to enhance links between community members and responding professionals allowing for a more efficient and effective response to flood events. The initiative aims to influence community members and create awareness on methods for creating more independence and autonomy and eliminating or reducing reliance on government bodies to implement procedures for monitoring and better management of natural disasters. This concept also presents the opportunity for the slow integration of societal change, increasing social resilience within vulnerable communities that are susceptible to flooding.

5.13 Community Engagement

As previously highlighted, current flood sensor networks have shown to be predominantly linked to responding community members and responding professionals. This showed a lack of participation from affected community members which results in the loss of local knowledge and expertise. The initiative proposed aims to reintroduce affected community members and this local knowledge to a community-based initiative to aid advancements in flood prediction. An infographic was generated (See Figure 51) to highlight where the community is anticipated to interact with this Community Flood Network.

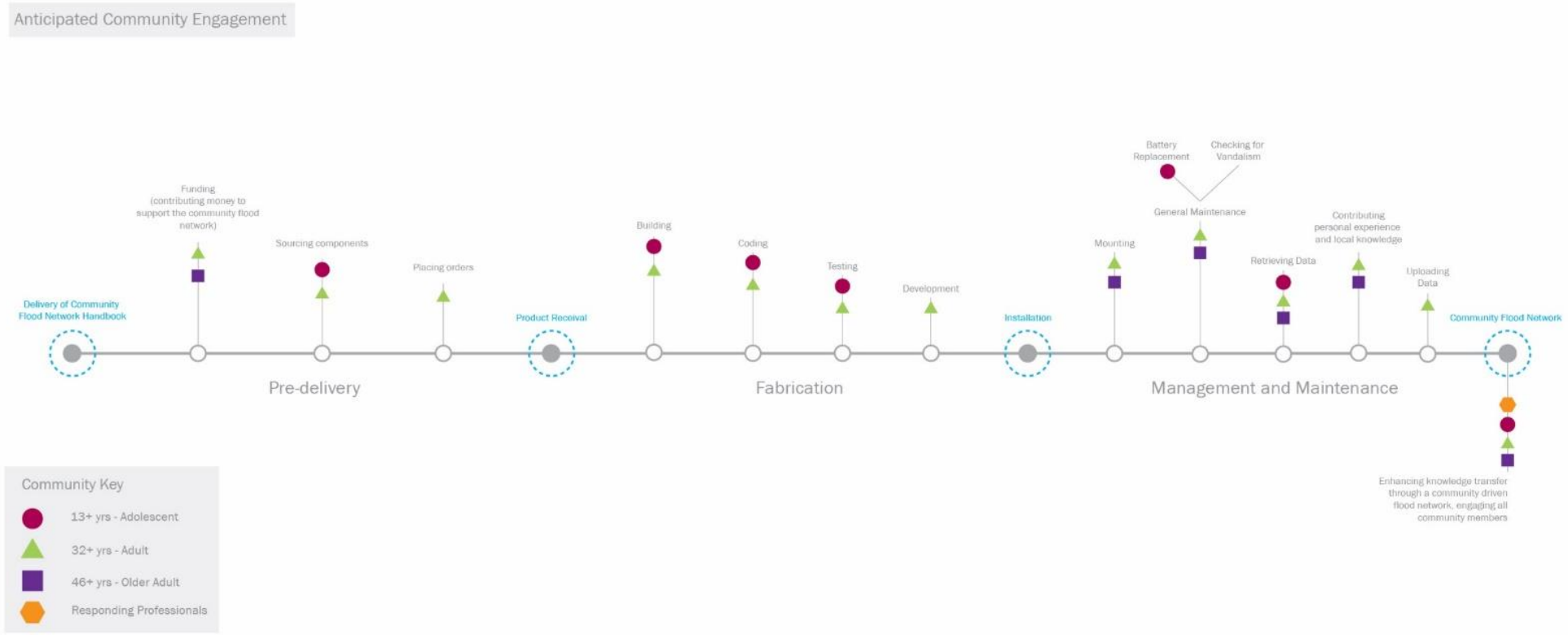
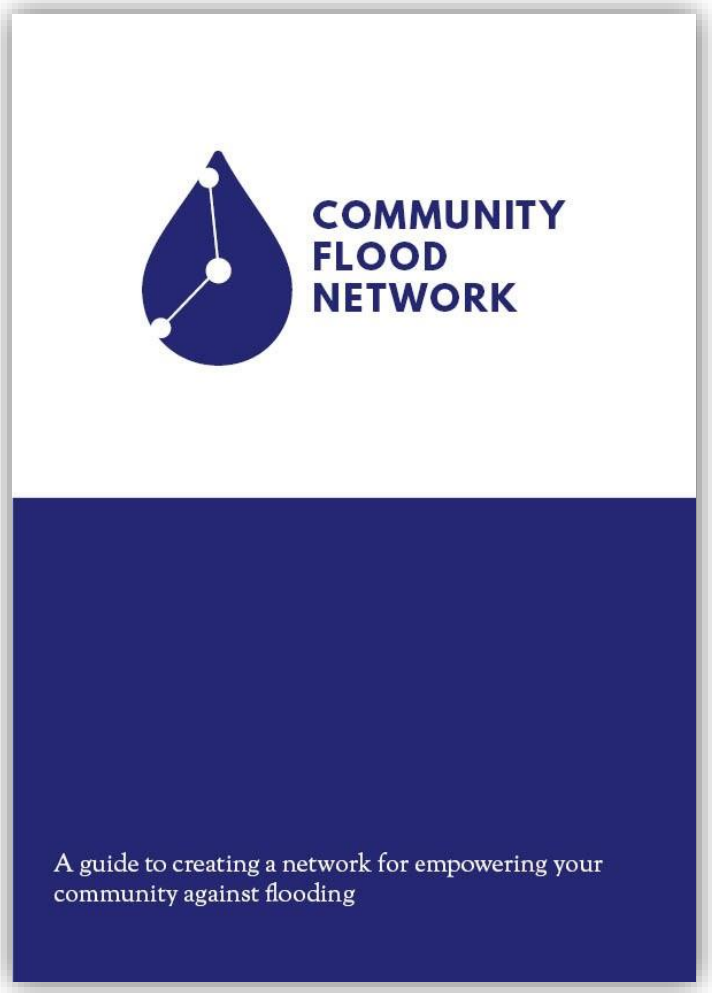


Figure 50 Anticipated Community Engagement Points with Proposed Sensor Network

To further ground this concept, a Community Flood Network booklet was designed. This booklet provides guidelines on how to set up your own flood sensor using Arduino and how to build your own housing. The document acts as a starting point for encouraging communities to form their own community based-initiative for an early warning system aimed at predicting flood events. This booklet can be found in Appendix A.



6.0 Results and Findings

6.1 Final Design Solution

Results generated from this study concluded that in order to enhance vigilance within communities affected by flooding, vulnerability must be reduced through a variety of actions. To combat vulnerability effectively, communities must be assessed as a whole, to determine areas that need to be strengthened both socially and environmentally. The three areas proposed for development within this research project include:

1. Social Resilience Model & Flood Model (Section 4.6 – 4.7)
2. Water level sensor technology (Section 5.4.3)
3. An online platform (Section 5.11)

When combined these three areas offer a more holistic approach to flooding issues. Each area of this concept could work independently of each other, however, when pooled together each area is supported by the other and provides a systematic approach toward flooding allowing communities to re-act appropriately to pre-and post-flood events.

The Social Resilience Model forms the starting point for the proposed concept. The Social Resilience Model provides communities with an outline of the six key areas that aim to enhance social resilience in relation to flooding. These six areas include;

- Awareness
- Understanding
- Information
- Education
- Communication
- Strength

In order to minimise the impacts that flooding has on communities it is important that they work effectively as unit. According to Fekete, 2009, the assessment of social vulnerability can highlight hidden strengths and weaknesses of a society toward a certain stress or hazard. The provision of a Social Resilience Model can assist communities to evaluate their own level of vulnerability in order to combat weakened areas effectively. Often, a high level of social resilience can be the most important factor for reducing the effects of any social implication on a group of people. Research to date had identified that Ireland is lacking information on the social repercussions of flooding and how to address these issues. The provision of this model aims to facilitate better community driven actions against flooding events.

A Flood Model was also developed as part of this study with the aim of enhancing community activity before, during and after a flood occurs. The model focuses on six key areas including;

- Measure
- Prevent
- Prepare
- Respond
- Recover
- Implement

The model acts as a benchmark for communities affected by flooding, outlining key actions to be taken in response to a flood related event. During the Literature Review and Field Research, it was highlighted that many communities do not possess sufficient knowledge on how to anticipate, cope, resist and recover from natural disasters. Nicholson and Gebre, 2016, highlight that there is little information tailored to the Irish community providing knowledge on preventative, resistive and recovery methods against severe weather events. This model can be customised to suit various communities depending on their size, location, population etc. and facilitates the development of more advanced preparation and response to flooding.

An Open-Source, Community-Based Initiative was developed as part of this study to allow communities to create a scheme for establishing an early warning system using ultrasonic sensor technology. To date, research has shown that a system like this has yet to materialise within Irish society. Initial research highlighted that communities rely heavily on Government Bodies and State Agencies to provide predictions on potential flood events. The United Nations Framework Convention on Climate Change, 2007, emphasises that hardware, software and networking facilitates the flow of information between stakeholders to enhance the development and transfer of technologies. In order to enhance the transfer of flood related data in Ireland this new community-led initiative proposes to allow communities to independently monitor water levels in their area, facilitating a more informed approach to monitoring water levels and river conditions.

The initiative incorporates the use of ultrasonic sensor technology and the Internet of Things, both of which are open-source, low cost and easily operated. This holistic approach toward minimising the effects of severe weather conditions in waterside communities aims to provide communities with the tools necessary to facilitate the slow integration of knowledge, skill and technology transfer, resulting in smaller communities working better, both independently and together, to decrease vulnerability and, in turn, reduce the impact of flood flooding within their and neighbouring communities.

7.0 Discussion of Results

7.1 Research Questions

The research questions highlighted after the initial investigation into existing literature included;

1. What are the necessary elements needed to assist in empowering a vulnerable person or group of people?

2. How can societal change be enhanced through open-source, user-centred design solutions?

3. Could the integration of skills and technology along with existing and new knowledge enhance community preparation against flood related events?

Research conducted throughout this study provided the researcher with positive answers for the research questions outlined above. The three questions were addressed throughout this study through the proposed community-based initiative for minimising the effects of flooding.

7.2 Key findings

An investigation into existing literature highlighted that;

1. The transfer of user-driven knowledge is needed to address a range of multidisciplinary and integrated approaches.
2. Transferring new and existing knowledge through open-source software is the most efficient and effective means for providing communities throughout Ireland with relevant knowledge of flood related issues and on methods for preparing, coping and recovering from both anticipated and unpredicted flood events.
3. Communities need to be made aware of methods for adapting to new, more frequent flood events.
4. In order to decrease the reliance of affected community members on Governmental Bodies, social vulnerability needs to be reduced.

5. The slow integration of new technologies into vulnerable community areas can assist in the development of new community-led initiatives resulting in increased resilience.

Secondary research revealed that communities rely heavily on Government Bodies and State Agencies to provide both pre-flood warnings and assistance before, during and after a flood occurs. Failure from responding professionals to provide relevant pre-flood warnings can result in communities being poorly prepared and severely affected by weather related disasters.

During primary research it was identified that it is difficult to implement societal change within communities as they are extremely complex and difficult to alter. By allowing communities to take the lead toward better flood response through an open-source, technology-driven initiative, it facilitates the slow integration of societal change and allows communities to adapt at their own pace to newly anticipated flood events.

When conducting interviews, the researcher identified two participants that expressed confliction opinions against the proposed design intervention. One participant indicated that extreme flooding is rare, every 50 years or so, and that there is no need for a design intervention. The second participant stated that they only look after their own property and would have little or no interest in partaking in a community-based initiative. These opinions showed that, firstly, there is not enough information outlining that due to a combination of factors, flooding is predicted to become more common. Secondly, certain individuals within specific areas showed no willingness to engage with other community members during previous or newly predicted floods.

Limitations/weaknesses associated with the final concept include;

1. This concept is primarily technology driven, therefore, it may not be best suited to a community occupied primarily by stakeholders of an older demographic who may not engage well with technology.
2. The initiative is cost effective, however, it is proposed to be self-funded by the community with an annual fee, which may cause issues.

3. Once set up, the concept would require a certain level of maintenance and upkeep to ensure all elements remain functioning effectively over time.

7.2.1 Suitability of Methods and Approach

The researcher followed an interpretivist paradigm for this study which allowed for the development of understanding through experience. Information related to specific values, opinions, behaviours and social contexts of community groups was gathered through the methods selected for conducting field research. The Inductive approach toward this research project proved most suitable for developing the tentative hypothesis for further investigation.

The methods selected for this research project facilitated effective engagement with a broad range of individuals across different stakeholder groups. Interviews with participants involved in this study were most valuable for gathering relevant insight into each area being examined, and allowed the research to be guided by communities affected by flood events.

7.2.2 Validity

Validation was achieved through face-to-face meetings with participants where the researcher presented their research findings at different stages to community members. This helped the researcher determine whether community members would be willing to engage with the proposed solution.

Findings derived from the narratives and the application of grounded theory were triangulated. This technique helped provide verification for the research outcomes/findings.

7.2.3 Bias

The researcher maintained a certain level of bias throughout this study. The title of the project resulted in the researcher maintaining a clear objective of creating community empowerment through open-source, user-centred design solutions. At the beginning of the project the researcher was unsupportive, however, had not ruled out, the use of technology as a solution. Through both primary and secondary research, the benefits of using open-

source technology and software were highlighted, which guided the researcher toward the proposed technology driven solution.

7.3 Unanticipated Findings

The most unanticipated finding identified during this research project highlighted that there is little collaboration between State Agencies and community members when planning and constructing hard defences for flood control. State Agencies also seemed to disregard input from the communities involved and use statistical data only for developing proposed flood defences. Enhanced collaboration between these groups is needed to facilitate the incorporation of local knowledge in the planning and development of flood defence structures.

This significant finding that highlights broken links between professional involved in the planning of permanent flood defences and affected communities. This results in the disregard and loss of important local knowledge and can have major impacts of the people inhabiting areas affected by flooding.

The researcher identified this late in the study during interviews with community members therefore it did not impact this study. This area warrants further work to ensure that the planning of hard defences is executed effectively, and facilitates relevant input from the stakeholders involved.

7.4 Significant ramifications of findings

Findings generated from the field research phase resulted in the establishment of a tentative hypothesis for further investigation. The hypothesis assisted the researcher throughout the design phase and allowed for the development of a design intervention for mitigating the effects of flooding by facilitating knowledge, technology and skill transfer. (See figure 52)

Existing models on flood control and prevention are available at global level where they experience harsher weather conditions and large scale flooding. Through research it was

identified that there is no flood model tailored specific to Irish Communities using open-source design solutions. The proposed solution aims to facilitate an iterative approach toward mitigating the effects of flood events. The system offers a cost-effective, open-source solution for transferring flood related data, allowing communities to modify and improve the system over time. Driven by key players, responding professionals and responding community members, each community is given the opportunity to take ownership of developing solutions toward mitigating flood events, facilitating the development of community empowerment.

The transfer of new and existing knowledge is one of the key aspects to this solution. During interviews, it was found that there is a significant loss of local knowledge within and between communities. This local knowledge is essential for planning and preparing for both predicted and unpredicted flood events. This, combined with new data generated from water level sensors, form a body of information, provides the groundwork for enhancing preparedness before, during and after a flood occurs. The introduction of a design intervention aims to enhance the transfer of old and new knowledge, skills and technology, within and between community groups. It is anticipated that this will result in extended community links between different stakeholder groups, advanced preparations toward flood events and increased community resilience.

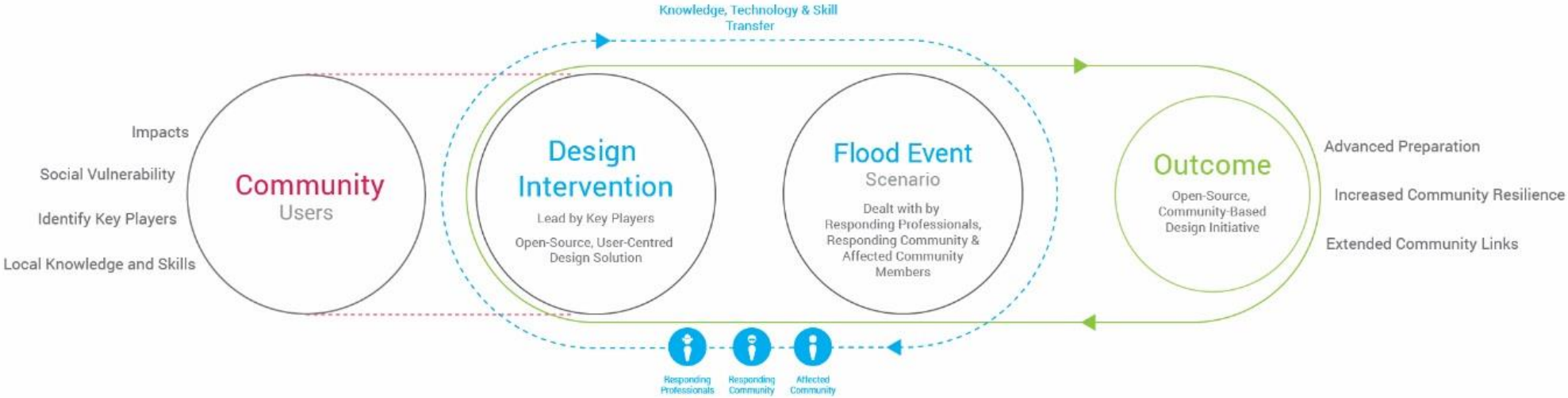


Figure 51 Design Intervention facilitating the transfer of Knowledge, Technology and Skills

7.5 Design Artefact in Context

The design artefact offers a preliminary solution for gathering data on water levels. The design is low-cost and open-source, however, it is not very accurate and improvements need to be made in terms of housing, mounting and security solutions. The technology itself is very effective and easy to use. It is suggested that a more precise sensor be sourced for future iterations.

The artefact has not been tested in context of a flood situation.

7.6 Research Questions

It was identified that communities have a strong dependency on Government Bodies to provide procedures for mitigating flood events. Further investigation highlighted that a user-centred approach has the potential to spark the development of community-based initiatives, both nationally and internationally, enhancing community vigilance and reducing their dependency on state agencies for predicting floods. This in turn, aims to bring about societal change, facilitating the development of community-driven strategies for combatting the effects of flooding. The results from this study were conclusive with the research question highlighted in the Literature Review; 'How can societal change be enhanced through open-source, user-centred design solutions?'

The field research phase of this study provided validation for the following research question; 'Could the integration of skills and technology along with existing and new knowledge enhance community preparation against flood related events?' During the field research phase it was discovered that there is insufficient transfer of knowledge, technology and skills within communities, resulting in the loss of local intelligence and expertise. Feedback from participants highlighted that local knowledge and expertise are essential in ensuring that communities have the ability to endure and survive flood related disasters. The outcome of this research aims to reintroduce local intelligence through open-source design, allowing users to combine existing knowledge with new information to ensure each flood related situation is reacted to and dealt with appropriately.

What are the necessary elements needed to assist in empowering a vulnerable person or group of people?'

To answer this question, it was necessary to undertake narrative studies involving communities with both high and low levels of community vigilance. The tools necessary for creating community empowerment are highlighted in Chapter 4 – Narratives. During this phase, it was identified that the provision of a Flood Model and Social Resilience Model along with a scheme aimed at reinstating experiential data within communities, combined with new data created through a community based initiative, could result in communities being better prepared to deal with unpredictable and accelerated rainfall patterns. This initiative is proposed to be supported by an online platform, i.e. The Things Network, which aims to facilitate the transfer of flood related data. The system allows users within each community to share information on pre-and post-flood activities with their own community and other affected communities.

It is envisaged that the reliance on responding professionals would be reduced through the introduction of a community-based initiative, facilitating flood prediction generated by key players within the community. This approach allows communities to create empowerment and enhance resilience through an initiative that aids the development of new knowledge and a means for transferring this data. Pre-flood data generated through this initiative allows communities to be better prepared before a flood occurs.

The proposed concept offers a means for collecting data during a flood allowing individuals to monitor water levels without the need to physically engage with rising flood water. Once a flood has occurred, the information gathered can be recorded and analysed so that the community can respond more effectively to new anticipated flood events.

The flood model and social resilience model provide communities with a guide for addressing both flooding and social vulnerability effectively.

7.7 Conclusions – hypothesis

> *"It is possible to increase community capacities for mitigating the effects of flooding by facilitating the transfer of knowledge, technology and skills through open-source, user-centred design."*

The outcomes of this research study support the hypothesis generated prior to the design phase. The open-source, user-centred design solution facilitates the transfer of knowledge technology and skills. Combined with models for increasing flood resilience and social resilience the initiative provides the tools necessary for increasing community capacities for mitigating the effects of flooding.

7.8 Long term impact

It is envisaged that the tools outlined in the thesis, provide the starting point for the development of a community based-initiatives nationwide. These tools are not static and can be altered and tailored to specific community needs. The ultrasonic sensor is a cost-effective, low-tech solution which can be modified to suit specific flood events. The online platform is easily accessible and facilitates the transfer of knowledge, technology and skills. Because all elements of the proposed solution are open-source, they can be adopted by a wide range of communities nationally with the potential of extending to communities at global level.

7.9 Further Work

For further work associated with this research project, it is proposed that;

1. The researcher would write a paper for publishing and/or presenting at a conference
2. Action Research be carried out fully through a testing and evaluation phase
3. Further validation be carried out involving members of the community to ground the concept

8.0 Conclusion of Thesis

The Literature Review formed the foundation of knowledge on the thematic areas; Community Based Initiatives, Open-Source User Centred Design, Community Resilience, Data Transfer, Social Vulnerability and Flooding. This initial research phase identified that knowledge, skill and technology transfer within and between communities is fundamental for reducing social vulnerability and creating community empowerment. By creating a community-based design initiative through open-source user-centred design solutions, vulnerable communities can assist themselves to reduce the social, economic, environmental, and financial impacts associated with flood events.

The theoretical insights acquired from the Literature Review acknowledged the lack of research in relation to community-based design initiatives for open-source, user-centred design solutions against severe weather conditions on waterside communities. Research questions were identified and addressed positively throughout this study.

Field research carried out provided practice based validation for theoretical conclusions and research questions identified in the Literature Review. This data guided the study and facilitated the development of a new initiative focused on assisting affected community members by adopting traditional methods and introducing new approaches and initiatives for reducing the impact on communities during both pre-and post-flood events.

The hypothesis formed after primary and secondary research acted as a starting point for further investigation. This design hypothesis proposed that; it is possible to increase community capacities for mitigating the effects of flooding by facilitating the transfer of knowledge, technology and skills through open-source, user-centred design. This ensured that the researcher maintained an informed and guided direction through the design phase of the project.

8.1 Limitations of the research

Due to time constraints and limited access to participants, the researcher proposes that it would be beneficial to engage with a wider demographic to further validate this concept. Additional involvement of a larger variety of age groups would allow for feedback from a

more diversified range of participants. This would also be of benefit during the design phase of the project, allowing participants with a broader range of skillsets to assist throughout the development of the project, from concept stage to iteration and testing.

During the design phase, the researcher was unable to incorporate the sending and receiving SMS function into the Arduino. This was due to time constraints and the researcher's limited knowledge of electronic engineering design. On reflection, the addition of this function would allow the researcher to test the sensor near a body of water over an extended period of time to ensure that the information gathered using ultrasonic sensor technology would be of benefit to affected community members.

The Open-Source criteria set out at the beginning of the project restricted the design of the housing unit for the ultrasonic sensor. In order ensure the design remained open source, the researcher was required to source materials and develop a housing unit that could be easily manufactured by community members. Upon completion, the researcher concluded that it would be beneficial to explore and test a larger variety of low-cost, open-source materials and manufacturing techniques, such as 3D printing and additive manufacturing technologies, to provide communities with an extended range of housing options.

During the testing phase, the researcher discovered that accuracy of the cost-effective sensor sourced for this project was insufficient for outdoor use over an extended period of time. In order to combat this issue, it is suggested that further exploration into ultrasonic sensors would be carried out to source a more accurate sensor while still retaining the open-source and low-cost criteria set out in the brief.

9.0 Further Work

Upon completion, the researcher identified several areas with the potential for future research to be conducted. Some of these areas are briefly described in the Limitations chapter of this thesis. Areas identified for further exploration include:

- Engage with focus groups to allow for collaboration between community members when conducting secondary research. This would provide the researcher with a better understanding of the area being observed.
- Engage more with younger members of communities to achieve a better understanding of the younger generation's willingness to participate in a community-based initiative.
- Further develop the Arduino water sensor to include a more accurate ultrasonic sensor and the SMS feature for sending texts and receiving data on real time water levels.
- Set up an experimental flood network using one or more flood sensors to further validate the concept.
- Explore a larger variety of enclosures for housing the sensor.
- Publish findings in a research journal.
- Apply methodologies utilised in this study to other similar issues.

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Appendix A

COMMUNITY FLOOD NETWORK

A guide to creating a network for empowering your community against flooding

WELCOME

In 2015/2016 Ireland saw some of the worst flooding in decades. These floods left the majority of the country devastated with many homes and businesses destroyed by flood water. Predictions outline than there is a high possibility that we will be experiencing more frequent and severe flooding.

In order to mitigate flooding we need to make advances in strengthening communities and creating empowerment. This document provides your community with the basic for setting up your own community flood sensor network.

This Community Flood Network will facilitate the transfer of knowledge and data on flood related events allowing your community and other surrounding communities to adopt methods for adaptation. This information can then be shared and enhanced through a network, powered by communities nationwide.

CONTENTS

ARDUINO

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery

COMPONENTS

Breadboard
2 Split power buses
10 columns
63 rows
830 tie points
Dimensions (165.1 x 54.29 x 9.68)

100 Ohm Resistor

Jumper wires (M/M)
30 pc

The Ultrasonic Sensor emits an ultrasound at 40 000 Hz which travels through the air and if there is an object or obstacle on its path It will bounce back to the module. Considering the travel time and the speed of the sound you can calculate the distance.
The HC-SR04 Ultrasonic Module has 4 pins, Ground, VCC, Trig and Echo. The Ground and the VCC pins of the module needs to be connected to the Ground and the 5 volts pins on the Arduino Board respectively and the trig and echo pins to any Digital I/O pin on the Arduino Board.

Piezo Buzzer

5V Screen White Character Blue Backlight LCD Module

9V Battery

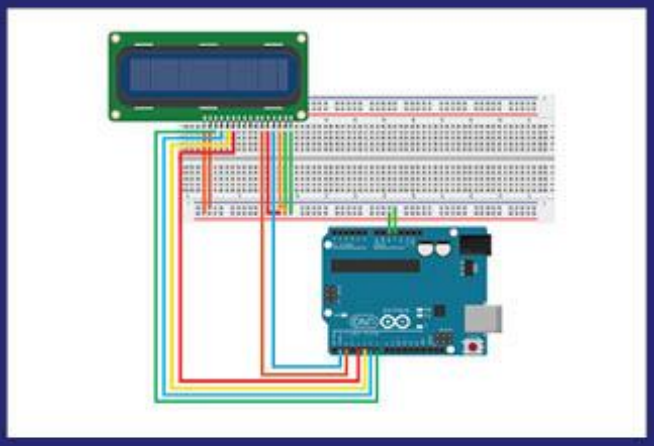
Brass contacts, nickel plated with vinyl or ABS covering.
Wires have tinned copper conductors, PVC insulation and the ends are stripped for easy connection

v

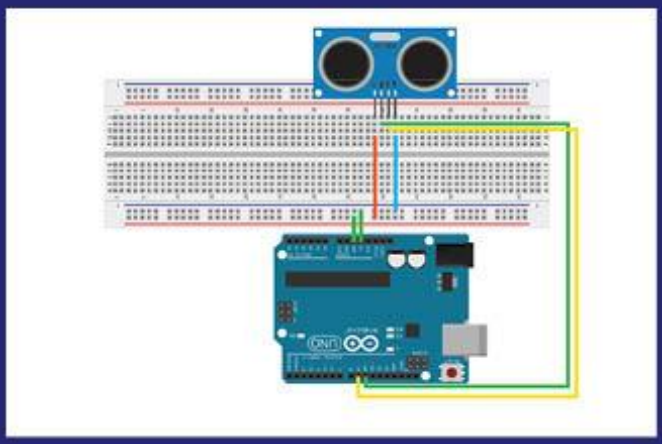
Price List

Component	Ireland	Price	Abroad	Price
Arduino UNO	Farnell – Element14 http://bit.ly/2smynDR	1+ €24.86 10+ €24.35	DealeXtreme (DX) http://bit.ly/2rbd7n0	1+ €7.17
Ultrasonic Sensor	Irish Electronics http://bit.ly/2rbiD94	1+ €4.49	DealeXtreme (DX) http://bit.ly/2rEPQuR	1+ €2.30
Jumper Wires	Irish Electronics http://bit.ly/2rbzUPu	m/m 65pc €4.95	Gear Best http://bit.ly/2qGs3Wq	m/m 60pc €1.82
	http://bit.ly/2qACsYF	m/f 40pc 4.49	http://bit.ly/2rESwsH	m/f 20pc 1.57
Breadboard	Farnell - Element 14 http://bit.ly/2qAM3ic	400 TP 1+ €3.20 100+ €2.43	TOMTOP http://bit.ly/2rbsFaa	400 TP 1+ €2.89
SD Card Reader	Ebay http://ebay.to/2qBanAF	.88c	Gear Best http://bit.ly/2se1REB	€1.10
9V Battery Duracel	Online or Instore http://bit.ly/2rb9xsU	€4.66	Online or Instore	€4.66
9V Battery Connector	Irish Electronics http://bit.ly/2qGeovR	.50c	Gear Best http://bit.ly/2rEF7AJ	10pc €2.33
Total		€48.03		€23.84

ASSEMBLY

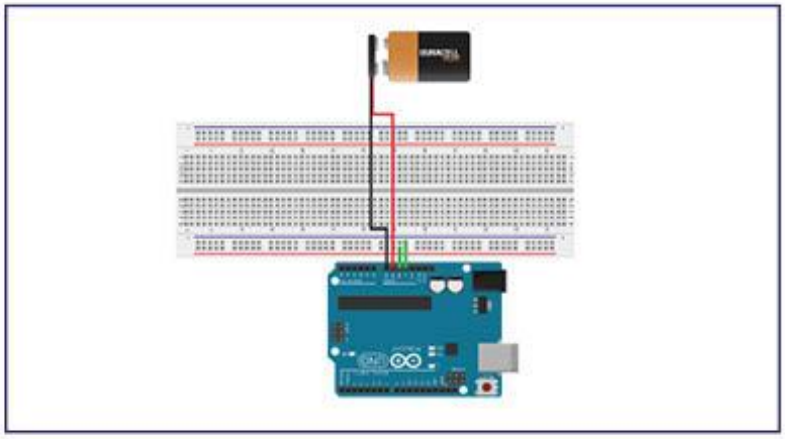


STEP 1
Connecting Arduino UNO and LCD Screen to Breadboard

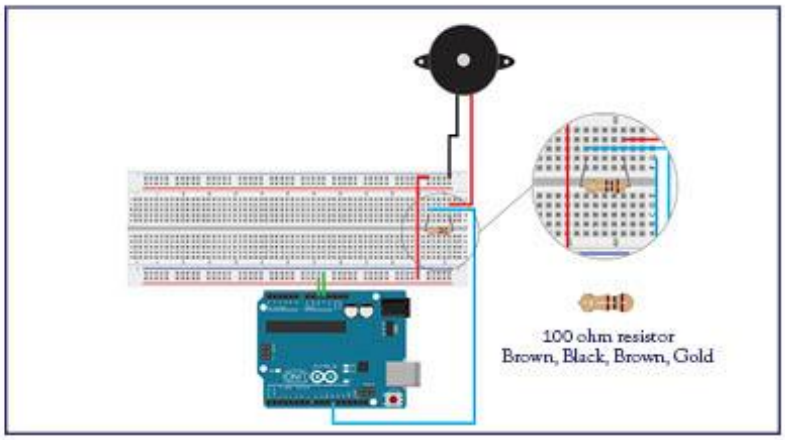


Step 2
Connecting Ultrasonic Sensor to Breadboard

ASSEMBLY

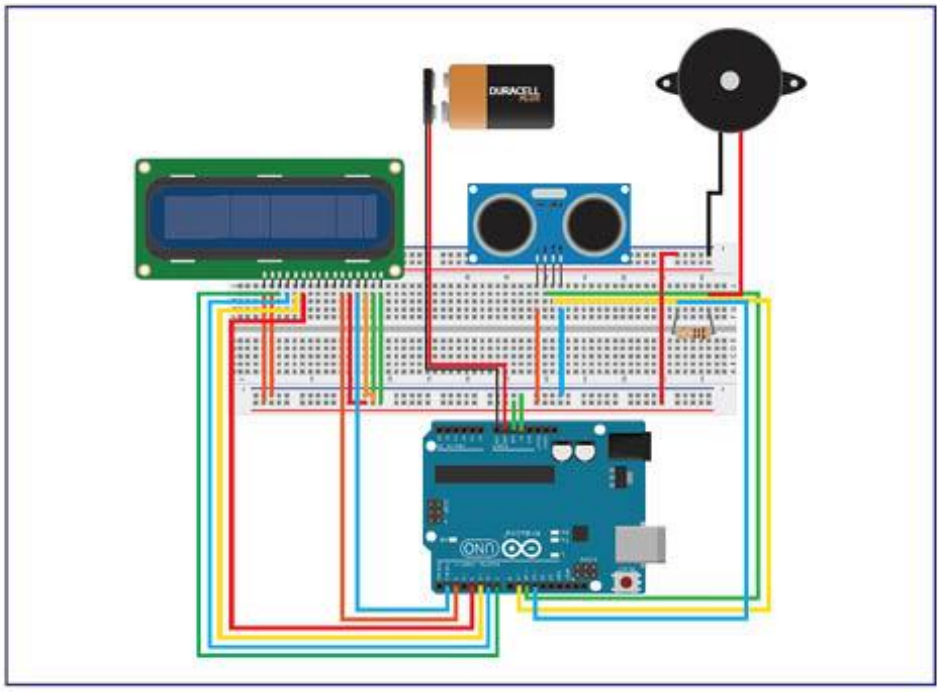


Step 3
Connecting Battery connector to Breadboard



Step 4
Connecting Piezo Buzzer and 100 Ohm resistor to Breadboard

ASSEMBLY



Your sensor should now look something like this. (See image above)
Once you have all of the components connected you can then upload your code to your Arduino. (See page 9)

CODING YOUR ARDUINO

Before getting started you need to dowload the Arduino Software package. This can be found on the Arduiono dowload page. (https://www.arduino.cc/en/Main/Software)

Once the download is complete, open the application and you should see something like this:

Once opened, click on the Tools button and select Board.

Then select Arduino Uno.

Once you have done this, insert the code (See page 10) into the sketch.

Don't forget to save your work!

x

Arduino Code

```
#include <LiquidCrystal.h> // includes the LiquidCrystal Library
LiquidCrystal lcd(1, 2, 4, 5, 6, 7); // Creates an LCD object. Parameters: (rs, enable, d4, d5, d6, d7)
const int trigPin = 9;
const int echoPin = 10;
long duration;
int distanceCm, distanceInch;
int time_delay=2000;  //time delay for the screen
const int buzzer = 11; //buzzer to arduino pin 11

//setup variables
void setup() {
lcd.begin(16,2); // Initializes the interface to the LCD screen, and specifies the dimensions (width and height) of the display
pinMode(trigPin, OUTPUT);
pinMode(echoPin, INPUT);
pinMode(buzzer, OUTPUT); // Set buzzer - pin 11 as an output
}

void loop() {

digitalWrite(trigPin, LOW);
delayMicroseconds(2);
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);
duration = pulseIn(echoPin, HIGH);

distanceCm= duration*0.034/2;
distanceInch = duration*0.0133/2;

if (distanceCm>100 && distanceCm <= 150) //use this for different warning levels
{
lcd.clear();
lcd.setCursor(0,0);
lcd.print("Distance: ");
lcd.print(distanceCm);
delay(500);
lcd.setCursor(0,1);
lcd.print("  WATER HIGH  ");
delay(1000);  //make sure that i have enough time to read
tone(buzzer, 1000); // Send 1KHz sound signal...
delay(1000);      // ...for 1 sec
noTone(buzzer);     // Stop sound...
delay(1000);      // ...for 1sec

}

else if (distanceCm>150 && distanceCm <= 200) //use this for different warning levels
{
//lcd.clear();
lcd.setCursor(0,0);
lcd.print("Distance: ");
lcd.print(distanceCm);
delay(500);
lcd.setCursor(0,1);
lcd.print("  WATER NORMAL  ");
delay(1000);  //make sure that i have enough time to read

}

else if (distanceCm>200) //use this for different warning levels
{
lcd.clear();
lcd.setCursor(0,0);
lcd.print("Distance: ");
lcd.print(distanceCm);
//delay(500);
lcd.setCursor(0,1);
lcd.print("  WATER LOW   ");
delay(3000);  //make sure that i have enough time to read

}
}
```

Arduino Code

After you have inserted the code, click Sketch and select verify to ensure that there are no issues with the code.

If the code is right you should see ' done compiling ' at the bottom of the sketch.

If the code is incorrect, the blue bar will turn orange. It will tell you what the issue is in orange text in the black section at the bottom of the sketch.

12

Arduino Code

Connect your Arduino Uno to your computer using the yellow USB cable included in your kit.

Once your arduino is connected to your computer, click Sketch and Upload to transfer to code to your arduino.

Your LCD Screen should not look something like this.

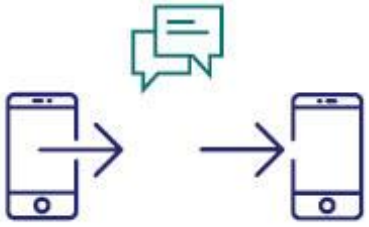
Connectivity

THE THINGS NETWORK

The Things Network is about enabling low power Devices to use long range Gateways to connect to an open-source, decentralized Network to exchange data with Applications and Platforms.

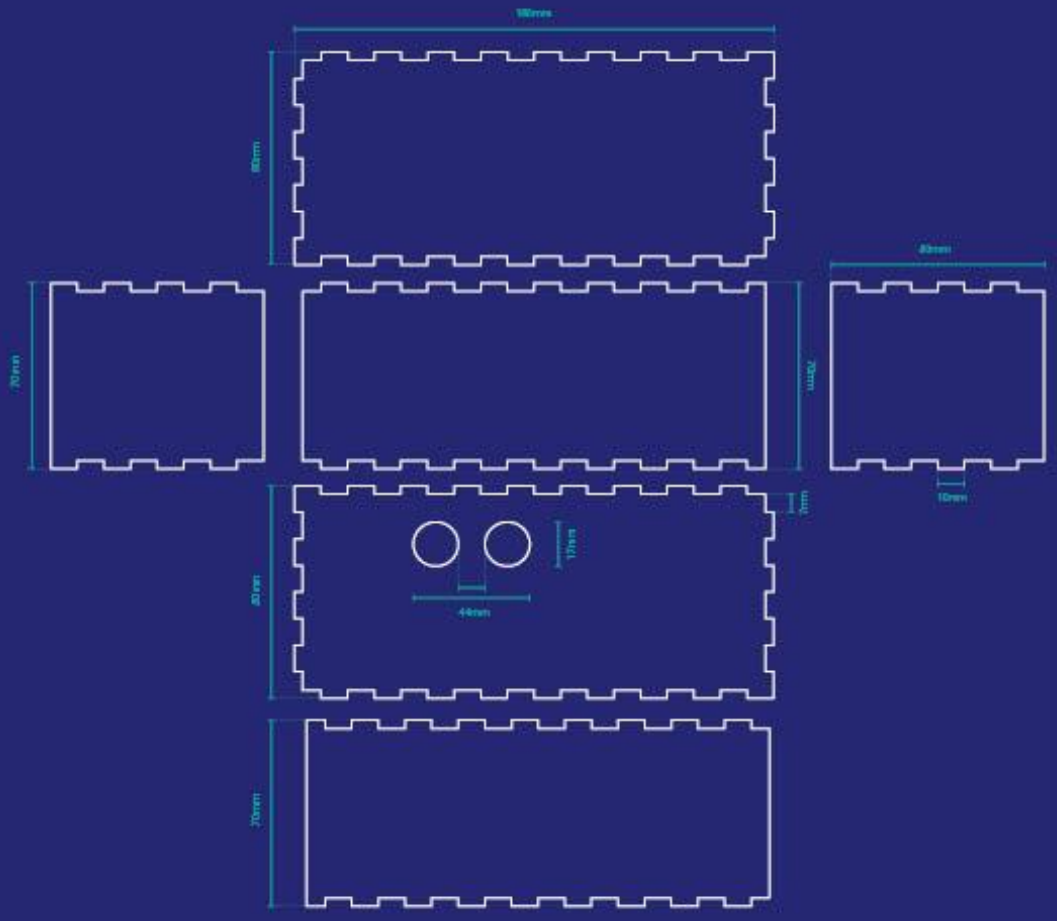
Alternatively

Alternatively, the information gathered could be distributed between community members and between communities through the use of notice boards and leaflets or as part of a community text alert system.



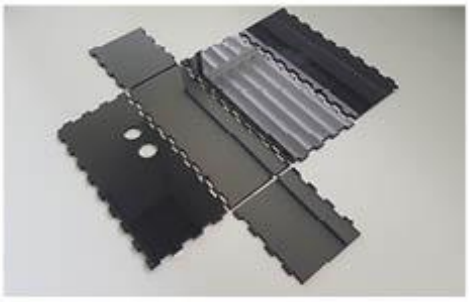
14

HOUSING
Laser Cut

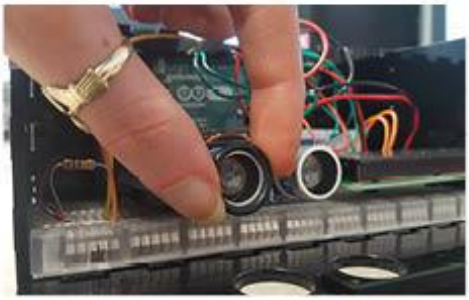


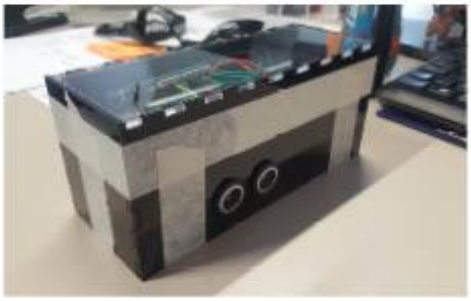
If your commmunity have access to a laser cutter, you can buit your own housing for your arduino. Be sure to use Acrylic or a material that is water-proof and durable.

HOUSING
Laser Cut



Housing - Before Assembly





Housing - After Assembly

Place 2 O-rings on the ultraconic sensor before fully assembling the enclosure and 2 O-rings on the outside when the enclosure is assembled to increase water resistance. (See above images)
The enclosure can be fixed together using any plastic adhesive - please use adhesives in a well ventilated area and avoid contact with skin.
For added water resistance, use silicone to seal the joined edges inside the enclosure.

HOUSING
Outsourced

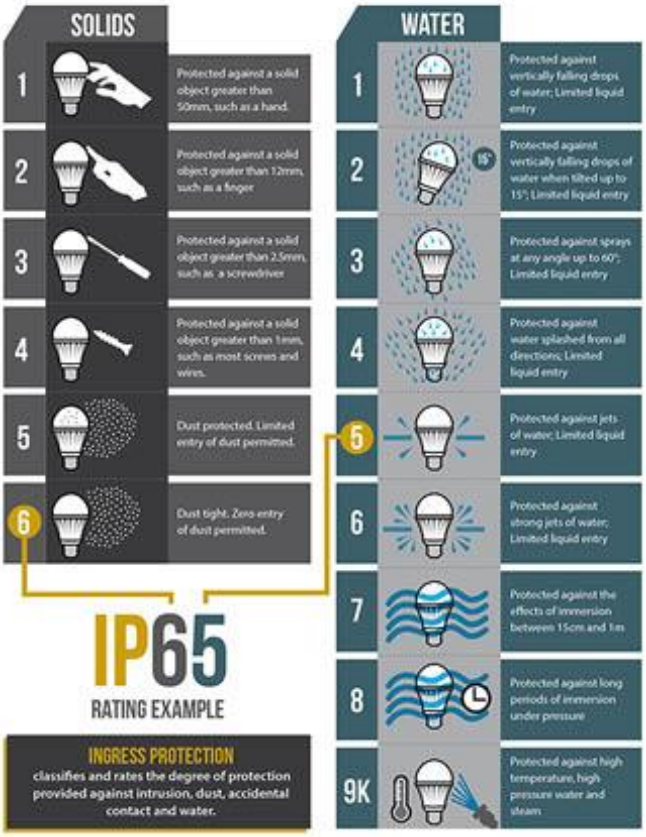
If you decide to buy in housing for your arduino then electrical junction boxes are a suitable option. An electrical junction box is an enclosure housing electrical connections, to protect the connections and provide a

Junction boxes can be sourced both online and in most hardware stores.

IP RATING

IP (or "Ingress Protection") ratings are defined in international standard EN 60529 (British BS EN 60529:1992, European IEC 60509:1989). They are used to define levels of sealing effectiveness of electrical enclosures against intrusion from foreign bodies (tools, dirt etc) and moisture.

The numbers that follow IP each have a specific meaning. The first indicates the degree of protection (of people) from moving parts, as well as the protection of enclosed equipment from foreign bodies. The second defines the protection level that the enclosure enjoys from various forms of moisture (drips, sprays, submersion etc).



MOUNTING & SECURITY

Junction boxes can be mounted to almost any surface including metal, wood, concrete etc.

Some junction boxes come with a dorr that allows a lock to be used to ensure that it cannot be tampered with.

A simple lock such as the one in the image (right) would be sufficient for securing the junction box. Other locks on the market would also be suitable.

COMMUNITY
FLOOD
NETWORK

Research Participants Information Sheet
Study Title: Water Based Communities vs. Climate Change

Researcher Title: Chloe Madden - MA Researcher – DesignCore IT Carlow
Research Supervisors: Bryan Leech – Emmet Sexton

Invitation Paragraph
Climate change is becoming more and more prominent over the last century causing severe weather changes. This has resulted in high winds, high tides and unprecedented rainfall. Climate change has left many home owners, businesses, local authorities and state agencies poorly prepared for the physical and financial damage to communities. These natural disasters also have an enormous emotional impact on individuals and communities. Climate change has highlighted the vulnerability of Irish towns and cities, which has made people very aware of how ill-equipped we are when dealing with the effects of flooding.
I would greatly appreciate it you would take a few minutes to carefully read over this information sheet. On completion you may either confirm or deny your willingness to assist in the research outlined within this document.

What is the purpose of this study?
To investigate and explore the possibilities of community-based, open source product design proposals in helping people most affected by climate change in Ireland.

To understand user and product design requirements of households and communities most vulnerable to the effects of climate change.

To conduct research in three stages.

Firstly, a research phase to investigate the impact on coastal and other communities, to identify the emotional, social and financial damage caused by weather-related incidents and to propose possible directions for further exploration.

Secondly, an exploration phase to propose suitable open-source design concepts that could eliminate or lessen damage to individual homes and businesses.

Thirdly, an implementation and testing phase where selected concepts are fabricated, tested and evaluated by individuals and/or community groups in affected communities.

The enquiry stage will include literature reviewing, field research and analysis whilst the implementation and testing stages will include practice-based research through design intervention, community engagement, testing and evaluation.

Do I have to take part?
Your participation is voluntary. You have been selected as we believe that you can make a very important contribution to the research area. I you wish to participate you have the

Figure 52 Participants Information Sheet

right to end your involvement at any stage of the project. If, having read this document, you no longer wish to participate then you will not be expected to engage with the project any further.

What will I do if I take part?
If you decide to take part in this research project you will be requested to take part in interviews/meetings to share some of your expertise and/or experiences in this research area.

What are the possible disadvantages and risks of taking part?
There will be no anticipated disadvantages or risks associated with this research, however you may be asked to share some of your experiences associated with flooding, which may bring up some sensitive issues. You will also be asked to dedicate a certain amount of your time to the project, but if it interferes with your day to day activities, another time will be arranged to accommodate your schedule.

What are the possible benefits of taking part?
Your participation will provide the study with valuable first-hand information that could assist in the design and development of systems and/or products to aid and empower communities to reduce the impact of flooding to their homes and businesses.

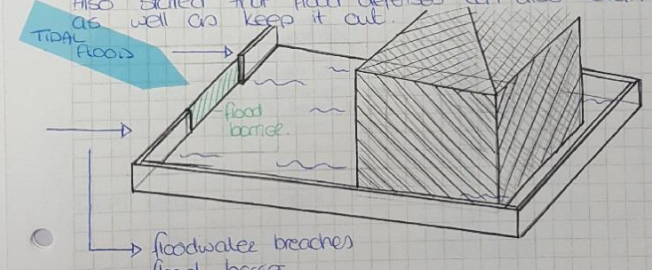
Will my taking part in the study be kept confidential?
Yes, all the information you provide will be confidential. The researcher must comply with the legal requirements in relation to the storage and use of personal data, (Data Protection Acts 1988-2003). All data will be stored anonymously to maintain participant confidentiality. Only members of the research team (researcher and two research supervisors) will have access to this information. No identifiable responses will be provides to any other third party.

4pm [redacted] 27/01/2016

On Wednesday 27th January I visited the county council offices to meet with Padraig Cahill. We had an informal conversation about the Christmas floods + some people it would be useful for me to contact.

1. Across from Riverdell / Palonez.
2. Rowing club
3. Mokans B+B
4. Centaur house - Caretaker
5. Pembroke - R. Burren.

Also stated that flood defenses can also retain water as well as keep it out.



- house floods
- when tide recedes - water cannot get out.
- can this be resolved?

EXPIRY DATE/ DATA IDITHE 13/10/15 EXPIRY TIME/ AM IDITHE 16:08 ZONE/ CEANTAR
TIME ISSUED/ AM ESITHE 15:08 FEE PAID/ TAILLE IOCTHA 1.00€ LOCATION/ SUIOMH ATHY RD
EXPIRY TIME/ AM IDITHE 16:08 EXPIRY DATE/ DATA IDITHE 13/10/15 FEE PAID/ TAILLE IOCTHA 1.00€
DISPLAY CORRECTLY - READ INSTRUCTIONS ON REVERSE DETACH & RETAIN AS REMINDER

3:10pm. 13/10/2015

ctivities. VERY LITTLE COMMUNITY INVOLVEMENT

main contacts - local authority
fire service
civil defense.

Two types of floods affect Carlow.
1. flash flood 2. Prolonged flood.

4 causes of flood in carlow town. REASONS FOR FLOODING IN - carlow
1. Rain.
2. Build up of rain over a long period of time.
3. High tide.
4. Barrow catchment, overflow.

Barrow originates in Glenbarrow

High Tide: water has nowhere to g

flood defensive works have been past number of years.

flooding of sewers now fixed.

- Jack - Athy
- Tom - Community wildlife organisations
- Jon Willem.

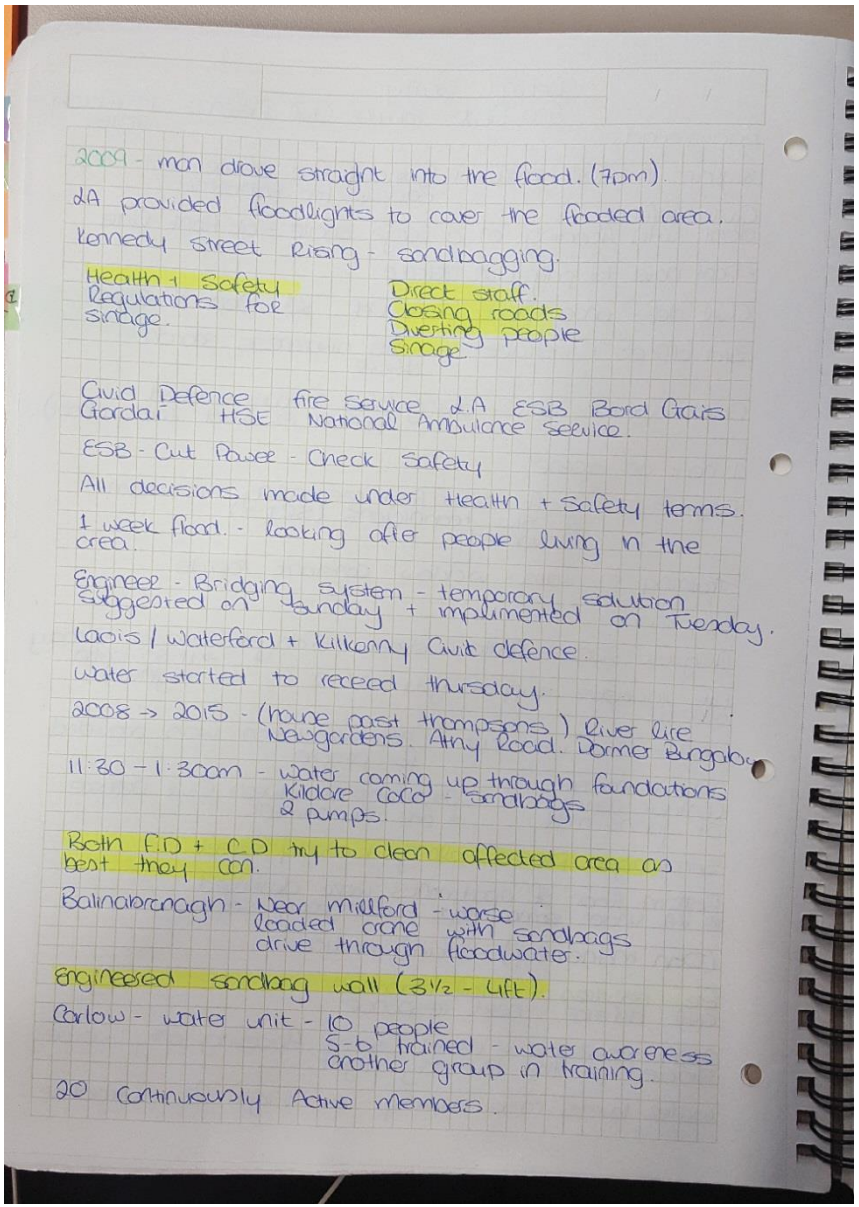
At times of high flood - water pumps are programmed to pump water at a certain height of the flood.

ESB - no electricity - generators.

Early Warning: Early warning Systems
Waterways Ireland - monitor inland waterbodies (Enniskillen HQ.)

monitors at strategic locations to warn people in advance.

@ certain point along the river floods - leaves a 24hour gap, before it reaches carlow.



2009 - man drove straight into the flood. (7pm).
DA provided floodlights to cover the flooded area.
Kennedy Street Rising - sandbagging.

Health + Safety Regulations for sinage.

Direct staff.
Closing roads
Diverting people
Sinage

Civil Defence fire service DA ESB Bord Gais Gardai HSE National Ambulance service.

ESB - Cut Power - Check Safety

All decisions made under Health + Safety terms.

1 week flood. - looking after people living in the area.

Engineer - Bridging system - temporary solution suggested on Sunday + implimented on Tuesday.

Laois / Waterford + Kilkenny Civil defence.

water started to recede thursday.

2008 → 2015 - (house past thompsons) River Rise Newgardens. Athy Road. Dormer Bungalow

11:30 - 1:30am - water coming up through foundations
Kildare CoCo - sandbags
2 pumps.

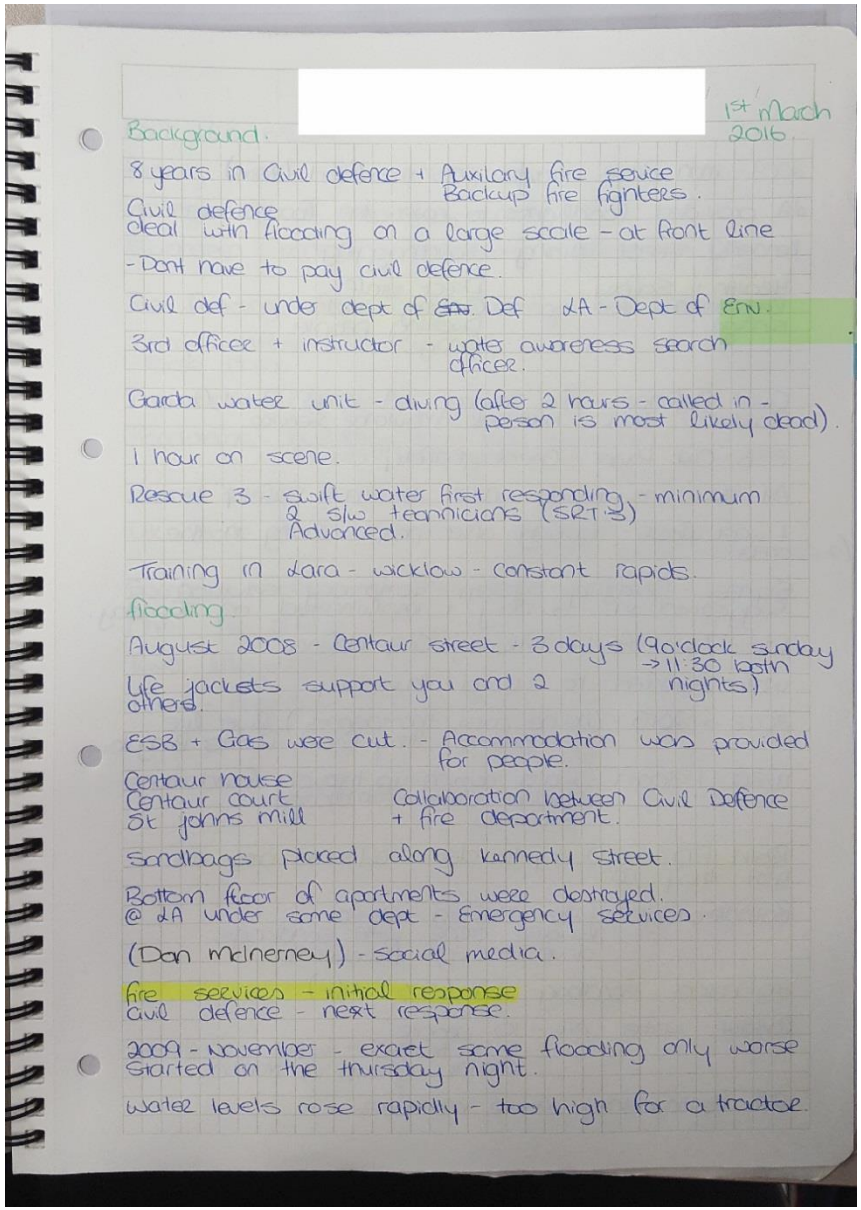
Both F.D + C.D try to clean affected area as best they can.

Balinabranagh - Near Millford - worse
loaded crane with sandbags
drive through floodwater.

Engineered sandbag wall (3½ - 4ft).

Carlow - water unit - 10 people
5-6 trained - water awareness
another group in training.

20 Continuously Active members.



1st March 2016.

Background.

8 years in Civil defence + Auxilary fire sevice
Backup fire fighters.

Civil defence
deal with flooding on a large scale - at front line
- Dont have to pay civil defence.

Civil def - under dept of ~~Env~~. Def DA - Dept of Env.

3rd officer + instructor - water awareness search officer.

Garda water unit - diving (after 2 hours - called in - person is most likely dead).

1 hour on scene.

Rescue 3 - swift water first responding - minimum 2 s/w teannicians (SRT-3)
Advanced.

Training in Lara - wicklow - constant rapids.

flooding.

August 2008 - Centaur street - 3 days (9o'clock sunday → 11:30 both nights)

Life jackets support you and 2 others.

ESB + Gas were cut. - Accommodation was provided for people.

Centaur house
Centaur court
St johns mill

Collaboration between Civil Defence + fire department.

sandbags placed along kennedy street.

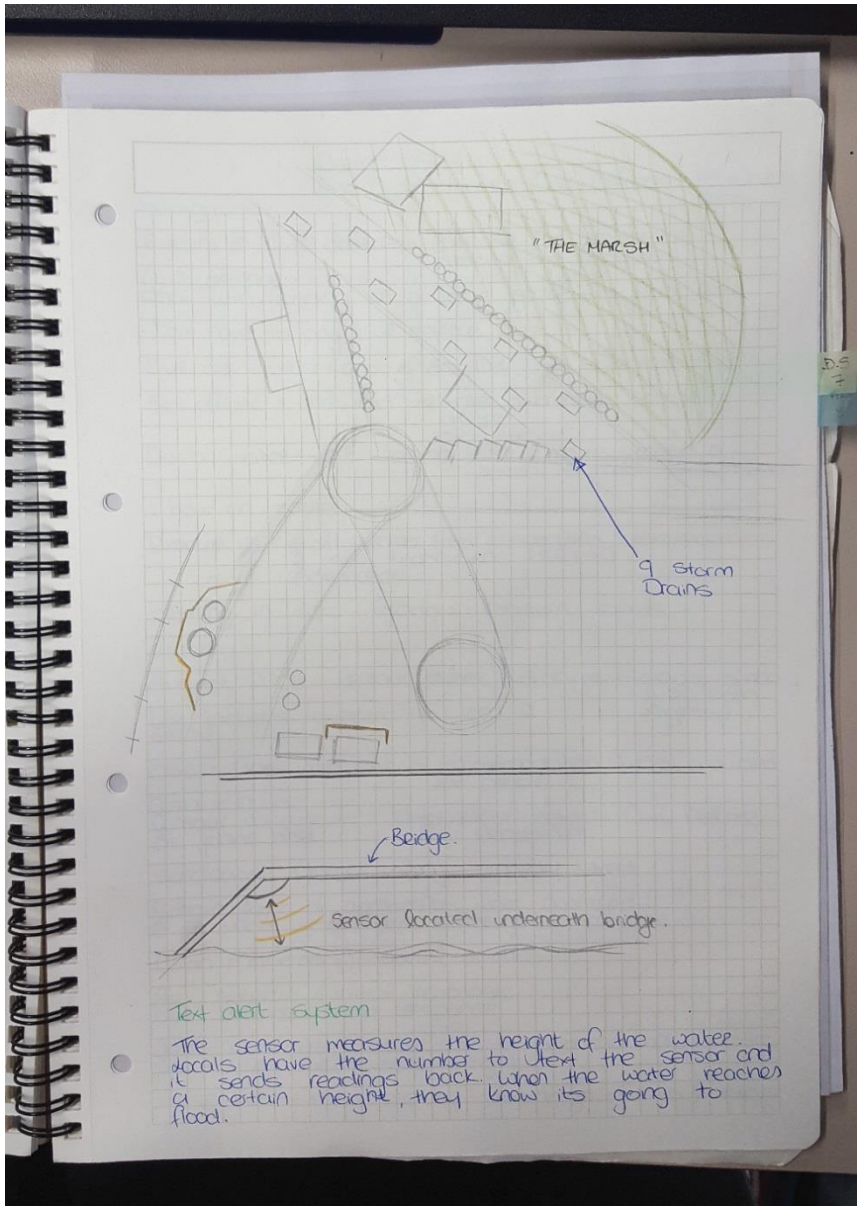
Bottom floor of apartments were destroyed.
@ DA under some dept - Emergency services.

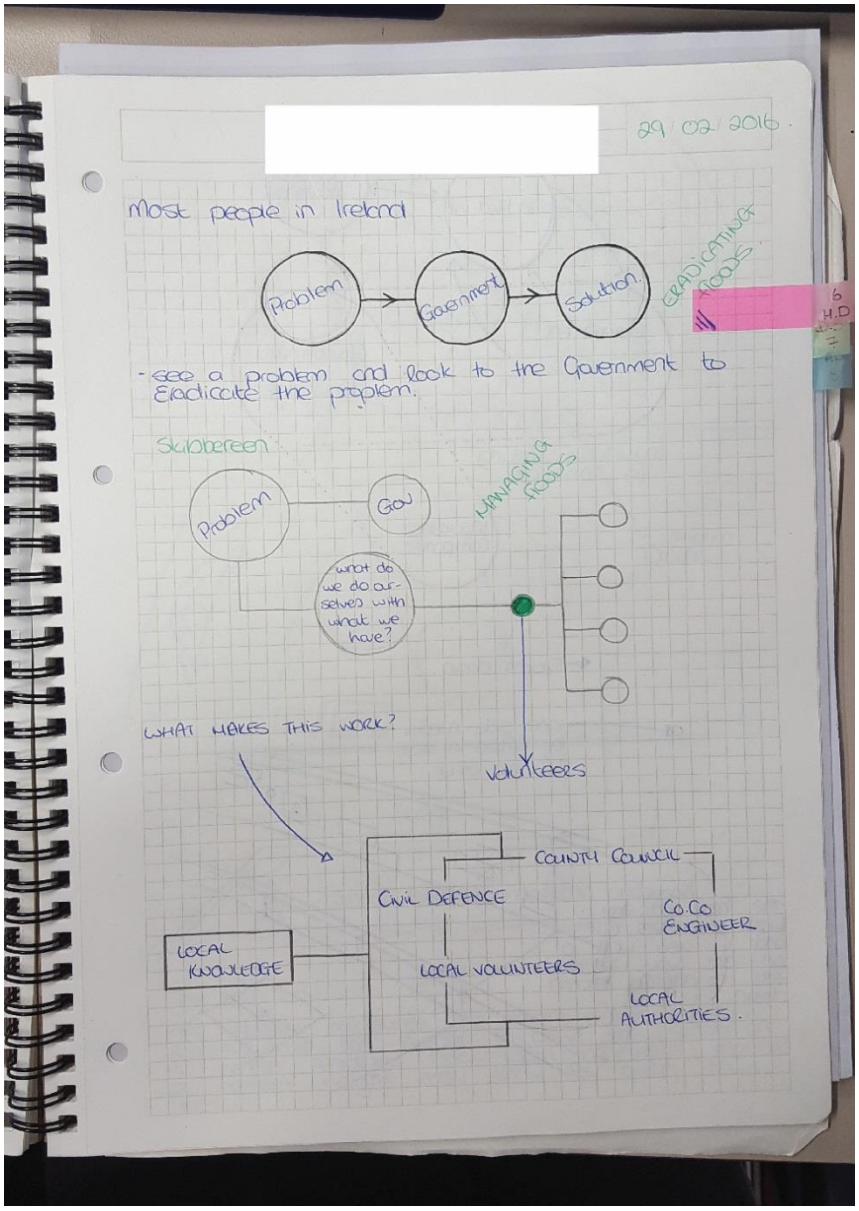
(Dan McInerney) - social media.

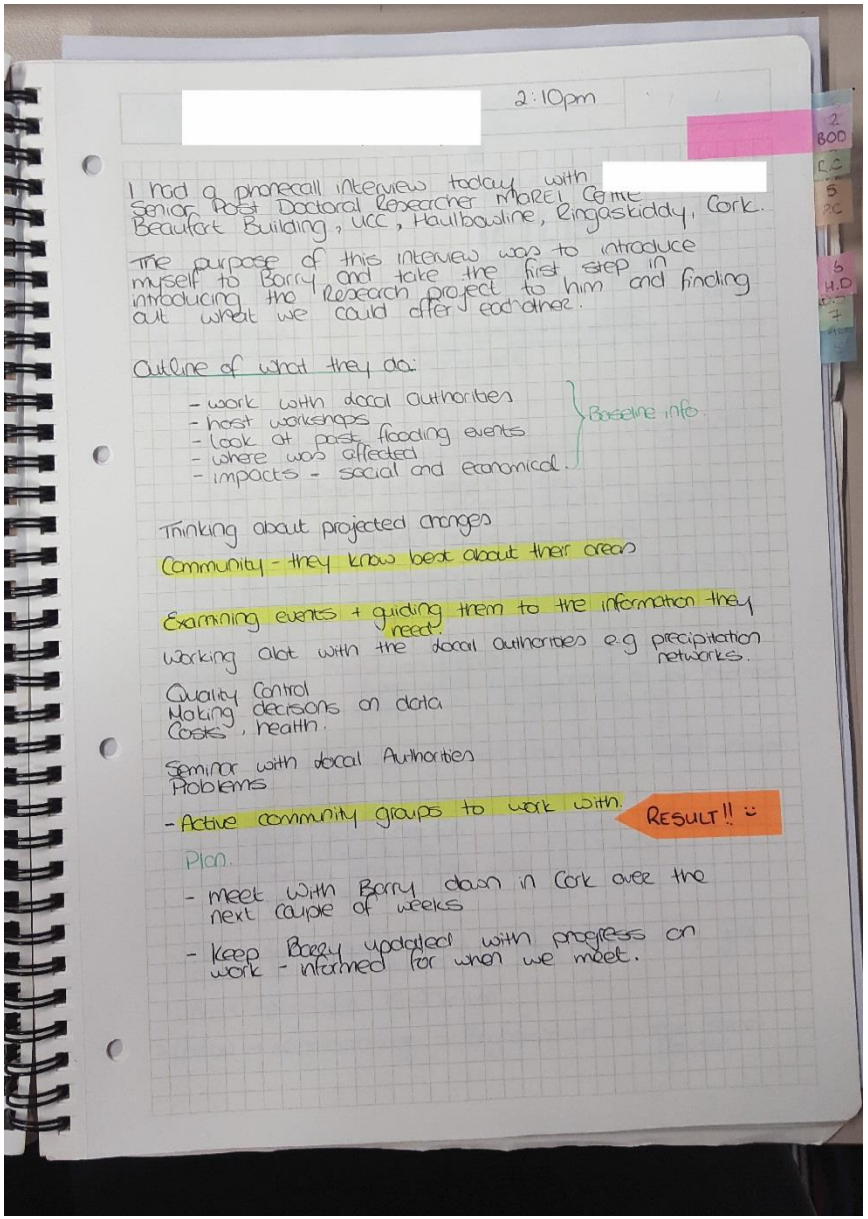
fire services - initial response
civil defence - next response.

2009 - November - exact same flooding only worse
Started on the thursday night.

water levels rose rapidly - too high for a tractor


"THE MARSH"
9 Storm Drains
Bridge.
Sensor located underneath bridge.
Text alert system
The sensor measures the height of the water. locals have the number to text the sensor and it sends readings back. When the water reaches a certain height, they know its going to flood.


29/02/2016.
Most people in Ireland
Problem
Gavernment
Solution.
ERADICATING FLOODS
- see a problem and look to the Gavernment to Eradicate the problem.
Skibbereen
Problem
Gov
MANAGING FLOODS
what do we do ourselves with what we have?
WHAT MAKES THIS WORK?
Volunteers
COUNTY COUNCIL
CIVIL DEFENCE
Co.Co ENGINEER
LOCAL KNOWLEDGE
LOCAL VOLUNTEERS
LOCAL AUTHORITIES.



2:10pm

I had a phonecall interview today with [redacted] Senior Post Doctoral Researcher MaREI Centre Beaufort Building, UCC, Haulbowline, Ringaskiddy, Cork.

The purpose of this interview was to introduce myself to Barry and take the first step in introducing the Research project to him and finding out what we could offer eachother.

Outline of what they do:

- work with local authorities
- host workshops
- Look at past flooding events
- where was affected
- impacts - social and economical.

} Baseline info.

Thinking about projected changes

Community - they know best about their area

Examining events + guiding them to the information they need.

Working alot with the local authorities e.g precipitation networks.

Quality Control
Making decisions on data
Costs, health.

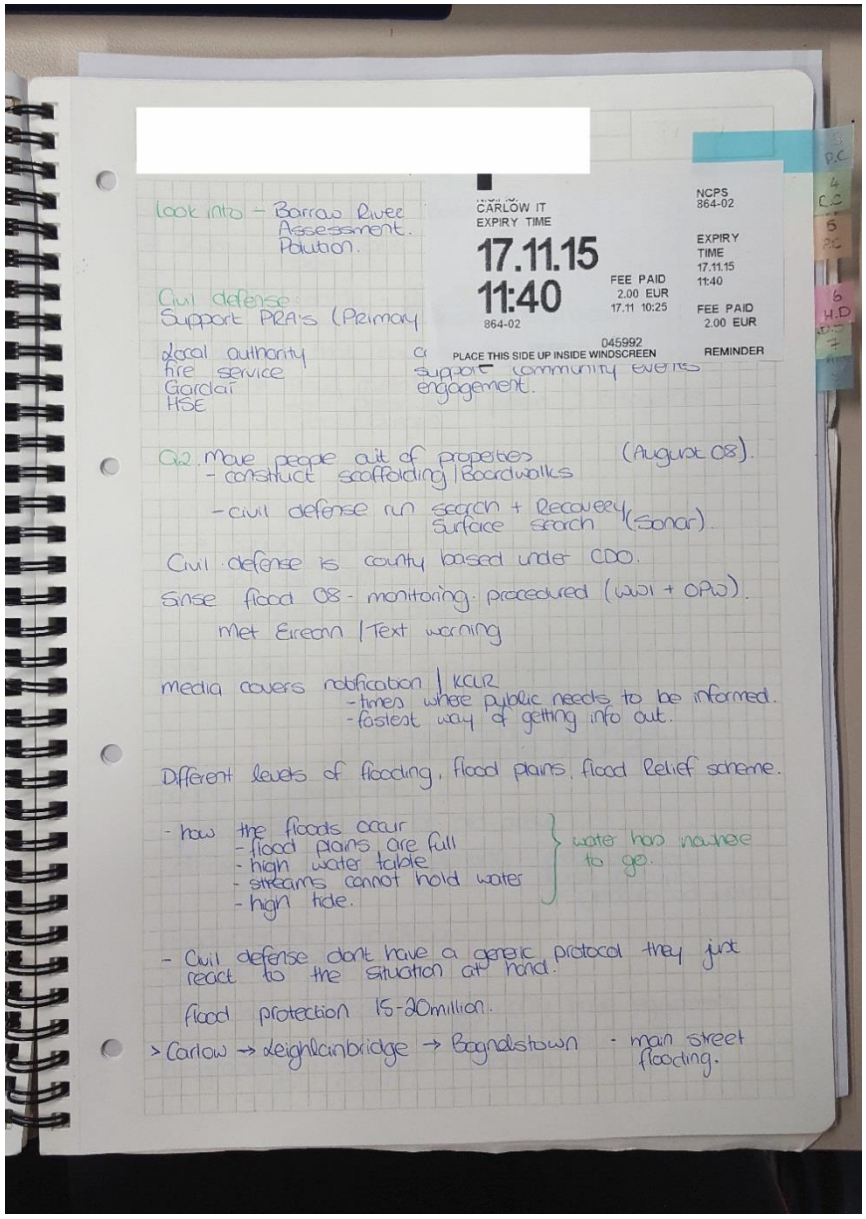
Seminar with local Authorities
Problems

- Active community groups to work with

RESULT!! :)

Plan

- meet with Barry down in Cork over the next couple of weeks
- keep Barry updated with progress on work - informed for when we meet.



Look into - Barrow River Assessment.
Pollution.

CARLOW IT
EXPIRY TIME
17.11.15
11:40
FEE PAID
2.00 EUR
17.11 10:25
864-02

NCPS
864-02
EXPIRY
TIME
17.11.15
11:40
FEE PAID
2.00 EUR

045992
PLACE THIS SIDE UP INSIDE WINDSCREEN
REMINDER

Civil defense
Support PRA's (Primary

local authority
fire service
Gardai
HSE

support community events
engagement.

Q2. Move people out of properties (August 08).
- construct scaffolding / Boardwalks
- civil defense run search + Recovery Surface search (Sonar).

Civil defense is county based under CDO.

Since flood 08 - monitoring procedured (WOI + OPW).

Met Eireann / Text warning

media covers notification / KCLR
- times where public needs to be informed.
- fastest way of getting info out.

Different levels of flooding, flood plains, flood Relief scheme.

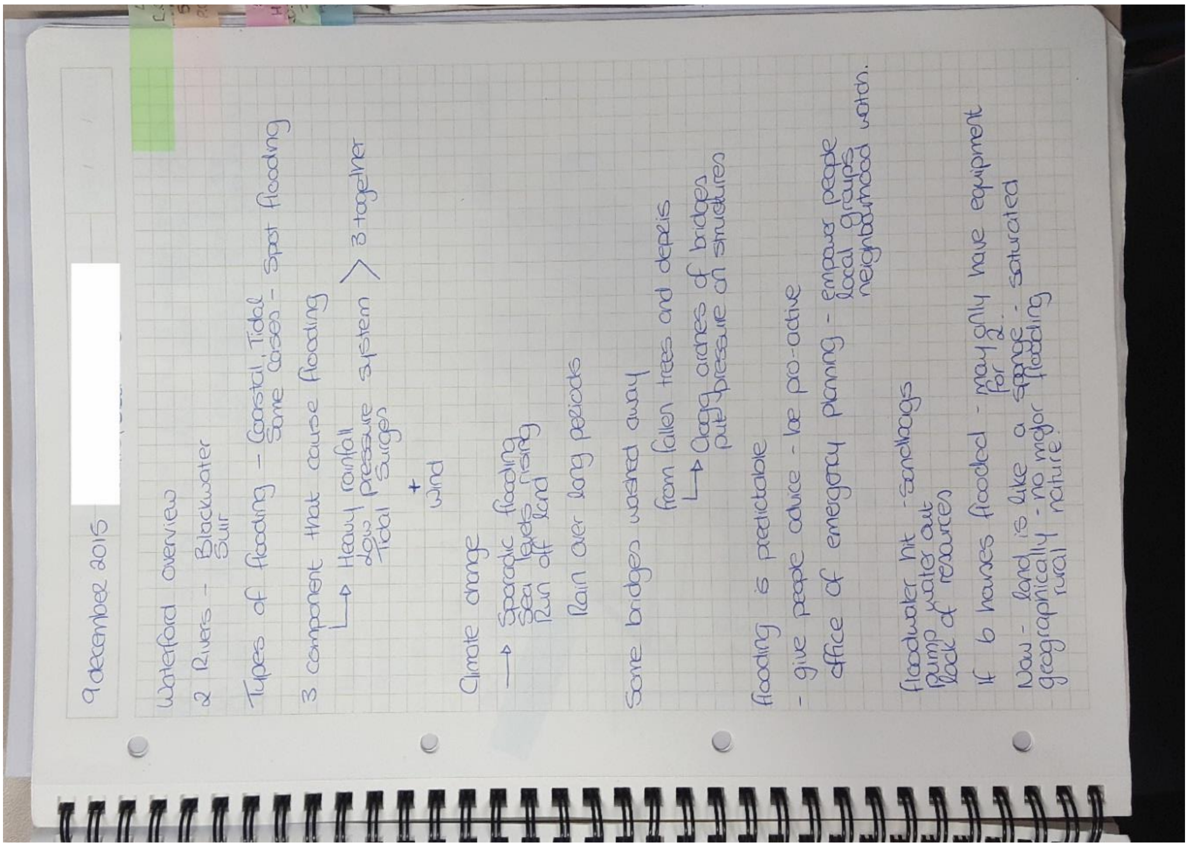
- how the floods occur
- flood plains are full
- high water table
- streams cannot hold water
- high tide.

} water has nowhere to go.

- Civil defense dont have a generic protocol they just react to the situation at hand.

flood protection 15-20million.

> Carlow → Leighlinbridge → Bagnalstown - main street flooding.


9 december 2015

Waterford overview

2 Rivers - Blackwater
Suir

Types of flooding - Coastal, Tidal
Some cases - Spot flooding

3 component that cause flooding
→ Heavy rainfall
Low pressure system
Tidal Surges
} 3 together
+
wind

Climate change
→ Sporadic flooding
Sea levels rising
Run off land
Rain over long periods

Some bridges washed away
from fallen trees and debris
→ Clogg arches of bridges
put pressure on structures

flooding is predictable
- give people advice - be pro-active
office of emergency planning - empower people
local groups
neighbourhood watch.

floodwater hit - sandbags
pump water out
lack of resources

If 6 houses flooded - may only have equipment for 2.

Now - land is like a sponge - saturated
geographically - no major flooding
rural nature.

Inistioge 28-04-2017

Assisted by the local Councillor

Interview 1 – Participant four

We called into participant fours house just a few doors down from participant one.

I presented my research area and the Idea I have come up with as a result of research.

Participant four seems to have been part of Creative Ireland or some Government led incentive scheme and they were very interested in the project. Their initial reaction was that anything that can help people prepare or mitigate the effects of flooding is great. Near the end of the interview the participant also asked would this be something that could be further developed and showed great interest in the outcome of the project.

How would you feel about constructing your own flood defences as part of a community based initiative? Inexpensive

or

Would you prefer if the sensors were provided to you? More costly option

When I asked participant four if they would be willing to construct their own flood sensors as part of the community engagement scheme she said it would depend on the level of skill that you would need to construct the device. The participant was unsure that they or the members of Inistioge would have the appropriate skill set to carry this out.

Participant four was of a slightly younger demographic and she was a very enthusiastic participant so I do feel that she would have the patience and, when provided with the correct instruction, she would be more than capable of making her own flood sensor.

What kind of knowledge transfer medium would you be comfortable using?

App

Software – PC

Phone – Text

Notice Board in PO – Physical Artefact

When asked what kind of medium she would prefer to gather and upload information, without hesitation the participant said that an App would be most suitable.

I feel an app or a piece of software would be extremely beneficial with the rate that technology is increasing in modern day society and if it is the case that Inistioge only suffer a severe flood every 20-30 years then technology will most definitely be a huge part of people's lives and the majority of people will be using it.

Would you be willing to invest in a community based initiative?

Contribute a fee for the running and upkeep of this system?

Participant four already contributes 200 euro per year to the local GAA so they said that if it was less than that they would be happy to contribute to upkeep of the system.

Participant four also highlighted that local knowledge transfer is essential. The participant told me that the last flood they encountered, there were local fishermen there who told the community that there wouldn't be another flood when the rest of the community were under the illusion that there would be. It turned out that the local fishermen were correct and that they did not experience a second flood event.

Inistioge 28-04-2017

Assisted by the local Councillor

Interview 1 –

We called into participant one's house where participant two and participant three were visiting.

I presented my research area and the Idea I have come up with as a result of research.

Both participant one and participant two were very enthusiastic about the idea I have come up with however participant three was not as convinced. He argued that a flood such as the one experienced at the end of 2015, is very rare and that there really is no need for something like this. But participant one and participant two understood the concept of climate change and agreed that flooding is expected to become more frequent as a result.

They all felt very strong about the flooding in Inistoge and really are looking for an immediate solution which made them less keen on implementing an idea such as mine but they thought it was a good idea and gave me some very good feedback.

They also said that it may be something that they could tie in with the community text alert scheme that they already have up and running which was a nice idea.

How would you feel about constructing your own flood defences as part of a community based initiative? Inexpensive

or

Would you prefer if the sensors were provided to you? More costly option

When I asked them if they would be willing to construct their own flood sensors as part of the community engagement scheme they said that it would all depend on the cost. If it were expensive to get the sensors pre made then they would consider making their own.

Because of their age group I feel it would be more difficult to ask them to construct their own flood sensors. Based on my own knowledge of constructing one of these products, I know it is difficult and I am not sue if they would have the appropriate skill set for making the sensors themselves. In saying that maybe they could contribute to a different area of the project such as contributing their own knowledge to the system or assisting in meeting etc.

What kind of knowledge transfer medium would you be comfortable using?

App

Software – PC

Phone – Text

Notice Board in PO – Physical Artefact

When asked what kind of medium they would feel most comfortable accessing the information on they suggested either PC or Text. After suggesting this the Councillor raised the option of having a notice board in the community hall where everyone has access to contributing information and accessing information.

I think they gave this answer due to the demographic they fall under. Each participant was between a 60-75 age bracket so they would not be as up to date with technology as a younger age group. However, it was interesting that they would suggest using a notice board in the community hall and were enthusiastic about using something like this.

Would you be willing to invest in a community based initiative?

Contribute a fee for the running and upkeep of this system?

They gave the impression that it would be something they would be willing to invest in but like anything it would depend on the cost. They also raised the point of that if it was only a case that Inistioge flooded once every 30 years then why would they invest money into something like this. However if the cost was minimal then they would consider it.

Interview with Participant – Thomastown

House located along the river in Thomastown

Interview 1 – 35.10 seconds

(Interrupted by a phone call) Explaining soft engineering

Some of that soft engineering and I can give you an idea of that, you know.

That's Perfect

Yeah, and so you can take a few photographs on your phone and before that we might go over to my office and I can show you that video and a few things.

Fantastic

And in relation to Thomastown itself, do you have a flood committee? Yet?

No, we did have various groups that would be interested in it. We don't have an organised flood committee (phone rings).

end of first recording

Interview 2 – 27.14.01

(First 39 seconds approx. just chit chat about the recorder on my phone)

But in relation to the town, there's only one or two areas in the town, like in terms of housing that use to flood. I'd be one of the first here, mainly because I'm lowest down. Em Marsh's street, over by the old library, would be the other place.

So they would be normal floods. So, in all of the years, like I would flood and the town would be dry.

Yeah

And Marsh's street would flood, there's one or two houses on that...

Okay

...that would flood. So that would be a normal thing, and what I've done, I'll show you downstairs. I've flagged floods downstairs and I put in two submersible pumps in the floor. So, when the water comes in, and my water pressure, I can have two or three feet out there on the roadway from the river and be dry in her but eventually the water table, it'll be pushed up through the floor. So that's that type of flood. (1:27:01)

So I get normally very clean water, so it's not full of sewage, it's filtered through the water table if you like, or through the, through the thing.

So, and I have two pumps and they handle most floods, right?

Now, em, I was living here with my daughter, eh, I don't know was it 2008, seven or eight. And the pumps kicked in, were grand were, and like I'm so use to it we just keep the furniture six inches above the water level, you know. And that was that, that was it.

So it's no big deal, I power hose the whole place out, dry it out, open the windows, get in dehumidifiers, and were grand.

But, em, the two pumps were rattling away and this particular flood, till about, what, 12 o'clock, and it just kept coming.

I had built a new kitchen on the basis of these pumps, and I lost it all.

And I can't get insurance for this area, you know what I mean, because I flooded.

So that was the time I decided, a very depressing time, so I moved up here and built a kitchen up here. So I'm upstairs out of it, and I've been turning downstairs into, eh, how would you say, em, storage.

But I'm coming back to it again because I put in a utility room and they're all up on platforms up 1 foot and a half.

And this year now I moved all the sockets up, I had them at 2 feet and I moved them to within six inches of the ceiling, you know, that's what I did there, about 2 months ago.

Eh, because when the sockets go there's a major problem, you know, em, with that, but in this particular flood it was like the 130 year flood, and I don't know if you know what that means.

No?

It doesn't mean that it comes every 130 year flood.

They have, eh, let's say a scale of flooding that averages for, within a 100 year period or 150 or 200 year period, the river will peak at least once, to this particular level, you could get another 130 year flood next year, you know what I mean, it's not to say that it comes every 130 years.

So, when they're doing their calculations, the do calculations for the 50 year flood, for the 100 year flood, for the 150, for the 200 year flood, that sort of stuff.

Like 1947 now, would have been the last really major flood here and the water would have been up to the window sills on the upper floor here.

People would have been rescued from this house by boat, from the back, you know.

But that was in 1947.

How high would that be now off... that's a good...

What, I'm six foot, it'd be fourteen foot off the ground at least. You know, yeah.

So the history of flooding in the town goes back the town through the sixteen, seventeen, eighteen hundreds, has lost bridges. In the mid 1700's, eh, at the new bridge up here or the old bridge, whatever, there's only one bridge. Eh there is a laneway called weavers lane with houses on it. That was flooded and I think was it five or six people were drowned. All the houses had been washed away and that was the mid 1700's.

I have, I can send you on packs in relation to the history of flooding. So bridges have been lost the whole way down, and repaired, and whatever.

So it's a continual sort of stuff, you live by the river, you die by the river.

And, you know, as I was saying to you earlier on. To me I don't mind any flood when you can look out there and you know, see salmon rising, well you don't see too many of those ether now.

(Talking about salmon)

5:50:10

I'll show you now before our weir breached in 2008 and we lost everything. One wall of the weir was a v shaped weir and I often photographed salmon, I must show you.

So, anyway there are two typed of flood, that's the one that comes up, well I'm sure there's many different types of flood. The one that comes up through the floor is my type of flood. But I suffer greatly and for many years with trucks and guys in 4x4's driving through when it's at 1ft or 1ft and a half and driving water in through the house, around the back in, you know.

And, em I'd have to say for many years, I'm the one who put the tar barrel out on the road to stop traffic. And I will be pleading with the local authority to have, there is a number of older women, eh up along the quay here, who had no one to help them. And I was suggesting things like can we not just get a pallet of sandbags to have them ready and that sort of stuff.

But, I have to say, in this year, the communications have improved dramatically.

We have all sorts of warnings. We have eh the local engineer would ring me so we have a whole sort of, so we know what's coming.

Eh, we had a great response like, I had my two pumps going here, I had an army pump going here and I had a big industrial diesel pump going here.

I still couldn't keep it below 2 ½ feet, you know, that was it.

But, em, a lot of shops on the main street, their flooding is different, the river rises (7:29:16) behind then, and it comes into the back of their houses and if you block it, it just rises, rises, rises up past the windows so you have to let the water through the premises, you know.

And one or two people were away. The woman in the book shop was away so they had to break down the door, she lost all the books in the book shop. And eh yeah so there's, those are the main types of and so there are different solutions I think for each one. But, I'd say in general what towns have to realise is that if you live by a river then you're in a flood plain and you're gonna get a flooded sometime so you have to set up for that.

So, I would start the process by, eh, trying to, how can each individual, homestead or business be protected and support that either with pumps, subterranean pumps or, or door damns or you know whatever the solution is.

An assessment and support to the, to the household owner or the business owner – that's the first step so that's dealing with right there and then, moving out a bit further I'd be for natural sort of eh, how would you say, revetment or, or so you'd have clay mounds rather that concrete planted with willow, d'ya know and cattle could graze those and go over them, not like a concrete wall d'ya know down, down along.

Eh, so. And there are heritage aspects of it as well. This wall here was falling in. It's the old quay wall and this use to be the quay or the main port of Thomastown up to 1970. SO all, you wouldn't think it now but all of the (9:09:84)

Export traffic of Kilkenny came down through here, went to the UK, limestone, the limestone that built St. Marks cathedral went down through here, you know, the Norman's would have brought lime, timber, limestone, eh, hydes, flour all of that…

Along the river?

This river was the M50, you know, of its time and eh boats of over 50 feet long were out there. So in this wall here there are lots of old iron rings, wrought iron rings where some of those big boats would have tied up to. So, heritage like when the OPW came around here they were thinking of knocking that and putting in, and I told them over my dead body will that happen, so there's a heritage you know and you cannot take the river away from the people.

Which is what they done in Clonmel and they will say look, Clonmel people are happy but they've taken the river away, they done it to an extent in Carrick on Suir, yeah, but people need to be able to get at the river, need to be able to see it, d'ya know what I mean, you cant. And again, it's really dealing with the, it's not dealing with the problem its dealing with some of the, eh, side effects really, of it. It's like, eh, I don't know if you build a wall 4 foot high or 5 foot high, let's just say you build it at 5 foot 2 inches, right? You can't stop it, you won't stop it and it creates a whole different problem once that's, that's breached you can't get that water out of there, you know, so it'll fill up. So, I think working with nature and trying to understand the dynamics of water is there way to go, you know (10.57.93)

(Interviewer talking about disadvantages of interfering with rivers – meandering rivers)

Well farmers are doing it continually, they're cutting down, eh, trees. They're draining bogs, em, there's a friend of mine working on the Dinan river and they're losing huge amounts. This farmer loses quarter on an acre to a flood, the other fella gains quarter of an acre down further., ya know what I men with the deposit, so the, the river is angry, its, it's not able to contain itself so by putting in concrete and stuff like that you're making it faster, you're taking no energy out if it. (12:00:00)

SO the idea is, attenuation (loss of intensity) slowing up, taking the energy out of the water, leaky damns, slowing it down, next stage, next stage, so the slow release and that has to be, that could account for, you know, a huge amount of, if we got that into our, how would you say, Modus Operandi (a particular way or method of doing something). (12.20.67)

XXX

OPW - RESEARCH QUESTIONS

1. **I acknowledge that from your title that you are head of the flood relief and risk management division along with being the chairman of the EU working group on floods. Could you give me a short run down of the general duties associated with these roles?**

   As Head of the Flood Relief and Risk Management Division, I have responsibility for the management of the business and performance of the Division, and have responsibility for the following areas of work:
   - The national flood risk assessment, mapping and management programmes (the CFRAM Programme) and the implementation of the EU 'Floods' directive in Ireland
   - The planning advisory service the OPW provides to DHPLG and planning authorities with respect to flood risk
   - The design of flood relief schemes

   I stepped down as Chairman of the EU Working Group on Floods at the end of 2015 after 6 year, but during that time my primary responsibilities included:
   - Planning and chairing meetings of the Working Group
   - Preparing / reviewing documents for and from the Group
   - Primary contact point and representative of the Group in other fora (other EU activities, national / international events, etc.)

2. **Do the Office of Public Works and the organisations that work alongside the OPW engage with the public on a small or large scale?**

   We engage heavily with the public and stakeholders in communities where we are proposing works, as we are looking for the most appropriate scheme for that community that takes into account local views, agreement and acceptance as well as other factors such as the economic benefit - cost ratio and environmental impacts.

   For either answer, how do they engage?

   For the CFRAM Programme (www.cfram.ie), in addition to the statutory national consultation, we have held nearly 400 Public Consultation Days (PCDs) to consult on the flood maps and the options for resolving the flood problems for that community. The PCDs are typically held from lunch-time to early evening in a suitable venue in the community (library, council offices, community centre, hotel, etc.), with staff from the OPW and our consultants, and often the local authority, in attendance. At these events, that are advertised locally in advance, we give members of the community the opportunity to come in to see the maps or options, and have face-to-face discussions with the team to explain what the maps are, find their home or business and see what they mean for them, answer questions, listen to opinions of what should be done to solve the problems, etc. We have invested significant resources in the programme PCDs, but consider these essential to have engagement with the communities to raise the awareness of the issue of flood risk, validate the flood maps and influence the proposals for solutions.

   For flood relief scheme projects (outside of the CFRAM Programme), similar PCDs are held in advance of the formal 'Exhibition' process that is the planning process within the Act we work under.

3. **Does the OPW primarily focus on built up towns and cities or does it also extend to smaller rural areas?**

   To date we have focussed on areas where the flood risk is concentrated and most significant, and hence where there it is more likely that we will be able to justify protection works. Individual projects have addressed towns and cities, and some smaller communities, and the CFRAM Programme includes 300 communities around the country.

   However, we are aware of the risk to isolated properties and rural areas, and the Inter-Departmental Flood Policy Coordination Group is considering policy options for schemes to assist with certain flood risk management measures such as individual property protection (e.g., flood gates across doorways) and voluntary home re-location. We anticipate also a greater focus on rural risk in the next cycle of the implementation of the 'Floods Directive' that runs to 2021.

4. **Do the OPW have any involvement in the placement of flood defences? Are the public consulted?**

   Yes. Although the Report of the Flood Policy Review Group (approved by Government in 2004) recommended a greater attention to non-structural flood risk management measures (e.g., sustainable planning, flood forecasting, emergency response, resilience, etc.), which has been implemented, structural flood protection works remain and will remain one of the corner-stones of our work. Examples would include the schemes in Kilkenny, Clonmel, Mallow, Fermoy, Waterford, Ennis and in Dublin (Dodder and Tolka Rivers, and currently along the Liffey South Quays).

5. **Roughly how long does it take for a flood defence scheme to be put in place from the date proposed?**

   The time taken to implement a scheme can vary, but does require a number of steps (feasibility assessment, environmental assessment, consultation and Exhibition, detailed design, contractor procurement and construction) to put in place. It is typically a few years before from the first step to construction commencing, and this can be much longer if issues arise.

6. **Are the new defence schemes designed to deal with the acceleration and severity of climate change/flooding?**

   Under the CFRAM Programme, we have assessed and mapped the flood risk for two future scenarios that take into account the potential impacts of climate change. The Mid-Range and High-End Future Scenarios (MRFS and HEFS) include, for example, a 0.5m and 1.0m mean sea level rise. These assessments then inform the consideration of the options and development of possible measures to address the flood risk, to ensure that the proposed measures are adaptable and/or do not impede potential future measures that may be necessary to address potential future risks.

Thomastown interview – 26th July 2017

You're picking a very good topic and this isn't going away

What you do want is people that are going to look at this objectively

Humans just take everything out of nature, nature is always the problem. Humans are never the problem. Humans are always the problem but we are also the solution

People of Bandon are happy enough to see the river destroyed. They really don't care.

80% of people fit into that category

What is happening is this upwell of resilience that is occurring in communities across the world and its spontaneous.

Generally indigenous communities. They understand that their prosperity and their way of life is depending on their natural ecosystem functioning

We don't get that in this country yet. Majority don't see the benefits of having one of the best salmon rivers in the country

I'm not saying it's not changing, it is slowly

The OPW don't look at any other alternative and they don't respect the communities

Complete lack of transfer of knowledge

Irish people are scared of sharing information. If they share information with you they are giving you a voice and how is that going to affect me, is that going to make things more difficult for me?

One of the problem we have is, the Met service were given 50ml of rain, on Thursday after noon it was downgraded to 5ml. There was a front the size of Western Europe coming across the western Atlantic. We knew it wasn't going to miss us. I advised that all the machinery be taken out but I was overruled by the info provided by the met service. We nearly lost a 50-ton machine. Lost loads of pumps. Whoever was sitting in the met office needs to be fired.

We need someone telling us about approaching weather.

At the minute were only seeing a delay of a couple of hours.

We need to be plugged into the Valentia station.

Who in this town is going to respond? What are their roles?

We need to identify where the water is coming from and who is responsible for what.

The other side of it is rather than spending money on walls we want to kit out all of the shops and homes so that they respond to flood water i.e. shelves that elevate, move electricity ports up etc.

After 2015 within 48 hours most people had mopped up. Local knowledge is being lost. Gates were left shut – artificial elevation that could have been avoided.

Nothing better than seeking local knowledge and expertise.

Early warning is vital

App – red amber green

Green – ok

Amber – 20-70ml rain

Red

New sandbags – dry material inside – soak up water and repel water

Hydraulic doors

If there's a small leak that's okay we can deal with that

An analysis of how the town flood is vital – every community is different

Everyone thinks that the flooding comes from the river but it doesn't. Here in Thomastown we estimate 3 cubic metres per second of water is coming off the catchment alone in a 50-80ml event

The little river here is carrying possibly 10 cubic metres of water per second. So we have 13 cm water per second coming off the land. River water is elevated is has nowhere to go.

The town is puros so the water comes up

Estimated 30million to erect the wall being suggested

Communities are the wall!

The Dynan could take 400-500 millilitres if it was attenuated properly and could possibly save us in most events

That's the nature of this but you are right if you look at the systems you are going to have a document there that might be useful

They have just battered us -we are the enemy – because we have reminded them of their job and their roles in helping the community – they just dint want to know.

We gave up – It's the system

This is the future. The resilience thing that you are talking about is where we want to see the money going – not hard defences etc.

We want the kids to see the river, the fish and to be exposed to their environment.

The government her don't understand that if we destroy our ecosystem – we don't function – it's over

SO many are devoid of understanding the basics never mind the intricacy

So that where your sell is – making people understand that what you're saying is ethically, financially and morally

I am actually seeing some changes

If we were relying on the community to implement it then it wouldn't happen – laborious or someone would need to be appointed to run it – t could happen – rare

Best idea would be to get a leader to take this on – someone passionate enough to get it done once – and that all we need – is someone to do it right once

The Bandon scheme could be done – then they get a 200 year event – that scheme would be a national disaster

Every time it rained heavily, you didn't sleep

Old bridges are taking everything that the 21st century is throwing at them – because the manner in which they built them

People with passion will engage – vital component of doing something well

To sell any concept you have to be passionate

Does flooding do any good?

Absolutely it is a vital function in the nature of a river – transportation of everything that goes to make up how a river functions

We spend million every year dredging silt from our ports and this is increasing – Murray River – biggest port in Australia – instead of spending millions they identified places where they have the highest rate of erosions and opened up flood plains – and it was as simple as that

The one thing you can show people is that if show them a satellite image of a river – and what you will see is trees and bends either side of the river – that river has been migrating back and forth across the flood plain – we think that the river is permanent – the fact is that a few generations down the line that river will have moved

If you got a 100 year flood event the river will change course

We're not prepared for a major flood – we have no concept of how that would be – we live in the here and now

We can't plan for something like that

It's a great wakeup call but we live in an age where the people will blame the COCO and the government and that's when they will come in and do something really stupid and that's what happened here in 2015 2016 – it was always someone else's fault

But they live in a flood plain along the fourth largest river in Ireland

If we got to that little milestone of people accepting that we have no control over the river – she will provide and she will destroy

You need to grab Graiguenamanagh and make it your own

Its drip drip drip and if you're dripping has an affect – you are doing something

PERCENTAGE ANALYSIS CHART

	A	B	C	D	E	F	G	H	I	J	K
1	Thomastown	1	2	3	4	5	6	7	8	9	10
2	**Stage 1**										
3											
4	Sandbags				X						
5	Sand and Shovels				X						
6	Barriers			X							
7	Pumps				X						
8	Drainage - Storm Drains		X								
9	Generators		X								
10											
11	Communication										
12	LA's + LA's					X					
13	LA's + Community				X						
14	Community + Community					X					
15											
16	Knowledge										
17	Past and future flooding					X					
18	Placement of defence mechanisms			X							
19											
20											
21	**Stage 2**										
22											
23	Community										
24	Filling + Placing Sandbags				X						
25	Assisting Community Members						X				
26											
27	Government / LA's										
28	Maintaining Floods					X					
29	Updating Community Members					X					
30	Monitoring Current Floods				X						
31											
32	Placement of:										
33	Sandbags				X						
34	Pumps + Hoses				X						
35	Medical Assistance			X							
36	Boat and Raft				X						
37	Paramedics			X							
38	Floating Pontoon			X							
39	Swift Water Response		X								
40											
41	**Stage 3**										
42											
43	Removing:										
44	Barriers, Sinage, Sandbags etc.			X							
45											

↓ (STATUS) LEVEL OF PREPAREDNESS

stage 1 37%

stage 2 39%

stage 3 67%

Figure 53 Percentage Analysis Chart - Thomastown

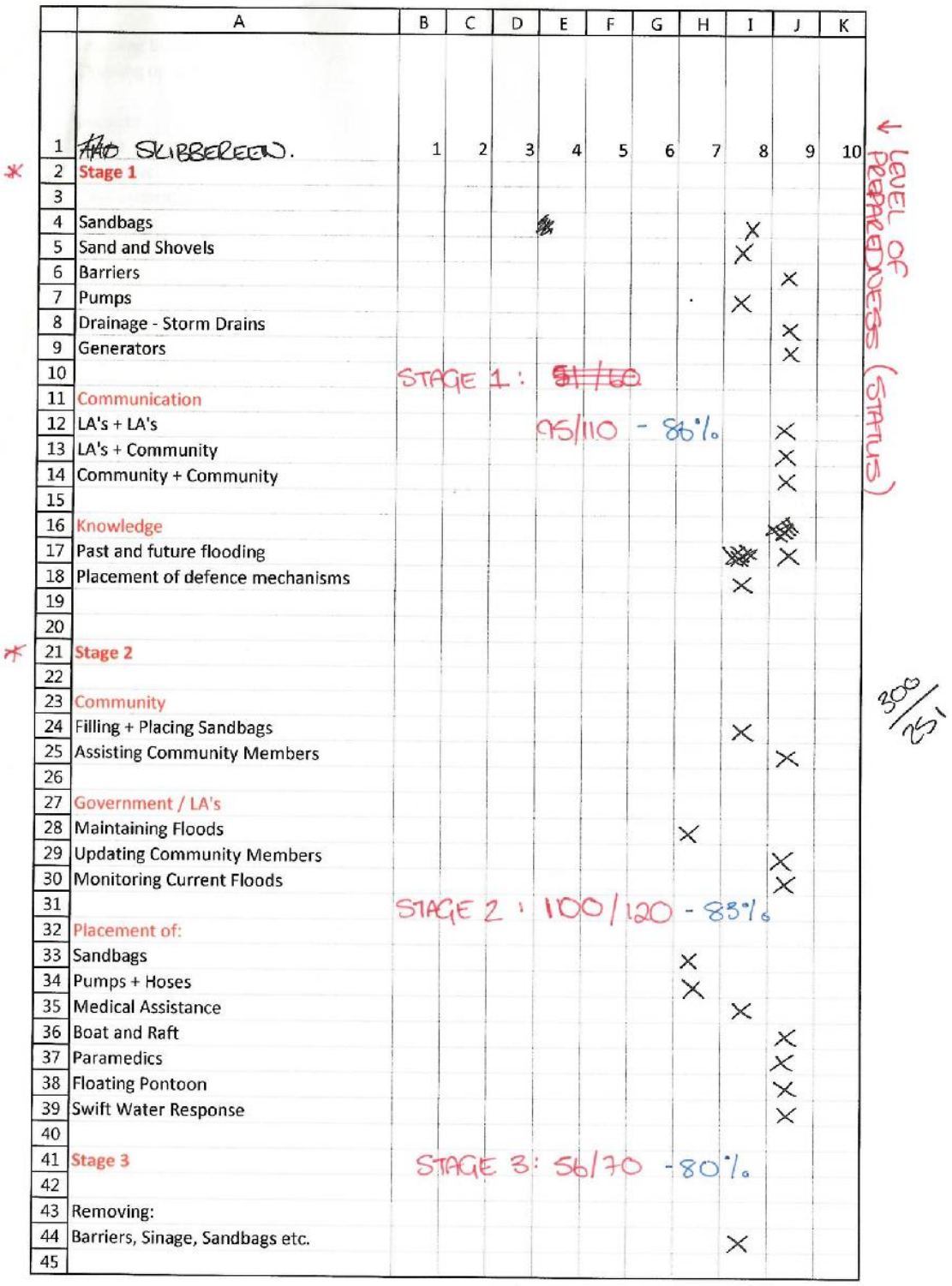


Figure 54 Percentage Analysis Chart - Skibbereen

Percentage Analysis Chart — Inishtoge, Kilkenny.

		1	2	3	4	5	6	7	8	9	10	
2	**Stage 1**											
3												
4	Sandbags						X					
5	Sand and Shovels					X						
6	Barriers				X							
7	Pumps				X							
8	Drainage – Storm Drains	X										
9	Generators		X									
10												
11	Communication											
12	LA's + LA's						X					
13	LA's + Community						X					
14	Community + Community							X				
15												
16	Knowledge											
17	Past and future flooding								X			
18	Placement of defence mechanisms					X						
19												54/110 / 49%
20												
21	**Stage 2**											
22												
23	Community											
24	Filling + Placing Sandbags						X					
25	Assisting Community Members							X				
26												
27	Government / LA's											
28	Maintaining Floods					X						
29	Updating Community Members				X							
30	Monitoring Current Floods					X						
31												
32	Placement of:											
33	Sandbags						X					
34	Pumps + Hoses					X						
35	Medical Assistance							X				
36	Boat and Raft								X			
37	Paramedics								X			
38	Floating Pontoon								X			
39	Swift Water Response							X				
40												26/120 63%
41	**Stage 3**											
42												
43	Removing:											
44	Barriers, Sinage, Sandbags etc.						X					
45						X						
46	Assisting Businesses + Homes:					X						
47	Cleaning up the Aftermath											
48												
49	Impacts											
50	Social								X	X		
51	Economic								X			
52	Environmental							X	X			
53	Emotional										X	
54												50/70 71%
55	Total											

Figure 55 Percentage Analysis Chart - Inistioge

Appendix C

Arduino Code

```
#include <LiquidCrystal.h> // includes the LiquidCrystal Library

LiquidCrystal lcd(1, 2, 4, 5, 6, 7); // Creates an LCD object. Parameters: (rs, enable, d4, d5, d6, d7)

const int trigPin = 9;

const int echoPin = 10;

long duration;

int distanceCm, distanceInch;

int time_delay=2000;  //time delay for the screen

const int buzzer = 11; //buzzer to arduino pin 11


//setup variables

void setup() {

lcd.begin(16,2); // Initializes the interface to the LCD screen, and specifies the dimensions (width and height) of the display

pinMode(trigPin, OUTPUT);

pinMode(echoPin, INPUT);

pinMode(buzzer, OUTPUT); // Set buzzer - pin 11 as an output

}


void loop() {


digitalWrite(trigPin, LOW);

delayMicroseconds(2);

digitalWrite(trigPin, HIGH);

delayMicroseconds(10);

digitalWrite(trigPin, LOW);

duration = pulseIn(echoPin, HIGH);


distanceCm= duration*0.034/2;
```

```
distanceInch = duration*0.0133/2;

if (distanceCm>100 && distanceCm <= 150)  //use this for different warning levels
{
lcd.clear();
lcd.setCursor(0,0);
lcd.print("Distance: ");
lcd.print(distanceCm);
delay(500);
lcd.setCursor(0,1);
lcd.print("   WATER HIGH   ");
delay(1000);  //make sure that i have enough time to read
tone(buzzer, 1000); // Send 1KHz sound signal...
delay(1000);       // ...for 1 sec
noTone(buzzer);     // Stop sound...
delay(1000);       // ...for 1sec

}

else if (distanceCm>150 && distanceCm <= 200)  //use this for different warning levels
{
//lcd.clear();
lcd.setCursor(0,0);
lcd.print("Distance: ");
lcd.print(distanceCm);
delay(500);
lcd.setCursor(0,1);
lcd.print("   WATER NORMAL    ");
delay(1000);  //make sure that i have enough time to read

}
```

```
else if (distanceCm>200)  //use this for different warning levels
{
lcd.clear();
lcd.setCursor(0,0);
lcd.print(“Distance: “);
lcd.print(distanceCm);
//delay(500);
lcd.setCursor(0,1);
lcd.print(“   WATER LOW     “);
delay(3000);  //make sure that i have enough time to read

}
}
```

Appendix D

Ver. 25 August 2016

CHLOE - INTERNSHIP TASKS

Your home: G:\FTC\U_Technology\TTCLEAR\5. TT_CLEAR - 2016\1. Internship_2016\4. Chloe

1. Develop new TT:CLEAR

Your principle task is to collaborate with the team developing the new TT:CLEAR website. You will be in charge of day-to-day activities on the project. This will include to:

- Analyse the new design and provide comments to improve it
- Monitor project implementation
- Liaise with the project team, including ICT colleagues (IT technicians), CO colleagues (communications) and the graphic designer.
- Support stakeholder engagement and buy-in of the new design (through holding sneak-peak presentations of the new website)
- Ensure the accurate migrating of old TT:CLEAR pages to the new TT:CLEAR (migrating of slots)
- Undertake testing and debugging to ensure that the new website is error free and fully functional
- Prepare and implement a website launch communication campaign
- Launch the new TT:CLEAR on the agreed date!

(a) To understand the project, read the documents here:

G:\FTC\U_Technology\TTCLEAR\5. TT_CLEAR - 2016\1. Internship_2016\4. Chloe\Developing TTCLEAR

All files for the new TT:CLEAR are here:

G:\FTC\U_Technology\TTCLEAR\5. TT_CLEAR - 2016\14. New website structure

(b) The latest version of the new TT:CLEAR is:

https://projects.invisionapp.com/share/G48E7348T#/screens/183834117

(c) We need to add you to the project management page so that you can follow developments:

https://phoenixdesignaid.teamwork.com/projects/254562/overview

2. Support in developing publications

For COP 22, we are currently making two new publications on UNFCCC technology work. You will provide input into the overall design and quality control of the publications.

(a) TEC 2016. All documents, including latest design:

G:\FTC\U_Technology\Communication and outreach\1. Activities\2016\7. TEC 2016 brochure

(b) TNA brochure. *Still to be initiated.*

3. Social media, especially for TEC 13

For the TEC meeting, 6-9 September, we will implement a social media campaign to raise awareness about the meeting. You will work with the team to implement this campaign. Information about the campaign:

G:\FTC\U_Technology\Technology Executive Committee\TEC meetings\13th TEC meeting Bonn 6-9 Sept 2016\Social media and outreach

4. Reading

Through-out the internship, I encourage you to take time out to read about the UNFCCC process and the work we do. As a starting point, read:

(a) The Technology Mechanism:

http://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/TEM/0e7cc25f3f9843ccb98399df4d47e219/174ad939936746b6bfad76e30a324e78.pdf

(b) Then see the readings in the following folder. Try to read an article a week:

G:\FTC\U_Technology\TTCLEAR\5. TT_CLEAR - 2016\1. Internship_2016\4. Chloe\Readings

5. Updating the Technology Portal

In 2016, developed countries submitted information on how they have supported developing countries with technology activities. We will need to upload that information to the TT:CLEAR Technology Portal. See the manual here for tips on what needs to be done:

G:\FTC\U_Technology\TTCLEAR\5. TT_CLEAR - 2016\1. Internship_2016\4. Chloe\BR2 Database

The 2016 database of all biennial reports (BR2s) may be found here:

G:\FTC\U_Technology\Nat coms and BRs\5. BR2\1. Database

For reference, also look at:

G:\FTC\U_Technology\TTCLEAR\4. TT_CLEAR - 2015\3. Internship\Internship_Marco\4. Technology Portal\NCs and BRs

6. Undertake maintenance to TT:CLEAR to ensure that it remains up-to-date and error free

To edit TT:CLEAR, go to:
http://pvsttclear01.unfccc.net/ttclear/acl_users/MultiPAS/login_form?came_from=http%3A//pvsttclear01.unfccc.net/ttclear/templates/render_cms_page%3Fs%3DTEC_only
Then->

Now you can edit any page of TT:CLEAR. Careful! Once changes are saved and published they are live.

(a) Updating the carousel

Update the carousel at least once a month. To update the carousel, use:
http://pvsttclear01.unfccc.net/ttclear/carousel_home

(Note that you have to use Firefox for this). For images, make sure we don't have to include accreditations! Here is a source of good free images: https://bootstrapbay.com/blog/free-stock-photos/

(b) Updating NDEs

http://unfccc.int/ttclear/templates/render_cms_page?TEM_ndes
Countries send us emails to update their details on this page. You will update this page as new nominations/information arrives. Before changing information, check the following:

- Is the nomination made by the country's UNFCCC focal point? http://maindb.unfccc.int/public/nfp.pl (Or is the focal point copied in the email?)
- Is all information there, is anything else required?

Once all new NDEs are added, we need to update the map. To update the map, use:
http://www.maproom.org/outline/world/mn.php. Then paste the new image into the TT:CLEAR page.

(c) Other pages

We will also update other pages from time to time.