IGP
INSTITUTO GEOFÍSICO DEL PERÚ

BIRMINGHAM CITY University

BUILDING RESILIENCE IN FLOOD DISASTER MANAGEMENT IN NORTHERN PERU

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FOREWORD

Our MPs declared an environment and climate change emergency for the UK in May, 2019 and Birmingham City Council followed swiftly just a month later. It is right that our city and national leaders have recognised the importance of taking responsibility for our actions on the environment. Our behaviours have direct impacts on the world in which we live and those impacts in turn affect the way we live. But we know that some communities in the world are already having to cope with the sometimes deadly effects of catastrophic environmental change.

It is vitally important that BCU, as an institution from a wealthier nation, takes responsibility to work with those areas of the world with fewer resources and less developed infrastructure. We know that these are not easy issues to resolve and they require integrated approaches. BCU and its Peruvian partner, the IPG, sets an example for our future efforts. By drawing together the expertise from across 30 UK and Peruvian universities, we have shown that the devastating floods that affected the people of Piura in northern Peru in 2017 are not just about the flood water but in how we need to anticipate risks and how we think about working with nature to plan for the future. Most of all it shows how universities and their partners need to take approaches which engage and work with local communities.

These are lessons for the UK as much as they are for Peru. As a university we cannot solve the environmental emergency but we can collaborate and share our expertise in meaningful ways. This report is a great example and points the way for how we can do just that.

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EXECUTIVE SUMMARY

This report provides a detailed account of the Newton Fund Peru Researcher Links Workshop held between 20th and 23rd August 2018 in Piura, Peru, entitled 'Building Resilience in Flood Disaster Management in Northern Peru'. The report provides some background to the workshop, the aim and objectives, problem definition, as well as an account of the workshop process and key workshop findings and recommendations.

The workshop was run jointly by Birmingham City University (BCU) in partnership with Instituto Geofísico del Perú (IGP) and was hosted by the Universidad de Piura (UDEP). The workshop was a response to the severe flooding experienced in Piura during the El Niño event of March 2017 which caused a number of fatalities, damaged over 100,000 homes and destroyed much local infrastructure including around 100 bridges. El Niño is a recurrent event and there is concern that its frequency and intensity may change in the future as a consequence of climate change.

The four-day workshop adopted a structured facilitation approach to encourage participants to work together towards a common goal. Forty researchers and practitioners from the UK and Perú were challenged with working across disciplines to identify key cross-cutting themes and make recommendations for building resilience to future flood events. The activities included the identification of key themes facilitated by some key expert presentations, a full day of site visits to communities in the Piura and Catacaos area, meeting people who had been affected by the flooding events of 2017; and culminating in the development of key findings and recommendations which were presented on the final day.

Six key and integrated themes emerged from the workshop activities as: i) Governance; ii) Risk Information; iii) Healthy Communities; iv) Infrastructure; v) Urban and regional planning; and vi) the River System. For each of these themes, the report provides an overview of the problem as well as some detailed suggestions and recommendations for addressing the difficulties and challenges identified. The key messages across these dimensions are:

Governance: The importance of establishing participative planning in Chira-Piura Basins was identified for building collaboration and enabling integration. This can be done in three steps: (1) problem analysis and prioritization involving stakeholder mapping; (2) defining new governance arrangements that improve integration and communication; and (3) detailed action planning which creates collaborative implementation and monitoring.

Risk Information: There is a clear need for the adoption of a risk model for the lowland basin of the Río Piura. An ideal risk model is comprised of data on hazard, exposure and vulnerability, with both outputs and inputs designed specifically to meet the needs and requirements of different stakeholders in the basin.

Health: To resolve the healthcare problems in this community will require a multidisciplinary approach. First, an appreciation of existing health issues from the perspective of the local community and especially of the vulnerable affected groups. Secondly, a better understanding of how to improve the uptake of available medical treatment and public health information programmes.

Infrastructure: Three priorities and associated future research ideas were identified: (1) sediment control, ideally by enhancing natural processes; (2) do not increase exposure to flood risk by allowing settlement development in the flood-plain; and (3) aim for integrated and co-delivered benefits in order to justify costs.

Spatial Planning: The key proposal would be to create an Urban-Rural Plan addressing the long term. For example, a 20-year plan supported by better communication, education programmes and a package of incentives to enable people to move to safer areas. This should be supplemented by the provision of basic health and community needs alongside fiscal measures and long-term planning for appropriate blue, green and grey Infrastructure.

River Management: The issue of the river system in Chira-Piura was addressed with the proposed plan of short and long-term goals by the ANA (National Water Authority). There have been some suggestions and recommendations to strengthen this institution as well as the water management organization. Early warning systems, forecasting and media reporting are key in bringing awareness and readiness to the community. Constructing drainage systems in affected urban areas is significant in order to channel the flow to the sea and also the promotion of green infrastructure.

The report concludes with a synthesis of the findings and overarching recommendations for the adoption of an integrated approach to catchment management. The final sections provide a summary of the dissemination activities and some reflections and lessons learnt from the workshop.

ACKNOWLEDGEMENTS

The editors would like to acknowledge the support of a number of organisations and individuals who made important contributions to the project and to the production of this report. Firstly, to the funding bodies, the British Council and the Newton Fund, who provided the financial support to enable the workshop to take place. To our hosts and representatives from the Universidad de Piura (UDEP) who provided the facilities and helped make the arrangements for the workshop activities. A huge thanks to the impoverished communities we visited in the Piura and Catacaos areas for their willingness to share their experiences and for their generosity in providing refreshments. Finally, to all our co-authors and workshop participants– thank you for your energetic contributions, determination and enthusiasm throughout the workshop – you all helped make this an unforgettable experience.

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1.0 INTRODUCTION

This report details the activities and findings of a workshop designed to build resilience to flood events in northern Peru. The workshop was run jointly by Birmingham City University (BCU) in partnership with Instituto Geofísico del Perú (IGP) and was hosted by the Universidad de Piura (UDEP). The event took place in August 2018 and was funded by the Newton-Paulet fund administered by the British Council. The workshop was a response to the severe flooding experienced in Piura during the El Niño event of March 2017 which damaged over 100,000 homes and destroyed much local infrastructure including around 100 bridges. El Niño is a recurrent event and there is concern that its frequency and intensity may change in the future as a consequence of climate change.

1.1 AIM AND OBJECTIVES

A group of around 40 early career researchers and practitioners from the UK and Peru were challenged with working together across disciplines to identify key cross-cutting themes and make recommendations for building resilience to similar future events. The main aim of the workshop was to encourage this new generation of researchers to engage with and develop a systemic approach to flood disaster management encompassing stages of preparedness; disaster management; rehabilitation; and recovery. Figure 1 shows the participants on the first day of the workshop.

Figure 1.0: Organizers and participants from UK and Peru (Day 1)

The organisers set out with a number of objectives:

1. To review and present the latest technological developments in flood risk monitoring and prediction.
2. To review and present community based approaches to flood disaster management.
3. To review the interplay between structural and non-structural solutions based on an actual recent flooding event in Chulucanas, Piura Region.
4. To generate ideas and connections relating to a systemic approach to flood disaster management incorporating technological and sociological solutions.

The remainder of this report describes the process undertaken to address these objectives and highlights the main outcomes of the workshop.

2.0 PROBLEM DEFINITION

El Niño represents the warm extreme of the El Niño-Southern Oscillation (ENSO) which is an irregularly periodic variation in winds and sea surface temperatures over the tropical eastern Pacific Ocean. Piura is located in the north-western region of South America which is a climate-sensitive area, prone to quasi-periodic hydro-meteorological anomalies associated with El Niño1. The El Niño Costero which led to the flooding events under study (2016-2017) constitutes a spatially confined phenomenon along the coasts of Ecuador and Peru and thus differs from the [Pacific] basin-wide El Niño phenomenon2. This recent event bears climatic similarities to the 1925 El Niño Costero, while the major events of 1982-1983 and 1996-1997 were more associated with the basin-wide El Niño phenomenon. Research is on-going to better understand these hydro-climatic patterns.

The frequency of the combined two phenomena is approximately once every 25 years (in engineering terms this would be termed as a return period of 25 years). Direct economic losses from the 2017 event are estimated at 3.1 billion dollars3. More than 1 million people were affected and Piura was the region most severely impacted4. The frequency and the severity of the damage are indicative of the urgency to act and the multitude of actors that will need to be involved. Implicit to the workshop goals set above, was the need to identify who these actors are and what is the coordination required to enable their effective engagement.

It was not only the severity of the El Niño event that led to the extent of the damage. Poorly conceived engineering decisions led to sedimentation in the lower parts of the catchment which limited the river's flow conveyance. Engineering of the river's path did not allow free discharge to the sea because flow was redirected to the lagoon in the south-west (see Figure 2.0). Piura city lies in the mid-low section, upstream of the formed irrigation land. The coastal zone is a desert normally receiving very little rainfall.

Also, part of the flood plain had previously been reclaimed for agriculture reducing further the space for water5. The development of this agricultural activity in the downstream area meant that the population grew and with-it exposure levels increased.

Figure 2.0: Piura catchment stretching from the Andes to the Pacific coast

3.0 WORKSHOP PROCESS

The organising team from Birmingham City University (BCU) and Instituto Geofísico del Perú (IGP) adopted a structured facilitation approach to encourage participants to work together towards a common goal. Researchers and practitioners from the UK and Peru were challenged with working across disciplines to identify key cross-cutting themes and make recommendations for building resilience to future flood events. The official language of the workshop was English but it quickly became apparent that translating most things into Spanish would enable everybody to get much more out of the event.

The format of the workshop was developed in advance by BCU and IGP in conjunction with the hosts, Universidad de Piura (UDEP). A preparatory visit to some of the affected areas revealed the lasting human consequences of the impact of the previous year's rain and floods. UDEP is actively engaging with affected communities to develop resilience and help them move towards longer term improvements. A field study visit to some of these communities was planned for day 2 of the workshop to give the participants (particularly those from the UK) a first-hand experience of the impacts suffered and the living conditions of the people affected.

3.1 DAY ONE: SETTING THE SCENE

The participants received a warm welcome from the University hosts and the Governor of the Piura Region, who stressed the prime importance of understanding and being ready to deal with the recurring phenomenon that is El Niño. Roger Wall from Birmingham City University welcomed the participants and set out the aims and aspirations of the workshop, stressing that it needed to encompass 'risk management' as well as 'disaster management'. The participants were challenged with the ambitious task of planning how Piura should prepare itself for the next major El Niño event sometime within the next 20 years. What steps does Piura need to take and how can these be achieved? It was acknowledged that this was an almost impossible task within the timescale but the intention was to focus minds and generate some interesting and, most importantly, potentially impactful proposals.

The need for preparedness was reinforced in the keynote speech on Urban Flood Resilience by Professor Bingunath Ingirige (University of Salford) who outlined a 3-step model of absorptive, adaptive and restorative capacity to help achieve community resilience[7, 8].

3.2 DAY ONE: IDENTIFYING KEY THEMES THROUGH FACILITATED DISCUSSIONS

Working in both English and Spanish was time consuming but the expert participants quickly generated a spirit of engagement and collaboration to identify the challenges that needed to be considered. Mike Grace from BCU led the facilitation which was designed to allow the participants to decide on their preferred objectives and priorities.

A consensus of key points emerged and these were initially grouped into seven themes: governance; risk information; community & economic development; health and well-being; infrastructure; urban & regional planning; and the Río Piura catchment system. After some further discussions and reflection, the participants agreed to combine the community & economic development theme with the health & well-being theme – retitled as 'healthy communities' - as it was clear that their key themes had substantial areas of overlap. Figure 3 shows the workshop in action and the development of key themes.

The rationale for these final six groupings can be summarised as follows:

Governance: For the delivery of effective responses and anticipation of flood risk, it is important to understand the complexity of the Peruvian context in water resources management. This has the characteristic of a multiplicity of actors at different levels and we find this same complexity within Piura's basin.

Figure 3.0: Identifying themes and groupings of collective ideas

Risk information: Data on the nature of the hazard, the exposure of the population and infrastructure, and the degree to which communities or infrastructure can be considered vulnerable, is essential to achieve the goals to build flooding resilience. Quantitative or qualitative data on risk can be extremely helpful to inform the other themes that the workshop identified, especially in order to ensure that the risk models respond to the requirements of affected communities.

Healthy Communities: There is a strong link between the flood event and its associated health impacts on the community living in and around the Piura and Chira rivers. Although it is an approximately 10-20 return period extreme event, it can have a severe long-term health consequences. The more common and serious illnesses include cholera, dengue fever/sica/ chucunguya, respiratory diseases, renal disease and deaths during birth. The impact of flooding on the healthcare of the population needs immediate attention.

Infrastructure: Absolute protection from flood risk is not possible nor financially viable. Increased uncertainty due to climate change alongside population growth and future development suggests that an adaptive approach toward infrastructure planning, focusing on a combination of different solutions rather than fewer big interventions, needs to be explored in Piura.

Urban & regional planning: The land uses that contribute to and which are affected by Piura's flooding are comprised of many different elements: built-up and urbanized areas, the rural and agricultural hinterland that supports the urban-based food manufacturing industries as well as the wider Chira-Piura River Basin ecosystem. A continuing re-distribution of population is evident in the basin with the establishment of numerous informal and vulnerable settlements; the basic needs of these communities are not being considered by the authorities.

The Chira-Piura river catchment system: This is a self-evident theme and the current management regime to supply water for drinking and agriculture is the most important context for understanding how flood risk and disaster management could be addressed in Piura. The Chira river allows drainage of floods from rainfalls and inflows from the watershed. Its source is in the Ecuadorian Andes near the town of Papaca and its mouth is 100km north-west of the provincial capital of Piura and 25km north of the port of Paita. After crossing the border to Peru, it is dammed up in the 885 million m^3 Poechos reservoir.

These themes were accepted as the means of initially organising groups for the next steps of the workshop. Working groups were established through an interesting mix of volunteering and direction; ensuring each group had a mix of UK and Peruvian academics, sufficient language skills to enable proper understanding and one or more members with local knowledge.

The end of Day One saw the groups generate the first outputs through feedback on the key issues and challenges they had identified. These outputs were to set the tone for the field visits on Day 2, sensitising the participants to the need to understand the 'big picture' if flood resilience is to be achieved.

3.3 DAY TWO: SITE VISITS

The workshop participants visited communities in the Piura and Catacaos area, meeting people who have been affected by the flooding events of 2017. The efforts of the UDEP and NGOs were very visible in Cumbibira where model designs had been developed which aimed to lift the quality of traditional housing including windows, block bases to walls, paved flooring and room dividers to provide separate sleeping areas for adults and children. In this community, it was clear in speaking with residents that there was a growing demand for these type of permanent houses (build cost about US$ 7K) within a local process of determining housing need. Figure 4 shows the key locations of the communities visited.

Figure 4.0: Map showing the key locations

Some of the people had already begun to embrace these new forms of both temporary and permanent housing using cheap, pre-fabricated kits of local materials which could be completed by the community. One of these new designs has a simple detail which is key to local social and economic development - a block paved floor. This helps to tackle health problems caused by disease prevalent in the usual mud floors. Elsewhere, they had begun to adopt the temporary house designs (see Figure 5.0) but otherwise their community still has no basic services, depending on water delivered by bowsers.

At a small community in the desert area further out of the town, 50 families displaced by the floods had simply created a 'new village' by moving onto land adjoining the Pan-American Highway (see Figure 6). These people's housing had been so badly affected by prolonged heavy rain that they were unable to continue living in their original homes. Temporary modular shelters (US$ 1K) were being used here. Although they were only meant to be in use for 1-6 months, there was the sense that they would have a longer life. This visit also revealed the wider lack of urban and infrastructure planning.

The nearby agricultural areas benefit from an extensive irrigation system but this settlement had simply grown up in the desert area where it was constructed and the residents had to rely on tanker deliveries for water supply. The lack of water was a common issue in this desert area for refugee communities too, despite the flood risk.

Figure 5.0: Site visit to the temporary shelter for affected victims and the study of construction method

Figure 6.0: Visit to the local community to understand their livelihood in their new village.

A common factor throughout the day was the unfailing friendliness of the people we met who, despite their adverse circumstances, were keen not only to share their knowledge and experiences but their food. Indeed, it was revealed that those community bonds extended to 'ex-pat' Piura residents in Lima where a group of women are active in raising support for their home community.

3.4 DAY THREE: DEVELOPING THE THEMES

The third day was a mix of short presentations to inform the participants further about the science and research underway and a continuation of the work being undertaken by the six themed groups (see Figure 7.0). The presentations highlighted research work by IGP into the El Niño effect, the causes behind the phenomenon and its impacts in Piura and elsewhere. Dr Danny Scipion from IGP described their developing use of weather radars and other remote sensing technology to understand the evolution of rainfall and weather events at different location in Peru, which seemed to be an evolving project with increasing levels of investment in buying and developing in-house instrumentation. This generated a local discussion about the possibility of connecting to sensor systems operated by other agencies.

Dr. Yamina Silva (IGP) gave some further insights into the El Niño phenomenon, clarifying that there are several versions of the event, all linked to changes in water temperatures in the Pacific and a change of ocean currents that affect precipitation. The ability to predict these seems to be limited to between 1 and 4 months. Whatever the build-up, the impact was extensive and happened quickly in Piura, affecting 395,000 people in 2017 and UAV film of the spatial extent and subsequent relief work highlighted the damage.

There was even more dramatic video footage from Lima of cars and trucks being swept away by alluvial flows affecting stream systems. IGP are researching alluvial and sediment flows in stream catchments in the city with the intention to create models to inform river management.

In plenary discussion, the participants reflected on the field visits and identified a number of additional concerns and suggestions. This generated quite an animated conversation about the importance of understanding the dynamics of the river system and seeing the bigger picture of the river and its relationship to people.

Figure 7.0: Generating ideas and discussion with information and data gathered from site visits.

3.5 DAY 4: FINAL PREPARATIONS AND PRESENTATIONS

The final day of the workshop was divided into two halves. In the morning session, the groups continued working together and evolving their vision of what they wanted to achieve.
At the start of this session, the groups were invited to mark on a wall chart the linkages between their theme and those of the other groups. The idea was to tease out synergies and explore the overlaps and potential for interdisciplinary solutions [see Figure 8.0 and Section 5]. This led to further interactions with some groups dispatching one or two of their delegates to consult with other groups to help deepen and develop the understanding.

This in-depth group work in the morning session was followed in the afternoon by the groups giving their final presentations. The six groups took it in turns to present their findings. The quality of the presentations was very impressive and you could clearly see a strong sense of comradeship as each group took their turn in delivering their presentations, with all members of the group taking the stage. However, we should set out the caveat here that whilst the outputs from the workshop are of a high standard and we consider they will be valuable as sources of advice to the Governor and other local and national decision makers, they are necessarily limited. They are the product of a relatively short 4-day workshop and will need further verification and exploration. The following chapters describe the challenges and themes we identified and the workshop recommendations in further detail.
The event ended with each participant being presented with a certificate by the organisers.

Dr. Danny Scipion from IGP and Professor David Proverbs from BCU made some closing remarks congratulating the participants on their engagement and the high standard of work and ideas they had produced. The event was brought to a close by a round of spontaneous applause from all participants.

Figure 8.0: Consolidation of group ideas in creating synergies of potential interdisciplinary solutions

4.0 PROBLEM DIMENSIONS

The problem dimensions of each of the themes identified are explored in more detailed below. An output of each of the themes was the recognition of connections and possible synergies across the theme boundaries. These were captured and evolved into an additional, overarching thematic approach of Integrated Catchment Management. This is set out in the summary section as a progressive and a comprehensive idea of how the participants envision the development of a flood resilient Piura.

4.1 GOVERNANCE

4.1.1 Overview

We can describe the definition of Water governance as "the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society"6. For the delivery of effective responses and anticipation of flood risk, it is important to understand the complexity of the Peruvian context in water resources management; this has the characteristic of a multiplicity of actors at different levels and we find this same complexity within Piura's basin.

It is important to say that Peru is a country with a very centralised governance model and that all the decisions are taken in a central way, despite an overall decentralization effort. In 2008, the government created the National Authority of water (ANA) as part of Ministry of Agriculture and Irrigation (MINAGRI). The new water resources Law (2009) supports decentralization in practice by allowing participation in water resources management and provides decentralized "tools" such as the water resources council (Consejo de recursos hídricos de Cuenca, CRHC). These offer institutional space for dialogue with the objective of planning, coordinating and concluding actions in one or more than one basin. The water resources Council of Chira-Piura basin was created in 2011 and in the committee, are representatives from all the water users: agrarian and non-agrarian, local governments, the administrative authority of water, professional bodies, local universities, communities and the international affairs minister-local office of the two basins: Chira and Piura. Chira is an adjacent basin which contributes through water transfers to Piura.

The water resource councils are deconcentrated areas of ANA, so they have an active interaction between Lima (capital of Peru) with the CRHC and the interaction of waters users for the two basins Chira and Piura. At the same time, there is another deconcentrated area in ANA: Autoridad Administrativa del Agua (AAA). It is found that, sometimes, CRHC and AAA do not adequately coordinate between themselves. Here, we find a big challenge not only for cross-sectoral coordination but also in the coordination between all the sectors in the usage of water of different scales from the Chira-Piura basin.

One additional challenge is that Piura has frequent extreme events as Fenómeno de El Niño which causing flooding and landslides along the river. Therefore, it is important to understand the complexity and the need for integrating the three existing systems: environmental management, water resources management and risk management. The current problem is the three systems are particularly disintegrated with very limited coordination. For this reason, it is necessary to clarify the functions of all institutions and design a mechanism of collaboration.

In that regard, one of the main problems is upstream deforestation and ecosystem degradation. It is necessary to implement conservation projects in maintaining and recovering the ecosystem services, water regulation, water quality, control of erosion, and avoidance of landslides. Such action will begin at the local level which could later be up-scaled with a wider scope. The outcome of this action will allow multi-sectorial and create multilevel participation. Another important action is the necessity to create dialogue with the input of local knowledge and scientific results that could lead to design modelling and implementation. In Peru, there is a diversity of local knowledge in the conservation of ecosystems especially in the water ecosystem services such as the "water harvest and seed" (Siembra y cosecha de agua).

4.1.2 Suggestions and recommendations.

We identified a number of possible steps to enable integration and collaboration among stakeholders to address the planning of Chira-Piura basin:

Step 1: Problem analysis and prioritization

- Stakeholder mapping and analysis
- Identify all the existing plans and also all the regulations
- Decision making criteria: effectiveness, feasibility, accessibility, efficiency.
- Problem analysis and prioritisation
- Identify priority areas for the short, medium and long term

Step 2: Define new governance arrangements

- Clarify and identify gaps in roles and responsibilities → assessment
- Strengthen integration between the existing committee and stakeholders, E.g. through changing membership, widening membership, flexible participation (e.g. observing, inviting speakers, etc.)
- Integration of academia (interface between science and policy)
- Identify and suggest communication mechanisms at different levels and factors (e.g. billboard, newsletter, social network, emailing list)
- Identify sources of finance and investments

Step 3: Detailed action planning
- Identify overlaps between all the plans
- Detail planning/means of implementation in a joint way
- Define the mechanism of collaboration, e.g. memoranda of understanding (MOUs), data sharing agreements, etc.
- Monitoring and evaluation system

4.2 RISK INFORMATION

4.2.1 Overview

Quantitative or qualitative data on risk can be extremely helpful in achieving the other goals addressed in this report (governance, urban planning, healthy communities, and resilient infrastructure). Whilst not an end in itself, the collection of data on the nature of the hazard, the exposure of the population and infrastructure, and the degree to which communities or infrastructure can be considered vulnerable, is essential to achieve the goals to build flooding resilience. At its most advanced, such data can be combined to generate integrated risk models. These tools are not without limitations. Data uncertainties can be difficult to quantify, and value judgements are inherent within assessments of exposure and vulnerability. A poorly-designed risk assessment can even end up benefitting certain communities over others. Community engagement is therefore necessary in order to ensure that the risk models respond to the requirements of affected communities.

This section describes the components of an ideal statistical risk model for the lowland basin on the Río Piura. These sections were compiled during the workshop with inputs from groups working on each of the other five problem dimensions. This 'ideal risk model' is comprised of data on hazard, exposure, and vulnerability, with both outputs and inputs designed specifically for the requirements of different stakeholders using the model in Figure 9.0. It is important to note that this model is hypothetical and no such model is currently planned or in existence, although some information is already available. We should also note that any risk model produced must be bespoke to the requirements of different stakeholders so it may be necessary to produce multiple models. Where we were aware of existing information, we have provided details, although it should be made clear that our knowledge is by no means exhaustive.

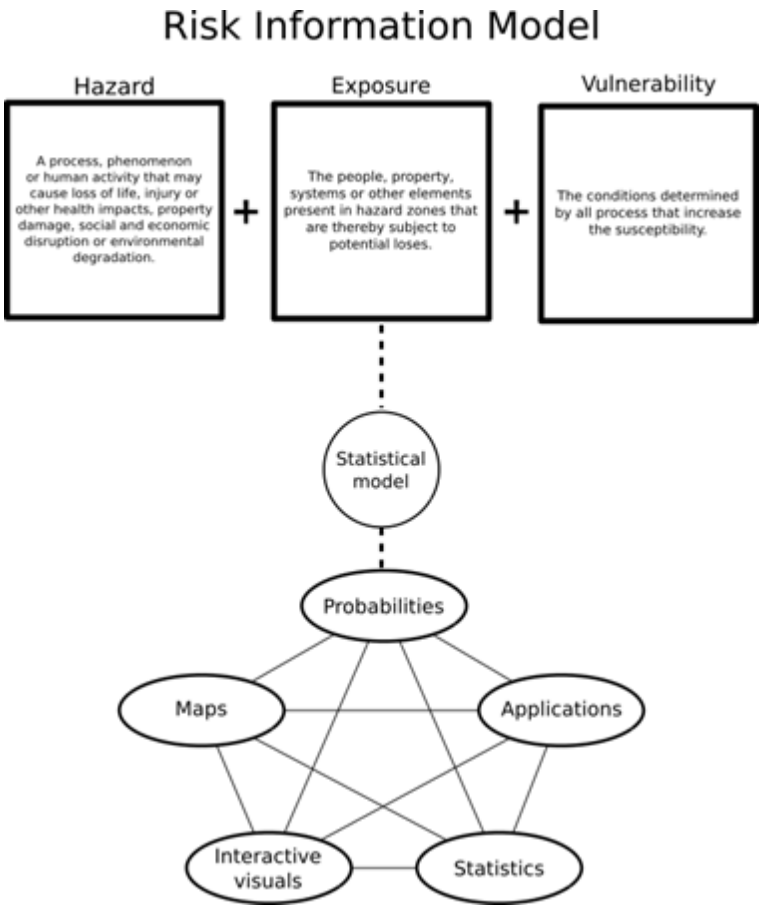

Figure 9.0: Components of an idealised risk assessment model

4.2.2 Risk Assessment Model and Solutions

4.2.2.1 Hazard Components
The requirements for a hazard model for Piura can be divided into data, data-processing, and outputs:

a. Data
The first data component of the model is climatic data. Data is required both to build long-term forecasts to determine when heavy rain seasons are likely to occur, (i.e. El Niño events) and short-term forecasts to determine the exact location and intensity of elevated rainfall events. This includes further monitoring of precipitation, temperature, wind, and evapotranspiration. To understand the relationship between rainfall and flooding events, information is also required on the hydrology, geology and geomorphology of the Sechura Desert, and the upland catchment of the river. Accurate information on past flooding events is already in existence as is geological mapping. The river's flow monitoring network needs to be extended, and at present information is missing on water quality, sediment transport and the sediment transparency of dams on the river. Detailed understanding of the regional geomorphological functioning will need to be developed.

Information will be required on the region's ecology, both in terms of the role of vegetation in attenuating flooding and the likely impacts of flooding on biodiversity. This includes vegetation, fauna mapping and information on ecological characterisation. Much of this information can be gleaned from accurate remote sensing, including regular aerial photos, LiDAR and information gathered through drone flights.

b. Data Processing

Two elements are required for data processing, modelling of meteorological and flooding information, and mapping of the information using GIS. The first task is the generation of accurate long-term forecasts of heavy rain seasons. These occur in Piura only during El Niño years, yet the existing long-range forecasts produced by the National Oceanic and Atmospheric Administration (NOAA) in the US can be misleading. Firstly, most El Niño events do not produce rainfall in northern Peru; moreover, significant flooding events in 1891, 1925 and 2017 event were associated not with El Niño as defined by NOAA, but by the poorly-understood "coastal El Niño". Accurate long-term models of El Niño events of the form that affect Peru therefore need to be developed, which may be either dynamical or statistical. At a more local scale, a high-resolution regional forecasting model is required for northern Peru. This can be used for both accurate weather forecasting and projections of likely changes under climate change. GIS mapping of the risk model includes hydrological and ecological modelling, as well as digital elevation maps. Finally, dynamical or statistical integrated flood models will need to be developed. These models need accurate input and monitoring data for calibration.

c. Outputs

The final hazard component concerns outputs for the community. A community-based early warning system has been developed by Soluciones Prácticas (Practical Actions), and the information gathered for this risk model can be used both to complement and improve this system. Hazard maps and water quality maps will need to be developed, which are not currently in existence. Work will be required to make sure that warnings meet local requirements, e.g. some warnings to evacuate were deliberately ignored in 2017 because of fears of empty properties being looted.

4.2.2.2 Exposure Components

The following key variables of exposure were identified in communication with key stakeholders present at the workshop. Note that this list is not exhaustive and further consultation with local communities and stakeholders is required:

1. Materials used to build homes;
2. Roof types;
3. State of sanitation in local dwellings;
4. Floor construction;
5. The number of communities located in vulnerable areas (see below);
6. The location of informal settlements;
7. Infrastructure used for public services (electricity/garbage/education/water); and
8. The quality, capacity and condition of the local road network.

4.2.2.3 Vulnerability Components

Much vulnerability data already exists for the region, either collected specifically in relation to the 2017 floods or as part of regular demographic data collection. Centro Nacional de Estimación, Prevencion y Reducción del Riesgo de Desastre (CENEPRED) have conducted vulnerability assessment for several districts in the region, specifically related to El Niño flooding. Organización Internacional para les Migraciones (OIM) collected demographic information on those affected by the 2017 floods directly from people in shelter, and the Asociación Instituto Interamericano de Ecología Integral (INECI) have also collected information on affected communities. Plan Concertado de Desarrollo have been published for each municipality, the most recent were published just before the 2017 flood, and the most recent census was published in October 2017. The priority is therefore for coordination of existing information, followed by collection of new information.

The following components of vulnerability were defined during the workshop. It should be noted that these were defined by researchers based either in the UK or in urban centres in Peru, and without the input of affected communities in the region. It is strongly advised that participatory methods such as Participatory Capacity and Vulnerability Assessment (PVCA; Turnbull and Turvis, 2012) are used both to determine what communities define as components of vulnerability, and to conduct vulnerability assessment:

- Age
- Gender
- Family size
- Occupations
- Ethnicity
- Education level
- Income level
- Ownership of livestock
- Ownership of property
- Health indicators
- Social capital

Finally, communication and perception of risk must be viewed as component of vulnerability, as differential access to risk information may give some communities an advantage over others. Vulnerability assessment must therefore also consider risk perception and risk comprehension. In the longer term, new frameworks of data collection may need to be developed to update any model that is developed.

4.3 HEALTHY COMMUNITIES

4.3.1 Overview

This theme investigates the role of water management in improving the health of the local community. There is a strong link between the flood and its associated health impacts on the community building up in and around the Piura and Chira rivers. Although it is a 10 to 20 return period extreme event, it can have a severe long-term health consequences. In literature, there are a number of prominent health issues that have been identified in this area. The more common and serious illnesses include: cholera, dengue fever, zika, chikungunya, respiratory diseases, renal disease and deaths during birth. The primary causes of these illness are contaminated drinking water, stagnant water as an agent for mosquito-borne vectors and extreme temperature variations. Along with these illnesses, there are also risks that are related to intermittent but severe flooding events. While other groups are focusing on the prevention or adaptations of these extreme natural events, it is also important to address the health and wellbeing of the affected communities. Improving the health levels of the community could help strengthen their resilience, safety and livelihoods during and after future flood events. We believe there is still a huge gap of understanding and awareness amongst the local community of the consequences of such impact. A key aspect of this process is to understand the perspective of the community towards the issue of health and to raise awareness as appropriate. The suggestion is to begin with a 'bottom-up' research approach, to explore health issues from the perspective of the local community. Participatory approaches to community wellbeing are considered the most effective mechanism to deliver public health improvements.

4.3.2 Finding and solution of health issues in the community

During the previous two severe flooding events, many members of the community left their settlements. Over time, some families returned to their homes whereas other families have never returned. For example, in Catacaos, 800 families initially left their village; 250 families returned and the remainder moved elsewhere. From Curamori, 1,200 families left during the floods but only 600 families returned. At a later flood event, 2,500 families left and made new settlements (mostly along the Panamericana). The relative health outcomes of these different groups (the returners and leavers) are not clearly known. The proposed research aims to quantify the relative health outcomes of those leaving, returning and/or departing. This would allow effective evaluation of the relative merits of different migration options post-flood events. Subsequent interventions to improve health outcomes, particularly to reduce health inequalities, could be more effectively targeted with this information. A good understanding of the people's migrations due to the flood impact needs further understanding to make better adaptive and sustainable healthcare plans.

Education is an important determinant of health; so we need to understand better how to improve the uptake of available medical treatment and public health information programmes. Health promotion and health prevention interventions could be supported with better knowledge of the health characteristics of the vulnerable affected groups. However, it is clear that there are some barriers to health improvement interventions; partly due to a lack of trust (confianza) within the community of modern medicine and a preference for traditional medicines. An appropriate research methodology requires a process of 'co-design' to explore the nature of the health situation with the local community. We think these communities have, for various reasons, lived outside of the circle of the modern healthcare system and developed a belief that they are okay without it. A thorough study is needed at the community level to assess their understanding of the risks and also to prepare a community-engaged report on proposed solutions. It is also believed that this community is ignored by the central government's healthcare planning. Another issue is linked to a language barrier: most of the related reports and publications are published in Spanish and historically this has failed to draw attention to this community.

In order to inspire positive change in healthcare and wellbeing across the community, a multidisciplinary approach is needed where people from different socio-scientific backgrounds work together to address the problem. This needs to start with an appreciation of existing health issues by adopting a 'bottom-up' research approach that explores health issues from the perspective of the local community. There is also a need to gain more attention from the international research community so that they come together to tackle the unique problem faced by this particular community. Education is an important determinant of health so we need to understand better how to improve the uptake of available medical treatment and public health information programmes. Health promotion and health prevention interventions could be supported with better knowledge of the health characteristics of the vulnerable affected groups.

4.4 INFRASTRUCTURE

4.4.1 Overview

Contemporary views of flood risk management (FRM) suggest that absolute protection is not possible nor financially viable. Rather, the approach taken should be one of managing the flood risk. With increased uncertainty of climate change, population growth, and future spatial development, an approach to flood risk management infrastructure planning and development in Piura needs to take an adaptive approach; by focusing on combination of different solutions rather than big civil engineering interventions.

In this theme, the focus is the development of a process for infrastructure planning, presented in Figure 10. Possible infrastructural solutions need to be developed in a collaborative manner, taking into account views, needs and expertise of all relevant stakeholders (i.e. from flood prone communities to decision makers). Consideration of this process during the workshop resulted in the generation of some possible solutions:

- Reinforcement of the existing embankments in the City of Piura
- Construction and reinforcement of dykes
- Dams on river or tributaries
- Attenuation reservoirs
- Green infrastructure in the City of Piura
- Sediment control measures
- Reforestation upstream
- Allowing space for water (i.e. room-for-the-river approach)
- Resettlement of vulnerable population
- Do-nothing

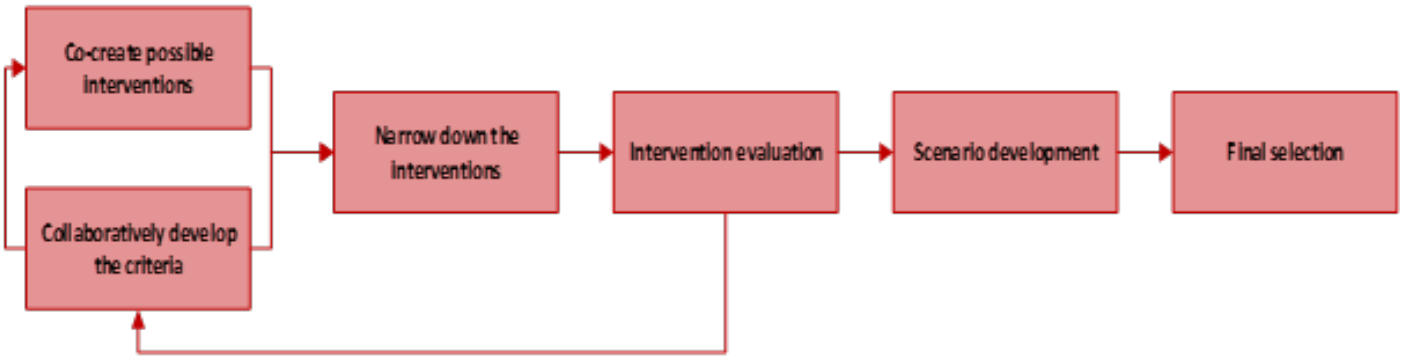

Figure 10.0. Proposed process for infrastructure planning in Piura

4.4.2 Proposed solutions and considerations

With these proposed solutions, we identified a need to consider and evaluate criteria necessary for collaborative development. During the workshop, participants have proposed the following criteria:

- Cost effectiveness
- Environmental impacts
- Social acceptance
- Priority/ Urgency
- Adaptability
- Maintenance requirements
- Social impacts
- Financing ability
- Influence of flood peaks

The proposed solutions will need to be evaluated once these criteria are fully developed. The next part of the process is scenario development. In this step, different considerations need to be taken into account: e.g. climate change, population growth, planned urban and spatial development in the region, and financial capability. A combination of different measures need to be generated and tested. This will require the use of sophisticated models (e.g. hydrological, hydraulic, climate, demographic models). Upon scenario development and evaluation, a set of meaningful infrastructural solutions can be proposed. The group believes that collaborative development and planning proposed through this process can be expected to deliver solutions that are more sustainable, robust to external threats and financially viable.

The group also discussed the considerations of planning processes. It was generally concluded that the process of infrastructure development has to mainstream different technical (e.g. technical feasibility), risk information, spatial planning and governance aspects (e.g. funding, participation). Based on the discussions and the proposed solutions, further recommendations were proposed in accordance to priorities and future research ideas as described in Table 4.1.

Priorities	Knowledge Gaps/ research Ideas
• Priority 1: sediment control - ideally by enhancing natural processes • Priority 2: do not increase exposure to flooding • Priority 3: co-delivered benefits to justify costs	• Introducing monitoring and measuring equipment • Detailed hydrological and hydraulic modelling for hazard characterisation • Probing the models for impact evaluation • Hydro-geomorphological modelling • Comprehensive risk modelling • Design of participation procedures for different stakeholders • Integration between infrastructure development and spatial planning • Governance as an enabler or a hindering factor for infrastructure?

Table 4.1. Priorities and knowledge gaps identified.

4.5 URBAN AND REGIONAL PLANNING – A RIVER BASIN APPROACH

4.5.1 Overview

The land uses that contribute to and which are affected by Piura's flooding are comprised of many different elements: built-up and urbanized areas, the rural and agricultural hinterland that supports the urban-based food manufacturing industries as well as the wider Chira-Piura River Basin ecosystem – see Figure 11.

Our site visits and the knowledge gained by the Universidad de Piura's work with local communities within the river basin revealed the existence of numerous informal settlements. As we have described in the preceding section, these communities are very vulnerable and have faced significant housing, social and health issues due to previous flood events. It is evident that alongside this continuing redistribution of population in the basin, the basic needs of these communities are not being considered by regulators and authorities.

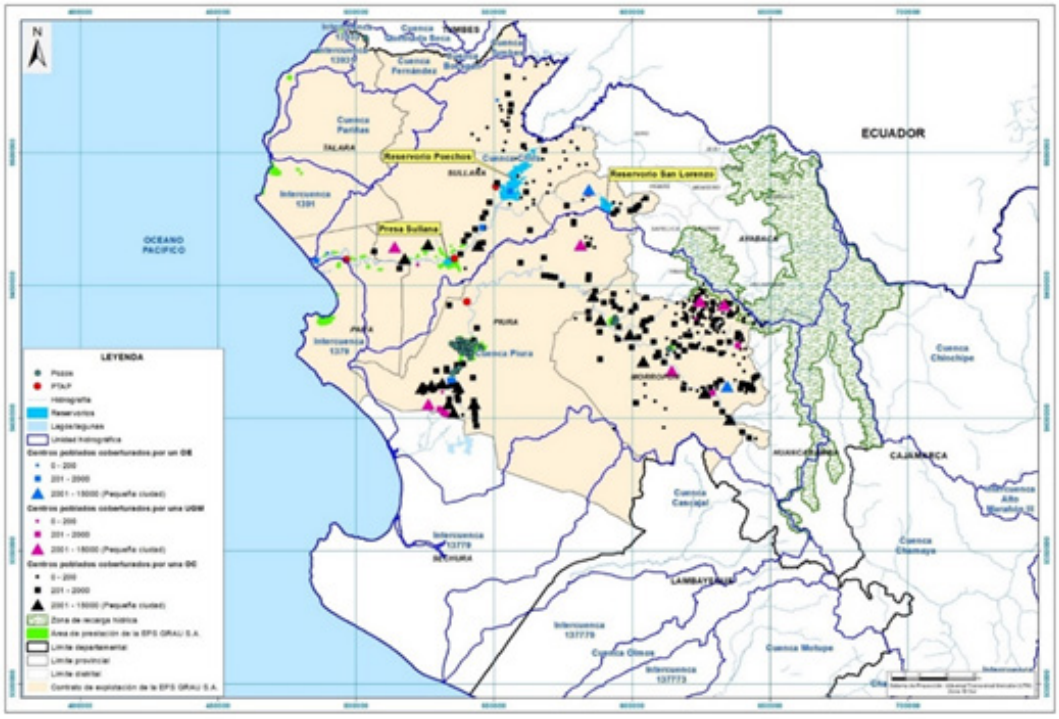

Figure 11.0: Land uses in the Chira-Piura River Basin

According to the local-expert workshop participants, the key characteristics in respect of land use planning are that the new and relocated communities are developing without a land use plan and their growth is happening in an unplanned way. This absence of wider land use planning holds true for the rural area as a whole:

- Governance: The responsibility and accountability for these communities is not clear. Where regulations and legal guidelines exist, these often haven't been applied in situ.

- Risk Awareness: there is a lack of information about risks for meaningful land use planning.

- Infrastructure: the current public investments into building infrastructure are occurring in an unstructured way, without a clear plan. It is also clear that limited resources are currently available for infrastructure and community investment.

- Public health services: where services are provided, these follow after the settlements establish themselves rather than being considered strategically.

- Cultural resistance: we observed a strength in the resilience of communities to cope with the flood disaster events. The increased demand for event-resilient new housing was encouraging but we also could note an inertia amongst communities and authorities to change and adapt.

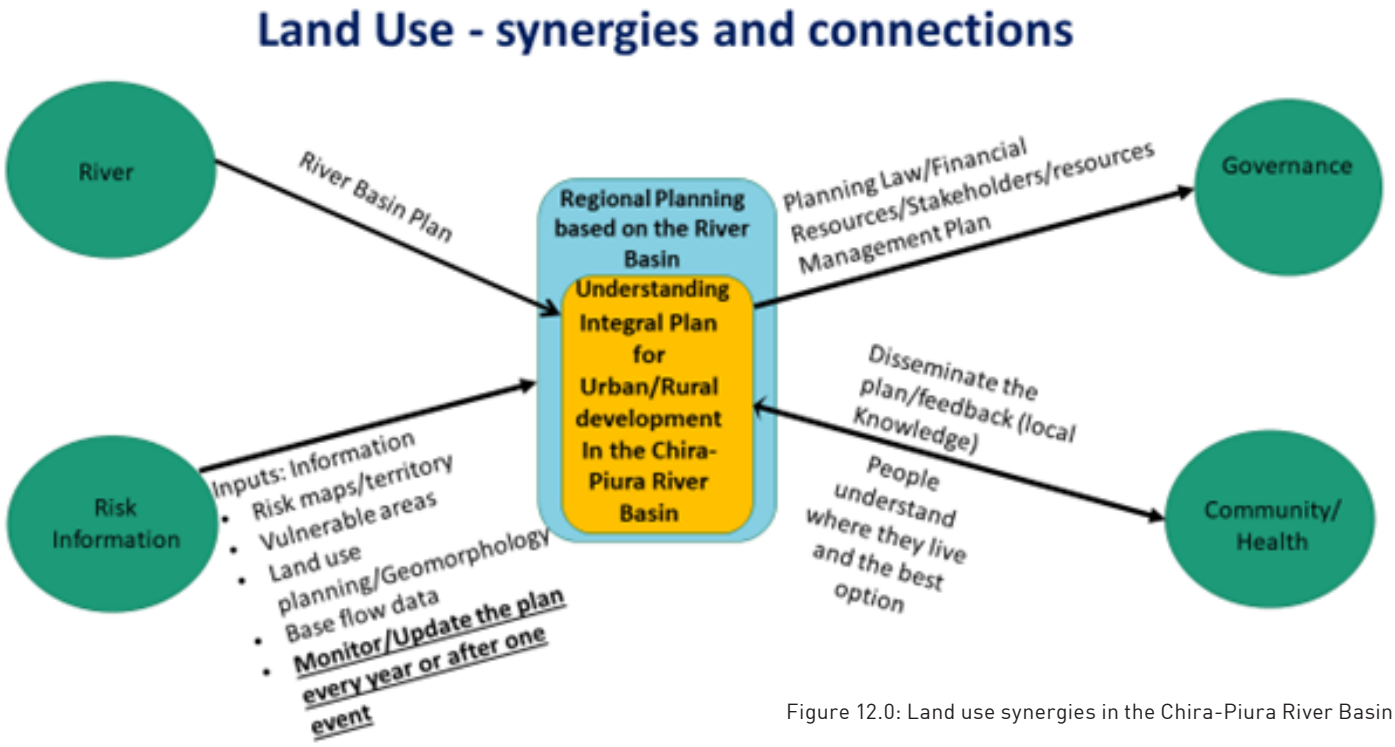

Figure 12.0: Land use synergies in the Chira-Piura River Basin

4.5.2 Suggestions and recommendations

1. Spatial Planning. The key proposal would be to create an Urban-Rural Plan addressing the long term; a 20-year plan with relevant staged achievements, milestones every 5 years and active monitoring of the plan every year. This plan would aim to integrate land use with the other relevant infrastructure and community needs. This would especially identify safe areas for living for communities. The plan needs to be underpinned by evidence and information about risks and gathering this ought to be an immediate priority. See Figure 12.0.

2. Communication and education programmes should be devised to underpin the success of the long-term plan. These should share information with the communities in easy to understand language to enable people to understand why they need to move. This should be an ongoing priority.

3. A package of incentives should be provided to enable people to move to these safer areas, including the provision of basic health and community needs alongside fiscal measures such as tax and insurance.

4. Infrastructure Planning. A long-term planning for appropriate blue, green and grey Infrastructure, linked to national/regional policies.

The members of the workshop appreciated that, to be implemented, their recommendations will require significant local commitment and political solutions. These are things beyond the remit of the workshop but we suggest that their success would need to be underpinned by further technical work through a programme of research to improve knowledge. This might include:

- A better understanding of evidence base lines to further understand risk, using real-world monitoring sites
- Geographic Information Systems to inform spatial planning and help establish the current situation
- Research into the behaviours of river flows and the river system
- Work to understand the effectiveness, costs and benefits of further infrastructure investment
- The development of a methodology for stakeholder collaboration and improved knowledge of the local communities.

4.6 RIVER SYSTEM

4.6.1 Overview

Chira is the name of a river in northern Peru whose mouth is 100 km north-west of the provincial capital of Piura and 25km north of the port of Paita (see Figure 13). Its source is in the Ecuadorian Andes near the town of Papaca in the province Loja from where it flows for 250 km in westerly directions. After crossing the border to Peru, it is dammed up in the 885 million m³ Poechos reservoir and later passes the town of Sullana. The Chira river allows drainage of floods from rainfalls and inflows from the watershed. The current basin of Chira-Piura contributes 65% to the use of agriculture and 50% use of drinking water to the community.

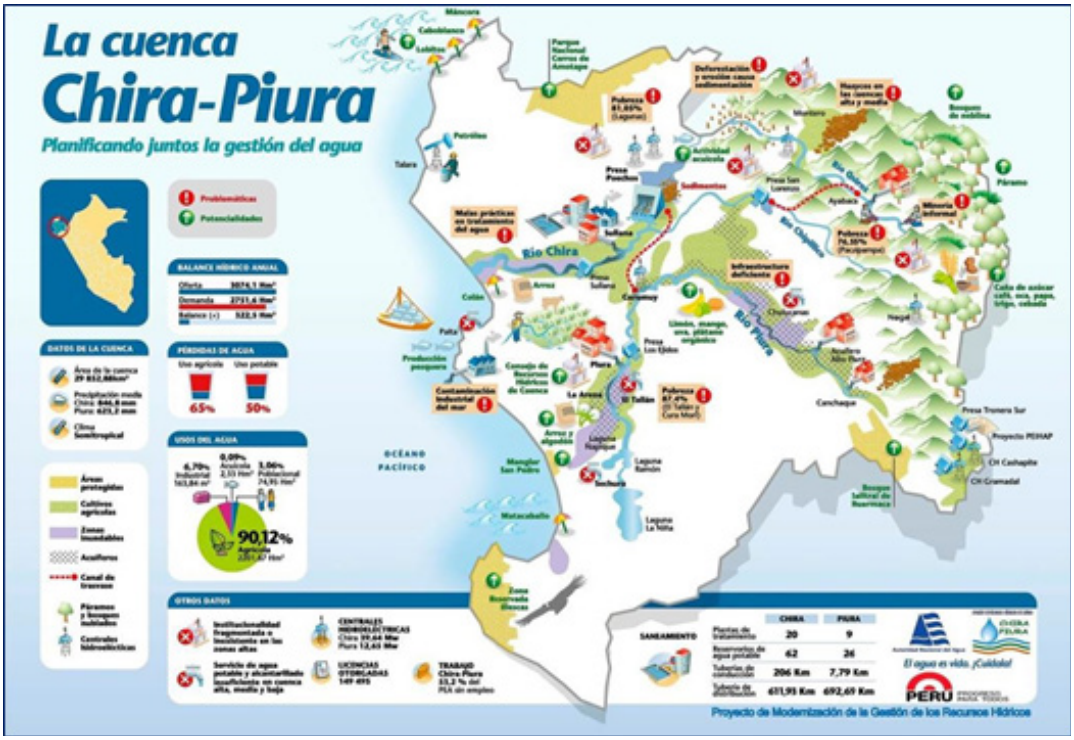

Figure 13.0: The current state of river system in Chira-Piura (Autoridad National del Agua, 2018)

In the recent extraordinary events (El Niño) occurred in 2016 and 2017, rainfall was very intense in Piura which resulted in the activation of a number of rivers and streams adjacent to the Chira River, causing severe damage in populated areas. The Chira River overflowed causing flooding of extensive crop areas and cities resulting in damage to agriculture, road infrastructure, housing, irrigation infrastructure and drainage. Currently there are vulnerable areas in river sections that require measures for flood mitigation as depicted in Figure 14.

Figure 14.0: Social infrastructure and services located in risk areas

4.6.2 Suggestions and recommendations

Figure 15 depicts the existing plans and measures to be considered in mitigating the issue. Below are some of the suggestions put forward by the workshop participants:

- Strengthening the institution and water management.
- Early warning system and forecasting.
- Role and responsibilities of media reporting.
- Constructing macro drainage pluvial in the affected urban area channelling to the sea.
- Polders for retention of flows in reservoirs.
- Green infrastructure (reforestation, conservation of ecosystems and soils).

4.6.2 Suggestions and recommendations

Figure 15 depicts the existing plans and measures to be considered in mitigating the issue.

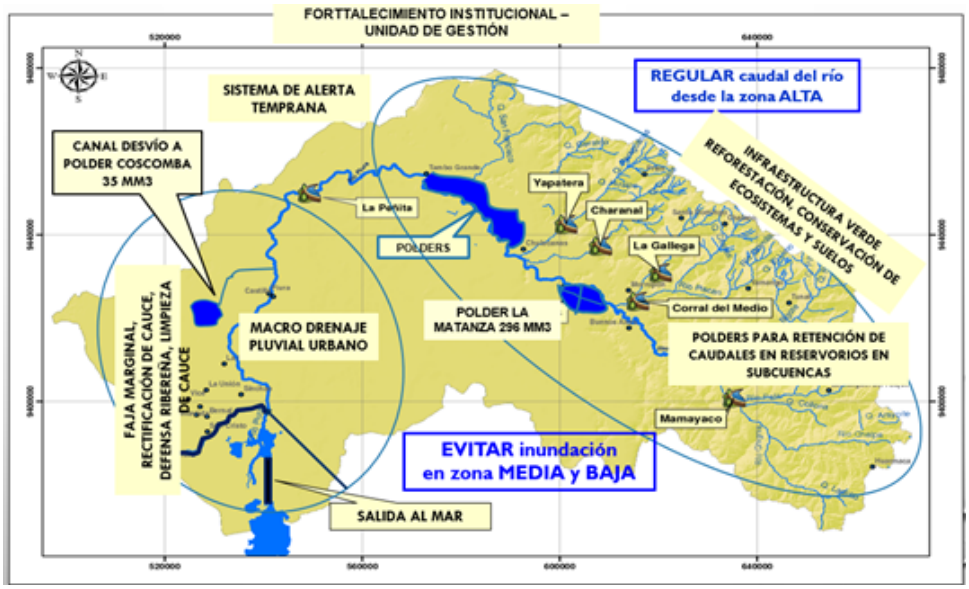

Figure 15: Integral proposal for the reduction of vulnerability against flooding and water scarcity in the Chira Piura basin (Autoridad National del Agua & Chira Piura Region, 2018)services located in risk areas

Below are some of the suggestions put forward by the workshop participants:

- Strengthening the institution and water management.
- Early warning system and forecasting.
- Role and responsibilities of media reporting.
- Constructing macro drainage pluvial in the affected urban area channelling to the sea.
- Polders for retention of flows in reservoirs.
- Green infrastructure (reforestation, conservation of ecosystems and soils).

The group also recommended short and long-term solutions that were planned out by the National Water Authority as depicted in figures 16 and 17 below:

Short term solutions: At 2020, the vision is to strengthen the institution and organization of internal water management and resources in making it more effective and efficient. This is to improve the quality of water management in accordance to standard and full participation of all stakeholders. The highlighted themes to address the issue are the role of government, adaptation of climate change and risk management, improvement to the human resources, water quality, water culture and finance.

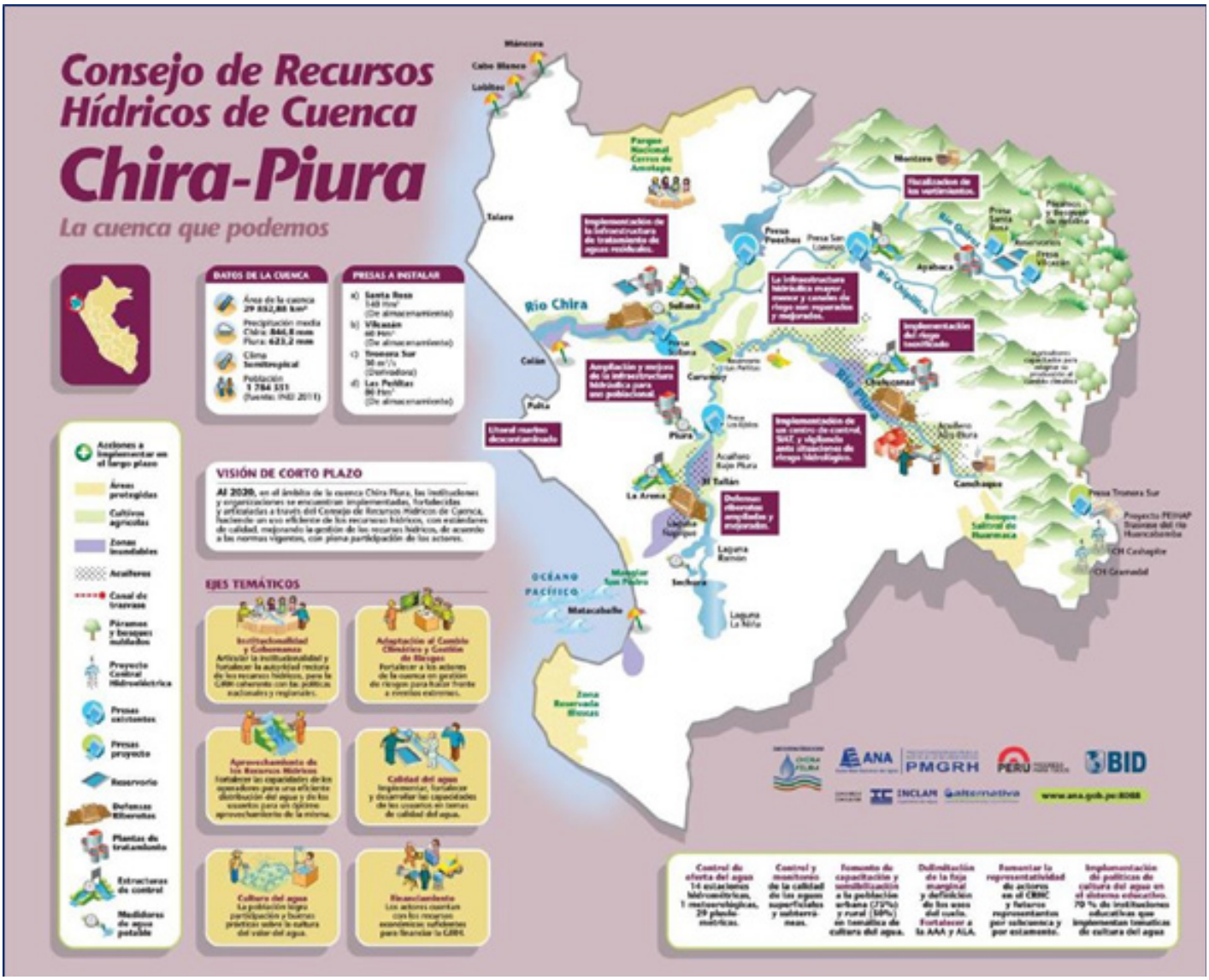

Figure 16.0: Short term solutions: "the catchment we can have" (Autoridad National del Agua & Chira Piura Region, 2018)

Long term solutions: At 2035, this long-term vision is for the organization to develop integral management of the water resources in undertaking the effort of improving the quality standard in accordance to the current legislation. Sustainable human development is also part of the effort in improving the current institution and organization. Construction of dams is also part of long term initiative in prevention, retention and diversion of the flood flow. Involvement of all stakeholders is significantly important in addressing the main themes of good governance, adaptation to climate change and risk management, improvement of human resources, water quality, water culture and finance.

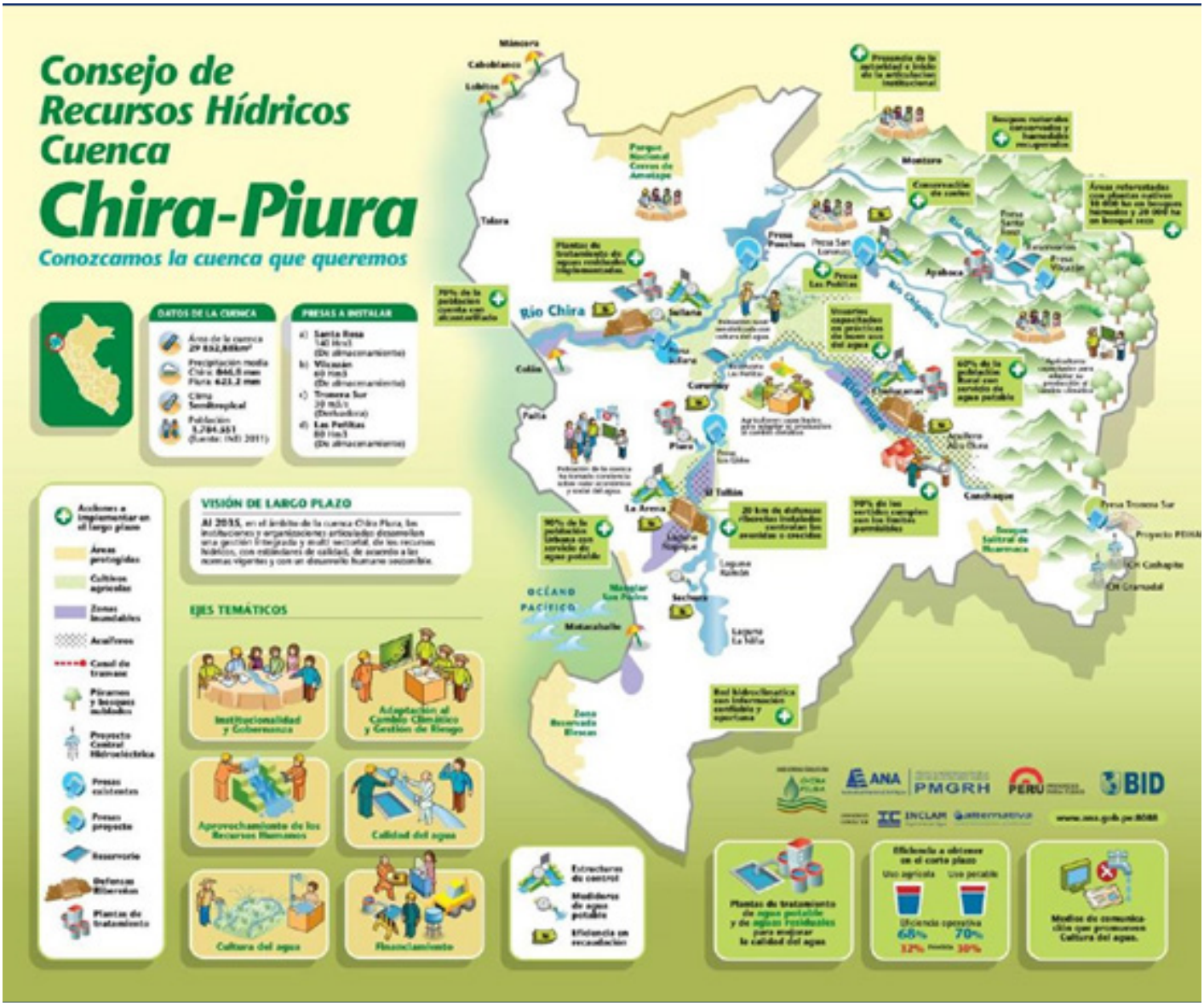

Figure 17: Long term solutions "the catchment we would like to have" (Autoridad National del Agua & Chira Piura Region, 2018)

5.0 SUMMARY AND SYNTHESIS - PROGRESSING TOWARD AN INTEGRATED CATCHMENT MANAGEMENT (ICM) APPROACH

5.1 Summary

The working groups provided a detailed analysis of the different dimensions which contribute to building flood resilience. As anticipated by the goals set out at the beginning of the workshop, the recommendation is for an approach that that works at the interface of engineering, sociological and institutional/political approaches. The key messages across these dimensions are:

Governance: The importance of establishing participative planning in Chira-Piura Basins was identified for building collaboration and enabling integration. This can be done in three steps: (1) problem analysis and prioritization involving stakeholder mapping; (2) defining new governance arrangements that improve integration and communication; and (3) detailed action planning which creates collaborative implementation and monitoring.

Risk Information: There is a clear need for the adoption of a risk model for the lowland basin of the Río Piura. An ideal risk model is comprised of data on hazard, exposure and vulnerability, with both outputs and inputs designed specifically to meet the needs and requirements of different stakeholders in the basin.

Health: To resolve the healthcare problems in this community will require a multidisciplinary approach. First, an appreciation of existing health issues from the perspective of the local community and especially of the vulnerable affected groups. Secondly, a better understanding of how to improve the uptake of available medical treatment and public health information programmes.

Infrastructure: Three priorities and associated future research ideas were identified: (1) sediment control, ideally by enhancing natural processes; (2) do not increase exposure to flood risk by allowing settlement development in the flood-plain; and (3) aim for co-delivered benefits in order to justify costs.

Spatial Planning: The key proposal would be to create an Urban-Rural Plan addressing the long term. For example, a 20-year plan supported by better communication, education programmes and a package of incentives to enable people to move to safer areas. This should be supplemented by the provision of basic health and community needs alongside fiscal measures and long-term planning for appropriate blue, green and grey Infrastructure.

River Management: The issue of the river system in Chira-Piura was addressed with the proposed plan of short and long-term goals by the ANA (National Water Authority). There have been some suggestions and recommendations to strengthen this institution as well as the water management organization. Early warning systems, forecasting and media reporting are key in bringing awareness and readiness to the community. Constructing drainage systems in affected urban areas is significant in order to channel the flow to the sea and also the promotion of green infrastructure.

5.2 SYNTHESIS

Throughout the final two days of the workshop, each of the working groups were asked to consider the potential connections and synergies with the other themes being discussed. This generated a synergies diagram (Figure 5.1) which helped to highlight key relationships. In particular, we can note:

- The importance of risk information in informing decisions across boundaries
- The emphasis on community health and wellbeing leading to increased resilience
- The close links between communities, governance and the development of spatial planning strategies

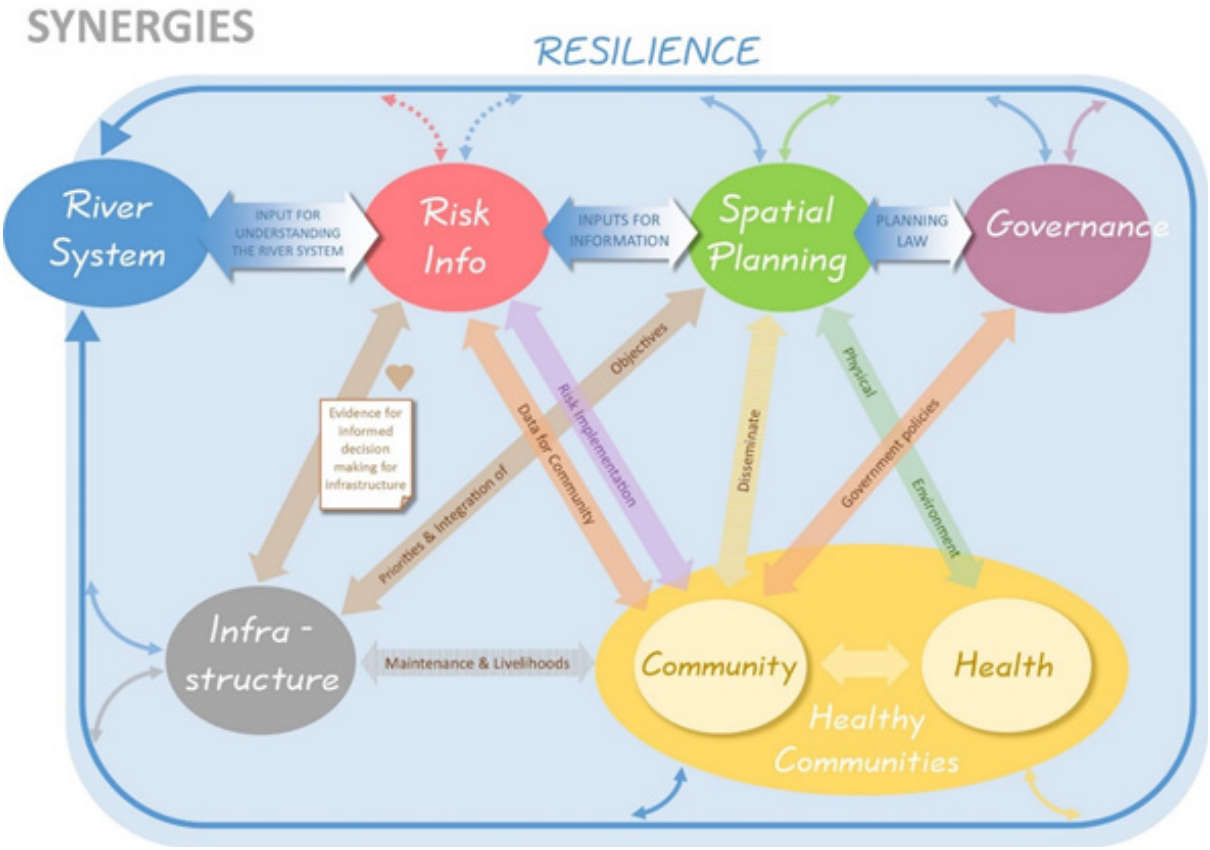

Figure 18: Synergies Diagram

In turn, this sparked and informed a broader proposal about integrating measures to manage the catchment. We set this out below as a potential model for further consideration and development.

5.3 AN OVERARCHING INTEGRATED CATCHMENT MANAGEMENT (ICM) APPROACH

The need for an ICM approach is easy to understand but, we acknowledge, much harder to implement. It requires stakeholders to collaborate and co-design in a truly multidisciplinary way. Organisational silos that have been reinforced over many years will need to be taken down to allow a systemic approach to reducing flood risk. Room for new concepts needs to be made as well as a possible shift of powers within the existing decision-making hierarchy.

The ICM approach is not concerned only with flooding, but also looks at improving livelihoods of people under non-flood conditions as well as protecting the environment. Water infrastructure built to deal with flood risk has the potential to provide safe and reliable water supply in an area which is essentially a desert. As noted in earlier sections, upstream reforestation to control erosion and infiltration offers clear hydro-environmental benefits.

Flooding patterns in the region are unique in the sense that no high frequency events (e.g. 1 in 2 years) take place, rather low frequency devastating events occur approximately every 25 years. Therefore, flooding in Piura has an almost "binary" nature, unlike the UK where floods occur at a range of frequencies with an associated range of flood damage impacts. The irregular patterns of El Niño floods make investment in infrastructure less of an urgency once the memory of the event has subsided (risk perception is dynamic). This means that other development projects can be prioritised as more urgent after a few years with no flood: in essence, decision-makers can take their chances that such an event will not happen again soon.

We capture this integrated thinking in Figure 5.2. This provides a schematic representation of how multidisciplinary work can help strengthening flood resilience. It can help actors identify their role in ICM and their need to collaborate with other actors/sectors.

1. **"Healthy communities"** are placed in the centre, signifying the key objective.

2. The **"Physical Space"** represents the existing and future physical infrastructure in place. It also includes the broader natural and build environment in which water infrastructure is developed.

3. The **"Digital Space"** includes the digital information which supports evidence-based decision-making. This has been broadly described in the Risk Information Section.

4. **"Spatial Planning"** constitutes the set of policies that dictate activities in the physical space: e.g. types of land use (residential, industrial, agricultural), spatial distribution of those (e.g. high density, low density housing), best water management practices. Most importantly, they are informed by the digital information thus maintaining risk at an acceptable level. Spatial planning is therefore cross-cutting by nature and an enabler of ICM.

5. The **"Governance"** system (see definition in previous section) that will enable the equitable and sustainable development and management of water resources and the delivery of water services at different levels of society. By definition, governance ought to cross-cut all other sectoral activities to be effective in enabling ICM.

6.0 IMPACT AND DISSEMINATION

The workshop was publicised via twitter and facebook. Several articles were published in the UK and Peruvian news:

Birmingham City University website:
https://www.bcu.ac.uk/news-events/news/unique-international-project-aims-to-tackle-flooding-in-peru

Instituto Geofísico del Perú website:
https://portal.igp.gob.pe/igp-universidad-birminghan-city-iniciaron-exito-taller-resiliencia-gestion-desastres-piura

Universidad de Piura website:
http://udep.edu.pe/hoy/2018/cientificos-ingleses-y-peruanos-analizan-riesgos-de-desastres-en-norte-peruano/

Environment Journal website:
https://environmentjournal.online/articles/uk-universities-to-help-tackle-flooding-in-peru/
https://environmentjournal.online/articles/how-uk-universities-are-building-flood-resilience-in-vietnam-and-peru/

Medical and Life Sciences website:
https://www.news-medical.net/news/20180831/Experts-launch-unique-knowledge-sharing-project-to-tackle-flooding-in-Peru.aspx

Travelling and Living in Peru website:
https://www.livinginperu.com/experts-from-birmingham-city-university-shared-knowledge-to-tackle-flooding-in-peru/

El Tiempo, Piura news website:
http://eltiempo.pe/igp-monitoreara-fenomeno-el-nino-y-cambio-climatico-desde-piura/
http://eltiempo.pe/hernando-tavera-inundacion-causa-dano-por-ciudad-desordenada/

El Regional Piura news website:
https://www.elregionalpiura.com.pe/regionales/150-piura/29554-taller-internacional-sobre-la-resiliencia-para-la-gestion-de-desastres-por-inundaciones-sera-en-la-udep

Two blogs were produced by Mike Grace and Leon Kapetas:

http://blogs.nottingham.ac.uk/blue-greencities/2018/09/14/human-environment-interactions-and-the-el-nino-costero-floods-in-piura-northern-peru/

[All websites last accessed on 30-Apr-19]

7.0 REFLECTIONS AND LESSONS LEARNED

7.1 Reflections

Delegates were asked to share some personal reflections on their workshop experiences. These highlighted a number of benefits as indicated in the following extracts by way of examples:

"To reach a result in an interdisciplinary group leaving aside the technical and open your thoughts to give some possible solutions to the problem in flood in the north of Peru is an excellent learning experience."

"The workshop was a great opportunity to think beyond our own disciplines. The field trip to flood-affected communities really got us thinking of the complexity of the problem and a need for holistic approaches."

"The workshop was an excellent opportunity to meet with an interdisciplinary group of researchers working in the field of disaster resilience. The atmosphere was very cordial and friendly and many new networks were made in the friendly and supportive event. The local hosts were really helpful in supporting the visiting scholars and many potential bids for future funding were explored."

The key expressions from these personal statements are captured in the diagram below (figure 19):

Figure 19.0: Personal reflections and key themes

All involved in the workshop agreed that it was important to build on the progress made and create a sustainable network. A facebook page (available here) and a Google documents drive (available here) have been established to facilitate ongoing communications and the development of post workshop research ideas including the production of a more detailed report.

7.2 LESSONS LEARNED

The workshop proved to be a stimulating and rewarding activity that was also enjoyable and memorable for all participants. As ever, with the benefit of hindsight and experience there are some lessons learned which would help to further improve the effectiveness of the process. It was clear that not all participants had the same level of understanding about the problem and perhaps more could have been done before the event in order to develop this. For example, a greater level of sharing significant and relevant documents and existing work would have been especially beneficial. The duo-lingual communication during the workshop was a necessity which meant activities took longer than anticipated and should be factored into timings and anticipated outcomes. Post the event itself, writing the report proved quite a task and perhaps some work on this during the workshop could have been undertaken. The workshop generated a lot of enthusiasm and promise but maintaining this after the event has proven a little difficult. Finally, it is clear that our funders wanted to maximise the impact of the workshop and workshop outcomes – more publicity would help in this regard and perhaps more could have been done ahead of the event to capitalise on the opportunities.

8.0 RECOMMENDATIONS FOR FUTURE KNOWLEDGE PRODUCTION

The process of the participatory workshop was very effective and produced some significant new insights and ideas in a positive and interdisciplinary learning environment. The practitioners were from a variety of backgrounds but collaborated well together. A tremendous amount was achieved in four days and it is hoped this report and its recommendations will inform future flood risk management policy and strategy in Piura. One of the key themes that emerged was the importance of good governance and the process could be repeated with key decision makers present so that insights developed could be acted upon.

There are clear recommendations to fund further work in the areas of monitoring and prediction but these have to be undertaken with the needs of the community in mind. Similarly, it is clear that great progress could be made to develop resilience through improving health and wellbeing of the affected community. Perhaps a co-design approach with local communities could help generate the additional collaborative and interdisciplinary research that is needed to establish how this can be done in the most effective way. This will also need to draw on the expertise from a range of disciplines and stakeholders enabling the development of integrated findings and recommendations. This workshop took a significant step forward and we suggest its finding can be a foundation for practical as well as academic outcomes.

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This report provides a detailed account of the Newton Fund Peru Researcher Links Workshop held between 20 and 23 August 2018 in Piura, Peru, entitled 'Building Resilience in Flood Disaster Management in Northern Peru'. The report provides some background to the workshop, the aim and objectives, problem definition, as well as an account of the workshop process and key workshop findings and recommendations.

The workshop was run jointly by Birmingham City University (BCU) in partnership with Instituto Geofísico del Perú (IGP) and was hosted by the Universidad de Piura (UDEP). The workshop was a response to the severe flooding experienced in Piura during the El Niño event of March 2017 which caused a number of fatalities, damaged over 100,000 homes and destroyed much local infrastructure including around 100 bridges. El Niño is a recurrent event and there is concern that its frequency and intensity may change in the future as a consequence of climate change.

Six key and integrated themes emerged from the workshop activities as: i) Governance; ii) Risk Information; iii) Healthy Communities; iv) Infrastructure; v) Urban and regional planning; and vi) the River System. For each of these themes, the report provides an overview of the problem as well as some detailed suggestions and recommendations for addressing the difficulties and challenges identified.

The report was jointly edited by:

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