Food and Agriculture Organization of the United Nations

INTEGRATED FLOOD MANAGEMENT

for resilient agrifood systems and rural development

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CONTENTS

FOREWORD vii
ACKNOWLEDGEMENTS viii
ABBREVIATIONS ix
EXECUTIVE SUMMARY xi

1. INTRODUCTION 1
1.1 Background 1
1.2 Objectives of the paper 2
1.3 Report structure 3

2. EVOLUTION OF FLOOD RISK MANAGEMENT 5

3 UNDERSTANDING RURAL FLOOD RISK AND RESILIENCE 7
3.1 Risk and resilience 7
3.2 Unique challenges in a rural context 8

4 MANAGING RURAL FLOOD RISK: ALIGNED, SYSTEMS-BASED, ADAPTIVE, AND INCLUSIVE 11
4.1 Governance and investment 12
4.1.1 Alignment: Bridging the gap between policy, planning and action 12
4.1.2 Strengthening governance for disaster risk reduction 16
4.1.3 Mobilizing investment 16
4.2 System-based: Managing hazards, exposure, and vulnerability 17
4.2.1 Managing rural flood hazards 20
4.2.2 Reducing exposure and vulnerability 28
4.3 Adapting towards a more resilient future 37
4.3.1 Adaptation pathways: Embedding adaptative capacity in response to climate change and emerging risks 38
4.3.2 Building back better 40

4.4 Ensuring an inclusive process and fair outcomes 41

4.4.1 Inclusive process of planning, implementation, and monitoring 41

4.4.2 Just outcomes 42

5 THE WAY FORWARD: CONCLUDING RECOMMENDATIONS TO ENABLE A STRATEGIC APPROACH TO MANAGING RURAL FLOOD RISK 43

REFERENCES 47

FIGURES

2.1 The evolution and development of flood risk management 6

3.1 The components of (flood) risk 8

3.2 Unique challenges slow progress towards rural flood resilience 9

4.1 A structured framework of whole-system thinking based on understanding the sources, pathways, and receptors of risk working with natural processes 18

4.2 Opportunities existing across the basin for natural infrastructure with natural processes and working 22

4.3 Breaking the hydroillogical cycle post: Using a flood event as a window of opportunity for change 38

TABLES

4.1 Attributes of strategic vision and alignment process 12

4.2 A system-based understanding of flood risk management: influencing factors 19

4.3 Flood types based on flood hazard types 21

4.4 Agroecology practice supports water management goals 24

BOXES

3.1 Case study: Rural vulnerability and resilience 10

4.1 Aligning goals in rural context: a win-win opportunity 15

4.2 Example of a national disaster risk reduction plan for the agriculture sector 16

4.3 Promoting opportunities to work with natural processes in flood management 22

4.4 Agroecology: Multiple benefits for water management 25

4.5 Hybrid solutions: Blending natural and built infrastructure 26

4.6 Dam repurposing for environmental benefits to rural livelihoods 27

4.7 Participatory flood mapping 28

4.8 Empowering local communities to take act 29

4.9 Adapting agricultural practice to reduce flood risk 30

4.10 Access to shelters and safe havens and use of improved building standards 31

4.11 Livelihood diversification and rural community action supports flood resilience 32

4.12 Temporary and permanent supported relocation 33

4.13 Anticipatory Action helps prevent a flood becoming a disaster 35

4.14 Post disaster needs assessment to inform disaster response and recovery efforts 37

4.15 Present day adaptation gap is increasing with climate change 39

4.16 Developing an adaptation pathway for Bangladesh 40

4.17 Engagement and collaboration in support of flood risk management 42

FOREWORD

In recent years, the world has witnessed dramatic impacts of floodings on both the economies and the environment, affecting the lives and livelihoods, food security and nutrition of billions of people worldwide. Recent floodings in Brazil, China, Germany, Libya, Mexico, Mozambique, Pakistan, and other countries have shown the massive devastation and tragic losses that can happen, both socially and economically. Along with earthquakes, the devastation of flooding is the deadliest type of natural disaster. Climate change is exacerbating risks and damages caused by floods.

On the other hand, flooding is an integral part of the natural water cycle. Through seasonal floods, materials (e.g. rocks, sediment and nutrients) are transported to the downstream areas, flood plains, river deltas and coastal areas, which form the most fertile lands of the planet for agriculture. Such natural flooding processes are also crucial for freshwater biodiversity and fishery resources. Good agricultural flood risk management can play a pivotal role in promoting desired societal, environmental and economic outcomes.

Most present and prevailing flood risk management strategies have focused on protection and control of floods to reduce the probability of a flood. However, there are emerging paradigm shifts in flood management: recognizing flooding as an integral part of the natural rhythm of health rivers and water cycle, shifting from flood response towards integrated flood risk management, shifting towards a more strategic and system-based approach, and shifting towards inclusive and adaptive response processes. In the face of the increasing likelihood and severity of floods due to climate change, such a paradigm shift is much needed. Understanding how flood management practices have evolved throughout history and learning from the past how to adapt towards more strategic, integrated and holistic approaches of flood management is vital for all people potentially affected and the planet.

We hope the recommendations presented in this report contribute to the aforementioned paradigm shifts, especially in agriculture and rural areas, providing benefits for the people, their economies and the environment. To overcome water related challenges such as floods in the future – and to achieve food security and zero hunger in a world of changing climate – we must learn how to live with the water instead of against it.

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ABBREVIATIONS

AA	Anticipatory Action
BDRCS	Bangladesh Red Crescent Society
CAP	Common Agricultural Policy
CBPFs	country-based pooled funds
CERF	Central Emergency Response Fund
CFSAM	FAO Crop and Food Supply Assessment Mission
DRR	disaster risk reduction
DIEM	Data in Emergencies Hub
ICIMOD	International Centre for Integrated Mountain Development
IFRC	International Federation of Red Cross and Red Crescent Societies
IPCC	Intergovernmental Panel on Climate Change
FFWC	Flood Forecasting and Warning Centre
GDA	General Directorate of Agriculture of the Ministry of Agriculture, Forestry, and Fisheries of Cambodia
GEF	Global Environment Facility
GIS	Geographic Information System
GLOFAS	Global Flood Awareness System
LMICs	lower-middle-income countries
MEFCC	Ministry of Environment, Forest and Climate Change
MOALI	Ministry of Agriculture, Livestock and Irrigation of Myanmar
NBS	nature based solutions
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
PDNA	post disaster needs assessment

PES payments for ecosystem services

PRESASS Regional Climate Outlook Forum for the Sudano-Sahelian Region

SFERA Special Fund for Emergency and Rehabilitation Activities

TNC The Nature Conservancy

UNDRR United Nations Office for Disaster Risk Reduction

WEF water–energy–food

WFP World Food Programme

EXECUTIVE SUMMARY

Water is essential for all agriculture and food systems and central to sustainable development. Flood-prone land is very fertile and productive, which has drawn people for millennia to live and work on floodplains. Too much or too little water, however, can have disastrous effects on people and ecosystems. Consequently, poorly managed flood and drought risks present a significant challenge in making progress towards achieving the Sustainable Development Goals. Today, more than 3 billion people live in agricultural areas with very high or high levels of water shortages or water scarcity and some 1.8 billion people are directly exposed to floods with significant risk to lives and livelihoods (Rentschler, Salhad and Jafino, 2022). Climate-related disasters are already worsening this picture with repercussions for agriculture and food systems, ecosystem health and social well-being around the world (e.g. FAO, 2011a; FAO, 2021a).

This report presents a perspective on the impact of flooding in rural areas and how to address them in an integrated way that delivers multiple long-term benefits for people (food, water, and economic security) and nature. The challenges faced by rural communities are illustrated and a strategic approach to flood management is presented. The approach advocated is based on a paradigm of planning that connects the short and long term, seeks to simultaneously manage flood risk to people, their agrifood system-related livelihoods and the economy, whilst promoting the positive (and necessary) role floods play in maintaining productive agriculture (and aquaculture) and ecosystem health. In doing so, the approach embeds the concepts of disaster risk reduction (DRR) that are integral to the Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015), which contributes to the 2030 Agenda for Sustainable Development and the crucial need to progress at pace towards the Sustainable Development Goals.

This report highlights how flood management practice has evolved throughout history largely in response to flood events. This heuristic approach has yielded some important advances in both policy and planning. Central to this has been the shift from a reactive emergency-based response towards a proactive approach, aimed at reducing and managing flood risks. There is however more to do. Recognizing that rural areas have received disproportionately less attention, and current approaches to planning and management are less well established in rural areas compared to urban areas (Asian Development Bank, 2018), a small number of recommendations are set to help make more rapid progress towards flood resilience in rural settings:

1. **Accept that absolute protection is not possible and plan for exceedance:** An acceptance that some flooding will occur, regardless of steps made to reduce the risk to people, places a focus on building resilience into all aspects of the planning. This includes ensuring that early warnings trigger Anticipatory Action (AA), carried out before the forecast floods occur, with the goal to mitigate their direct impacts on lives and livelihoods. Further, humanitarian assistance should aid the timely and risk-informed recovery from a flood and act to underpin long-term resilience, addressing any underlying disaster risks.
2. **Understand the resilience of agrifood systems at national and global scales:** A lack of a global assessment focused on flood risks in agriculture and food systems, and rural areas is a brake on mobilizing investment to prevent flood risks, in early warning systems, proac-

tive preparedness, AA, and capacities of rural communities. A strengthened risk assessment process would encourage investment and support timely action to reduce vulnerabilities and to prevent a hazard from triggering a disaster, saving lives and livelihoods.

3. **Work with natural processes as part of a whole system approach to managing risk:** Working with natural processes as part of a flood risk management strategy implicitly encourages choices that support healthy freshwater and marine ecosystems, healthy soils, and the ecosystems and the services they provide: all are prerequisites for productive and resilient agriculture.

4. **Assess the resilience of agrifood systems at a catchment and community scale to better understand and communicate any present-day risk and how it may change in the future:** Understanding the flood hazard, as well as the exposure and vulnerabilities of agrifood systems and related livelihoods (including people's coping and adaptive capacities), and how they combine to generate the risk faced, is the starting point for any planning process. Communicating this risk using modern communication tools alongside traditional stories enhances risk awareness, which may be translated into interventions to reduce risk and help avoid disasters.

5. **Involve agriculture and rural communities in the process and promote socially just outcomes:** Rural smallholder farmers, women and Indigenous Peoples have significant knowledge to contribute and a substantial role to play in flood risk management. Inclusive planning processes encourage ownership and action.

6. **Align and integrate planning and policy within and across sectors to reduce risk and maximise co-benefits:** Managing flood risk does not take place in isolation of other risks and development objectives. An active process of alignment (and, where necessary, integration) within and across sectors and in consideration of the multiple and often conflicting risks provides opportunities for delivering multi-objective solutions, helps manage trade-offs and maximize co-benefits, and avoid future conflicts, creating new risks or exacerbating existing ones. Good land use planning at catchment scale not only considers development but identifies appropriate areas to store flood water upstream to reduce flood magnitude downstream. Natural habitats should be conserved or restored.

7. **Mobilize increased investment to scale-up resilience of agrifood systems and rural communities:** Scaling-up investment in the resilient agrifood systems and rural risk management through national adaptation planning and disaster risk management (and other mechanisms across sectors) will be critical if adaptation is to be successful. Increasing international humanitarian support – including flexible and accessible resources to support emergency response and recovery – will also be needed to address the inevitable residual risk. Financing mechanisms that secure long term investment are needed to support the implementation of adaptation pathways that are clear on how future choices will be made, and who will make them.

8. **Take proactive action to adapt and promote an integrated approach to water:** Building upon the shift in philosophy towards a more strategic, integrated approach to water management more broadly offers an opportunity for countries to slow and store flood waters in the landscape (rather than evacuating flood waters rapidly downstream where they may cause additional flooding) to help manage drought risks and develop system-based approaches to hydropower and agriculture[1] that deliver multiple benefits for people, their livelihoods, economy, and nature.

[1] Including crops, livestock, forestry, fisheries, and aquaculture subsections.

1 INTRODUCTION

1.1 Background

Flooding is an integral part of the natural rhythm of healthy rivers. Through seasonal periodic inundation, sediment and nutrients are exchanged between a river and its floodplains and transported downstream to nourish deltas and near shore coastal areas to form the most fertile lands on the planet for agriculture. These natural flood processes are crucial for freshwater biodiversity and migratory species that provide about 20 percent of the global fish catch. Flood-prone land is fertile and productive, which has drawn people for millennia to live and work on floodplains. Flooding, however, is also one of the most frequent and catastrophic climate-related hazards, severely impacting agriculture as well as other sectors. As the first ever quantification of the impact of disasters on agriculture at the global scale shows, natural disasters cause agricultural production losses of about USD 123 billion over the period 1991–2021. Floods inflict the second largest impact, after extreme temperatures and droughts (FAO, 2023a), with a responsible loss of around 16 to 20 percent (FAO, 2021b; FAO, 2023a). However, due to the limitations of data reporting and challenges in data disaggregation for particular hazard types, these figures are likely to be underestimations (FAO, 2023a).

Behind these losses lies a human story, since an estimated 1.8 billion people are exposed to a significant flood hazard (Rentschler, Salhab and Jafino, 2022). The most socially vulnerable communities are often at greatest risk, including the rural poor. Those who rely on agriculture and food systems for their livelihoods are often the worst affected, potentially placing their livelihoods, food security and nutrition at serious risk. Loss of livestock and crop production, and damage to food storage facilities and distribution of the systems upon which agriculture and food depend (e.g. transport), can rapidly undermine fragile food systems and supply chains. This, coupled with limited financial resources to aid recovery, can make the impact of a flood on a rural community both acute and long lasting, continuing to undermine development for many years after the flood waters have receded.

Rural resilience challenges are often exacerbated by a legacy of poor development choices that increase flood risk, by creating environmental vulnerabilities, including fragmenting the longitudinal or lateral connectivity of the river. Such choices embed unnecessary fragility within the landscape, starving agricultural soils of nutrients and degrading freshwater ecosystems. Flood risk management has a pivotal position in promoting a more strategic development pathway and one that delivers desired societal, environmental, and economic outcomes. In contrast to the often narrowly defined single objective of a flood control paradigm, the approach advocated here places an emphasis on developing systemic resilience by reducing risk (to people, their agricultural and food-related livelihoods, and the economy) in a way that promotes healthy ecosystems, social well-being, and economic prosperity. Achieving these outcomes will inevitably involve trade-offs, and understanding these trade-offs lies at the heart of the risk-informed approach set out here.

1.2 Objectives of the paper

Managing rural flood risk is at the centre of the vision for climate resilient development pathways set out by the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (IPCC, 2023). The United Nations (UN) envisions a future where smallholder farmers, rural entrepreneurs, and industries across the agrifood system reap the benefits of available water and are adaptive, equitable, and equipped to thrive in the face of climate related hazards whilst protecting nature (UN, 2020). Making progress towards this goal will require a combination of mitigation and adaptation, as well as disaster risk reduction (DRR) actions in agriculture and food systems, water and natural resources systems, and infrastructures and services to manage climate-related risks in rural territories (as set out in the Marrakech Partnership for Global Climate Action). The importance of prioritizing the poorest and most socially vulnerable (including rural communities in the poorest countries) must be increasingly recognised if we are to successfully reduce risks, adapt to climate change and promote resilience (e.g. IPCC, 2022) and the importance of adopting a long-term, strategic approach to flood risk management as part of these efforts (e.g. Sayers *et al.*, 2014).

This paper develops guidance for rural flood risk management, focusing on the translation of these framing principles to address the flood challenges faced by rural communities. The risk-based approach set out here seeks to manage rural flood risk in a way that protects people (and their agrifood systems and related livelihoods) whilst also promoting the healthy freshwater and marine ecosystems that rural communities often depend on. The approach advocated is a practical, strategic approach based on the use of a portfolio of measures (structural and non-structural) to proactively reduce and manage flood risk over the short and long term.

1.3 Report structure

The report is structured as follows:

Chapter 2 - Evolution of flood risk management: Over many decades our approaches to flood risk management have continued to evolve. This chapter provides a brief overview of this evolutionary journey and the contemporary thinking that guides this report.

Chapter 3 - Flood risk and resilience in a rural context: This chapter presents the unique challenges faced in rural areas, the need for system-based perspective and an adaptive response to proactively reducing and managing flood risk based on a portfolio of measures.

Chapter 4 - Managing rural flood risks: This chapter presents the central aspects of flood risk management to help prevent the creation of new risk, reduce existing risk, and increase resilience (reducing exposure to hazards, reducing vulnerability, and enhancing coping capacity). A series of sub-chapters are included addressing issues of: (i) governance and investment; (ii) a system-based approach to managing hazards, exposure, vulnerability and coping capacity; (iii) adapting towards a more resilient future; and (iv) ensuring an inclusive process and fair outcomes.

Chapter 5 - Summary and guiding recommendations to enable a strategic approach to managing rural flood risk: This chapter presents a series of recommendations to help guide a sound approach to managing rural flood risk. The recommendations are presented not as policies but in support of developing strategic actionable plans to reduce and manage risk and enhance resilience in rural settings.

2 EVOLUTION OF FLOOD RISK MANAGEMENT

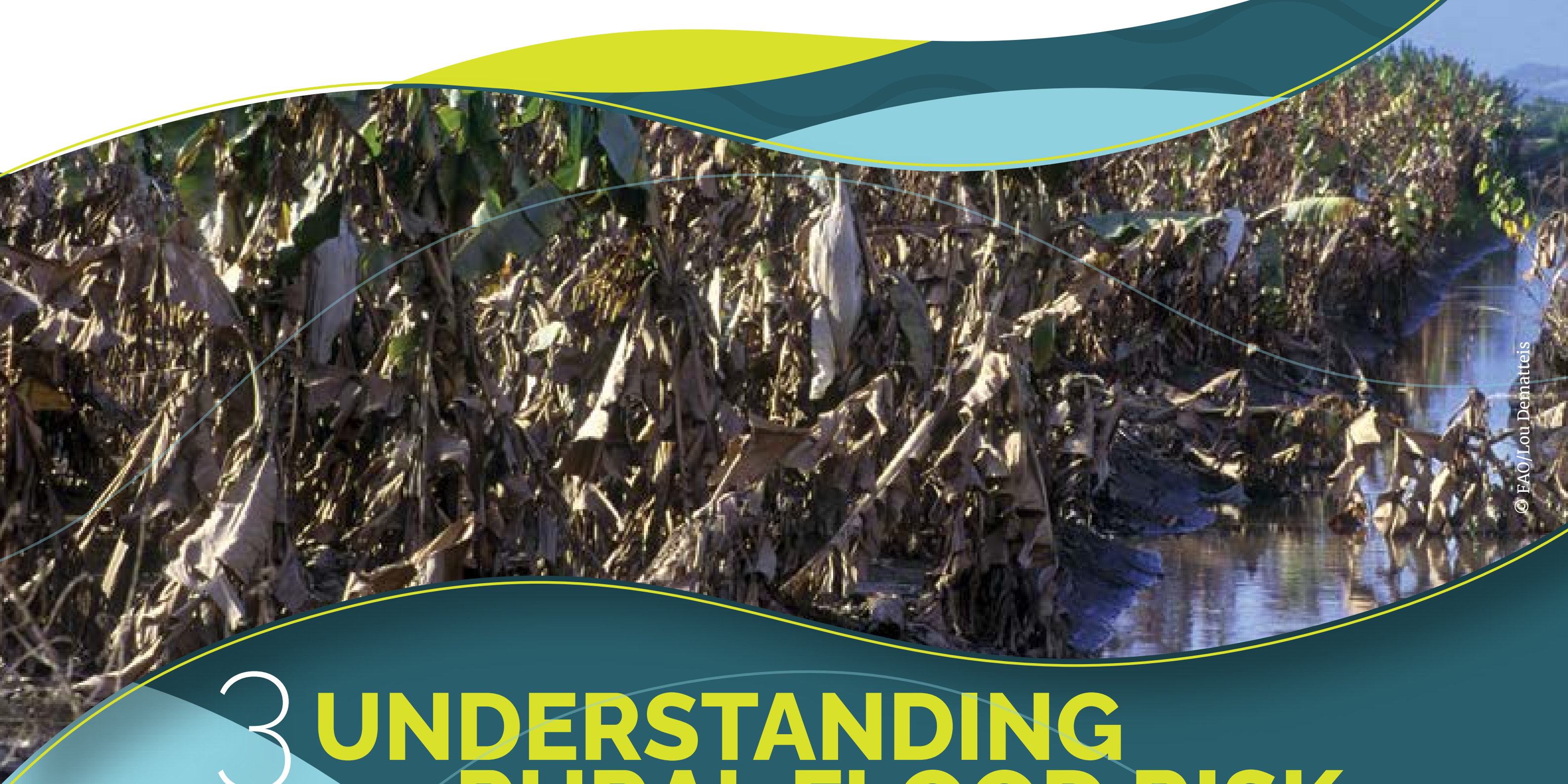
For millennia, people have recognised and benefited from the fertile and productive soils floodplains provide. Consequently, floods have been, and remain, an ever-present natural occurrence in rural settings. In many countries, authorities and communities respond to rural floods "as they happen", and often struggle to deliver sufficient emergency relief and aid for recovery. As a result, rural flood risk management has largely been developed on an ad hoc basis, reflecting lessons learnt from flood episodes. This does not mean that flood events have had no influence on policy or practice. Flood risk management has undergone significant change throughout history, learning lessons and adopting advances in science (Figure 2.1). This evolution towards an approach that proactively seeks to manage flood risk and promotes opportunities for people and nature, recognises that there is seldom a single solution to managing flood challenges and promotes the use of an integrated portfolio of flood risk management measures that align with multiple planning processes and instruments (Evans *et al.*, 2004b; Sayers *et al.*, 2014; WWF, 2020). Such a portfolio brings together actions to: **manage the flood hazard** (e.g. using a blend of built and natural infrastructure); reduce exposure to flooding when it occurs (e.g. through better spatial planning and AA); **reduce the vulnerability** of those exposed (e.g. before a flood by ensuring critical services will be able to continue operating during and post flood, and by providing both an effective response and enhanced coping capacities to aid recovery); and **manage flood risk** through governance arrangements that are able to develop and implement flood risk management strategies and plans at local and regional (national and basin) scales.

Figure 2.1 | The evolution and development of flood risk management

A willingness to live with floods	• Individual and small communities adapt to nature's rhythm
A growing demand to use the floodplain	• Fertile land in the floodplain is drained for food production • Permanent communities are established on the floodplain • Local (uncoordinated) levees start to be constructed
A focus on flood control	• Efforts are directed towards controlling flood flows and defending against flooding • Large scale structural approaches (levees, dams and other controls) are planned and implemented through organized governance
Flood control is complemented by actions to reduce flood damage	• A recognition that engineering alone has limitations • Effort is devoted to reducing economic damages should a flood occur • (Some) effort is devoted to mitigating loss of ecosystem services
Limited resources are prioritized based on risk	• A recognition that budgets are limited and not all problems are equal • Risk management (a combination of probability and consequence) is seen as a means to target limited resources
Risks managed strategically through integrated whole-system and adaptive approaches	• Adaptive management is seen as effective in managing the severe uncertainties in future climate change, funding and demographics • Working with natural processes is encouraged to both reduce risks efficiently and achieve gains in ecosystem services • Managing flood risk is seen through the lens of resilience

Source: Adapted from **Sayers, P., Penning-Rowsell, E. & Horritt, M.** 2017. Flood vulnerability, risk, and social disadvantage: current and future patterns in the UK. *Regional Environmental Change*, 18: 339–352. doi.org/10.1007/s10113-017-1252-z

As the climate changes and populations continue to grow, there is increasing pressure on space (for people, nature, energy production, food production, etc). Adopting a strategic, systems-based approach will be increasingly important if flood risks are to be well managed. Floods are projected to intensify and become more frequent in the future (particularly across many regions of Africa and Asia), and sea levels are projected to rise by over 1 m over the next 100 years due to climate change (COCLICO, 2022). An increasing frequency of flooding will put further pressure on agrifood systems and related livelihoods, further compromising food security and nutrition in some of the world's poorest regions. Contaminated flood water often also leads to outbreaks of diarrheal diseases, including cholera and other gastrointestinal infections. The trauma suffered during a flood is often significant and increasingly associated with short- and longer-term mental health impacts. In response to these pressures, an integrated, systems-based, adaptive and inclusive risk framing is now seen as a prerequisite for making progress in managing risk and promoting resilience. This evolutionary journey continues today and underpins the discussion presented here.



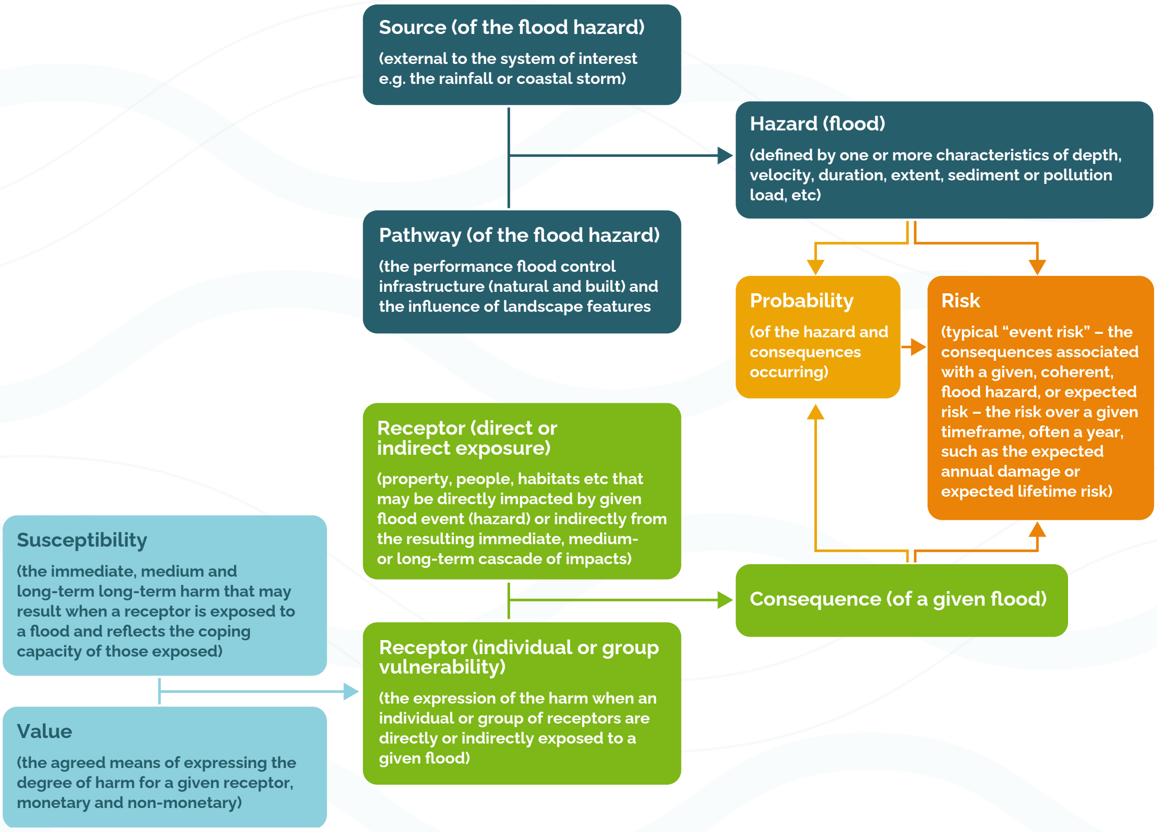
3 UNDERSTANDING RURAL FLOOD RISK AND RESILIENCE

3.1 Risk and resilience

Risk concepts are widely used across many disciplines and fields of endeavour, including finance, investment, insurance, disaster management, adaptation, conflict, and peacebuilding, and are equally applicable in a rural context (FAO, 2023a). Although the concepts vary in detail, risk has two basic components: the **probability** of a situation occurring with the potential to cause harm (the **hazard** – in this case, a flood hazard that may lead to a loss of social well-being, economic output, ecosystem health), and the **magnitude** of the harm caused, should that situation arise (the **consequences** – involving a combination of **exposure** and **vulnerability**, including the moderating influences of **coping capacity**). This framing enables changes in climate, coping capacity and flood protection to be reflected in the assessment of risk. This versatility has enabled the concepts of risk to gain significant traction across all decision realms. The central advantage of a risk-based approach is its ability to help decision-makers compare and prioritize alternative courses of actions in a structured and coherent way.

Flood risk emerges from the interaction between flood hazards, who and what is being exposed to those hazards (the receptor – in this case the agrifood systems and related livelihoods), and the vulnerability of those exposed (Figure 3.1). Their relationship is complex, as risks can cascade, escalate, and compound through interconnected components of the food system (including infrastructure, supply chains, and social networks) to cause indirect impacts far from the area directly affected by the hazard (in time or space). The significance of the risk is not simply determined as the product of probability and consequence, but reflects the rarity of the hazards and the magnitude of the short- and long-term impacts in a given context. These impacts in turn reflect efforts to prevent flooding where necessary, and the ability of those who are vulnerable and remain exposed, to prepare for, to respond to, recover from, and, if necessary, adapt to a changing context (for example, in response to climate change).

Figure 3.1 | The components of (flood) risk



Source: Adapted from **Sayers, P., Yuanyuan, L., Galloway, G., Penning-Rowsell, E., Shen, F., Wen, K., Chen, Y. & Le Quesne, T.** 2013. *Flood Risk Management: A Strategic Approach*. Manila, ADB, Beijing, China General Institute of Water Resources and Hydropower Planning and Design (GIWP), Paris, UNESCO & Woking, UK, World Wildlife Fund (WWF)-UK. https://unesdoc.unesco.org/ark:/48223/pf0000220870

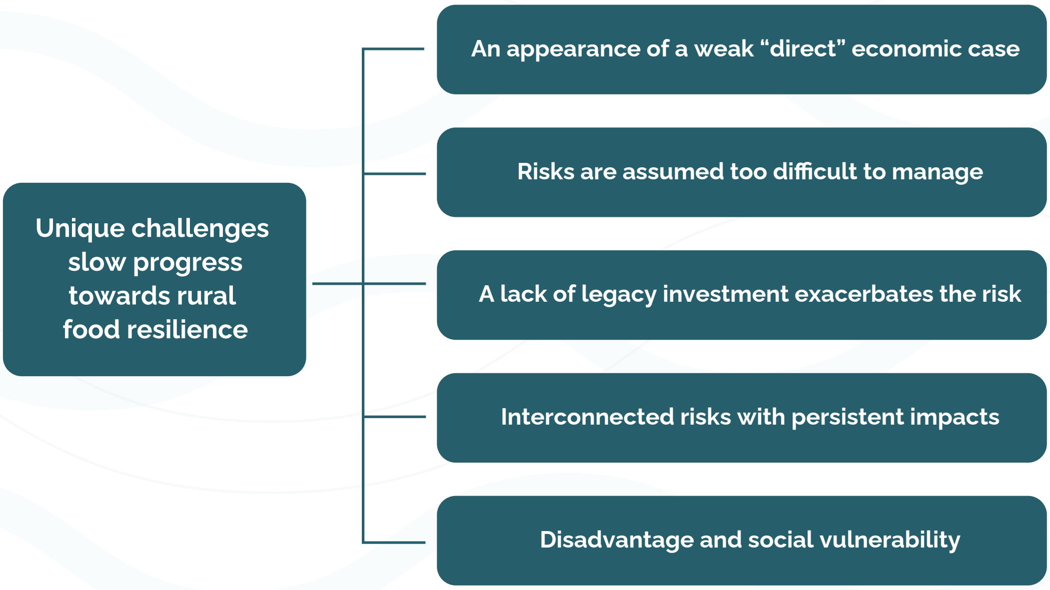
The notion of "resilience" has emerged in recent years as a key component of sustainable development. Although no blueprint is yet available as to what constitutes resilience in a practical sense. It is generally agreed that the environmental, social, and economic functions of a human and ecological system are required to "continue to function, and deliver its benefits, in the face of change, no matter the rate of change" (Urban Futures Team, 2012). A resilience lens is increasingly central to flood risk management to help identify the fundamental drivers of risk and act accordingly. A "flood-resilient system" is able to appropriately reduce the hazard and its impact (e.g. Sayers, Galloway and Hall, 2012; Twigger-Ross *et al.*, 2014). This includes the ability to **respond** and **recover** from a flood event, **adapt** to incremental changes, and make **transformational** changes as necessary (e.g. to accommodate a tipping point in the climate response). Understanding how to promote rural flood resilience "through (better) risk management" (UN, 2020) – including enhancing coping capacities – underpins the discussion here.

3.2 Unique challenges in a rural context

In many developing countries rural flood risk is significant. This reflects a combination of exposure to frequent floods as a consequence of exploiting flood-prone land, having limited coping capacities and vulnerable livelihoods and agrifood systems upon which they rely.

However, recent developments in flood risk management practices have tended to concentrate on addressing urban flood risk (e.g. World Bank, 2023). Although urban and rural areas share many challenges around flood risk, there are differences too. Rural flood risk and the challenges rural communities face reflect a different context to those experienced in urban areas (Figure 3.2).

Figure 3.2 | Unique challenges slow progress towards rural flood resilience



Source: Authors' own elaboration.

These differences include the nature of the risk faced and challenges in mobilizing and implementing actions to improve resilience, including:

- **An appearance of a weak "direct" economic case:** People and property are dispersed in rural settings. Despite facing substantial individual exposure and vulnerability, the use of conventional approaches to monetize direct damage can fail to capture a full range of impacts over the short and long term (including local and regional impacts on food security and farmers' welfare) and across sectors. Consequently, the case for action can appear weak when compared to more densely populated urban areas and high-income locations: a bias that means rural communities are left neglected despite the acute risk to lives and livelihoods.

- **Risks are assumed too difficult to manage:** Rural floods often cover vast areas as functional floodplains are inundated, often driving significant spatial heterogeneity in the impacts that result. Such floods cannot be readily controlled by local conventional defences and require a coordinated multi-sectoral and whole-system approach to planning, restoration and targeted interventions that work with natural processes. This contrasts with the relatively constrained spatial extent of urban floods, where focused (natural and built) infrastructure can be more effective.

- **A lack of legacy investment exacerbates the risk:** Rural communities are often less well served by supporting infrastructure compared to urban areas. Communication infrastructures are often less reliable and limited (or even absent). There is restricted access to flood forecasting (radar etc.) and flood warning. Physical infrastructure is also typically less extensive, and more fragile and informal in rural locations compared to urban settings. Rural communities can become isolated during flood events as fragile transport networks are disrupted, making access to (and by) emergency services – as well as to markets – more difficult.

- **Overlaying, interconnected, and compounding risks with persistent impacts:** Floods are rarely generated locally. This is particularly the case in rural areas, with rural communities and livelihoods often being impacted by external and remote choices, including commercial exploitation of the upstream catchment. Deforestation or urban and agricultural development on the functional floodplain can have significant impacts on the downstream communities and freshwater ecosystems, in terms of both water quality and flood events. Intense rainfall on degraded landscapes can cause significant soil erosion, impacting the long-term health of the soil, while blocking rivers and leaving degraded land surfaces impermeable, further increasing run-off.

- **Disadvantage and social vulnerability:** Rural communities are often amongst the poorest, least educated, isolated and most socially vulnerable, thus experiencing a systemic disadvantage when compared to others (e.g. Sayers, Penning-Rowsell and Horritt, 2017; FAO, 2022a). In tandem with investment in reducing flood hazards, addressing the social drivers of disadvantage and systemic vulnerabilities (including access to health care, education, nutrition, clear water) remain central prerequisites to making progress in managing flood risk (Box 3.1).

Box 3.1 | Case study - Rural vulnerability and resilience

In central Viet Nam, economic and human losses from flooding can push rural households into poverty, through damage to people, building structure and contents, paddy rice, and road networks (Vu and Ranzi, 2017). However, while poor households in the Red River Delta are not more exposed to floods than others and do not take less proactive flood risk reduction measures than others, they are more vulnerable, as their livelihoods and incomes are more sensitive to relative impacts from floods on their agriculture, livestock rearing and fishing (McElwee *et al.*, 2017). Timing of floods is important: for example, the 2003 flood in the Red River Delta hit in early September when paddy rice was still in the field, causing the near-complete destruction of the summer–autumn rice crop (McElwee *et al.*, 2017).

The Lower Shire Valley, Malawi, is a region of medium to high vulnerability, mainly arising from social (e.g. poverty, literacy, and community participation), **economic** (e.g. low incomes and diversity of employment), and **environmental susceptibility** (e.g. availability of natural resources) (Mwale *et al.*, 2015).

In rural Malawi, the factors defining the community's flood resilience were purpose-built infrastructure, early warning systems for preparedness and Anticipatory Action (AA) (Dewa, Makoka and Ayo-Yusuf, 2022). A strong sense of place and resistance to relocation were presented as key elements of resilience, maintaining community system function, and preserving livelihoods supported by a well-resourced village civil protection committee able to prepare and mobilize stakeholders in response to flood emergencies.

Sources: **Vu, T.T. & Ranzi, R.** 2017. Flood risk assessment and coping capacity of floods in central Vietnam *Journal of Hydro-environment Research* 14: 44–60. doi.org/10.1016/j.jher.2016.06.001. **McElwee, P., Nghiem, T., Le, H., & Vu, H.** 2017. Flood vulnerability among rural households in the Red River Delta of Vietnam: implications for future climate change risk and adaptation. *Natural Hazards,* 86: 465–492. doi.org/10.1007/s11069-016-2701-6 **Mwale F.D., Adeloye, A.J. & Beevers, L.** 2015. Quantifying vulnerability of rural communities to flooding in SSA: A contemporary disaster management perspective applied to the Lower Shire Valley, Malawi. International *Journal of Disaster Risk Reduction*, 12: 172–187. doi./10.1016/j.ijdrr.2015.01.003 **Dewa, O., Makoka, D. & Ayo-Yusuf, O.A.** 2022. Measuring community flood resilience and associated factors in rural Malawi. *Journal of Flood Risk Management*. 16(1): e12874. doi. org/10.1111/jfr3.12874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4 MANAGING RURAL FLOOD RISK: ALIGNED, SYSTEMS-BASED, ADAPTIVE, AND INCLUSIVE

The Sendai Framework for Disaster Risk Reduction 2015-2030 (UNDRR, 2015) sets out four priorities to help prevent the creation of new risk, reduce existing risk, and increase resilience (reducing exposure to hazards, reducing vulnerability, and enhancing coping capacity) and promotes the importance of "building back better" in the aftermath of a disaster (including floods). This framing underpins four broad avenues of activity set out here to address rural flood risk:

- **Activities across sectors and governance levels need to be strengthened** and aligned (from national to local), and investment promoted to enable policies and plans to be translated to integrated action to reduce risk and realise opportunities.

- In a broad sense, the "flood risk system" represents the whole system within which flood risks and opportunities arise and are managed. **The whole flood risk system needs to be managed,** using a portfolio of actions to reduce the flood hazard, reduce exposure to the flood hazard (either direct or indirect) and reduce vulnerability (and improving coping capacity) when exposed to a flood. This includes the implementation of local level vulnerability reduction measures, early warning and AA and preparedness plans, so that acute humanitarian impacts can be avoided or reduced and a flood risk can be prevented from becoming a flood disaster.

- **It is necessary to adapt for a more resilient future**, developing the capacity to adapt to future floods and "build back better" when the opportunity arises, especially in the recovery efforts after a flood disaster.

- **Policies and plans need to be developed through an inclusive and multi-stakeholder process**, within and across sectors and levels that deliver just outcomes and build capacities to prevent, prepare, anticipate, absorb, respond, recover, and transform.

These broad themes and the activities they involve are discussed in the following section.

4.1 Governance and investment

4.1.1 Alignment: Bridging the gap between policy, planning and action

At any given time, regional and national policies are being refined, strategies developed, and local schemes and actions promoted and implemented across a range of sectoral interests and at multiple levels of governance. Flood risk management sits at the intersection of many other management considerations and as such, it is influenced and shaped by choices across multiple sectors and, in turn, is supportive of multiple agendas. Coordination and a degree of integration is needed to avoid future conflicts and the emergence of unnecessary risks (for example through inappropriate development of the functional floodplain or unnecessary environmental degradation). Horizontal alignment within and between sectors and vertical alignment between plans and actions at multiple temporal scales (short to long term) and spatial scales (from local to regional and even transboundary) are also needed to identify opportunities, "win-win" outcomes and compromises that deliver wider benefits (such as soil and ecosystem health, crop yields, and livelihood diversification). This does not demand a goal for "perfect" integration, but it does need a willingness to understand trade-offs between sectors and seeks proactive collaborative solutions. By aligning flood risk management with other strategies, additional wider goals can be achieved, such as managing water resources, reducing soil erosion and river sediment loads, and enhancing biodiversity. Proactive alignment is therefore central if flood risk management is to contribute positively in moving towards the Sustainable Development Goals (Table 4.1).

Table 4.1 | Attributes of strategic vision and alignment process

Attributes of alignment within "good" flood risk management	Description
Basin planning* (vision, objectives, and actions).	Basin planning typically involves a series of nested statements of intent which together forms the means by which basin plans are developed and implemented. These relate to the basin vision and more specific objectives and actions. Vision statements are often aspirational rather than specific, providing a preliminary indication of political purpose before difficult decisions over trade-offs and investment need to be made. To be implemented, vision statements need to be translated into meaningful cross-jurisdictional collaboration and specific and measurable objectives and actions that are achievable with the available resources and given timeframe.
Inclusive and cooperative	Including those with an interest in flood related issues, including Indigenous knowledge, and the contribution of all voices, including those directly and indirectly impacted, who are likely to remain unsupportive of the plan because of the potential implications for them.

Table 4.1 (Cont.)

Attributes of alignment within "good" flood risk management	Description
Vertical and horizontal alignment*	Coherent flood planning that contributes to broader social, economic, and environmental imperatives can seldom be achieved without a proactive process of alignment. This includes: (i) vertical alignment, which helps ensure projects contribute to both local (including the important role of community-based flood risk management) and national objectives; and (ii) horizontal alignment, which identifies inter- and cross-sectoral opportunities and minimizes unnecessary conflict to realise potential synergies (e.g. changing agricultural practices to better manage soil health and reduce runoff).
Proactive approach to compromise and synergies	Proactively seeking synergies and where necessary compromise to maximize the widest set of benefits across sectors is fundamental to strategic planning processes, and is particularly the case in bring together agricultural, disaster risk management, environmental, economic, and social objectives.
Temporal alignment	The context of any basin is always changing. A proactive and continuous process to maintain alignment as needs change and adapt actions in a timely manner, ensure the approach to flood risk management continues to deliver as desired and needed. Meaningful monitoring and evaluation systems and the capacity to reform and update governance arrangements as necessary are underpinning enablers of adapting to a changing context.

Source: Adapted from **Pegram, G., LeQuense, T., Li, Y., Speed, R. & Jianqiang, Li.** 2013. *River Basin Planning: Principles, Procedures and Approaches for Strategic Basin Planning.* Paris, UNESCO, Manila, ADB, Woking, UK, WWF-UK and Beijing, GIWP.

Water–energy–food

Agriculture is the largest consumer of the world's freshwater resources, and more than one-quarter of the energy used globally is expended on food production and supply. Consequently, agrifood systems are at the centre of the water–energy–food (WEF) nexus approach (framing the highlights of the interdependence of water, energy, and food security and ecosystems) (FAO, 2014). The demand for freshwater, energy, and food is expected to increase significantly over the next few decades, due to population growth, economic development, cultural changes, and climate change. Identifying mutually beneficial responses for water, energy and food requires an ability to understand and identify synergies and translate these into water, energy, and agricultural policies (e.g. Carmona Moreno, Dondeynaz and Biedler, eds., 2019). Addressing the WEF nexus in the context of changing climate and development will be central to achieving food security and sustainable agriculture. The approach to flood management set out here has an important contribution to play in this broader context.

Agriculture

Agricultural productivity is directly related to the availability of water to support the growing of crops and forests, for aquaculture, and the nurturing of livestock. Agriculture areas are often subject to periodic inundation that can in some cases provide natural irrigation and nutrient–rich sediment, while in others can destroy the ability of an area to support agricultural activity. A landscape- or catchment-scale planning approach can identify areas where flood water can be stored upstream, reducing flood magnitude downstream. Many countries are considering schemes to offer farmers and landowners financial reward for managing land in a way that it delivers ecosystem services, including reduced downstream flood risk. Recent decades have witnessed a considerable increase in payments for ecosystem services (PES), such as programmes that exchange value practices intended to provide or ensure ecosystem services (e.g. FAO, 2011b). A study from 2018 found that there were over 550 active programmes around the globe and an estimated USD 36 to 42 billion in annual transactions (Salzman *et al.*, 2018). For example, payment for environmental services was considered when promoting conservationist farming practices in headwater catchments in Brazil (Simedo *et al.*, 2020), or when, in 2021, the European Union reached an agreement on reform of the Common Agricultural Policy (CAP) to better support payment for environmental outcomes (EC, 2023). If flood risk management plans (together with other disaster risk reduction and adaptation plans) and agricultural development plans are carefully coordinated and appropriately integrated, true win-win situations can emerge (Box 4.1).

Freshwater and marine ecosystems services

Floodplains are among the most biologically-productive areas on earth and floodplains and provide numerous services to both freshwater and marine ecosystems that benefit nature and humans. Coordinating the management of natural infrastructure (such as maintaining functional floodplains and deltas) together with built infrastructure where necessary, can offer win-win opportunities, providing appropriate protection and enhancing ecosystem goods and services. Developing natural and built infrastructure in combination is increasingly promoted as central to sustainable management of river systems (e.g. Sayers *et al.*, forthcoming) and the growing community of practice around a hybrid "green-gray" approach to infrastructure and associated guidance (Green-Gray Community of Practice, 2020).

Hydropower and energy security

Planning and managing water infrastructure that delivers multiple objectives relating to energy, water resource management, disaster risk reduction, climate resilience and ecosystems objectives across sectors relies upon policy alignment and the integration of actions. The benefits of such alignment may seem obvious, but it is often perceived as a significant challenge (OECD, 2015) with 75 percent of sub-national infrastructure promoters (such as a regional power or water provider) reporting an absence of a joint investment strategy. Globally, it is estimated that 54 percent of installed hydropower capacity competes with irrigation water provision, and a complementary relationship exists for only 8 percent of that capacity (Zeng *et al.*, 2017). Adopting an aligned approach to hydropower could generate significant benefits including an estimate of between USD 285 billion to USD 770 billion per year in additional water services at the global scale (Opperman *et al.*, 2017).

Water supply and quality

Ensuring the availability of water for people, business and agriculture is one of the most important responsibilities of government. Steps taken to reduce flood risk can either worsen or improve water availability and quality. The use of natural infrastructure as part of the management of flood waters can produce significant supply bonuses during subsequent drought periods and careful management of reservoir operations can meet the needs of both flood risk management and water supply if their plans are well coordinated.

Box 4.1 | Aligning goals in rural context – a win-win opportunity.

Proactive alignment flood risk management provides opportunities to deliver multiple outcomes

Agriculture and food security: The reconnection of floodplains and river helps to restore the natural agricultural cycle of flooding (to support fisheries), capture the flood recession (to promote natural crop irrigation) and help maintain post-flood soil moisture (to support cattle grazing pastures), as reported in Cameroon in 2004 (Loth, ed., 2004). In the Mekong Delta in Viet Nam, strategies have been developed to help farmers "work with floods" (Tran, Nguyen and Vod, 2019). These include: (i) growing freshwater giant prawns to take advantage of the high flooding system; (ii) building ponds to raise fish and using trash fish caught in the flood season as feed for cultured fish; (iii) switching to more profitable cash crops (e.g. sesame) rather than rice; (iv) adopting multiple cropping systems (e.g. double or triple rice crops) within an embanked system; and (v) practicing integrated freshwater aquaculture (e.g. integrated rice–fish farming). A range of similar practices are also reflected in traditional and modern integrated farming methods that provide an important component of sustainable food production systems in India (Sathoria and Roy, 2022).

Safeguarding and enhancing freshwater and marine ecosystems services: Following large floods of the Yangtze River in 1999, the Government of China implemented a national payment for ecosystem services scheme, known as the Sloping Land Conversion Program, to reward farmers in abandoning intensive farming on sloping terrains in the upper area of the watershed (as they contributed to extensive soil erosion and floods), to restore degraded lands and restore forest cover (Scherr *et al.*, 2006).

Improving energy security, flood management without ecosystem impact: The Hydropower by Design (HbD) initiative led by The Nature Conservancy (TNC), explores the opportunities for "sustainable hydropower" (defined as energy development that is consistent with maintaining a broad spectrum of values from river systems). The TNC reports (Hartmann *et al.*, 2013; Opperman, Grill and Hartmann, 2015; Opperman *et al.*, 2017) illustrate how system-scale solutions enable innovative approaches to be developed that blend natural and built infrastructure to deliver co-benefits for power generators, the environment, and other services without compromising energy generation.

Water supply and quality: If well designed, flood management can also contribute positively to water supply, quality, and health. Holding water in the landscape, rather than evacuating it as quickly as possible after floods, makes it available as a resource during dry periods. For example, in Bolivia (Department of Beni) livestock refuge mounds (small mounds covering an area of about 0.5 to 1 ha) are used to provide shelter for people, livestock and agricultural products during floods. The refuge mounds typically have a capacity for up to 800 heads of dairy cattle, which can be fed during the flood season, with the peripheral canal providing water storage that can be used in times of drought to supply water to livestock (FAO, 2020).

Strategic oversight: In the United Kingdom of Great Britain and Northern Ireland, the Environment Agency (EA, 2020) provides strategic oversight of all aspects that relate to flood management across government and works with individuals, communities, the third sector (such as charities, social enterprises and voluntary groups), businesses, farmers, land managers and infrastructure providers to contribute to planning and adapting to future flooding. This role offers an opportunity to provide a soft alignment of actions to identify multiple functional actions.

Sources: **Loth, P.**, ed. 2004. *The return of the water: restoring the Waza Logone floodplain in Cameroon*. Gland, Switzerland, IUCN. **Tran, T.A., Nguyen, T.H. & Vod, T.T.** 2019. Adaptation to flood and salinity environments in the Vietnamese Mekong Delta: Empirical analysis of farmer-led innovations. Agricultural Water Management, 216(1): 89–97. doi.org/10.1016/j.agwat.2019.01.020. **Sathoria, P. & Roy, B.** 2022. Sustainable food production through integrated rice-fish farming in India: A brief review. Renewable Agriculture and Food Systems, 37(5): 527–535. http://dx.doi.org/10.1017/S1742170522000126. **Scherr, S., Bennett, M., Loughney, M. & Canby, K.** 2006. Developing Future Ecosystem Service Payments in China: Lessons Learned from International Experience. In: *Forest Trends*. Washington, DC., Forest Trends. [Cited 2023]. https://www.forest-trends.org/publications/developing-future-ecosystem-service-payments-in-china/. **Hartmann, J., Harrison, D., Gill, R. & Opperman, J.** 2013. *The Next Frontier of Hydropower Sustainability: Planning at the System Scale*. Washington, DC., The Nature Conservancy. https://conservationgateway.org/ConservationPractices/Freshwater/WaterInfrastructure/Documents/The%20Next%20Frontier%20of%20Hydropower%20Sustainability%20-%20Planning%20at%20the%20System%20Scale%20-%20FINAL.pdf. **Opperman, J., Grill, G. & Hartmann, J.** 2015. *The Power of Rivers: Finding balance between energy and conservation in hydropower development.* 2015. Washington, DC., The Nature Conservancy. **Opperman, J.J., Hartmann, J., Raepple, H., Angarita, P., Beames. E., Chapin, R., Geressu, G.** *et al*. 2017. *The Power of Rivers: A Business Case.* Washington, DC., **The Nature Conservancy**. https://lowimpacthydro.org/wp-content/uploads/2020/07/The-Power-of-Rivers-TNC-Executive-Summary-2017.pdf. **FAO**. 2020. Family Farming Knowledge Platform. Refuge mounds, deworming, preventive vitaminization and mineralization. In: FAO. Rome. [Cited 2023]. https://www.fao.org/family-farming/detail/en/c/1614250/. **EA**. 2020. *National Flood and Coastal Erosion Risk Management Strategy for England*. Bristol. https://www.gov.uk/government/publications/national-flood-and-coastal-erosion-risk-management-strategy-for-england--2

4.1.2 Strengthening governance for disaster risk reduction

Flood risk management contributes to, and interacts with, a broad set of policy and planning choices, from local to regional scales (including transboundary basins). Coordination across these activities and levels remains difficult in higher and lower income countries alike. Reducing flood risks relies upon embedding DRR into all aspects of humanitarian actions and development planning in a coherent and integrated way. As a minimum, this means having in place actionable risk-informed plans and policies across all pillars of action set out in the Sendai Framework at national and local levels (UNDRR, 2015), with flood risk management mainstreamed into sectoral plans, including the development of specific agricultural DRR strategies and plans (Box 4.2).

Box 4.2 | Example of a national disaster risk reduction plan for the agriculture sector

In Cambodia: Cambodia's Plan of Action for DRR in Agriculture 2014-2018 sets out an actionable risk-informed approach to reducing agricultural risks (MAFF, 2013). This plan was established under the leadership of the General Directorate of Agriculture (GDA) of the Ministry of Agriculture, Forestry, and Fisheries as a living document and roadmap. It includes agricultural specific DRR interventions in the country that aim to reduce the adverse impacts of disasters, such as floods, droughts, storms, pests, and diseases.

In Myanmar: The agricultural sector is a backbone of Myanmar's economy, contributing about 30 percent of national gross domestic product (GDP). Almost 70 percent of the rural population rely on it for their livelihoods and incomes. Myanmar ranks in the top three countries most affected by weather related events globally. Together with the Ministry of Agriculture, Livestock and Irrigation (MOALI) the FAO Agriculture Action Plan for DRR has been developed (FAO, 2020), setting out a series of priorities to enhance resilience across a range of hazards. The plans include transitions to cropping varieties to better understanding the hazards and risks and governance arrangements at local and regional levels.

Sources: **MAFF (Ministry of Agriculture, Forestry and Fisheries).** 2013. *Plan of Action for Disaster Risk Reduction in Agriculture 2014-2018*. Phnom Penh. https://coin.fao.org/coin-static/cms/media/21/14109270844140/etfinal_national_poa_drr_gda_main_eng.pdf. **FAO**. 2020. Action Plan on Disaster Risk Reduction. Naypyidaw, Ministry of Agriculture, Livestock and Irrigation (MOALI) & Rome, FAO.

4.1.3 Mobilizing investment

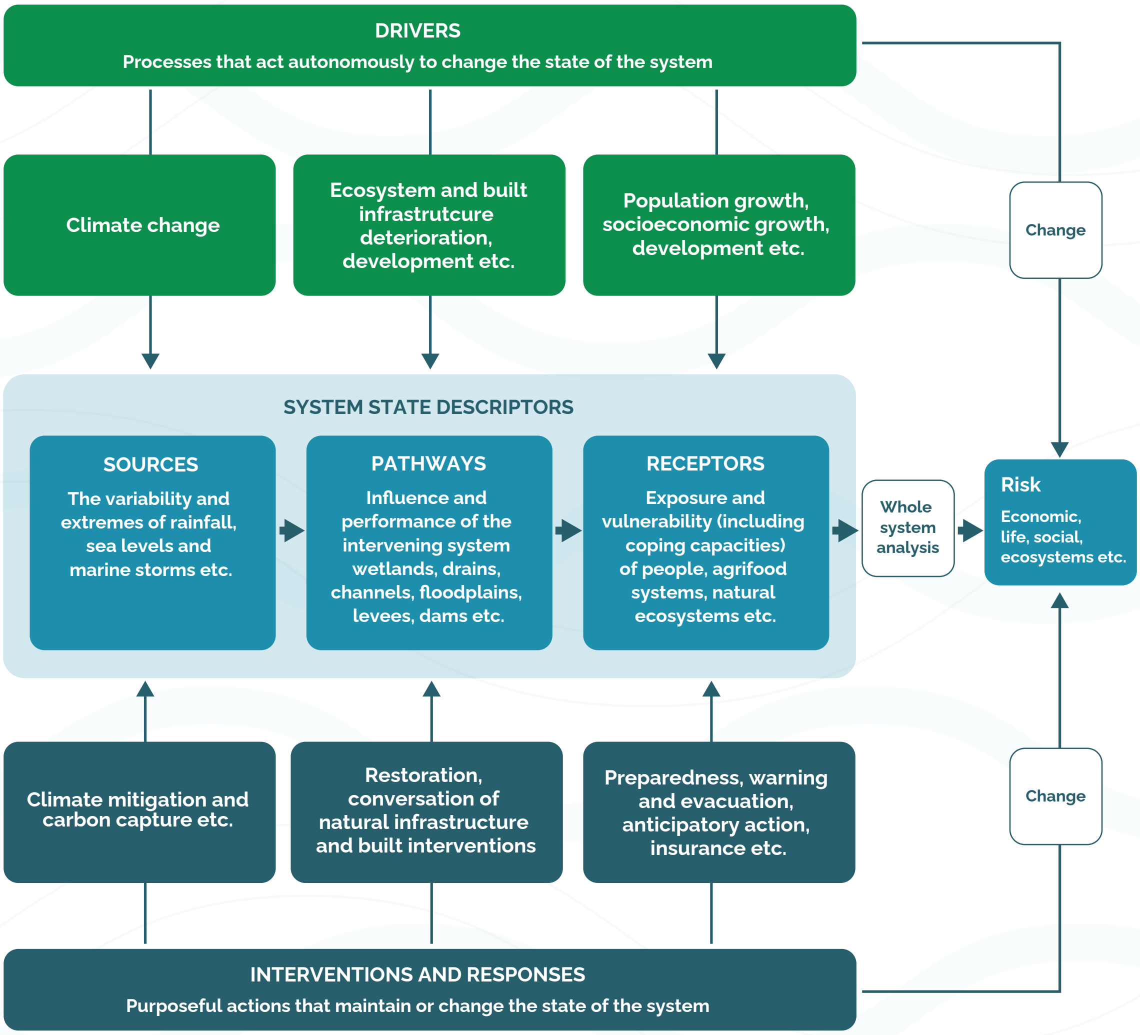
Present-day global expenditure on water infrastructure is projected to almost double by the 2040s to over USD 300 billion per year, (GI Hub and Oxford Economics, 2017) with significant additional support needed if water-related Sustainable Development Goals are to be met. The investment need, relative to the size of the economy and existing low level of basic services provision, is greatest in some of the poorest (and predominantly rural) regions in the world (GI Hub and Oxford Economics, 2017). Disasters continue to highlight the urgency of this investment and the magnitude of the challenge. For example, in the aftermath of the severe flooding that occurred between July and September 2022 in Pakistan, the recovery and reconstruction needed was estimated to be USD 4 billion (FAO, 2022b). Scaling finance to support flood resilience in agriculture and rural areas presents a significant challenge but it is nonetheless vital. To provide multiple outcomes that address flood risk together with issues of deforestation and land degradation, the case for investment in ecosystem-based agricultural solutions will need to be an integral part of international and national financing plans alongside ring-fenced support for post-disaster recovery.

There is widespread agreement that action on climate adaptation is moving too slowly (e.g. UNEP, 2021), due to a shared understanding of the fragility of global food systems to flood risks in the short and longer term and the ability to make the credible case for collaborative transformational action (at a local and global scale). Recent years have seen "stress testing" growing in importance as a tool to better understand the resilience of particular sectors to climate-related risks. The importance of the agricultural sector to global security (and by extension, the importance of managing rural flood risk) is often lost (or at least not fully captured) in broader economic damage estimates and seldom reflects the impact on the most vulnerable and the challenges rural communities face. Despite the increasing pressures on rural areas (such as unsustainable natural resource management through deforestation, and land degradation exacerbated by climate change) there is no standardized global assessment or regional scenario stress tests for agriculture and rural flooding to better understand how risks are distributed, how they may change and how they may impact global and regional security. A strengthened assessment of risk offers an opportunity to better understand the rural risk and mobilize investment in preventive and preparative early warning systems, coupled with AA and humanitarian response and recovery capabilities, as well as restoration of natural infrastructures, capacities of local communities and key institutions. Being clear on how investments support timely action saves lives and livelihoods and prevents a risk becoming a disaster.

4.2 Flood system-based approach for the agrifood system: Managing hazards, reducing exposure and vulnerability and enhancing coping capacities

An appropriate understanding of the flood risk system (and how it responds to change) is being increasingly recognised as a fundamental building block of good flood risk management of relevant agrifood systems (e.g. Sayers, Hall and Meadowcroft, 2002; Evans *et al.*, 2004a, 2004b; Sayers *et al.*, 2013). The discipline that derives from adopting a whole-system framework presents several advantages. Most notably it forces the systematic consideration of all aspects that influence risk, including the sources and pathways of the flood hazard, and the different components of the agrifood systems in question that may be exposed to the flood hazard – directly or indirectly – and their vulnerabilities and coping capacities. It also forces an assessment of how the system may change due to primarily external drivers (such as climate change and socio-economic influences) as well as internal management responses within the agrifood systems in question (including both structural and non-structural measures) Figure 4.1.

Figure 4.1 | A structured framework of whole-system thinking based on understanding the sources, pathways, and receptors of risk



Source: adapted from **Sayers, P., Yuanyuan, L., Galloway, G., Penning-Rowsell, E., Shen, F., Wen, K., Chen, Y. & Le Quesne, T.** 2013. *Flood Risk Management: A Strategic Approach*. Manila, ADB, Beijing, China General Institute of Water Resources and Hydropower Planning and Design (GIWP), Paris, UNESCO & Woking, UK, World Wildlife Fund (WWF)-UK. https://unesdoc.unesco.org/ark:/48223/pf0000220870

Human and natural systems – including agrifood systems and all its components from production to consumption – are rarely stationary in time and change in response to external and internal pressures (from climate change, development, and broader societal influences (Table 4.2). A meaningful analysis of flood risk therefore necessarily involves consideration of the risk for the agrifood system and all its elements (hazards, exposure, vulnerability, and the influence of coping capacities) and how it may change in the future. Understanding how this relationship has been overlaying agrifood systems (including production, processing, distribution, markets, and consumption) and its interactions with flood processes (how agrifood system risks are generated) is central to the management of rural flood risks. This understanding is a prerequisite to the identification of appropriate interventions and responses, including exploiting options to work with natural processes, how agricultural practices interact with flood risks (and how they may be changed to improve resilience), and how rural communities can better prevent, mitigate, be prepared for, and be better able to respond to and recover from flood.

Table 4.2 | A system-based understanding of flood risk management: influencing factors

Factor	Description
Hazard: The flood waters (reflecting the sources and pathways within the system)	
Depth, velocity, duration, and timing and season	The area of land inundated, the depth and duration of inundation, and speed of flood flows are all important aspects of the flood hazard. The intensity of the storm as well as the hydrogeology and topography will be influential. For example, the steepness of the slopes will influence velocity and soil loss, while a lack of drainage could leave the flooded area waterlogged for long periods. The timing (day or night) and the season may be important when understanding the potential impact (such as on crop yield).
Erosion and debris	Flood flows can erode surface soils, leading to the loss of topsoil, and can erode riverbanks and shorelines. Debris is often recruited and carried with the flows, increasing the potential for downstream blockage.
Contaminants	Flood water over-mobilizes pollutants (such as through agricultural runoff, or by overwhelming sewerage works) and carries them downstream.
Frequency	How often a flood occurs will influence how it is best managed, making space for the most frequent floods but appropriately buffering the impacting of the rarest events. Approaches to describing the frequency of flooding are often confused and misunderstood by professional and the public alike (Sayers, 2015).
Exposure: Receptors that may be directly or indirectly exposed to a flood hazard	
Direct exposure	When a person, property, crop, or any other receptor directly experiences the flood. Reducing direct exposure often relies upon the ability of natural infrastructure to moderate flood flows and the performance of built control structures (where they exist).
In-direct exposure	The impact of a flood can cascade through interconnected networks of infra-structure and communities. For example, a whole community lying outside of the flooded area may lose access to drinking water due to flooding of the bore-hole, their treatment plant and distribution pump; or their regional food supplies due to the flooding of agricultural land.
Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2022)	
Freshwater and marine ecosystems	Floods form part of the natural functioning of the river or coast on which ecosystems rely. Distribution to these processes (through loss of connectivity or reduced environmental flows), as well as exposure to contaminated flood waters can degrade ecosystem health and increase vulnerability.
Economic (local/macro)	Poorly constructed buildings, fragile infrastructure systems, poor governance, and social exclusion can all increase economic vulnerability.
People (including coping capacity)	Not all people experience a flood hazard in the same way, as some are more vulnerable than others. The poorest often have a restricted ability to cope, only using their available skills and resources, to manage adverse conditions, risk or disasters (UNDRR, 2023a). The coping capacity will reflect the combination of all of the strengths, attributes and resources available within an organization, community or society to manage and reduce disaster risks and strengthen resilience (UNDRR, 2023b).

Table 4.2 (Cont.)

Factor	Description
Drivers of changes in the system	
Adaptation (autonomous and planned)	Interventions and responses to reduce flood risk, either through planned actions (such as managing flood flows) or autonomous choices (such as changing crop choices). Adaptation can influence the hazard, exposure, or vulnerability. Doing so successfully relies upon proactive actions to reduce risk and to better adapt (in the short and long term). This includes building on indigenous knowledge to better manage the flood risk and to enhance coping capacities.
Climate change	Climate change has the potential to influence all aspects of the climate (e.g. frequency, intensity, and sequence of events, as well as the likelihood of compound events). Climate change also influences land cover (including vegetation), and crop and ecosystem stress within the system. These influences are likely to change not only the rainfall, but also runoff processes, and the likely impact of the flood on soil erosion and ecosystem health. Understanding the uncertainty and subtleties of the influence of climate change supports better management choices.
Population, social, and economic change	Urban development, land use change (expansion or change in agricultural practice) and infrastructure development (hydropower etc) can have a profound impact on the flood risks influencing land surfaces (and hence the hazard) as well as the exposure and the vulnerability to flood hazard. Although not external to flood management, flood management is influenced by and influences these activities.

4.2.1 Managing rural flood hazards

To successfully manage the flood hazard, all sources of flooding need to be considered, along with any direct or indirect interactions with people that affect their well-being and livelihoods, the agrifood systems (and all elements from production to consumption), and natural ecosystems in a given context (Table 4.3). These interactions define the flood system of interest for the specific agrifood systems. This "all sources" and "whole system" lens helps promote the need to work with natural processes in managing flood hazards rather than against them. This includes maintaining natural storage and flow of flood water where possible to support ecosystem health and support agricultural practices (inland fisheries) and provide protection to people, property, assets, and livelihoods where necessary. Agricultural solutions offer opportunities to safeguard agricultural crops and environmental protection using natural infrastructure (such as land management, wetland storage and floodplain reconnections) alongside conventionally-built infrastructure measures (such as bypass channels or controlled storage), whilst simultaneously delivering effective and efficient flood risk reduction. A landscape or catchment scale approach is essential. Flood water must go somewhere and allowing flood water to be stored in an upstream location reduces the flood magnitude downstream, so that planning becomes a trade-off that can identify where best to store flood water and where best to protect land from flooding. Some of the most important considerations in developing an approach to managing the flood hazard that maximize these multiple outcomes are introduced in the following sections.

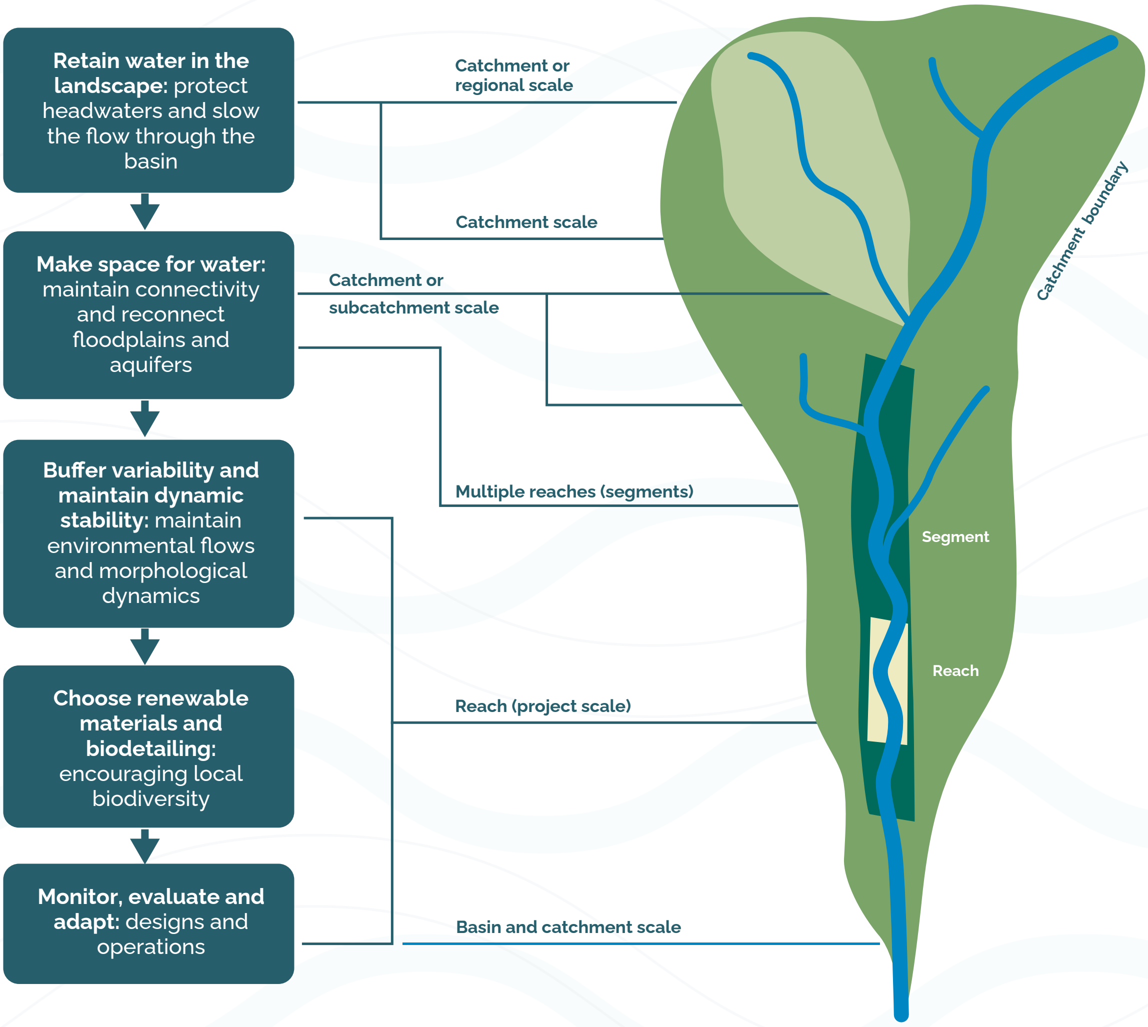
Table 4.3 | Flood types based on flood hazard types.

Flood type	Description
Fluvial (riverine) flooding	Inundation of land, that is not normally underwater, when a river overflows its banks. Control structures, embankments and debris will all influence the chance of a flood. In lowland areas of large rivers, the driving cause of a flood tends to be prolonged wet periods and heavy rainfall (or snow melt) on saturated (or frozen) ground. Lowland river floods may be slow to rise and remain resident for days or even weeks. In upland areas with steep slopes and small catchments, flood flows respond rapidly to intense rainfall causing "flash floods" with high velocity flows, often causing soil erosion and recruiting debris.
Pluvial (surface water) flooding	Inundation of land not typically underwater, due to rainfall exceeding the infiltration capacity of the land surface or the capacity of underground drainage. In urban settings, impervious areas such as roofs, roads and car parks exacerbate pluvial flooding, with flooding occurring within minutes or hours of intense rain.
Lake flooding	Inundation of land not typically underwater when water flows over the lake shore, either in response to direct rainfall, remote rainfall increasing stream inflows, and, on large lakes, through wind driven waves and any associated setup.
Groundwater flooding	Inundation of land not typically underwater when water emerges at the ground surface through permeable surface deposits (such as gravels) or aquifers (such as chalk or karst rock geologies). All groundwater floods respond to surface waters. In the case of gravels, the groundwater response can be closely coupled with the water levels in the river or coast, but for aquifers the response tends to be much slower: often taking weeks, or even months, to appear after a period of prolonged rainfall.
Coastal flooding	Inundation of land not normally underwater. General areas flooded due to astronomical tidal influences are not considered a "coastal flood" in the context of risk management. A coastal flood is caused by a combination of surge tides and wind and waves, driven by local and remote weather events (wind and pressure).
Tsunami flooding	A flood caused by a geological event, such as an earthquake or underwater landslide, that generates a tsunami wave. Such events can occur suddenly with little to no warning, and lead to flooding in areas far from the epicentre of the generation event.
Outburst (or dam break) flooding	A flood caused by the sudden release of water from a reservoir formed behind a glacier or a response to ice "jam" (and accumulation of ice in a river). When a built dam or embankment fails, a similar behaviour emerges.

Working with natural processes

Flood waters are the life blood of many environments and rural communities and, perhaps more than in any other location, rural flood management involves learning to live with the natural flood dynamics and maximizing the contribution of natural infrastructure (forests, wetlands, functional floodplains, etc.) to water management goals (e.g. Sayers *et al.*, forthcoming). Many rural livelihoods rely on healthy ecosystems that in turn rely on connected river systems (such as the periodic flooding of floodplains and the longitudinal migration of fish). Well-designed solutions find the balance between appropriately managing extreme floods and maintaining connectivity at the system scale (between the channel and functional floodplain, and upstream and downstream processes). This can be achieved by working with natural processes with targeted built interventions where necessary to manage the flood hazard and provide multiple additional benefits (Figure 4.2).

Figure 4.2 | Opportunities existing across the basin for natural infrastructure and working with natural processes



Source: **Sayers, P., Yuanyuan, L., Galloway, G., Penning-Rowsell, E., Shen, F., Wen, K., Chen, Y. & Le Quesne, T.** 2013. *Flood Risk Management: A Strategic Approach.* Manila, ADB, Beijing, China General Institute of Water Resources and Hydropower Planning and Design (GIWP), Paris, UNESCO & Woking, UK, World Wildlife Fund (WWF)-UK. https://unesdoc.unesco.org/ark:/48223/pf0000220870. adapted from Speed *et al.*, 2016

Box 4.3 | Promoting opportunities to work with natural processes in flood management

The importance of functional floodplains to ecosystem health: As a result of periodic inundation, the floodplains of the major rivers including the Amazon, Irrawaddy, the Niger, and Zambezi support wetland ecosystems of exceptional productivity, particularly in comparison with the surrounding arid and semi-arid rangelands where the dry season is long. For centuries, floodplains have played a central role in the rural economy of the region, providing fertile agricultural land that supports a large human population. The flood waters provide a breeding ground for large numbers of fish and bring essential sediments, moisture and nutrients to riparian areas and soils. Water that soaks through the floodplain recharges the underground reservoirs which then supply water to wells beyond the floodplain. As the flood waters recede, arable crops are grown. Soil moisture often persists into the dry season and provides essential grazing for migrant herds.

The floodplains yield valuable nutrients to support fish and provide crucial habitats for wildlife, especially migratory birds (e.g. Acreman, 1996).

Restoring and safeguarding floodplains to reduce downstream flood hazards: A systematic review of case studies from across Africa found strong evidence that functional floodplain wetlands decrease downstream flood magnitudes alongside the attended benefits to biodiversity and healthy of the freshwater ecosystem (Acreman *et al.*, 2021). The Inner Niger Delta in Mali, for example, stores flood water throughout the wet season that is then available for slow release during the dry season (ipud). Reconnecting lakes, such as to the Yangtze River in Hubei Province, China, also enhance flood storage and support restoration efforts (WWF, 2008).

Making space for water – saving costs and improving ecosystem health: The Yolo Bypass in California is a 240 km² leveed floodplain designed to protect Sacramento from flooding. Although the bypass was originally constructed to protect cities from flooding and to maintain agricultural land use, more recently it has been recognized as valuable floodplain habitat that supports significant populations of fish and wildlife (Sommer *et al.* 2001). Approximately one-third of the bypass is now non-agricultural habitats, including ponds, wetlands, grassland, and riparian forest. This means that in addition to providing effective flood protection and summer agriculture, large areas of wetlands provide critical habitat for bird and aquatic species. Allowing the floodplain to be inundated, rather than disconnecting it from the river has resulted in a whole host of environmental benefits, including an important fish spawning ground, rearing nursery and migration corridor. Similarly, from 2006 to 2018, the Room for the River programme in the Kingdom of the Netherlands increased the standard of safety against flooding through various actions, including moving levees back from rivers and creating a "Green River" to serve as an occasional flood bypass acting as a functional floodplain to increasing ecological value (Dutch Water Sector, 2019).

Nature's own protection from coastal storms – mangroves: The Sundarban mangrove forests protect the coast of Bangladesh from flooding and erosion and protect biodiversity including economically important fisheries and tigers (Pitchaikani, 2020). In Chile, estuarine intertidal and permanent salt marshes prevent flooding of coastal land valued at USD 55 million (Rojas *et al.*, 2022), A mix of temperate coastal wetlands reduced flood heights and thus avoided more than USD 625 million in flood damages across 12 coastal states affected by Hurricane Sandy, from Maine to North Carolina, United States of America (Narayan *et al.* 2017). In addition, mangroves are among the world's most valuable coastal ecosystems, providing local communities with numerous services and benefits, such as crab, prawn, and fish resources (Nagelkerken *et al.*, 2008) and thereby also help to contribute to food security and nutrition as well as livelihoods when these fish products are sold.

Sources: **Acreman, M.C.** 1996. Environmental Effects Of Hydro-Electric Power Generation in Africa and the Potential for Artificial Floods. *Water and Environment Journal,* 10(6): 429–435. https://doi.org/10.1111/j.1747-6593.1996.tb00076.x **Acreman, M.C., Smith, A., Charters, L., Tickner, D., Opperman, J., Acreman, S., Edwards, F., Sayers, P. & Chivava, F.** 2021. Evidence for the effectiveness of nature-based solutions to water issues in Africa. *Environmental Research Letters*, 16(6). doi.org/10.1088/1748-9326/ac0210. **World Wildlife Fund (WWF).** 2008. *Water for life: Lessons for climate change adaptation from better management of rivers for people and nature*. Gland, Switzerland, WWF International. http://assets.wwf.org.uk/downloads/water_for_life.pdf. **Sommer, T., Harrell, B., Nobriga, M., Brown, R., Moyle, P., Kimmerer, W. & Schemel, L.** 2001. California's Yolo Bypass: Evidence that flood control can be compatible with fisheries, wetlands, wildlife, and agriculture. *Fisheries*, 26(8): 6–16. **Dutch Water Sector.** 2019. Room for the River Programme. Dutch Water Sector, 15 April 2019. The Hague, Kingdom of the Netherlands. [Cited 2023]. https://www.dutchwatersector.com/news/room-for-the-river-programme. Pitchaikani, J.S. 2020. Integrated coastal zone management practices for Sundarbans, India. Indian Journal of Geo-Marine Sciences, 49(3): 352–356. https://core.ac.uk/reader/326041666. **Rojas, O., Soto, E., Rojas, C. & Lopez, J.** 2022. *Assessment of the flood mitigation ecosystem service in a coastal wetland and potential impact of future urban development in Chile*. Habitat International, 123(2): 1–10. doi.org/10.1016/j.habitatint.2022.102554 Narayan, S., Beck, M.W., Wilson, P., Thomas, C.J., Guerrero, A., Shepard, C.C., Reguero, B.G. *et al*. 2017. The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA. Scientific Reports, 7(1): 9643. http://dx.doi.org/10.1038/s41598-017-09269-z. N**agelkerken, I.S.J.M., Blaber, S.J.M., Bouillon, S., Green, P., Haywood, M., Kirton, L.G., Meynecke, J.O. *et al.*** 2008. The habitat function of mangroves for terrestrial and marine fauna: a review. *Aquatic Botany,* 89(2): 155–185. http://dx.doi.org/10.1016/j.aquabot.2007.12.007

Better spatial land planning to manage the flood hazard

Flood water must go somewhere, and while allowing it to flow and be stored naturally is desirable, this is not always possible. Using a landscape or catchment scale approach to spatial planning is therefore important, and one that explicitly includes consideration of the flood processes and identifies upstream storage areas and flow pathways where flood benefits are greatest and impacts are least. This hazard lens on spatial planning complements a focus on directly reducing (or avoiding increasing) exposure and vulnerability (an important issue which will be returned to later in the chapter). This approach can be coupled with spatial planning of financial incentives, awareness raising, and flood warning and emergency support. In the United Kingdom of Great Britain and Northern Ireland, the Somerset Levels and Moors flood plains are areas that benefit from floods (e.g. that support flood-tolerant grazing pastures) and are preferentially allowed to become inundated, enabling flood protection to be focused on vulnerable areas (e.g. villages, roads, and arable land) (EA, 2021).

Better agricultural land management practice

Productive agricultural systems require healthy soils and freshwater ecosystems. These prerequisites are under pressure, with up to 52 percent of global agricultural lands now being moderately to severely degraded (Iseman and Miralles-Wilhelm, 2021). Intensive and monoculture farming systems contribute to these problems, with poor agriculture practice cited as the primary driver in 80 percent of native habitat loss, biodiversity loss, and soil degradation (Iseman and MirallesWilhelm, 2021). Adopting regenerative and conservation farming practices (Table 4.4) helps to re-establish or maintain soil health, reduce surface water runoff, and improve water quality (e.g. Antolini *et al.*, 2020; Adimassu *et al.*, 2017). These methods work with natural processes and the natural infrastructure of the agricultural landscape contributing to soil management and food security, but in doing so, also contribute to the objectives of good water management (Box 4.4). This includes, for example, reducing the water quality impacts from agriculture runoff through in-field practices – such as improved nutrient management and reduced tillage – to practices such as cover crops, controlled drainage, and field buffers to reduce nutrient and sediment loss. There also may be (where appropriate), opportunities to transfer some land out of direct production (ensuring that this is not done at the expense of the most vulnerable whose livelihoods depend on agrifood systems) through wetland restoration, space for preferential flood routes, and riparian buffers that further reduce nutrient and sediment loss and support wider benefits of biodiversity. The diversity within the agricultural landscape developed through these approaches also tends to encourage pest- and disease-resistant, nutrient-conserving, and bio-diverse food production, and provides multiple economic, cultural, and ecological benefits (Ewel, 1999).

Many countries are considering schemes to offer farmers and landowners financial incentives for managing land for delivering ecosystem services such as reduced downstream flood risk. Incentives can be used to support spatial plans for flood zoning to allow certain areas to flood whilst giving greater protection for others against flooding (see Section 4.1).

Table 4.4 | Agroecology practice supports water management goals

Response theme	Associated measures	Examples
Infiltration: Improving soil health and the water retention through management of infiltration into the catchment	Arable land use practices	Spring cropping (versus winter cropping), use of cover crops. Intensification, set-aside, and arable reversion to grassland.
	Livestock land practices	Lower stocking rates, reduced poaching, restriction of the grazing season.
	Tillage Practices	Conservation tillage, cross-slope ploughing.
	Field drainage (to increase storage)	Deep cultivations and drainage, to reduce impermeability.
	Buffer strips and buffering zones	Contour grass strips, hedges, shelter belts, bunds, riparian buffer strips.
	Machinery management	Low ground pressures, avoiding wet conditions.
Storage: Improving biodiversity and water retention through enhanced natural storage schemes	Upland water retention	Farm ponds, ditches, wetlands
	Water storage areas	Washlands, polders, reservoirs

Table 4.4 (Cont.)

Conveyance: managing connectivity	Management of hillslope connectivity	Blockage of farm ditches and moorland grips
	Buffer strips and buffering zones to reduce connectivity	Contour grass strips, hedges, shelter belts, bunds, field margins, riparian buffer strips
	Channel maintenance	Reduced maintenance of farm ditches
	Channel realignment	Re-establishing meanders

Source: **Sayers, P., Yuanyuan, L., Galloway, G., Penning-Rowsell, E., Shen, F., Wen, K., Chen, Y. & Le Quesne, T.** 2013. *Flood Risk Management: A Strategic Approach.* Manila, ADB, Beijing, China General Institute of Water Resources and Hydropower Planning and Design (GIWP), Paris, UNESCO & Woking, UK, World Wildlife Fund (WWF)-UK. https://unesdoc.unesco.org/ark:/48223/pf0000220870

Box 4.4 | Agroecology: Multiple benefits for water management

In **Burkina Faso**, northern **Cote d'Ivoire** and **Mali**, contours retain rainwater on fields between the ridges, where it filters into the soil (infiltration is about 10 percent of the total rainfall), while the excess water drains away slowly to the ends of the field (Gigou *et al*., 2006). Contour ploughing has also been found to be effective in Kenya, on slopes with less than a 10 percent slope, where it reduced soil erosion and increased water infiltration (Gowland-Mwangi *et al*., 2010), in **Tigray, Ethiopia,** where it reduced runoff (Gebreegziabher *et al*., 2009) and in **Tunisia**, where it reduced runoff by 75 percent compared to the fallow plot (Al Ali *et al*., 2008).

In **Ethiopia**, conservation tillage – involving contour ploughing and the construction of invisible subsoil barriers – decreased surface runoff, waterlogging and soil loss and increased crop yield (Temesgen *et al*., 2012) with surface runoff reduced under conservation tillage by 48 and 15 percent for wheat and teff, respectively. The establishment of furrows and ridges as part of conservation agriculture in Ethiopia decreased runoff by 51 percent and soil loss by 81 percent protecting downslope areas from flooding (Nyssen *et al*., 2011). The benefits of soil conservation practices applied in the Shkedim catchment, Israel, were shown by lower runoff yields and peak discharges (Bekin *et al*., 2021).

In **Taiwan**, terraced paddy fields play a crucial role in water and soil conservation in mountainous areas, where their water-storage capacity reduces floods (Chen *et al*. 2014).

In **Israel** the ancient stone terrace walls constructed in the dry valleys of the central Negev highlands, slow runoff, and trap sediment enabling agricultural production in places crops would not grow if unaided (Ore and Bruins, 2012).

Sources: **Gigou, J., Traore, K., Giraudy, F., Giraudy, F., Coulibaly, H., Sogoba, B. & Doumbia, M.** 2006. Farmer-led contour ridging can reduce water runoff in African savannahs. *Cahiers Agriculture*, 15(1): 116–122. **Gowland-Mwangi, J., Odiaga Oloo, J. & Wambugu Maina, S.** 2010. The effectiveness of Farmer Field Schools' extension methodology in conserving soil and water using contour ploughing, unploughed strips and farm yard manure. *Problems of Education in the 21st Century*, (26): 52–65. http://www.scientiasocialis.lt/pec/files/pdf/vol26/52-65.Gowland-Mwangi_Vol.26.pdf. **Gebreegziabher, T., Nyssen, J., Govaerts, B., Getnet, F., Behailu, M., Haile, M. & Deckers, J.** 2008. Contour furrows for in situ soil and water conservation, Tigray, Northern Ethiopia. *Soil and Tillage Research*, 103(2): 257–264. https://doi.org/10.1016/j.still.2008.05.021. **Al Ali, Y., Touma, J., Zante, P., Nasri, S. & Albergel, J. 2**008. Water and sediment balances of a contour bench terracing system in a semiarid cultivated zone (El Gouazine, Central Tunisia). Hydrological Sciences Journal, 53(4): 883–892. **Temesgen, M., Uhlenbrook, S., Simane, B., Van Der Zaag, P., Mohamed, Y., Wenninger, J. & Savenije, H.H.G.** 2012. Impacts of conservation tillage on the hydrological and agronomic performance of Fanya juus in the upper Blue Nile (Abbay) river basin. *Hydrology and Earth System Sciences*, 16(12): 4725–4735. https://doi.org/10.5194/hess-16-4725-2012. **Nyssen, J., Govaerts, B., Araya, T., Cornelis, W.M., Bauer, H., Haile, M., Sayre, K. & Deckers, J.** 2011. The use of the marasha ard plough for conservation agriculture in Northern Ethiopia. *Agronomy for Sustainable Development,* 31(2): 287–297. https://hal.science/hal-00930453/document#:~:text=Farmers%20traditionally%20use%20the%20marasha,after%20crop%20emergence%20(shilshalo). **Bekin, N., Prois, Y., Laronne, J.B. & Egozi, R.** 2021. The fuzzy effect of soil conservation practices on runoff and sediment yield from agricultural lands at the catchment scale. *Catena*, 207: 105710. https://doi.org/10.1016/j.catena.2021.105710. **Chen, S.K., Chen, R.S. & Yang, T.Y.** 2014. Application of a tank model to assess the flood-control function of a terraced paddy field. *Hydrological Sciences Journal,* 59(5): 1020–1031. https://doi.org/10.1080/02626667.2013.822642. **Ore, G. & Bruins, H.J.** 2012. Design features of ancient agricultural terrace walls in the Negev desert: human-made geodiversity. *Land Degradation and Development*, 23(4): 409–418.

Blending natural and built infrastructure

Blending natural and built water infrastructure offers an opportunity for the strengths of one to be used to compensate for the weaknesses of the other. Built infrastructure, for example, will remain essential in some instances, providing well-targeted protection from extreme floods to supplement the performance of natural infrastructure (Sayers *et al.*, forthcoming). Recognising the value of natural infrastructure (such as forests, functional floodplains, and wetlands) within this blended context underpins an ecosystem-based approach to disaster risk reduction (Eco-DRR) (PEDRR, 2020) as well as important initiatives such as Engineering with Nature (Bridges *et al.*, 2018) and nature-based solutions (NbS) (including blue-green natural infrastructures). The United Nations Office for Disaster Risk Reduction (UNDRR) Words into Action (UNDRR, UNEP and PEDRR, 2021), for example, reinforces the positive role natural infrastructure and NbS can play in managing risk and provides guidance on how NbS can help governments address the growing challenges of climate change, biodiversity loss, increased frequency of extreme weather and natural hazards as well as other human-made environmental disasters. Through these initiatives there is a growing acceptance of the benefits of natural infrastructure working alongside well-targeted built interventions from local project scales to landscape scale actions to reduce flood flows (Box 4.5). Such solutions also offer a wide range of benefits for water risk management (Sayers *et al.*, forthcoming), water quality (e.g. constructed wetlands to treat agricultural runoff) and resources (promoting infiltration and storing water for slow release). Reconfiguring legacy infrastructure also provides a significant opportunity to restore connectivity with the river system and soil health. This includes the re-purposing or even removal of dams which are no longer fit for purpose (Box 4.6).

Box 4.5 | Hybrid solutions - Blending natural and built infrastructure

"Greening the grey" around Europe's coast: Across the North Sea region, a great emphasis is being placed on using combinations of built in concert with nature-based solutions. In Belgium, Germany, and the Kingdom of the Netherlands this is an important but difficult task as about 85 percent of the coast has a legacy of built structures. Increasingly the application of nature-based design concepts to develop hybrid design solutions is being actively pursued. In Germany, for example, the Wadden region is protected by dikes (embankments) against flooding from the Wadden Sea, a shallow marine area, marked by barrier islands, sand and mud flats and coastal marshes. Some sections of dike do not meet current safety standards, so are being transformed into wide green dikes. These are built with a historical design using only natural materials, such as clay covered with grass, and have a mildly sloping seaward face that merges smoothly into the adjacent salt marsh (Van Loon-Steensma and Vellinga, 2019).

Creating rural field based leaky storage: CCatchment storage ponds, constructed with a "leaky" timber barrier, store flood water and release it slowly back to the river once the flood peak has passed. Such features have enhanced surface water storage in the Belford Burn catchment, United Kingdom (Welton and Quinn, 2011). The bunds hold water all year round for ecological benefits.

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Catchment storage pond, Belford, United Kingdom, with a "leaky" timber barrier

Tchida village, west of Niamey in the Niger is developing the use of demi-lunes (shallow pits to slow floodwaters and enjoy infiltration). The approach seeks to improve soil health, encourage vegetation growth and opportunities for framing to help address seasonal flooding and improve food security. The programme uses a traditional land management practice (zaï pits) to restore 120 hectares of degraded land. The programme was funded by the World Bank, Global Environment Facility (GEF), and the Government of the Niger (GLF, 2017).

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Demi-lunes used as local landscape improvements to support agriculture in drylands in Niger

Sources: **Van Loon-Steensma, J.M. & Vellinga, P.** 2019. How "wide green dikes" were reintroduced in The Netherlands: a case study of the uptake of an innovative measure in long-term strategic delta planning. *Journal of Environmental Planning and Management*, 62(9): 1525–1544. https://doi.org/10.1080/09640568.2018.1557039. **Welton, P. & Quinn, P**. 2011. *Runoff Attenuation Features A guide for all those working in catchment Management*. Bristol, UK, EA & Newcastle-upon-Tyne, UK, Newcastle University. https://research.ncl.ac.uk/proactive/belford/papers/Runoff_Attenuation_Features_Handbook_final.pdf. **GLF (Global Landscapes Forum).** 2017. The Niger is a surprising success story in Forest and Landscape Restoration (FLR). *Think Landscape*, 9 October, 2017. Bonn, Germany. [Cited 2023]. https://thinklandscape.globallandscapesforum.org/24278/niger-a-hidden-beauty-in-implementing-forest-and-landscape-restoration-flr-on-the-ground/

Box 4.6 | Dam repurposing for environmental benefits to rural livelihoods

Prior to construction of the Manantali dam on the River Senegal in Mali, the natural inundation of the floodplain supported up to 250 000 ha of flood recession agriculture, fisheries, and forests which provide fuelwood and construction timber, and wildlife habitat along the Senegal Mauritania border. The dam was built to supply hydroelectricity to urban people and industry, but there was little rural electrification, so the rural poor did not benefit and suffered from the loss of floods. Cost–benefit analyses showed that the best economic option was to use the dam both to release managed floods and to generate some hydropower, so this was undertaken for a transitional period of ten years. However, the releases made were small, inundating only 50 000 ha, and halted after turbines were installed, as power generation was given higher priority (Hollis, 1996).

Under natural conditions, flood waters from the River Logone in northern Cameroon, inundate 6 000 km^2 of floodplain in northern Cameroon providing vital ecosystem services for local communities including fishing, grazing and flood recession agriculture valued at USD 2.5 million per year (Loth, ed., 2004) and 150 000 ha of Waza National Park supporting elephants, giraffes, lions, and various antelope. Due to low rainfall in 1970s and increasing food demands from a rising population, a dam and embankments were built along the river and across the floodplain, creating Lake Maga (20 ha) to feed an intensive rice cultivation scheme. This led to reduced floodplain inundation, loss of biodiversity and reduced tourist potential of the park and devastated the floodplain fisheries and pastoral economy (Acreman, 1994). To rectify this situation, the embankments were modified in 1994 and releases subsequently made from Lake Maga to allow flood waters to reach the floodplain, which revitalized the traditional natural resources, farming practices and biodiversity in the park. The existence of the dam and embankments means that floods can be controlled and are more consistent from year to year compared with the natural high hydrological variability which often brought massive floods one year and no flood the following year (Loth, ed., 2004).

Sources: **Hollis, G.E.** 1996. Hydrological inputs to management policy for the Senegal River and its floodplains. In: **M.C. Acreman & G.E. Hollis, eds**. *Water management and wetlands in sub-Saharan Africa*. Gland, Switzerland, IUCN. **Acreman, M.C.** 1994. The role of artificial flooding in the integrated development of river basins in Africa. In: C. Kirby & W.R. White, eds. *Integrated River Basin Development*. New York, USA, Wiley. **Loth, P., ed.** 2004. *The return of the water: restoring the Waza Logone floodplain in Cameroon*. Gland, Switzerland, IUCN.

4.2.2 Reducing exposure and vulnerability

Reducing exposure and vulnerability are necessary frontline actions. In any flood risk management strategy, the central considerations are to enhance the coping capacities of people, communities and institutions, reduce vulnerabilities, take actions to proactively reduce exposure in the face of flood risks, prepare before a flood occurs, and to take effective AA ahead of a forecast flood (e.g. Sayers *et al.*, 2013; FAO, 2023b). Some of the key measures are discussed in the next section.

Proactive risk reduction interventions before the flood

Understanding and effectively communicating flood risks

A prerequisite for effective and efficient flood risk management is an appropriate level of knowledge of the prevailing hazards and risks. Multiple mechanisms exist to enhance flood risk understanding. These include flood risks maps and assessments, sharing of flood stories, and educational outreach activities to develop a collective understanding of the flood risks faced by the context relevant agrifood systems (Box 4.7). The process of mutual awareness raising facilitates dialogue, and creates a platform for collaboration between disciplines and sectors as well as between planners and local communities.

Box 4.7 | Participatory flood mapping

In **India**, the flood hazard zones of the Kasari River catchment, were defined through a combination of remote sensing, geographic information system (GIS) techniques and a digital elevation model (DEM). More than 50 percent of agricultural land areas came under the zone of very high flood vulnerability (Sapkale *et al.*, 2022).

In the **Hindu Kush Himalaya**, moraine-dammed glacial lakes are common and numerous glacial lake outburst flood events have been traced back to the failure of moraine dams. Although there is still much to learn about the dynamics of glaciers and glacial lakes, the International Centre for Integrated Mountain Development (ICIMOD) is continuing to bring together collective knowledge to better understand the various drivers of change and their impacts and develop a set of evidence-based and actionable policy solutions and recommendations (Wester *et al.*, 2019).

In **Indonesia**. participatory mapping is one of the solutions in reducing the impact of future floods by promoting risk-informed development and land use through a process of flood zoning (highlighting areas at greater and lesser hazard and identifying appropriate land uses depending upon the hazard). The community plays an important role in participatory mapping using remote sensing World View-2 data so that people also understand the conditions they face (Sudaryatno and Pratiwi, 2017).

Sources: **Sapkale, J.B., Sinha, D., Susware, N.K. & Susware, V.** 2022. Flood Hazard Zone Mapping of Kasari River Basin (Kolhapur, India), Using Remote Sensing and GIS Techniques. *Journal of Indian Society of Remote Sensing*, 50: 2523–2541. doi.org/10.1007/s12524-022-01610-y**Wester, P., Mishra, A., Mukherji, A. & Shrestha, A.B.** 2019. *The Hindu Kush Himalaya Assessment: Mountains, Climate Change, Sustainability and People,* p. 627. Berlin, Springer Nature. **Sudaryatno, D.A. & Pratiwi, S.E.** 2017. Participatory Mapping for Flood Disaster Zoning based on World View-2 Data in Long Beluah, North Kalimantan Province. *Earth and Environmental Science*, 98(1): 012011. https://ui.adsabs.harvard.edu/link_gateway/2017E&ES...98a2011S/doi:10.1088/1755-1315/98/1/012011

In the absence of major public flood control schemes (as may be promoted for urban areas) community-based flood risk management is often key to strengthening resilience in rural settings. Local communities therefore necessarily have a lead role in flood risk management planning, implementation, and monitoring, and this action builds coping capacity. Raising awareness of the risks faced and how they are generated, both helps motivate involvement and supports the identification of measures that can make a real difference (Box 4.8).

Box 4.8 | Empowering local communities to act

In **South Africa**: In the northern Limpopo Province, rural communities are acting to improve their flood resilience. Actions being taken range from digging furrows and diverting surface flood flows, to constructing raised areas around their homes. The local indigenous knowledge is helping to form part of a wider programme of integrated development planning (Munyai *et al.*, 2021).

In **Nepal**: The livelihoods of rural populations in Nepal rely heavily on monsoon rains. However, highly variable and erratic rainfall patterns can often result in floods or droughts. A community-based flood and drought risk management plan in Nepal, led by a local task group, was developed and promoted adaptations including suitable crops and agronomic management practices, such as the adoption of suitable crop varieties, proper spacing and application of plant nutrients based on the number of rainfall events (FAO, 2020).

In the **United Kingdom**: Local landowners are encouraged to enhance natural flood risk management measures on their own farmland, such as leaky woody dams, earth field bunds, silt traps, dry ponds, and offline storage areas to intercept flows (Short *et al.*, 2018). Environmental land management (ELM) payments are being actively explored.

In **China**: The establishment of farmers' cooperatives have enabled local farmer communities to play a key role in disaster risk management. Tailor-made training plans were developed for capacity building of farmers' cooperative leaders and a series of community-level training activities were held to support the development of cooperative actions, with active participation of women specifically addressed (FAO, 2010).

Sources: **Munyai, R.B., Chikoore, H., Musyoki, A., Chakwizira, J., Muofhe, T.P., Xulu, N.G. & Manyanya, T.C.** 2021. Vulnerability and Adaptation to Flood Hazards in Rural Settlements of Limpopo Province, South Africa. Water, 13(24): 3490. doi.org/10.3390/w13243490. **FAO**. 2020. Community Action Planning (CAP) to promote adaptation to drought and flood risks in Nepal. Rome. https://www.fao.org/3/CA3030EN/ca3030en.pdf. **Short, C., Clarke, L., Carnelli, F., Uttley, C. & Smith, B.** 2018. Capturing the multiple benefits associated with nature-based solutions: Lessons from a natural flood management project in the Cotswolds, UK. *Land Degradation and Development.* 30(3): 241–252. https://doi.org/10.1002/ldr.3205. **FAO**. 2010. P*romotion of Farmers' Cooperative (FC) development for Community-Based Disaster Risk Management (CBDRM)* in China. Rome. https://www.fao.org/3/ca4595en/ca4595en.pdf

Encouraging the transition to flood sensitive agricultural practices

In addition to the regenerative and conservation practices to better manage the flood hazard (introduced earlier), there are also opportunities to adopt wetter farming practices that have greater flood tolerance. This may include growing different crops more suited to wetter conditions or seasonal uses that reflect the natural rhythm of rivers (Box 4.9).

Box 4.9 | Adapting agricultural practice to reduce flood risk

IIn **Orissa, India**, one way to make agricultural systems more resilient is by developing and adopting higher-yielding and more flood tolerant crop varieties and livestock breeds. One flood tolerant rice variety yielded 45 percent more than the most popular variety (Dar *et al*. 2013).

In **Balaka District, Malawi**, flood recession agriculture, depression agriculture, spate irrigation, and inundation canals and dugouts are all used, but external investment will be needed as well as actions to increase farmers' awareness to increase take-up and realise the full benefits of flood-based farming (Msume, Mwale and Castelli, 2022).

In the **Mekong River Delta, Viet Nam**, new flood-based farming practices are used which result in improved household income during the flood season. These actions are having impacts on household confidence in securing food, income, health, and enabling evacuation during floods, recovery after floods as well as generating wider interest in learning and practicing new flood-based farming practices (Narayan, Nguyen and James, 2013).

Common insights into the social aspects that influence the uptake of flood-based farming practices are also emerging. In **eastern Nepal,** where existing adaptation tends to be limited to conventional seed storage and planting flood-tolerant rice,a study showed that the lack of take up of a broader set of measures was linked to the age, education and income of the head of the household, and the area cultivated, as well as previous flood experience, the perception of flood risk, access to relief programmes, and the membership of social groups (Pathak, 2021).

In **Zambia**, farmers diversified into the selling of reeds and thatching grass, firewood sales, charcoal production, and wild food collection (Mabuku *et al*., 2018). In Namibia, farmers have sought to live with the floods with the addition of mafisa cattle trade, changing planting dates and fish farming (Mabuku *et al*., 2019). Farmers in flood-prone areas in **northern Ghana** adopted mixed farming practice with a current focus on the rearing of goats and poultry, the cultivation of new and improved crop varieties, and the planting of early-maturing crop varieties (Abarike *et al*., 2018).

Sources: **Dar, M., de Janvry, A., Emerick, K., Raitzer, D. & Sadoulet, E.** 2013. Flood-tolerant rice reduces yield variability and raises expected yield, differentially benefitting socially disadvantaged groups. *Scientific Reports*, 3(1): 3315. http://dx.doi.org/10.1038/srep03315. **Msume, A.P., Mwale, F.D. & Castelli, G.** 2022. Inventory, and drivers of the adoption of flood-based farming systems in South-Eastern Africa: Insights from Malawi. *Irrigation and Drainage*, 71(2): 521–533. https://doi.org/10.1002/ird.2664. **Narayan, S., Nguyen, K.V. & James, H.** 2013. Measuring Household Resilience to Floods: a Case Study in the Vietnamese Mekong River Delta. *Ecology and Society,* 18(3): 14. doi. org/10.5751/ES-05427-180313, **Pathak, S.** 2021. Determinants of flood adaptation: Parametric and semiparametric assessment. *Journal of Flood Risk Management,* 14(2): e12699. doi.org/10.1111/jfr3.12699. **Mabuku, M.P., Senzanje, A., Mudhara, M., Jewitt, G. & Mulwafu, W.** 2018. Rural households' flood preparedness and social determinants in Mwandi district of Zambia and Eastern Zambezi Region of Namibia. *International Journal of Disaster Risk Reduction*, 28: 284–297. doi.org/10.1016/j. ijdrr.2018.03.014. **Mabuku, M.P., Senzanje, A., Mudhara, M., Jewitt, G.P.W. & Mulwafu, W.O.** 2019. Strategies for coping and adapting to flooding and their determinants: A comparative study of cases from Namibia and Zambia. *Physics and Chemistry of the Earth*, 111(1): 20–34. https://doi.org/10.1016/j.pce.2018.12.009. **Abarike, A.M., Yeboah, R.W.N. & Dzomeku, I.K.** 2018. Strategies of Farmers in the Bawku West District of Ghana to Mitigate the Impacts of Climate Variability on Farming. In: **O. Saito, G. Kranjac-Berisavljevic, K.A. Takeuchi, & E. Gyasi,** eds. *Strategies for Building Resilience against Climate and Ecosystem Changes in Sub-Saharan Africa*, pp. 217–235. Singapore, Springer.

Proactive spatial planning to avoid inappropriate development and establish "safe" shelters

Spatial planning, land use zonation and development controls are perhaps the primary vehicles for managing flood risk in a sustainable manner, working directly to reduce exposure and vulnerability to flooding, while avoiding any change in development which could unnecessarily increase risk. A proactive spatial planning process can act to reduce flood risk through:

- **Reducing exposure through flood zoning:** Identifying the type of land use that may be appropriate given the nature of the flood hazard. For example, identifying areas as functional floodplains, preferential flood routes and flood detention areas to "store" water at times of peak flows. This may require creating space within rural developments as well as being clear on locations to be maintained for periodic storage (including some agricultural and wetland areas).

- **Reducing vulnerability through risk proofed infrastructure:** Designing buildings to prevent or reduce flood water entering them, along with internal arrangements to safeguard contents (such as raising tools and seeds above the flood level, and waterproof storage for seeds, grains and farming tools) and using construction techniques capable of withstanding flood loads or that can be easily repaired are all opportunities to reduce vulnerability.

- **Save havens:** Establishing safe havens, located appropriately within the floodplain, and making communities aware of their locations can play a vital role in saving lives and livelihoods during times of flood (Box 4.10). This includes providing safe refuge for people, equipment, fishing boats, and livestock, to aid recovery when the flood water recedes. Such activities range from the creation of community safe havens (such as part of a school or similar building) to individual property modifications (such as creating roof access or property wall strengthening) depending on the local context.

Box 4.10 | Access to shelters and safe havens and use of improved building standards

Shelters provide a safe haven in Bangladesh: A low-lying delta nation at the foot of the Himalayas, Bangladesh is a country exposed to many climate related hazards, especially floods, tornadoes, and cyclones. More than three million people live in high-risk areas along the 400 km coast. Disaster preparedness has long been a central focus of the government, including the use of flood shelters (e.g. Sayers *et al*., 2013). Three types of flood shelters exist in Bangladesh: community shelters, school-cum-shelters, and individual homesteads. Issues include accessibility to shelters, land availability, protection of lives and livelihoods, basic facilities and services, the safety and security of women and children, the willingness and priority of potential users, and maintenance and cost-effectiveness (Rahman *et al*., 2015).

The construction of hurricane-resistant livestock shelters in Saint Lucia: Livestock producers in Saint Lucia are highly vulnerable to the impact of hurricanes and windstorms, which occur annually. The animal shelters often do not adequately address the material and design requirements to appropriately strengthen these structures in order to minimize the risks and losses to the farmer. Sometimes this is due to the lack or limited technical advice the farmers have obtained before constructing the structures as well as the limited access to finance to adequately build the shelters. Using climate proofing interventions, the construction of an affordable, simple and practical livestock housing incorporates design features that aim to minimize structural damage from strong winds, minimize disease risks and provide facilities for rainwater harvesting and storage. The installment of hurricane clamps and bolts as part of the design feature helps to reinforce the roofs and foundations of their structures. Existing structures can also be retrofitted (FAO, 2013).

Adapting buildings reduces flood damage in the Philippines: The typhoons and severe floods in September 2011 in the Philippines did little damage to building structures that were well adapted to frequent flooding and thanks to local ways of protecting property during floods (Ohara *et al*., 2016). Even when covered with 1m of floodwaters, residents had moved furniture and household goods to the second floor or to neighbours' houses before water arrived. During inundation, people preferred to stay on the roof or in dry spaces inside houses even during inundations instead of evacuating because they preferred to protect their property. Inundation above the height of electric plugs caused more hindrance to daily life because it prevented electricity use. Residents took liquefied petroleum gas tanks to the second floor or to the roof top to use them for cooking during evacuation.

Sources: **Sayers, P., Yuanyuan, L., Galloway, G., Penning-Rowsell, E., Shen, F., Wen, K., Chen, Y. & Le Quesne, T.** 2013. *Flood Risk Management: A Strategic Approach.* Manila, ADB, Beijing, China General Institute of Water Resources and Hydropower Planning and Design (GIWP), Paris, UNESCO & Woking, UK, World Wildlife Fund (WWF)-UK. https://unesdoc.unesco.org/ark:/48223/pf0000220870. **Rahman, A., Mallick, F.H., Mondal, M.S. & Rahman, M.R.** 2015. Flood Shelters in Bangladesh: Some Issues from the User's Perspective. In: **Collins, A., Jayawickrama, J., Jones, S., Manyena, B., Walsh, S. & J.F. Shroder, eds.** *Hazards, Risks, and Disasters in Society,* pp. 145-159. Amsterdam, Elsevier. **FAO**. 2013. *Construction of a hurricane-resistant small ruminant shelter*, St. Lucia. Rome. https://www.fao.org/3/CA3022EN/ca3022en.pdf. **Ohara. M., Nagumo, N., Shrestha, B.B. & Sawano, H.** 2016. Flood Risk Assessment in Asian Flood Prone Area with Limited Local Data – Case Study in Pampanga River Basin, Philippines. *Journal of Disaster Research*, 11(6): 1150–1160. https://www.jstage.jst.go.jp/article/jdr/11/6/11_1150/_pdf

Livelihood diversification and lifestyle changes

Subsistence producers and small farm wage labourers in the rural areas of low-income countries constitute over twothirds of the global poor and food insecure populations (FAO, IFAD and WFP, 2015). Diversification of livelihoods is a commonly applied strategy for coping with economic and environmental shocks and instrumental in poverty reduction. Livelihood diversification (through occupational diversification or off-farm diversification) can help rural families and communities develop a diverse array of resources that help them survive and improve their living standards (e.g. Ellis, 1998). It is generally accepted that diversification to non-farm livelihood strategies (rather than relying only on subsistence farming) enables households to have better incomes, enhances food security, and increases agricultural production through modernization (e.g. Gautam and Anderson, 2016). Encouraging appropriate diversity in agriculture by using more climatetolerant varieties and choosing different crops provides an opportunity to build flood resilience, while also supporting a broader agenda of poverty reduction, and as part of the flood risk management strategy (rather than forcing diversification in response to the losses incurred during a flood) (Gautam and Anderson, 2016).

Both non-farm and farm-based opportunities exist to diversify livelihoods. The diversification of farm-based activities are those most likely to be accessible to poorer households and connect closely with flood management in rural settings. Within this farm-based context, innovative and flood-appropriate approaches to diversification are emerging, from the increasing use of aquaculture to symbiotic farming (such as integrated rice–fish/crab farming) (Box 4.11).

Box 4.11 | Livelihood diversification and rural community action supports flood resilience

Farm-based diversification in Viet Nam: In the Mekong Delta, Vietnamese farmers are actively diversifying to farming methods that are either less vulnerable to flooding or use the opportunity flooding provides by: (i) growing freshwater giant prawns to take advantage of the high flooding system; (ii) building ponds to raise fish, using trash fish caught in the flood season as feeds for cultured fish; (iii) switching to more profitable cash crops (e.g. sesame) rather than rice; (iv) adopting multiple cropping systems (e.g. double or triple rice crops) within an embanked system; and (iv) practicing integrated freshwater aquaculture (e.g. integrated rice–fish/crab farming) (Narayan, Nguyen and James, 2013).

Rural community organizations play a vital role in reducing risk – Oti basin, Togo: The underlying drivers of vulnerability are being addressed through the creation of new income generating opportunities and increasing the capacity of communities to manage their own flood risk (Komi, Amisigo and Diekkrüger, 2016). This includes seeking to establish local, village-level, flood risk management committees to help access emergency funds and insurance for local households, embed flood risk management as part of the school curricula, and address the lack of early warning systems and emergency plans.

Farm and non-farm-based diversification in the Okavango Delta, Botswana: Across the delta, floods often cause widespread damage to crops and property, livestock are lost to drowning and being caught in the mud, and public infrastructure and services are often disrupted or even lost (Motsholapheko, Kgathi and Vanderpost, 2011). Many households in rural villages depend on access to natural capital, which is threatened by population growth, land use changes, policy shifts, upstream developments, global economic changes, and climate change. Livelihood and income diversification is seen as the key to improving resilience, as it works alongside proactive planning to enable temporary relocation to less affected areas, and the use of canoes for early harvesting or evacuation and government assistance, particularly for the most vulnerable households, and training in non agricultural skills.

Sources: **Narayan, S., Nguyen, K.V. & James, H.** 2013. Measuring Household Resilience to Floods: a Case Study in the Vietnamese Mekong River Delta. *Ecology and Society*, 18(3): 14. doi. org/10.5751/ES-05427-180313. **Komi, K., Amisigo, B.A. & Diekkrüger, B.** 2016. Integrated Flood Risk Assessment of Rural Communities in the Oti River Basin, West Africa. *Hydrology*, 3(4): 42. http://dx.doi.org/10.3390/hydrology3040042. **Motsholapheko, M.R., Kgathi, D.L. & Vanderpost, C.** 2011. Rural livelihoods and household adaptation to extreme flooding in the Okavango Delta, Botswana. *Physics and Chemistry of the Earth*, 36(s 14–15): 984–995. http://dx.doi.org/10.1016/j.pce.2011.08.004

Reducing existing exposure by supporting relocation

Between 3.6 million people were displaced annually between 2008 and 2018 across India, primarily due to flooding (ReliefWeb, 2020). In some of the locations it was possible for some of the diplaced to return. At the coast, as sea levels rise, sea defenses will become increasingly difficult and costly to maintain and the permanent relocation of some communities will be inevitable (Sayers *et al.*, 2022).

The decision to relocate permanently, especially if done proactively rather than reactively through necessity, is complex and shaped by many different factors (Box 4.12). People have strong place-based associations, and these attachments are important determinants, not only of the decision to move, but also of the success of the relocation process. Realignment of the community to make space for the natural function of the river or sea reduces flood exposure and can, if undertaken with consent, be an important aspect of flood risk management processes. Doing so successfully relies on close engagements, raising awareness of risks (and how this may change) and providing support (financial, planning, and social) for those affected. Relocating within the area, rather than to more remote locations, can help maintain the community cohesion and important place-based associations.

Box 4.12 | Temporary and permanent supported relocation

Temporary relocation and safe havens: In July 2020, in China, the Chinese government set up 88 temporary relocation sites in East China's Anhui Province to house residents displaced by rain-triggered floods wreaking havoc across the province, with more than 3 200 people taking shelter at the sites (ReliefWeb, 2020). The UK Government work with charities and the local councils to provide emergency accommodation if residents need to be evacuated during a flood. Research in Thailand identified appropriate locations of temporary shelters that maximize the number of flood victims that can be covered or can reach a shelter within a fixed distance and to minimize the total distance of all flood victims to their closest shelters (Chanta and Sangsawang, 2012).

Post-flood resettlement in rural Mozambique involved a movement away from rainfed subsistence agriculture towards commercial agriculture and non-agricultural activities (Arnall *et al.*, 2013). The ability to secure a viable livelihood was a key determinant of whether resettlers remained in their new locations or returned to the river valleys despite the risks posed by floods.

Permanent relocation: In the United Kingdom, local housing plans are more closely aligned with the long-term shoreline management plan, identifying, and purchasing or repurposing land (land banking) that is at high flood risk for future community development. A key step is to ensure affected communities are meaningfully engaged in the decision-making process. This is followed by support to property owners (and local authorities) to access assistance packages (for demolition and relocation) including buy-back or lease-back schemes and preferential access to development land. Unfortunately, for high-risk coastal communities that face the prospect of relocation: compensation, or compulsory purchase (at risk free market prices) are not generally available as a taxpayer-funded coastal management option (Sayers *et al.*, 2022).

Sources: **ReliefWeb.** 2020. *Chinese flood-hit province sets up 88 temporary relocation sites*. ReliefWeb, 10 July 2020. New York, USA. [Cited 2023]. https://reliefweb.int/report/china/chinese-flood-hit-province-sets-88-temporary-relocation-sites. **Chanta, S. & Sangsawang, O.** 2012. Shelter-Site Selection during Flood Disaster. The 4th International Conference on Applied Operational Research. *Volume: Lecture Notes in Management Science 4*, July 2012. https://www.researchgate.net/profile/Sunarin-Chanta-2/publication/272831306_Shelter-Site_Selection_during_Flood_Disaster/links/54f13ae00cf2f9e34efdad95/Shelter-Site-Selection-during-Flood-Disaster.pdf. **Arnall, A., Thomas, D.S.G., Twyman, C. & Liverman, D.** 2013. Flooding, resettlement, and change in livelihoods: evidence from rural Mozambique. *Disasters*, 37(3): 468–488. https://doi.org/10.1111/disa.12003. **Sayers, P., Moss, C., Carr, S. & Payo, A.** 2022. Responding to climate change around England's coast - The scale of the transformational challenge. Ocean and Coastal Management, 225: 106187. https://doi.org/10.1016/j.ocecoaman.2022.106187

Managing the residual risk: Improving preparedness and Anticipatory Actions

Regardless of the effort devoted to reducing flood risk, a residual risk will always remain. Emergency management has therefore always been a crucial component of disaster risk management focusing on preparing for floods and planning the response to be made during a flood emergency. This includes raising awareness and encouraging investment in forecasting and warning systems alongside the ability to scale up AAs as a flood becomes increasingly certain to occur.

Being prepared for a flood and taking AA in the short time frame between the early warning and the flood occurring can significantly reduce its impact. Therefore, investment in enhancing preparedness and enabling AA must take place to complement longer-term flood risk management measures which are aimed to address the root causes of vulnerability and exposure. However, to be successful, any measures need proactive planning and coordination.

Being prepared: emergency management

Developing an understanding of the residual risk, improving forecasting and early warning, creating safe refuges and havens for people, equipment, assets, and livestock, and establishing preferential routes of access and egress from potential flood areas, are all actions that should be considered long in advance of a flood event, and should all be defined in consideration of the relevant agrifood systems in the given specific context. Enhancing preparedness involves the creation of clearly marked and controlled access and egress routes and raising awareness of escape routes (to enable successful self-evacuation), as well as access to markets. Preparedness also has a strong connection to governance, as effective emergency response relies on leadership and coordination across all emergency services, local and regional governments and aid agencies, and with a view on a planned response and recovery. This then allows the chance build back better (see section 4.3), and thus, to reduce root causes of risk and vulnerabilities in the face of future disasters. This in turn requires efficient and reliable communication channels to be established (and routinely practiced) to ensure information is exchanged and AAs are coordinated within and across sectors and for all the elements of the agrifood systems in question.

Anticipatory Action

Anticipatory Action is key to preventing a flood becoming a disaster. Acting ahead of time, AA can reduce acute humanitarian impacts before they fully unfold. Anticipatory Action also forms a central component of flood risk management (Box 4.13). For example, although long lead time forecasts are often uncertain, they nonetheless provide an opportunity to initiate low regret preparations, such as defining livestock evacuation routes, as well as kick-starting AA such as cash for work to reinforce river banks and clear irrigation canals, or animal health support to prevent flood-induced disease outbreaks. As the lead time shortens and the uncertainty in the forecast reduces, additional AAs can be triggered, such as the evacuation of livestock, the distribution of cash and equipment to protect productive assets, and early crop harvesting, among others. It is crucial to have plans in place to ensure the timeliness and effectiveness of the anticipatory approach, including budget allocations and financial instruments, and the use of social protection mechanisms to allow timely distribution of resources for the implementation of the planned AA.

Box 4.13 | Anticipatory Action helps prevent a flood becoming a disaster

Multi-agency coordination supports AA in Bangladesh: In 2020, an interagency AA framework for floods was established in Bangladesh, specifically in the Jamuna river basin, with collaboration between the UN Office for the Coordination of Humanitarian Affairs (OCHA), FAO, the International Federation of Red Cross and Red Crescent Societies (IFRC), Bangladesh Red Crescent Society (BDRCS), the United Nations Population Fund (UNFPA) and the World Food Programme (WFP), and in close coordination with the Government of Bangladesh. The triggers for action were based on an early warning system that combined the forecasts of two institutions: the national Flood Forecasting and Warning Centre (FFWC) and the Global Flood Awareness System (GLOFAS). In July 2020, the early warning system reached the pre-agreed threshold and triggered the rapid release of funds from the UN Central Emergency Response Fund (CERF). FAO rapidly distributed waterproof storage drums and animal feed to 18 700 families before the flood reached its peak. Six percent of beneficiaries reported improved health of their livestock and 21 percent reported increased storage space for food, water and seeds and other items in their household. Households who stored crop seeds in the drums were better able to plant during the Boro rice season, which directly follows the monsoon season (OCHA, 2021).

Multiple AAs reduce the impact of flood in the Niger: In May 2022, the seasonal forecast for the Sahelo-Sudanian zone (PRESASS) pointed to a high risk of flooding possibly leading to losses in human and animal lives, crops, and assets. The Maradi region is usually among the most impacted from flooding and is one of the key millet producing areas, the main cereal crop in the Niger. With funds from the Swedish International Development Agency (SIDA) for an AA window of the Special Fund for Emergency and Rehabilitation Activities (SFERA AA), FAO acted to mitigate the impact of potential floods on those most at risk through no-regret Anticipatory Actions. Cash for work activities were implemented to reinforce embankments, river guards, irrigation canals and protect crop plots. Vaccination and animal health support was also provided by FAO, along with unconditional cash transfers, and support for the control of the millet caterpillar, a pest that often damages crops during heavy rains. These activities were complemented by training sessions and awareness raising on prevention and preparedness against floods. The interventions successfully protected crops and animals from the intense floods that occurred during the 2022 rainy season, and farmers reportedly managed to sustain food production. The case of the Sirba river in the Niger demonstrates that an operational community and impact-based early warning systems for floods can be set up by leveraging the existing tools, local stakeholders, and indigenous knowledge. Bridging the gap between top-down and bottom-up approaches is possible by directly connecting the available technical capabilities at the local level through a participatory approach. This allows the beneficiaries to define the rules that will develop the whole system, strengthening their ability to understand the information and act. Moreover, the integration of hydrological forecasts and observations with community monitoring and preparedness system provides a lead time suitable for operational decision making at national and local levels. For international river systems, implementation requires the commitment of governments to the transboundary sharing of flood information (Tarchiani *et al*., 2020).

Sources: **OCHA (United Nations Office for the Coordination of Humanitarian Affairs).** 2021. *Bangladesh monsoon flooding 2020: anticipatory action pilot.* In: UNOCHA. New York, USA. [Cited 2023]. https://www.unocha.org/bangladesh-monsoon-flooding-2020-anticipatory-action-pilot. **Tarchiani, V., Massazza, G., Rosso, M., Tiepolo, M. Pezzoli, A., Ibrahim, M.H., Katiellou, G.L. *et al.*** 2020. Community and Impact Based Early Warning System for Flood Risk Preparedness: The Experience of the Sirba River in Niger. *Sustainability*, 12(1802): 24. http://dx.doi.org/10.3390/su12051802

To be successful, AA requires proactive planning, including:

- **Developing of forecast systems capable of providing early sight of future floods.** This might include the use of global, regional and climate weather forecasts; global flood models (e.g. GLOFAS), as well as local level forecast systems.

- **Connecting forecasts to early warning systems (and associated risk analysis) that include thresholds to trigger action.** Such triggers should lead actions that are proportionate and appropriate given the trade-off between forecast certainty (with the potential for false alarms), lead-time and the time needed to implement different AAs.

- **Pre-agreed AA protocol or plan to ensure timely delivery.** Depending on the information used, the lead time to support at risk communities ahead of floods can be relatively short. Therefore, a limited set of actions are available that can be implemented in the AA window of opportunity:

  - reduce exposure (evacuate animals or people to shelters or higher ground);

  - enhance the coping capacity of households (for example, by providing cash, or waterproof storage equipment);

  - ensure the hazard is reduced where possible (reinforce riverbanks, clear local debris from rivers, drainage canals and culverts);

  - distribute equipment to the community (such as waterproof storage drums and temporary livestock shelters);

  - construction of flood protection measures (if time allows); and

  - livestock evacuation, among others.

- **Pre-allocated finance that can be released immediately once a trigger has been reached.** Research suggests that around 55 percent of humanitarian funding goes to crises but only 1 percent of this funding is organized in advance (Anticipation Hub, 2023). In response to this mismatch, an increasing range of financing instruments, mechanisms, and partners is emerging to make finance available to support those most in need (from individuals to communities and national governments). Doing so requires the collaboration of actors, financing mechanisms and coordination across the humanitarian, development, peace, climate sectors. For example, the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) seeks to be provide predictable and strategic humanitarian financing through the Central Emergency Response Fund (CERF) and Country-Based Pooled Funds (CBPFs), The AA window of FAO's Special Fund for Emergency and Rehabilitation Activities (SFERA) ensures FAO country offices can access rapid, flexible and reliable funding for AA along with initiatives such as "Start Ready" that pre-positions funding for crises.

- **Post disaster needs assessment.** Post disaster needs assessment (PDNA) plays an important role in providing an objective and comprehensive estimate of recovery needs, while facilitating quick decision-making and action (Box 4.14). PDNA also provides insight into what has happened and how risk can be better managed in the future.

Box 4.14 | Post disaster needs assessment to inform flood disaster response and recovery efforts

Post disaster needs assessment (PDNA): As part of the humanitarian programme cycle, PDNA is a cross sectoral, methodologically sound and streamlined data collection, analysis and report writing exercise aiming at impartial and comprehensive situation analyses, which provide the foundations and justifications for interventions to support humanitarian response, recovery and future resilience of populations affected by natural disasters, conflicts or protracted crises. The approach seeks to help develop an objective and coordinated approach to the assessment of the post disaster damages, losses and recovery needs, and paves the way for a consolidated recovery framework.

Delivering time critical information: The Data in Emergencies (DIEM) hub collects, analyses, and disseminates data on shocks and livelihoods in countries prone to multiple shocks, including floods, allowing FAO to provide time critical information on the specific impact of disasters on agricultural livelihoods and crop, livestock, fisheries, and forestry subsectors by layering data on hazard exposure with information on natural resources. The data collected through FAO's DIEM hub were crucial in responding to the floods in Chad and its neighbouring countries in 2022 by providing impact assessments and implications for food security (FAO, 2023).

Assessing the impact on food supply – Timor-Leste: A FAO Crop and Food Supply Assessment Mission (CFSAM) visited all main food producing areas in Timor-Leste in 2021 to estimate 2021 crop production and the import requirements during the 2021/22 marketing year. The mission's aim was to provide an accurate picture of the severity and extent of the shocks that affected the agricultural sector in 2021, the impact of the tropical storm and floods, and identify the country's main agricultural support needs until the next harvest (FAO, 2021).

Rapid geospatial assessment on crops and the exposure of rural people – South Africa: Heavy rainfall caused severe flooding and landslides affecting parts of South Africa in April 2022, with loss of lives, infrastructure damages and inundated cropland. The Geospatial Unit of the FAO Land and Water Division (NSL) and local teams conducted a rapid geospatial assessment on crops and the exposure of rural people, which provided information at the district, local municipalities, and ward levels of interest (Ghosh *et al.*, 2022).

Sources: **FAO**. 2021. *Special Report - 2021 FAO Crop and Food Supply Assessment Mission (CFSAM) to the Democratic Republic of Timor-Leste*. Rome. https://www.fao.org/3/cb5245en/cb5245en.pdf. **Ghosh, A., Mushtaq, F., Jalal, R., Henry, M., Adhikari, S., Hove, L., Kassa, S. *et al.*** *A rapid geospatial analysis of the flood impacts on crops in KwaZulu-Natal and Eastern Cape provinces of South Africa in 2022*. Rome, FAO. https://www.fao.org/3/cc1046en/cc1046en.pdf. **FAO**. 2023. DIEM – Data in Emergencies Monitoring brief, round 4: Chad Results and recommendations, March 2023. Rome. https://www.fao.org/3/cc4898en/cc4898en.pdf

4.3 Adapting towards a more resilient future

Planning to adapt is neither simply a "wait and see" nor a zero-cost option. It is based on a proactive risk-informed exploration of the future to help avoid maladaptation and justify upfront costs that may be needed to forego "high regret" development opportunities until the reality of the future is better known. Adaptation is also an agile framing, as it seeks to take hold of opportunity when the future changes in unexpected ways and "build back better" in the aftermath of a flood.

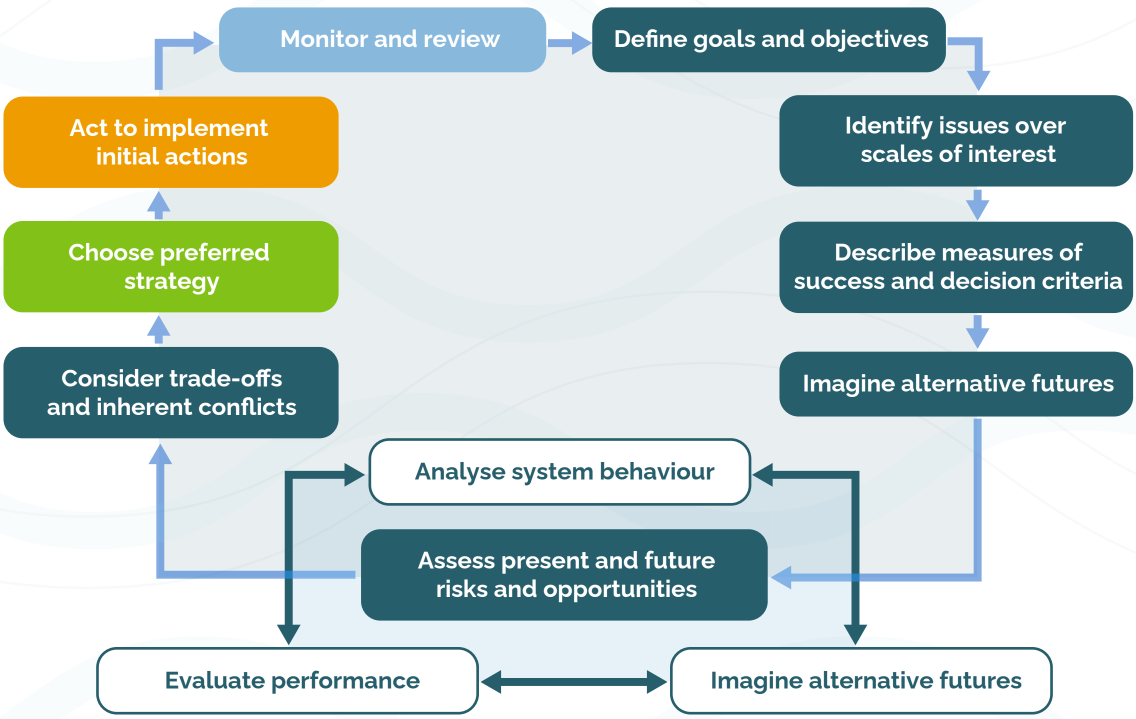
4.3.1 Adaptation pathways: Embedding adaptive capacity in response to climate change and emerging climate-related risks

As an old Chinese saying reminds us: "It is not possible for a person to step into the same river twice". The river is constantly changing, as is the flood risk.

Flood risk is already significant and climate change is exacerbating the adaptation deficit (Box 4.15). Future change is likely to increase risk in unknown ways, presenting the flood risk manager with a rational doubt as to what action to take to improve agrifood systems' resilience. The deep uncertainties, associated with climate or demographic change, for example, cannot be reduced through improved data or models. There is however increasing clarity on the drivers and triggers for change (FAO, 2022c). Flood risk management brings together these perspectives based on a longer-term, strategic planning process that aligns the agrifood systems with the broad sustainable development context. Such an approach urges those involved to recognise the future may be different from the past and seeks to embed adaptive capacity within the choices made. This is done in the expectation that the future will be different from the present, and prevention and preparations that assume the future will resemble the present are doomed to failure.

A strategic approach to flood risk management to enhance the resilience of agrifood systems and related livelihoods (e.g. Sayers *et al.*, 2013) takes place as a continuous process of setting goals and objectives: describing success criteria (for people, agrifood systems and related livelihoods, as well as nature); imagining alternative futures (in consideration of the different drivers of risks, including climate, social, environmental and economic changes); assessing the risks; deciding how to act (recognising the trade-offs and conflicts that exist between choices made); implementing the selected actions; and monitoring their performance before reappraising and adapting as necessary (Figure 4.3).

Figure 4.3 | Flood management takes place as a continuous cycle of planning, acting (to design and implement), monitoring, reviewing, and adapting



Source: **Sayers, P., Yuanyuan, L., Galloway, G., Penning-Rowsell, E., Shen, F., Wen, K., Chen, Y. & Le Quesne, T.** 2013. *Flood Risk Management: A Strategic Approach.* Manila, ADB, Beijing, China General Institute of Water Resources and Hydropower Planning and Design (GIWP), Paris, UNESCO & Woking, UK, World Wildlife Fund (WWF)-UK. https://unesdoc.unesco.org/ark:/48223/pf0000220870

Box 4.15 | Present day adaptation gap is increasing with climate change

There is a significant adaptation deficient in many countries around the world. The 2010 floods in Pakistan affected 4.5 million workers, two-thirds of whom were employed in agriculture and over 70 percent of farmers lost more than half of their expected income. The floods caused USD 10 billion in damage and losses, including USD 5 billion to the agriculture sector. By contrast, just USD 200 million was allocated to the country's agriculture sector in the 2014/15 national budget (FAO, 2015). The influence on global agriculture is significant as the frequency of droughts, floods, windstorms, and other disasters alter in response to climate change, increasing the damage caused to the agricultural sectors of many developing countries and putting them at risk of growing food insecurity. In rural Uganda, for example, climate change is increasing flood risk for the natural resource dependent communities, worsening the already difficult conditions (Lwasa, 2018). By 2080 the situation is likely to be much worse than at present.

Climate change is increasing the risks we face: The sixth assessment report from Intergovernmental Panel on Climate Change (IPPC, 2022) highlights the significant changes in the climate system and how this is changing and increasing flood risk. Monsoon precipitation is projected to increase at the global scale, particularly over South and Southeast Asia, East Asia, and West Africa, apart from the far west Sahel (IPCC, 2021). As a result, increases in direct flood damages are projected for the future with higher values associated with greater global warming without adaptation (IPCC, 2022). Flood-related acute food insecurity and malnutrition have increased in Africa and Central and South America. As sea levels rise, by 2100 an estimated 36 million Indians are likely to be living in areas experiencing chronic flooding (ReliefWeb, 2020).

Monitoring climate change and progress towards resilience is increasingly part of good national governance: In 2008, the Climate Change Act was implemented in the United Kingdom, establishing an independent committee to assess and present future climate-related risks (including flood risk) and determine the national progress in mitigation and adaptation. The assessment is updated and revised every five years, with the first reporting in 2012. The government is required to respond to the assessment and how future risks will be managed. This provides a powerful means of motivating action across sectors and hazards. Similarly, in Colombia in 2012, a law was passed to create a national risk management policy and system to identify, monitor and analyse risks related to climate change, prepare measures to address situations of emergency, establish relevant financial instruments, and develop a comprehensive communication and stakeholder engagement system (Hallegatte *et al.*, 2020).

Sources: **Lwasa, S.** 2018. Drought and Flood Risk, Impacts and Adaptation Options for Resilience in Rural Communities of Uganda. *International Journal of Applied Geospatial Research*, 9(1): 36–50. doi. org/10.4018/IJAGR.2018010103 FAO. 2015. The impact of disasters on agriculture and food security: Avoiding and reducing losses through investment in resilience. Rome. https://www.fao.org/3/cc7900en/online/cc7900en.html. **IPCC (Intergovernmental Panel on Climate Change).** 2021. Climate Change 2021 Climate Change 2021: *The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK. https://doi.org/10.1017/9781009157896. **IPCC**. 2022. *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, UK. https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf. **Hallegatte, S., Rentschler, J. & Rozenberg, J.** 2020. Adaptation Principles: A Guide for Designing Strategies for Climate Change Adaptation and Resilience. Washington, DC., World Bank.

Developing adaptive capacity is a central response to managing future uncertainty in an evolving risk landscape (in terms of knowledge around future climate and climate-related hazards, our ability to assess and forecast risk, and the governance arrangements in place to respond and be more resilient to them) (Box 4.16). However, developing and implementing adaptive strategies that respond to an uncertain future relies upon creativity and innovation in selecting responses that do not foreclose future options (or unnecessarily constrain future choices) but still address present-day risks. The characteristics that make flood risk management strategies inherently flexible and adaptive are now well recognised (for example, reducing vulnerability and exposure in preference to providing protection, maintaining the functional floodplain and room for the river, and options that deliver multiple rather single benefits). But an uncertain future also influences the process of planning, and implies that recognising risks and priorities can change in unexpected ways. As part of a flexible flood risk management approach, and to be better placed to face and manage future risks and uncertainties, there is a need to be clear on how future risks may change and what the future impacts could be.

Box 4.16 | Developing an adaptation pathway for Bangladesh

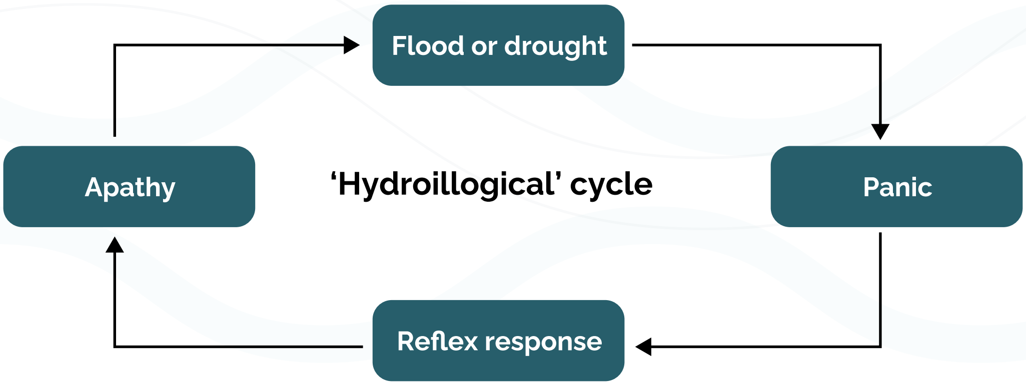
In **Bangladesh**, the Ministry of Environment, Forest and Climate Change published an ambitious national adaptation plan (MEFCC, 2022). The resilience of the agrifood systems amid climatic and non-climatic challenges is central to adaptation actions. The plan sets out 12 key actions for agriculture and 12 actions relating to fisheries, aquaculture and livestock. As Roy *et al*, (2021) highlight, the success of those adaptation pathways designed to enhance livelihood resilience of flood-affected households, will rely upon (as a minimum) developing the capacity at a local level to: (i) assess livelihood resilience by constructing resilience indices; (ii) determine adaptation options; and (iii) design pathways of selected adaptation options. Workshops revealed that about one-third of total households had capacities to reduce flood shocks and stresses and improve livelihood opportunities (Roy *et al*., 2021).

Sources: **MEFCC (Ministry of Environment, Forest and Climate Change).** 2022. *National Adaptation Plan of Bangladesh (2023-2050).* Dhaka. https://www4.unfccc.int/sites/SubmissionsStaging/Documents/202211020942---National%20Adaptation%20Plan%20of%20Bangladesh%20(2023-2050).pdf. **Roy, R., Gain, A.K., Hurlbert, M.A., Samat, N., Tan, M.L. & Chan, N.W.** 2021. Designing adaptation pathways for flood-affected households in Bangladesh. *Environment Development and Sustainability,* 23(3): 5386–5410. https://link.springer.com/article/10.1007/s10668-020-00821-y

4.3.2 Building back better

All too often when floodwaters recede and the impacts of the flood are forgotten, momentum to better prepare for the next flood is lost. However, it is prudent to break the "hydroillogical" cycle (Figure 4.4) and use the opportunity a flood presents to recover and "build back better" and address the root causes of risks and vulnerabilities. This implies not building back the same risks and vulnerabilities, but reconfiguring the managing of the hazards, exposure, and vulnerabilities and coping capacities to reduce risks and vulnerabilities, and therefore reduce the likelihood of future negative impacts when the next flood arrives. Doing so is however challenging and requires a deep understanding of the root causes of disaster risks, what worked and what did not, the physical processes involved as well as the human recovery mechanisms. Taking the opportunity to adapt towards a more resilient future requires a commitment from all involved (from policymakers and technical staff in national governments, to international aid agencies and donors, and farmers and communities themselves) to challenge the status quo, and take the opportunity to address root causes of risks and vulnerabilities of the relevant agrifood systems and related livelihoods.

Figure 4.4 | Breaking the "hydroillogical" cycle post flood: Using a flood event as a window of opportunity for change



Source: **Browder, G., Nunez Sanchez, A., Jongman, B., Engle, N., Van Beek, E., Castera Errea, M. & Hodgson, S.** 2021. *An EPIC Response: Innovative Governance for Flood and Drought Risk Management*. Washington, DC., World Bank. https://openknowledge.worldbank.org/entities/publication/a98b2251-f185-55a0-8ebc-6a4cb78b43e9

4.4 Ensuring an inclusive process and fair outcomes

4.4.1 Inclusive process of planning, implementation, and monitoring

Engagement and collaboration are key requirements to successfully enhance flood risk management (Box 4.17) (Dodman, Archer and Satterthwaite, 2017). An inclusive process, however, is much more than simply "including" stakeholders in discussions on flood risk management measures. A process of "dynamic, collective learning involving for whom an issue is of particular concern" (Lane *et al.*, 2011) is needed to ensure all those that may be impacted by a flood or have a role to play in the future management of flood risk are meaningfully involved. This not only builds a sense of the ownership of decisions and actions but also ensures "no one is left behind" in having their voice heard, and indigenous and local knowledge is valued and used in problem-solving and analysis, and most importantly, in the decision-making process. Inclusive and participatory processes are central to all stages of planning, including the earliest stages of implementation, monitoring, and evaluation before the direction is set,. The positive circle of collective learning it engenders (valuing local wisdom and public knowledge as a credible source of expertise) also helps ensure that solutions are context-specific, locally meaningful and, consequently, much more likely to be successful. An inclusive and participatory framing also extents to the process of monitoring and review, again valuing local wisdom, public knowledge, and community observations as a credible source of expertise and monitoring data.

Practical questions can be used to challenge the degree of inclusion. For example: Are all those that may be impacted by a decision, or have a role to play in the future management of flood risk (either their own or others) appropriately involved? Is their involvement purposeful and meaningful, both to the stakeholders and to the decision makers?

Box 4.17 | Engagement and collaboration in support of flood risk management

Supporting community-based flood risk management: Early engagement with local rural communities and understanding their perspective has been important in **Thohoyandou, South Africa** (Sinthumule and Mudau, 2019). They recognise that flooding is a natural process, but human activities such as clearance of natural vegetation, cultivation in steep slope areas, urbanization, poor designs and maintenance of drainage system and settlement in inappropriate areas all enhance the risks of flooding. Local communities did not cope well when there was flooding. However, they still suggested strategies that should be used to cope with future flood hazards, rather than only relying on strategies imposed by the government or private companies as has been the situation in other countries. Sinthumule and Mudau (2019) demonstrate that flood disaster management requires local strategies coming from local communities.

Co-design of the flood risk management strategy: In **Nepal** collaboration between the implementing entities, international aid providers, government and academic organizations and the local community groups significantly shaped the approach to flood risk management at the earliest stages. Local community members (including women and marginalized communities) actively co-owned the outcomes through their involvement in awareness-raising activities, training sessions, mock drills, and even infrastructure-related works (Aguilera, 2021).

In **Denmark** local municipalities take the lead on spatial planning, but the landowners are responsible for flood risk management. Without collaboration, development can fail to take account of the current or future flood risk. In **Ringkøbing-Skjern** municipality, a more collaborative approach is being adopted. This approach involves raising awareness of the sources of flood and the associated risk and sharing this information with spatial planners and residents. Present and future flood risks are explained through face-to-face and digital participation processes. The communication of risk is accompanied by information and engaging animations on how individual homeowners can modify their homes to reduce their risk. It also emphasises the need for, and benefits of, collective action to reduce flood risk to the community (Cloud2Coast, 2023).

Sources: **Sinthumule, N.I. & Mudau, N.I.** 2019. Participatory approach to flood disaster management in Thohoyandou. *Journal of Disaster Risk Studies*, 11(3): 711. doi.org/10.4102/jamba. v11i3.711. **Aguilera, J.J.** 2021. Community-Based Flood and Glacial Lake Outburst Risk Reduction in Nepal. *weADAPT*, 26 November 2021. Stockholm, weADAPT. [Cited 2023]. https://www.weadapt.org/solutions-portal/community-based-flood-and-glacial-lake-outburst-risk-reduction-in-nepal. **Cloud2Coast.** 2023. Approach. In: Cloud2Coast. Brussels, European Commission. [Cited 2023]. https://www.c5acloud2coast.eu/c2c-approach/

4.4.2 Just outcomes

There are many dimensions to discussions related to fairness and equity (e.g. de Göer de Herve, 2022). Flooding, and actions taken to manage floods, are not fair per se (e.g. Johnson, Penning, Rowsell and Parker, 2007). There is a clear concern that the impacts of climate change will disproportionately affect the disadvantaged and most socially-vulnerable communities as sea level rise, and floods and droughts change (e.g. Sayers *et al.*, 2017b; IPCC, 2018). These changes, without targeted action, are set to increase social inequalities. Achieving socially just outcomes is therefore not easy to achieve, but significant progress must be made and can be made.

By placing social justice at the heart of the choices made, outcomes for the most socially vulnerable can be maximized. In many rural areas, for example, while women and female-headed households are often in more vulnerable positions, with limited access to knowledge and little financial capacity, they play a substantial role in community cohesion and resilience in many countries, especially developing countries. Developing flood management approaches that successfully address the unique risks faced by different groups and genders within rural communities underpins the need to reduce risk fairly (including for the most socially vulnerable who often depend on agriculture for their livelihoods) (FAO, 2022). It is only by developing solutions that work for all that risks to life and livelihoods can be reduced and long-term climate resilience secured.

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5 THE WAY FORWARD

CONCLUDING RECOMMENDATIONS TO ENABLE A STRATEGIC APPROACH TO MANAGING RURAL FLOOD RISK

This paper presents a strategic approach to flood risk management as being central to making progress in enhancing the resilience of rural communities, agrifood systems and natural ecosystems. Flooding issues are always context specific and consequently there is not a single blueprint of "good" flood risk management and plans differ in the combination of actions they prescribe. However, a common understanding of the strategic framing necessary for "good" flood risk management is now increasingly recognised (e.g. Sayers *et al.*, 2014; Browder *et al.*, 2020). These approaches urge those involved in flood-related decision-making (from local to regional scales, and from communities to institutions) to base their interventions on comprehensive flood risks assessments for the relevant agrifood systems and related livelihoods, recognising that the future will likely be different to the past (perhaps significantly). It is necessary to seek to embed adaptive capacity and the prevention of the creation of new risks and reduction of existing ones within the choices made, by contributing to reduce root causes of risks and vulnerabilities, as well as enhancing preparedness, anticipatory response and recovery capacities, to promote resilience at every turn.

A strategic approach to flood risk management promotes working with natural processes, food security, social justice, and healthy ecosystems as important aspects of developing flood-resilient rural communities and agrifood systems where people and livelihoods are safe and supported. A small number of high-level recommendations are set out here to help guide this process. These draw upon the ten "golden rules" of flood risk management (Sayers *et al.*, 2014) to reinforce the central attributes necessary (together with investment of time and resources, appropriate expertise and knowledge) to make progress at pace towards greater flood resilience in rural settings. They are as follows:

1. **Accept that absolute protection is not possible and plan for exceedance:** There will always be a "bigger" flood. It is important to accept that some flooding will occur in a given place, and focus upon building resilience within and across sectors, along the relevant agrifood systems, and into all aspects of the planning process (from development choices to agricultural crop, livestock, and storage choices), and work with communities to raise awareness and ownership. This acceptance encourages proactive preparedness, AA, and the response planning to ensure timely humanitarian assistance to save agrifood systems and related livelihoods from flood related disasters and underpins long-term resilience. This includes developing preparedness, investing in forecasting and early warning systems and the ability to progressively scale up AAs as forecast certainty improves and pre-agreed thresholds for action are reached (including financial mechanisms to support households, food options and other aid mechanisms) as well as developing response and recovery plans.

2. **Understand the resilience of agrifood systems at national and global scales:** The food and agriculture sector is fundamental to global security and managing rural flood risk is an integral aspect of international, national and local DRR strategies and financing plans. Despite this central importance and the increasing pressures on rural areas (e.g. by deforestation, land degradation, and climate change) there is no standardized global or regional assessment or scenario stress tests for agriculture and rural flooding to better understand how risks are distributed and how they may change. A strengthened assessment of flood risk will be an important step towards understanding how best to respond and mobilize investment in preventive and absorptive measures to reduce risks and vulnerabilities at local and landscape levels. These include: early warning systems coupled with AA; proactive preparedness; effective response and recovery; enhancing capacities of communities and key institutions; and supporting timely action to prevent a hazard from becoming a disaster, thus saving lives and livelihoods.

3. **Work with natural processes as part of a whole system approach to managing risk:** Healthy and diverse ecosystems, such as forests, pasture, arable land, floodplains, and wetlands, are central to many rural livelihoods and related agrifood systems. Seeking to work with natural processes as part of a flood risk management strategy implicitly encourages choices that maintain the natural dynamics of water systems, from the source to the sea. In turn, this approach supports healthy freshwater and marine ecosystems and helps maintain healthy soils: all prerequisites for productive and resilient agriculture and food systems. To be successful, the philosophy of working with (not against) nature needs to be embedded within a whole system-wide portfolio of measures for flood risk management: from technical solutions on the ground to policy design at global, national and basin levels

4. **Assess the resilience of agrifood systems at a catchment and community scale to better understand and communicate present-day risk and how it may change in the future:** In all but the simplest of settings, flood risk often reflects a range of interacting issues. Developing an appropriate understanding of the flood hazard (exposure, vulnerabilities, and coping capacities, how they are generated, and how they combine to generate the risk faced) is the starting point for any planning process. Making sense of these complex interactions in the context of relevant agrifood systems and related livelihoods relies on multiple forms of evidence (both qualitative and quantified), which then needs to be translated into clear messages, resulting in communications tailored to specific stakeholders. This includes developing meaningful and actionable messages for rural communities, delivered through the appropriate combination of modern communication tools alongside traditional stories, reflecting their crucial role in managing rural floods risks and avoiding disasters.

5. **Involve agriculture and rural communities in the process and promote socially just outcomes:** Rural smallholder farmers, women and Indigenous Peoples play a substantial role in flood risk management and resilience building in many countries. Their involvement in the planning, design, implementation, and monitoring of flood risk management actions is a pre-requisite of a just process. This inclusive approach moves beyond simply including stakeholders in discussions, and instead ensures the meaningful involvement of all those that may be impacted by a flood or have a role to play in the future management of flood risk and have a legitimate contribution to make. This also helps to ensure that no one is left behind and all have their voice heard. Doing so successfully places social justice at the heart of the choices made and guarantees that outcomes for the most socially vulnerable are maximized.

6. **Align and integrate planning and policy within and across sectors, and along agrifood systems to reduce risk and maximize co-benefits:** Multiple opportunities and constraints exist in any rural setting, and managing flood risk does not take place in isolation of other development objectives. Achieving and understanding multiple and changing objectives presents many challenges, particularly as some objectives may conflict in the short or long term, and at local or regional scales. An active process of alignment (and, where necessary, integration) within and across sectors and along agrifood systems helps manage trade-offs and maximize co-benefits. It avoids future conflicts and avoids new risks from being created, or existing and emerging risks being exacerbated through inappropriate development or unnecessary environmental degradation. Agricultural, water and flood risk management policies, plans and financing at the national, river basin and local levels are mutually strengthened by developing integrated strategies that both reduce climate and disaster risks and promote "win-win" outcomes that maximize social, economic, and environmental co-benefits. Natural flood risk management measures that safeguard soil and ecosystem health, for example, are also likely to improve water quality and reduce drought risks (with associated benefits for crop yields and diversity livelihoods, etc).

7. **Mobilize increased risk-informed investment to scale up resilience of agrifood systems and rural communities:** Recognising that the greatest opportunity to reduce the impact of a flood is before it occurs includes investing in an appropriate portfolio of measures to reduce the flood risk (by managing the hazard, exposure, vulnerability, and coping capacity). In a rapidly changing world, the development and implementation of risk and vulnerability reduction measures, as well as adaptive strategies (and associated governance mechanisms) that respond to an uncertain future, rely on creativity, innovation and finance. Scaling up investment in the resilience of agrifood systems and rural risk management through national adaptation planning and disaster risk management (and other mechanisms across sectors) will be critical if adaptation is to be successful. Increasing international humanitarian support, including flexible and acces-

sible resources to support emergency response and recovery, will also be needed to address the inevitable residual risk. Financing mechanisms that secure long term investment are needed to support the implementation of adaptation pathways that are clear on how future choices will be made, and who will make them.

8 **Take proactive action to adapt and promote an integrated approach to water:** It is often said that there is only one river. The management of water-related hazards in terms of floods, drought, and poor quality are inherently connected, with opportunity for nature-based approaches and reliance upon actions to deliver multiple benefits and reduce all water-related risks. Seizing this opportunity builds upon the shift in philosophy towards more strategic, integrated flood risk management. Doing so offers an opportunity for countries to slow and store flood waters to help mitigate drought risks and develop system-based approaches to hydropower, aquaculture, agriculture, and food systems that deliver multiple benefits for all people, the economy and nature.

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This report presents a perspective on the impact of flooding in rural areas and how to address them in an integrated way that delivers multiple long-term benefits for people and nature. The challenges faced by rural communities are illustrated and a strategic approach to flood management is presented. The approach advocated is based on a paradigm of planning that connects the short and long term, seeks to simultaneously manage flood risk to people, their agrifood system-related livelihoods and the economy, whilst promoting the positive, and necessary, role floods play in maintaining productive agriculture and ecosystem health. In doing so, the approach embeds the concepts of disaster risk reduction that are integral to the Sendai Framework for Disaster Risk Reduction 2015–2030, which contributes to the 2030 Agenda for Sustainable Development and the crucial need to progress at pace towards the Sustainable Development Goals.

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