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Toward Resilient Rivers

Insights from the Kafue, Magdalena and Atrato River Basins in Zambia and Colombia

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Key messages

- Forests and fisheries are interconnected, and both are impacted by changes in land use within watersheds.
- Watershed functions are affected by climate, land-use change, overfishing, deforestation and forest degradation.
- Riparian communities value watersheds but lack political structures for effective integrated management.
- Community-based governance of natural resources within watersheds can protect ecosystem services and support livelihoods of riparian communities.
- Even where there is little data now, actions can be taken to enhance monitoring and management of watersheds.

Introduction

Resilient River Basins: Counting Fish from Forests for Food Security was initiated by the Center for International Forestry Research (CIFOR-ICRAF), the Food and Agriculture Organization of the United Nations (FAO), WorldFish and Fundación Humedales in 2020–2022 with activities in Zambia and Colombia to assess the integration of forestry and fisheries activities and to identify opportunities for watershed-based monitoring and management. In Zambia, the project focused on the upper Kafue River basin above the Itezhi-Tezhi dam, highlighting linkages between forests and freshwater systems, and identifying next steps toward a more integrated and effective management of this important freshwater ecosystem. In Colombia, the goal was to identify and communicate the interdependence of fisheries and forests in the Magdalena and Atrato River basins.

Forests are essential for healthy freshwater ecosystems to thrive. Although the importance of forests for freshwater ecosystems has long been understood, there has been little empirical research into these connections in the tropics and sub-tropics (Lo et al. 2020). Perhaps this is why few countries have adopted integrated watershed management that brings the forestry, fisheries and water sectors together in planning, monitoring and enforcing regulations designed to promote healthy watersheds. Deforestation in woodlands and forests across watersheds and along riverbanks can lead to declines in water quality and quantity, shifts in flow timing, reductions in abundance and health of fish populations, and loss of biodiversity. These changes often negatively affect the livelihoods and food security of already impoverished communities near rivers and lakes, particularly in land locked and low-income countries with high dependence on freshwater systems (Funge-Smith 2018).

The Kafue, Magdalena and Atrato Rivers

The Kafue River. The headwaters of the Kafue River lie in Zambia near its border with the Democratic Republic of Congo. The river flows for about 1 500 km before draining into the Itezhi-Tezhi reservoir. The Kafue River basin comprises about 20 percent of Zambia's land area, hosts the major urban centres of the country, services major industrial areas, and ensures the health of precious

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2 Fundación Humedales
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4 WorldFish

Kafue wetland ecosystems including Lukanga Swamp and the Kafue flats. The Kafue River irrigates about 50 000 hectares of cropland (Casarotto 2013).

Deforestation impacts the amount of water that is available in the Kafue River as trees play an important role in maintaining healthy soils and in retaining water. The combination and interaction of deforestation and climate change are likely to result in lower water levels which have negative effects on downstream communities and fisheries. Under normal hydrological conditions, the water resource base might appear adequate; however, Zambia has experienced a recurrence of droughts in 1991/92, 1994/95 and 2000/01 due to lower than average rainfall (Casarotto 2013). The Zambian Republican President declared the prolonged 2023/2024 season dry spells as a National Disaster and Emergency. The country faces a severe drought, the worst of its kind, caused by the El Niño weather conditions in the 2023/2024 rain season and influenced by the climate change phenomenon (GRZ 2024).

The Magdalena River basin is densely populated, housing over 90 percent of the Colombian population (DANE 2018) and contributing 90 percent to the country's gross domestic product (DANE 2022). Out of the 5.3 million hectares of vegetated floodplains in the Magdalena River basin, 2.7 million are used for agriculture (including 58 percent pasture and 42 percent crops) (CLC 2018). Furthermore, Hernández et al. (2021) indicates that an area of 2.8 million hectares of wetlands, representing 50 percent of the socioecological fishing system in the Magdalena River basin, has been transformed into agricultural territories (61 percent).

The Atrato River basin, on the other hand, contains only 1.4 percent of the Colombian population, making it a critical enclave for a wide variety of species and the ninth most biodiverse hotspot globally. Additionally, it accommodates three percent of all known plant species globally, with 1.4 million hectares of vegetated wetlands. Out of these, 1 million hectares are forests and semi-natural areas (71.2 percent), while 24.8 thousand hectares are designated for agriculture (17.5 percent).

Forest cover change

Forest cover data from 2000 and 2020 were used to describe the extent and location of deforestation, revealing distinct patterns of forest cover loss in each of the three basins (Figure 1). In the upper Kafue River basin, forest area has been lost every year from 2000 to 2020. The loss of forest cover was estimated by subcatchment to reveal the greatest losses in the headwater areas where there are also the largest human populations. In the Atrato River basin, forest loss primarily occurred in the middle and lower basins, driven by a 22 percent conversion of land for cattle ranching. In the Magdalena River basin, deforestation has heavily impacted the middle and lower portions of the basin, but it has also occurred throughout the entire basin leaving isolated forest fragments within agricultural areas.

Riparian forests are particularly important for bank stabilization, supporting freshwater habitat complexity, protection against erosion, and providing shade and food for fish. An assessment of riparian forest cover loss was also conducted for the Kafue River basin (Figure 2) indicating that in some subcatchments such as the Lunga River and the upper Kafue and Kafulafuta Rivers, over 3 000 hectares of riparian forest have been recently lost. Much of this riparian forest was likely cleared for settlements, riverbank farming and drying fish.

Climate change

Climate change, both temperature and precipitation, will influence where local tree species will be able to survive in the future and how much water will be available for forests and people during all seasons. Impacts are not likely to be consistent across watersheds; therefore, mapping forecasted change can be a very useful management tool.

Forecasts indicate increasing temperatures across all three study basins with little spatial or seasonal variability. The exact magnitude of the increase in temperature depended on the model assumptions and emissions scenario. Climate change forecasts of precipitation, however, indicate the potential for substantially higher rainfall in the headwaters of the Atrato River and drier conditions across the lower parts of the upper Kafue River watershed (Figure 3). Importantly, forecasted changes in precipitation differed across seasons with the wettest parts of the year getting wetter even in the upper Kafue River and reduced precipitation in the Kafue River occurring during the already dry season.

Community knowledge and scientific research linking forests, fish and nutrition

A joint team of researchers from WorldFish and CIFOR-ICRAF carried out 171 household interviews

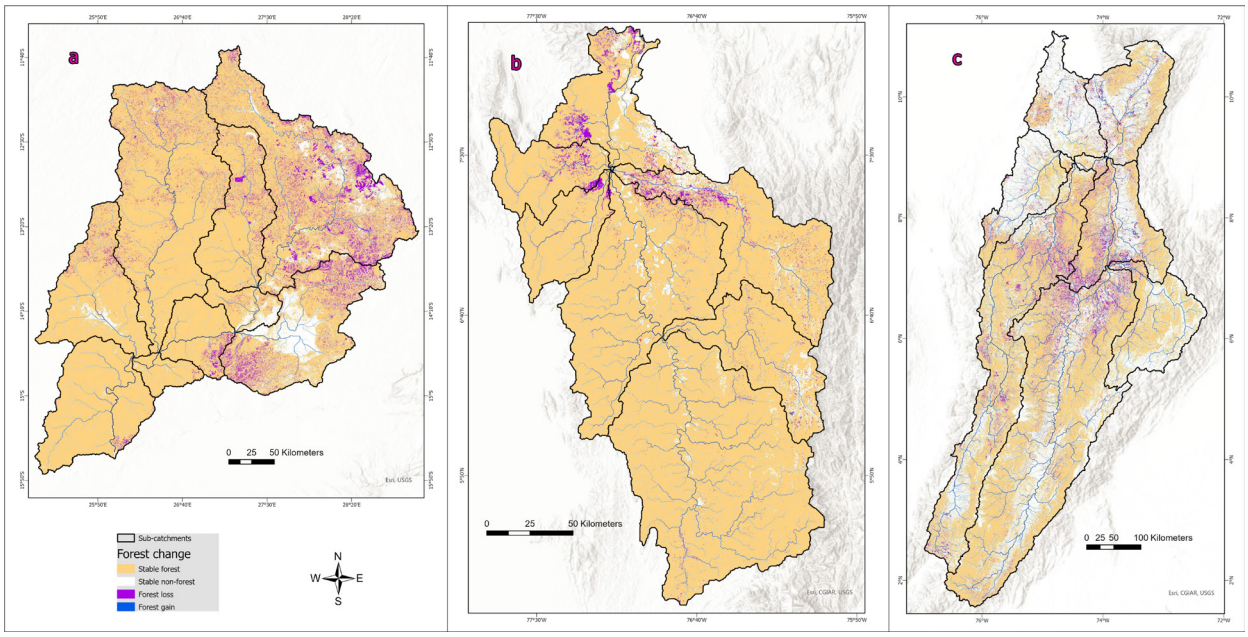

Figure 1. Forest cover change, 2000 and 2020, across the (a) upper Kafue, (b) Atrato and (c) Magdalena Rivers.

Source: Teopista Nakalema/FAO

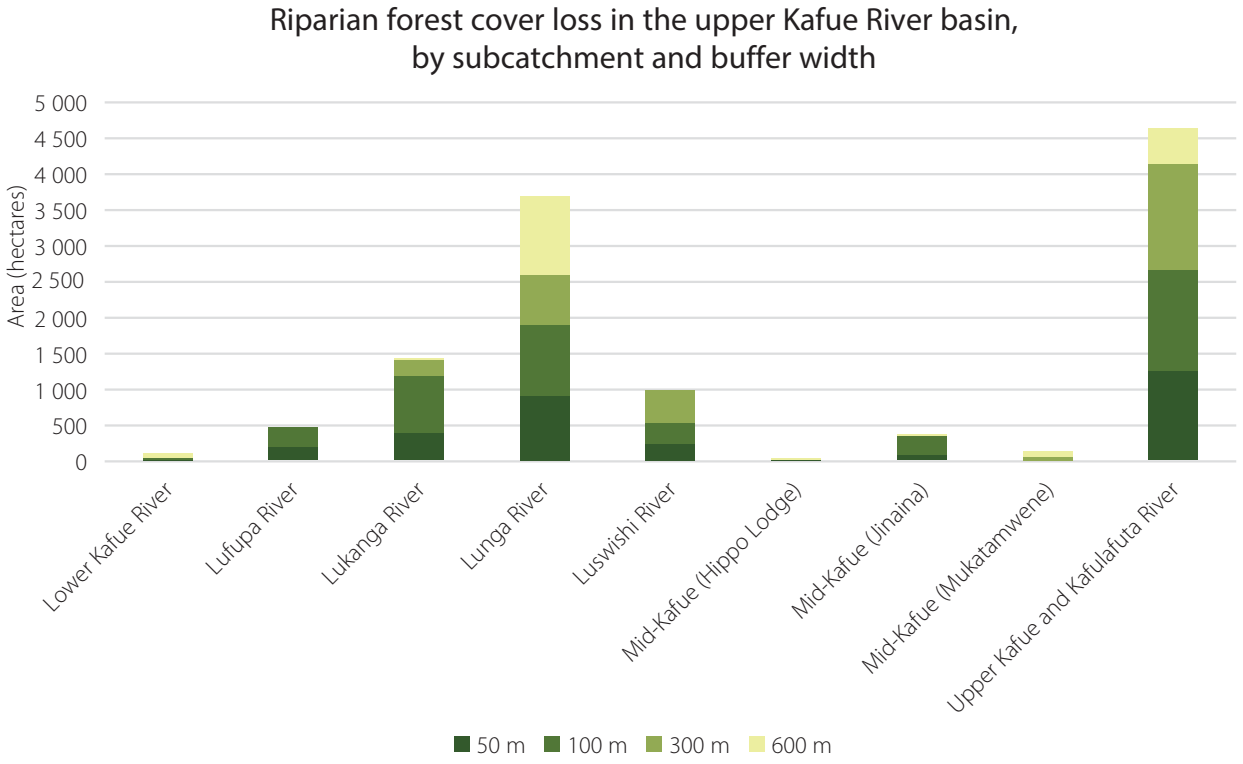

Figure 2. Loss of riparian forest in hectares from 2000 to 2020 by subcatchment and buffer width. Riparian areas were estimated using distance from the channel centre line; 50 m, for example, indicates an area including 50 m on either side of the centre line of the channel.

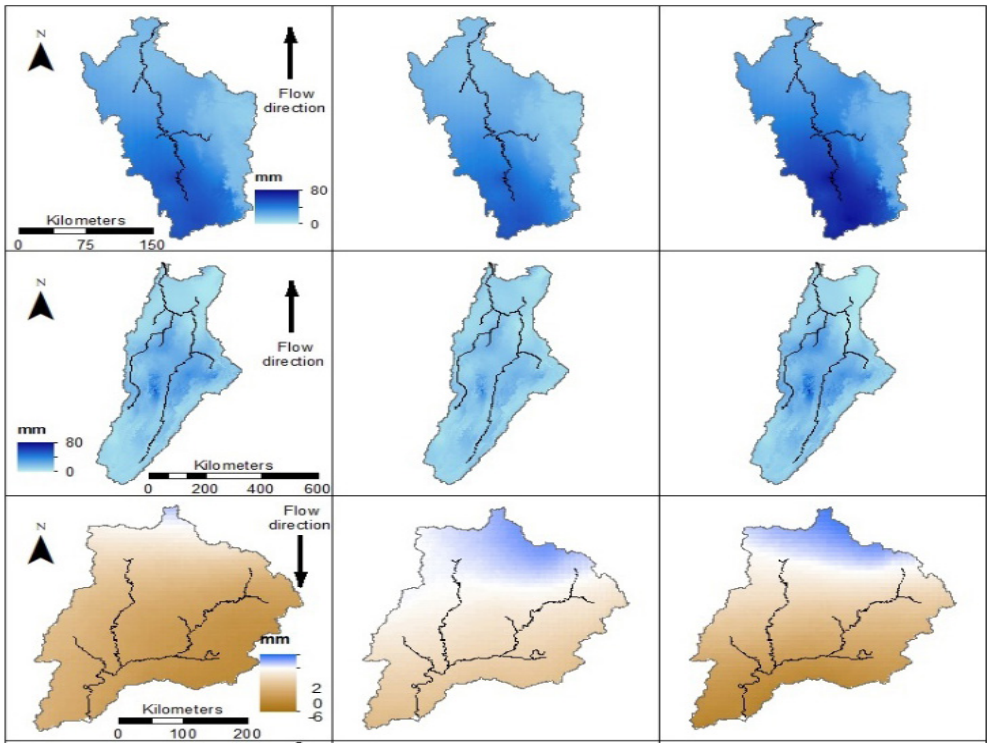

Figure 3. Forecasted changes in precipitation across the three basins. Top row: Atrato River, middle row: Magdalena River, bottom row: upper Kafue River. Columns, from left to right, represent emissions scenarios 2.6, 4.5 and 8.5 averaged across multiple available climate forecast models.

and 20 key informant interviews across the lower, middle and upper Kafue River subcatchments in September 2022, targeting people who had lived more than two years within the subcatchment area. The goal of these interviews was to understand community perception of the interlinkages between forestry and fisheries, of any changes in condition, and of how these changes have impacted people.

The vast majority of respondents (71 percent) understand and agree that there is a connection between forests and fish, with 44 percent of respondents reporting the disappearance of particular tree species from local forests (FAO 2023). Both key informant interviews and individual surveys of local riparian community members describe a strong dependence on the Kafue River for both food security and income, as well as concerns about these resources being impacted by multiple challenges (Figure 4). They reported to have observed changes in temperature, fish prey abundance and habitat loss, as well as changes in water level and over-fishing. Only 5 percent of respondents listed deforestation directly; yet many of the observed changes in habitat condition are closely tied to upstream deforestation.

As upstream deforestation is linked to local fisheries, it is also tied to food availability and nutrition. About half of the households interviewed primarily consume fish caught by someone in the household. The importance of fish in diets shifts with the season. On average, fish are consumed 3.9 times per week during the dry season when fish catches are high, compared to 2.7 times per week in the rainy season when catches are low. During the rainy season, water moves with high velocity, coupled with other weather events like wind leading to lower fish catches. In the dry season, fish are consumed about twice as often as beef and chicken. Of respondents, 89 percent reported a reduction in fish consumption over the last ten years. In qualitative interviews, many stakeholders explained that fish catches had declined, and some species had become locally extirpated.

In Colombia, Hernández et al. (2022) found that 61 percent of the dynamics in fishery production in the Magdalena River basin could be explained by environmental degradation. Among the six variables evaluated, deforestation, demographic growth and reservoir volume best explained this relationship.

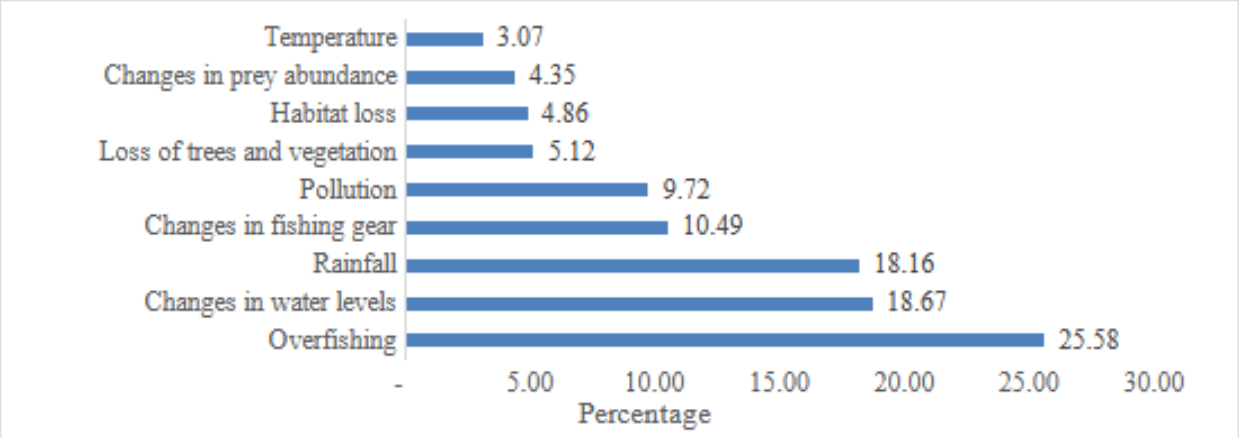

Figure 4. Riparian community survey respondents' perceptions of factors affecting fish availability (N=171 households).

Watershed governance

A review and analysis of legislative institutions and relevant regulations in Zambia identified diverse institutions working to protect and manage the Kafue River basin. Governance mechanisms include establishment of river basin institutions, freshwater resources management plans, programmes for the protection and restoration of habitats and fish, water quality standards, protected areas and protections for biodiversity. Available enforcement mechanisms include monitoring, inspection, assessment, licensing, compliance, liability and redress. These mechanisms are nested in at least nine policy instruments supported by more than eight acts of parliament and guidelines (Table 1). The acts acknowledge and provide for collaboration. They enable opportunities for integrated landscape approaches to natural resources management that include community involvement via governance structures like committees, councils and associations (Casarotto 2013; GRZ 2011a).

Despite the comprehensive policy and legal measures in place for management of forests and fisheries (e.g., licensing, bans, restrictions on use of certain nets and methods), challenges remain in sustainable, integrated management of watersheds. For example, although riparian forests and fisheries management areas are explicitly protected in Zambia law (GRZ 2011b, 2015), there has been widespread deforestation of riverbanks along the Kafue River and difficulties in sustainable fisheries management exist. Economic activities within the Kafue Flats system downstream of the study area (Figure 1a) continue to pose problems despite the legal frameworks in place for natural resources management.

In response to environmental challenges in Colombia, community governance processes have been identified. These include development of conservation strategies for striped catfish (*Pseudoplatystoma magdaleniatum*) in the middle Magdalena River, legally designating the Atrato River as a Rights-Based River, and advocacy and implementation of forest conservation by *Consejos Comunitarios de Comunidades Negras, Afrocolombianas, Raizales y Palenqueras*. In these innovative processes, riparian communities apply alternative governance procedures to preserve the ecosystem services provided by the basin and, consequently, their livelihoods.

Conclusions

Co-management is essential but difficult. Multiple institutions are available in Zambia and necessary for the effective governance of watersheds, including those focused on environmental management and protection, and those focusing on empowerment of local communities. However, implementation of policies and practices is often weak. Better implementation of community governance processes has the potential to enable the protection of valuable ecosystem services provided by a river basin while safeguarding the livelihoods of riparian communities. With the right conditions and prerequisites, co-management can be successful in improving compliance with regulations and in maintaining or enhancing the quality of the resource (Casarotto 2013; Khan et al. 2004). The creation of watershed management entities in Colombia, for example, is leading to successes in natural resources management.

Table 1. Aspects of the Zambian regulations with relevance for fisheries, forests, and watershed management

National Acts, and their relevant aspects	Aquaculture	Basin/ catchment/ watershed	Biodiversity	Community management/ empowerment	Climate change	Ecosystem preservation	Effluent wastewater/discharge	Enforcement/compliance	Environmental planning, management and protection (air, water, soil, flora, fauna, fish, fisheries)	Fishery management and conservation/establish fisheries management areas	Fishing authorization	Forest management/ forest conservation	Freshwater resources management/ freshwater quality/pollution	Governance/institutions (committees, associations, etc.)	Natural resources conservation	Policy/planning	Prevention and control of pollution and environmental degradation	Protected areas, including forest and fisheries	Protection of habitats	Protection of species	Reforestation/restoration	Reptiles	River basin institution	Soils and water conservation	Sustainable management and use of natural resources	Traditional knowledge/Indigenous knowledge	Water abstraction	Water conservation zone	Water users' associations	Water pollution/quality standards
Fisheries Act 2011 (No. 22 of 2011) / Fisheries Regulations 2012	√		√					√		√		√				√		√	√	√			√							
Environmental Act 2011 (No. 12 of 2011)		√	√					√						√									√	√						
Zambia Wildlife Act 2015(No.14 of 2015)			√	√				√				√				√		√	√	√		√			√					
Forests Act 2015 (Act No. 4 of 2015)		√	√	√								√		√		√		√	√	√	√			√	√	√				
Water Resources Management Act 2011 (No. 21 of 2011)	√	√			√		√	√	√				√	√				√					√				√	√	√	√
Environmental Management Act 2011 (No. 12 of 2011)	√		√				√	√	√	√	√		√		√		√	√							√					
Biosafety Act 2007 (No. 10 of 2007)								√							√					√									√	
Mines and Minerals Development Act 2015 (No. 11 of 2015)								√			√			√			√			√										
Tourism and Hospitality Act 2015 (No. 13 of 2015)		√						√		√	√																			

Multidisciplinary management is also essential and challenging. Effective watershed management involves collaboration across disciplines including energy, forestry, fisheries, wildlife and water management. Forests and fisheries, for example, are clearly interlinked. Changes in forest cover can lead to changes in water temperature and flow which influence downstream fisheries. Often changes are difficult to document in the short term because river systems are quite variable from year to year. Research in the Magdalena River, however, was able to document the effects of land-use change on fish production.

More information is needed but action is possible now. Stakeholders from the Kafue River agreed that challenges are interlinked, and discussed what could be done to build more effective watershed management. Discussions highlighted a need for more information about the extent of forests and about the types and quantities of fish landed in the river basin; however, some of this information can already be found from satellite imagery and historical records. Discussions made clear that policymakers and other decisionmakers do have enough information to take immediate action. First steps could focus on raising awareness among stakeholders of what is already known and improving coordination across sectors to identify effective solutions to the challenges.

Recommendations

Build the foundation from local stakeholder knowledge. Data and knowledge may be found even in what appears to be low-information settings. Co-build with stakeholders the entire monitoring and management system from an on-the-ground foundation including local knowledge. Enable a continuous, open and truthful dialogue.

Enable and enhance collaboration and integrated land-use planning across sectors to manage stakeholder conflicts of interest. Inter-sectoral collaboration begins with trust building and partnerships between individuals. Multisectoral watershed-based management may eventually require a willingness to step outside predefined mandates. Responsibilities need to be clarified; and work co-designed for all participants to claim future successes.

Aim for, expect and lock-in small on-the-ground successes to leverage bigger successes in the future. The immediate focus needs to be on on-the-ground restoration, enforcement, management or conservation action, in addition to developing multistakeholder platforms like discussion groups and workshops. Since change is likely to be slow, expecting and enabling small on-the-ground change and then implementing procedures to secure that change into the future will provide a strong foundation for larger scale watershed monitoring and management. Waiting for a complete plan or full funding for large-scale action will leave watersheds vulnerable.

Monitor across watershed using innovative tools and technologies. The development and application of integrated monitoring indicators can provide long-term data that serve as an early warning system and a basis for understanding system linkages. Building on Indigenous technical knowledge as a foundation, data on water, forest cover change, and metrics of fish and fishery activities can be overlaid.

Build capacity in integrated monitoring and management. The eLearning, Resilient Rivers, https://elearning.fao.org/course/view.php?id=944 developed as part of this project supports cross-training, initiation of monitoring plans, development of watershed councils or creation of integrated university courses.

Acknowledgement

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Dedicated to the memory of Dr. Davison Joe Gumbo. His work empowering local communities and supporting integrated watershed management as well as his insight and inspiration are embedded in this InfoBrief.