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Stakeholder Consultation, Site Prioritization, and Flood Model Development for Index-based Flood Insurance in Southern Province, Zambia

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CGIAR Initiative on Diversification in East and Southern Africa

The CGIAR Initiative on Diversification in East and Southern Africa aims to help smallholders transition to sustainably intensified, diversified, and de-risked agri-food systems based on maize in 12 ESA countries. Specifically, it seeks to enable 50,000 value chain actors, including farmers (at least 40% women, 40% youth), to adopt climate-smart maize-based intensification and diversification practices and one million to access digital agro-advisory services. Emphasizing the role of the private sector in driving such transformation, the Ukama Ustawi (UU) initiative targets to support at least 30 start-ups and SMEs.

Disclaimer

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Summary

The Index-based flood insurance (IBFI) is one of the outputs of the research under the initiative on Diversification in East and South Africa (UU), Work Package two (WP2): Bundling climate insurance solutions focusing on a case study in districts in Southern part of Zambia. This research was developed by the International Water Management Institute (IWMI) co-designed with an insurance institution and insurance product developers and co-implemented with the Ministry of Agriculture (MoA) and Disaster Management and Mitigation Unit (DMMU) of Zambia. The first part of the study covers Flood index development from observed rainfall and river stream flows, and flood model development to produce flood parameters in terms of flood depth, flood duration, and extent - complemented with remote sensing flood inundation to develop flood index products. The second part of the study focuses on interaction with the community, which is gender-sensitive, and stakeholder engagement at all levels. The development of the IBFI also relies on previous – post surveys on the IBFI implementation experience from insured communities.

This report consists of the activities we have undertaken to operationalize the IBFI implementation in Zambia. Satellite flood maps were produced to indicate the hazardous location and extent of flood impact in the southern province of Zambia that occurred at the beginning of 2023. The flood maps were used as a benchmark for IBFI product development in the pilot area. Multi-level stakeholder consultation has been conducted – first, a District-level stakeholder consultation aiming at site prioritization, knowledge sharing, and understanding the level of flood impact on the livelihoods. Second, stakeholder consultation with higher officials in Lusaka from the MoA, Zambia Meteorological Department (ZMD), Water Resources Management (WARMA), World Food Program (WFP), insurance institutions, and product developers. The meeting was aimed at laying a road map on how to co-develop and co-implement the index-based flood insurance in the selected pilot area. Together with stakeholders engaged in the district and complimented with earth observation flood maps, Namwal District, which is in the southern province of Zambia has been prioritized for bundling IBFI. Tabular data on the flood exposure elements from the district has been shared with IWMI, as presented in this report, which will be analyzed and used to support the development of IBFI products.

The first phase of product development for IBFI is to use observed data to produce the indices. Here, the observed rainfall, stream flow, and water level data were used to produce a design flood index insurance product in the Kafue flats. The second phase of the design of the flood index insurance product will be produced using flood modeling. So far, the flood model tool has been developed to produce flood parameters that will be used for insurance product development and the calibration and validation of the model is in progress.

Content

1.0 Background

Climate change poses significant risks to individuals, particularly farmers, and households with small-scale agriculture. The increasing frequency and severity of extreme weather events, such as floods and droughts, have highlighted the need for innovative risk management solutions. One such solution gaining traction is the bundling of climate index insurance. Bundling of index-based climate insurance solution represents an innovative forward-looking approach to addressing the complex challenges under changing climate conditions. By combining innovative insurance products, advanced analytics, and collaborative efforts, this solution aims to build resilience and promote sustainable practices in the face of increasingly unpredictable climate extremes. The Consultative Group for International Agricultural Research (CGIAR) identified the bundling of climate insurance as an innovative climate risk management solution for smallholder farmers in South and Eastern Africa under the regional initiative called Ukama Ustawi (UU).

The bundling climate insurance solutions approach consists of regional selection, fieldwork, community interaction, including current experience from communities on index insurance feasibly, stakeholder meetings, and discussions (e.g., private sector, insurance companies) on the role of climate Index insurance solutions and their interest. This approach promotes sustainable climate risk reduction practices that can enhance resilience. The index-based insurance solution prioritizes smallholder farmers designed with equity equity-centric approach.

As part of the index-based insurance solution, the WP2 of the UU initiative focuses on Index-based flood insurance at the first stage, and at the later stage, it will consider the drought part as well. The WP2 was led by Dr. Giriraj Amarnath, a research group leader – of Water Risk to Development and Resilience, with technical support from Dr. Yakob Umer – a Water Risk and Data Science specialist, and Dr. Mirriam Makungwe – Geospatial specialist. The team aimed to develop insurance products through analysis of observed hydroclimatic data, collecting community-based flood vulnerability and exposure data, modeling flood parameters, and harnessing earth observation data. The implementation of the product aimed to achieve through multi-stakeholder engagements and community interactions, which are going to be gender sensitive.

2.0 Multi-level Stakeholders` Engagement

Two-level stakeholder engagement was conducted. First, a district-level stakeholder meeting with District officers from DMMU, the Ministry of Community Development, and the Ministry of Agriculture was held in Monze District on 25 September 2023 (Figure 1). The purpose of the meeting was to co-identify the vulnerable area at a community level and select the testing site. The participants were from the Monze, Mazabuka, and Namwala Districts. The session highlighted the impact of multi-system flood impact in the southern province of Zambia (Table 1) and the need for resilient options such as index-based insurance at the community level against the flood impact.

The key discussion points were:

Yakob Umer spoke on the extent of the 2023 flood hazard in the districts based on the results from the earth observation satellite flood maps:

- The level of the hazard and its impact is large, so there is a need to coordinate efforts for data sharing and collection for better flood management.
- There's a need for knowledge sharing, coordination, and collaboration between CGIAR and other R&D organizations and stakeholders at all levels.

Mirriam Makungwe led the discussions on co-identification of the flood-affected site:

- In discussion with key stakeholders from three Districts on flood impact, and the need for community-level vulnerability assessment.
- Villages/communities more vulnerable to flood impact were co-identified.
- Strengthening and expanding knowledge-sharing networks can help bridge these gaps and foster more effective collaboration in knowledge management, this is where UUs Learning comes in.

At the end of the meeting, the questionnaires were distributed to the stakeholders to fill in the vulnerable areas from each District and sent them back to us. As per the results of the questionnaires, Nanwala District (10) areas and Mazabuka District (7) areas are considered flood-vulnerable areas. We are expecting the questionnaires from Monze District in the coming weeks. Currently, the identification of the specific flood-vulnerable area for IBFI product development is in progress.

Flood Exposure and Vulnerability Consultative Meeting with District Officers from DMMU, MoA, and Community Development Identified actual locations of communities/farmers affected by floods in Monze, Mazabuka, and Namwala districts. Collect relevant data on flood exposure and vulnerability of identified sites. Plan on field visits to the communities for focus group discussions.

Table 1. *Flood exposure data in Namwala.*

Name of the area/ ward	2023				2022				2021		
	HH affected	Crop damage (ha)	No of Livestock affected	Sources of Flood	HH affected	Crop damage (ha)	No of Livestock affected	Sources of Flood	HH affected	Crop damage (ha)	Sources of Flood
Chinyemu (Namwala)	203	234	400	rainfall	15	107		River	34		
Chitongo (Chitongo)	34	372	657	rainfall	34	134		River	47	5	Rainfall
Nachuumba (Mbeza)	350	813	218	rainfall	769	354	763	River	67	12	Rainfall
Shamunkunchi (Kantengwa)	127	163	98	rainfall	23	97		River	46	3	Rainfall
Shokombwe (chitongo)	245	325	56	rainfall	17	20		River	54	6	Rainfall
Mandondo (Mandondo)	138	312	127	rainfall	18	96		River	97	9	Rainfall
Nakamboma (Nakamboma)	350	360	476	rainfall	376	1832	845	River	42	6	Rainfall
Kabulamwanda (Kabulamwanda)	98	306	285	rainfall	10	5		River	13	11	Rainfall
Chilumino (Mandondo)	165	127	73	rainfall	42	5		River	10	11	Rainfall
Total	**1,710**				**1,304**				**410**		

Figure 1. *Group photo during stakeholders meeting in Monze, Zambia.*

The second stakeholders` meeting was a roundtable meeting held in Lusaka on 04th October 2023 (Figure 2). The meeting objective was to engage with government, non-government institutions, Insurance institutions, SMEs, and other concerned stakeholders to address climate risks through bundled climate index insurance, specifically to discuss:

- Product development for flood index insurance
- The role of Insurance Institutions, Corporations, and SMEs in addressing index insurance
- Funding strategy to be considered, focusing on pilot areas: Farm level Insurance or Community level?

The key discussion points were:

Giriraj Amarnath presented the previous experience from communities (A survey prepared by IWMI HQ on flood insurance feasibility) and an ex-post survey on the IBFI implementation experience from Southeast Asia:

- The role of the earth observation satellite flood data for IBFI product development.
- Strategies to develop flood index products from Earth observation data.
- The applicability of the developed product and its perception in the community.

Yakob Umer presented the extent of the 2023 flood hazard in the districts based on the results from the earth observation satellite flood maps and flood inundation modeling perspective.

Building on the foundational work undertaken as part of Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) on the Prototype of Flood Forecasting and early warning system for Zambezi River Basins, the International Water Management Institution (IWMI) led CGIAR Initiative on the Diversification in East and Southern Africa (better known as Ukama Ustawi) is fostering the application of flood model outputs into Flood Index Insurance applications in collaboration with Madison Insurance Company and Pula. The flood hazard product in combination with the groundwork on vulnerability and exposure (such as the case with crop damage, number of households affected…etc.), helps us to produce risk maps or flood index information. This helps us to contribute to the development of Flood Index Insurance products. The detail on the role of the multi-stakeholder meeting and the index-based flood insurance product development in alleviating climate risk was published as a blog: https://www.cgiar.org/news-events/news/managing-floods-and-droughts-in-east-and-southern-africa-mitigating-the-effects-of-global-warming/.

Figure 2. *Group photo during stakeholders' consultation in Lusaka, Zambia.*

Moreover, the perspectives of stakeholders were well reflected at the meeting in supporting the development of the index-based flood insurance product and its implementation. Consequently, the insurance company called Madison in collaboration with PULA, the company responsible for developing the product, as evidence to work with us on developing the product, as shown in Figure 3.

Figure 3. *Group photo during the meeting with Maddison insurance and PULA, the product developer, Lusaka, Zambia.*

3.0 Approaches and Site Selection

Figure 4 shows approaches taken in constructing IBFI in the case study. The approach consisted of five steps: (1) flood parametric development; (2) Community vulnerability assessment; (3) Co-develop the IBFI with insurance and product development institutions; (4) act-providing pay-out; (5) monitoring the applicability of the approach. Under this approach, the flood index parametric product development has two phases. first, using station-based observed data, and second, detailed flood parametric product at a pilot location using flood modeling and satellite flood maps.

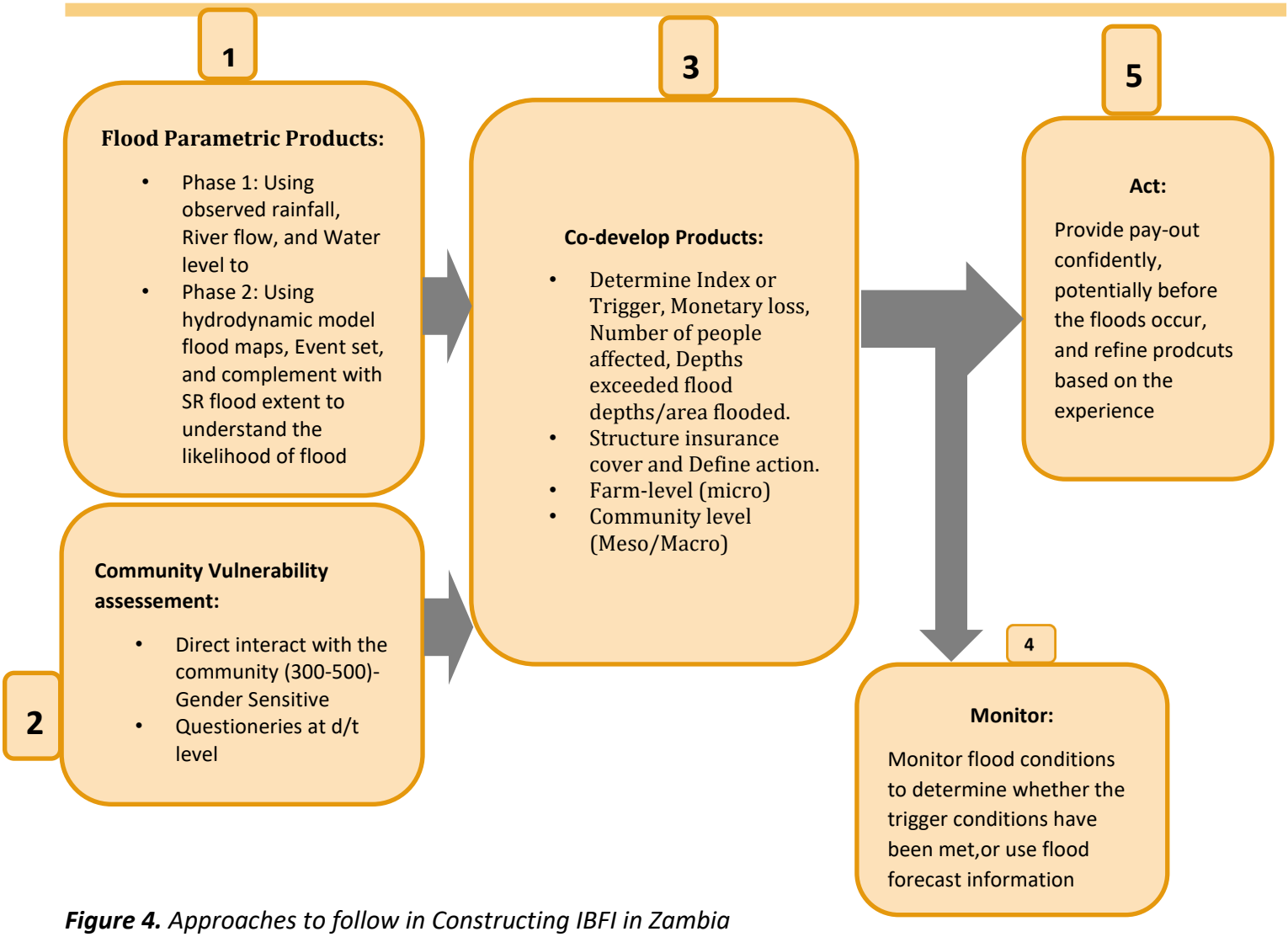

Figure 4. *Approaches to follow in Constructing IBFI in Zambia*

Based on the flood maps produced using MODIS and community-based stakeholder interaction, we selected Namwala District as a test site. Figure 5 indicates the location of Namwala District in the Kafue catchment. The Kafue River is the longest river lying wholly within Zambia about 1,576 kilometers long. It flows through a wide, flat flood plain after leaving Lake Itezhi-Texhi through the Itezhi-Texhi dam. It is the largest tributary of the Zambezi and of Zambia's principal rivers. The flats cover areas from Lusaka and Southern Provinces. The selected test site, Namwala District, is in the Southern Province. The land cover of the district was produced using information from Sentilel-2 using Google Erath Engine. The produced Land cover classes will

be used for flood modeling for the second phase of flood parametric product development and to assess flood risk on crop fields.

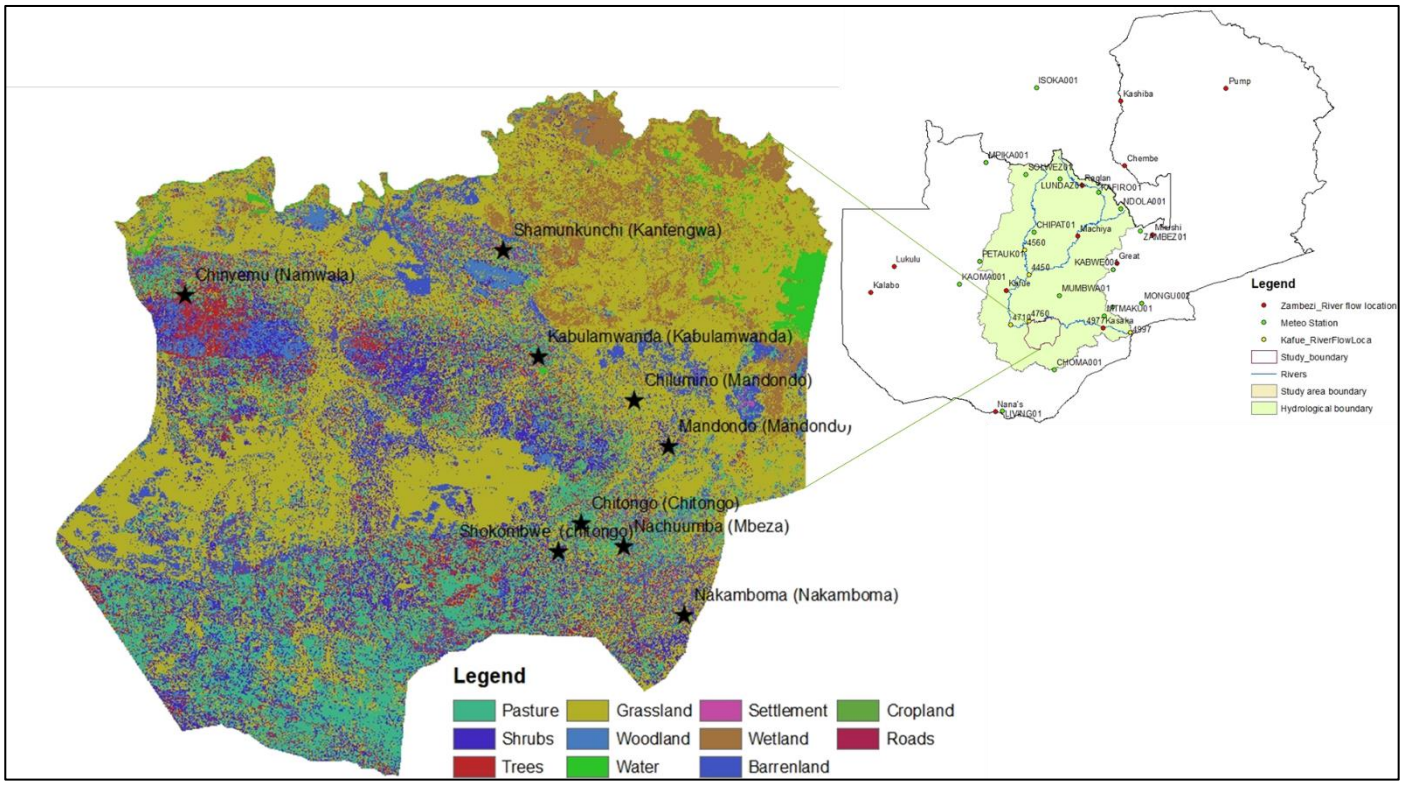

Figure 5. *Selected site (Namwala) for IBFI development with its different land cover classes. The points represented by Black starts indicating the location and names of the communities affected by flood risk.*

4.0 Setting the Scene on Flood Impact using Earth Observation Flood Maps

Flood impact in Southern Zambia: During the wet season majority of the southern Province of Zambia is exposed to violent flooding affecting livelihoods, damaging crops, and displacing hundreds of people.

Extreme rainfall is the main cause of the flooding that affects crop fields, which exerts pressure on the existing causes of flooding such as low-lying topography and clay soil with poor drainage systems. Figure 6 shows the flood maps produced using MODIS, and the result indicates the extent of flooding (red color) in February 2023 and the districts such as Namwala, Itezhi-tezhi, Monze, and Mumbwa were hardly affected by the flooding. Focusing only on Namwala District, as shown in Figure 5, the selected site for Index-based flood insurance, 3290 ha of crop areas have been affected by the flooding.

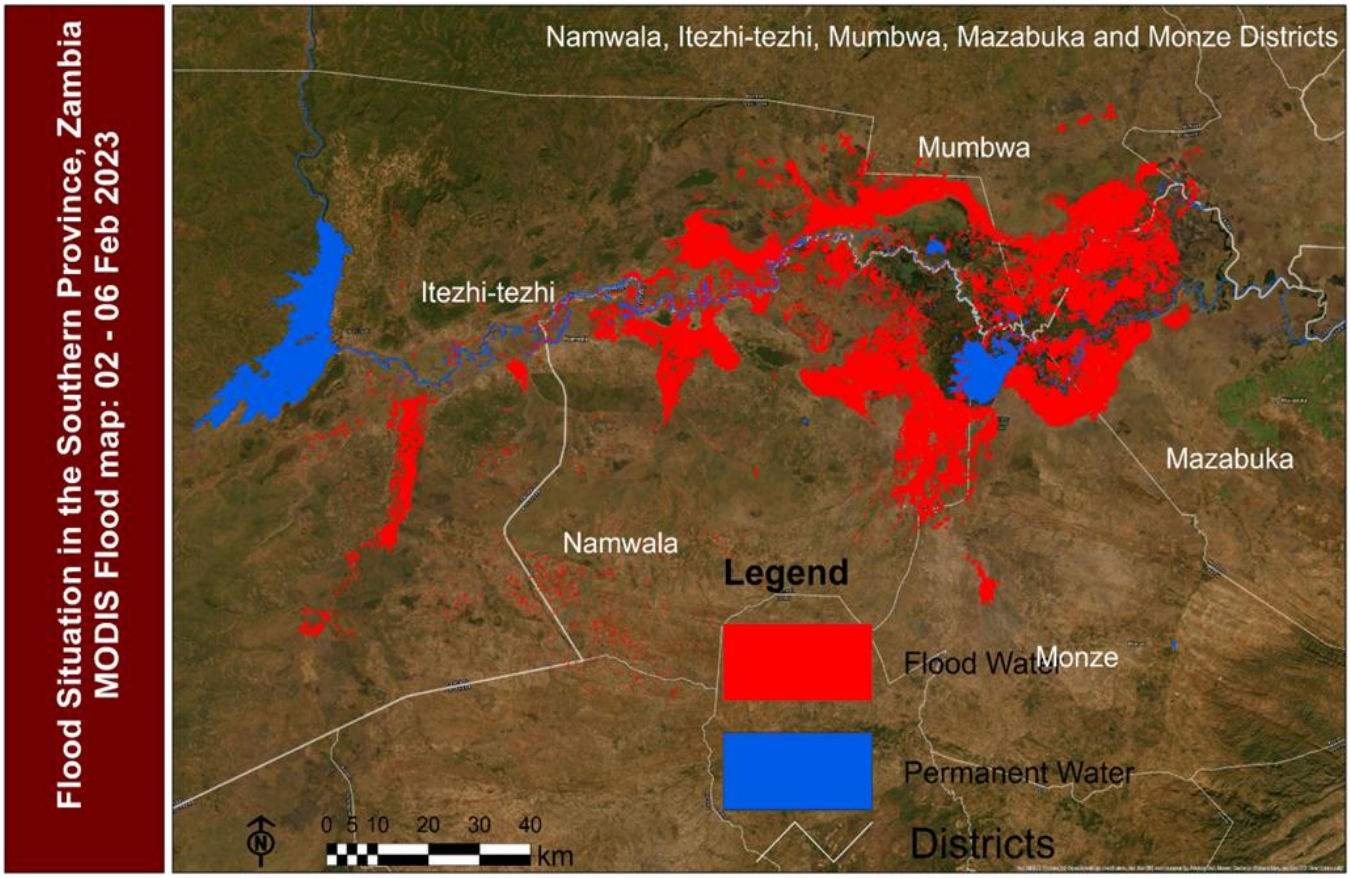

Figure 6. *MODIS flood map on 02 – 06 Feb 2023 in the southern Province of Zambia (author illustration with satellite data from IWMI database).*

5.0 Developing Flood Index Products based on Flood Inundation Modelling

The flood inundation based IBFI requires flood parameters, such as flood depth, duration, and extent. These parameters come from the flood inundation model. Strategies for producing flood inundation parameters rely on effective prediction from the flood inundation model. One of the essential inputs for the inundation model is hydrological input (i.e., the actual river peak event that triggered the hazard or design floods of river discharge corresponding to a given return period). Actual peak river discharge that triggered floods on often not available. The design floods used for producing flood hazards derived from the historical discharge record of the catchment. For this case study, the discharge data observed at Kafue Namwala Pontton (ID 4760) and Itezi-Tezhi dam (ID 4710) gauging stations were used for the design flood estimation. The Gumbel (EV1) distribution function commonly used in extreme value analysis in hydrology was fitted to the annual maximum discharge series to derive the 1-in-2 and 1-in-100-year design floods (Figure 7).

However, the flood in the Kafue flats, which includes Namwala, Itezhi-tezhi, Monze, and Mumbwa Districts requires multi-system simulation. The river flow is regulated by the Itezhi-tezhi dam and the hydrology of the river before the dam has less effect on downstream flooding. Hence, the floods in the Kafue flats can be due to Dam release as well as flash floods. Therefore, the model development requires modeling floods using first, multi-system events derived from discharge data extracted from the station (ID 4760) and associated rainfall values, and second, flash flood simulation only.

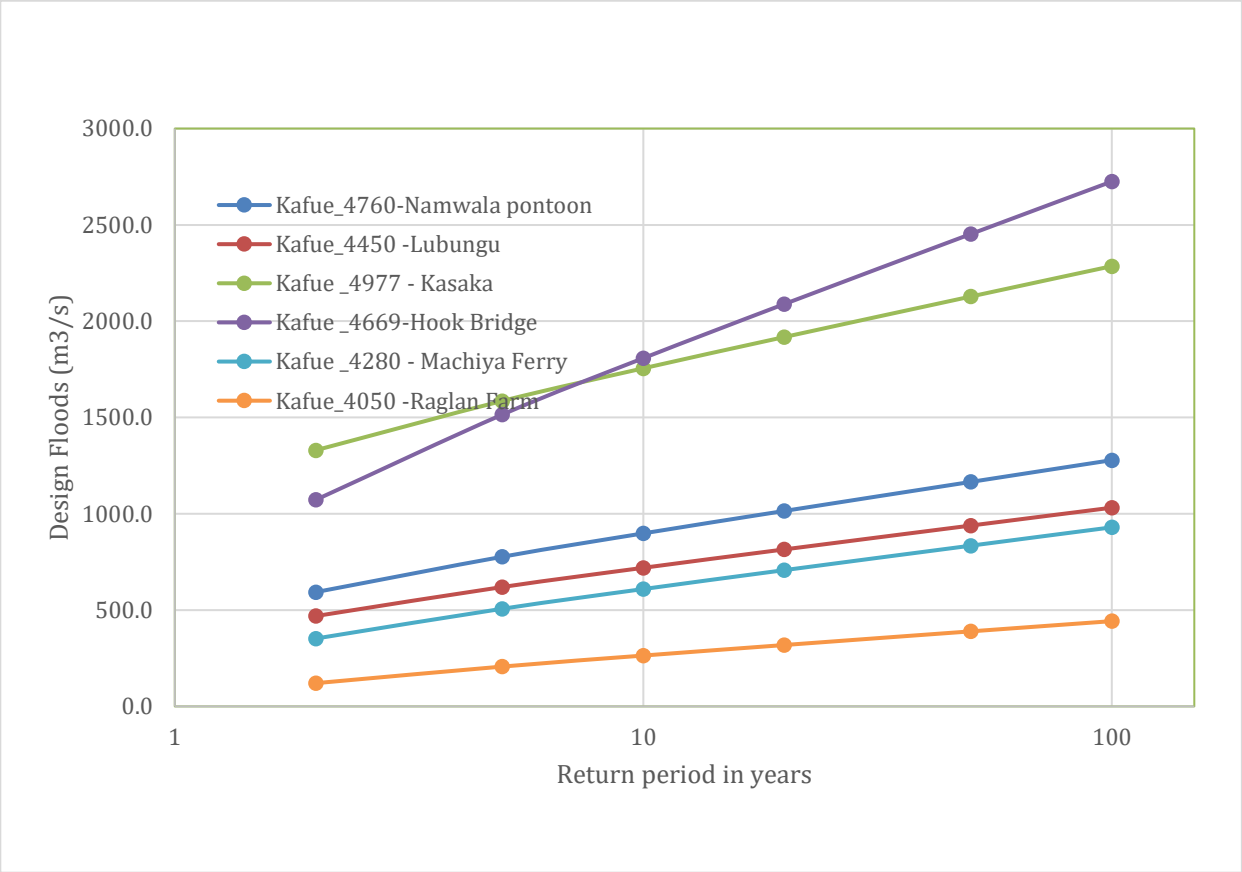

Figure 7. *Design floods of different return periods (the circle on the line represents results from 1– in-2 to 1-in-100 return periods)*

Another essential data for flood inundation modeling is the topography and river geometry (river width, Manning Coefficient, and River bankful geometry) data. We used the Digital elevation model (DEM) from FABDEM, the river width and river masks from GRWL, and the bankful depth derived from DEM.

For flood modeling, we used the LISFLOOD-FP hydrodynamic model (Neal et al 2012), a subgrid channel code that solves the full shallow water equations except for the convective acceleration term. It was largely used for floodplain inundation and has been proven to properly perform in numerous test sites (e.g., Kitten et al 2020; F.E. O`Loughlin et al, 2019). The model set up for the main Kafue reaches to propagate the discharge for 1-in-100 years from the Itezhi dam to the head of Kafue Gorge Upper Power Station. We used design floods from Namwala Pontton (ID 4760) and Itezi-Tezhi dam (ID 4710) gauging stations. The model was simulated for five days using the steady state of design flood discharges set as the upstream boundary conditions and we assumed a free slope at the downstream boundary conditions.

Figure 8 shows a flood map produced using design floods of 1 -in -100-year return period. It indicates large-scale flood inundation in the Kafue flats in the southern province of Zambia. The flooding shown here is mainly due to the rising water depths from river floods, hence, it inundated largely the wetlands and areas in the vicinity of the wetlands. As the croplands are far from the wetlands, the produced flood maps can be used for infrastructure planning, livestock management, and ecosystem management. For flood risk assessment on crop fields, multi-system flood events that include flash floods and soil properties need to be modeled.

This result is the first attempt at setting up the LISFLOOD-FP model to simulate Floods in the Kafue flats, and the model calibration and validation are currently in progress. Moreover, for index-based flood insurance product development, a detailed flood modeling needs to be developed by including flooding from other sources, and the dam effect on flows, which is the next phase of the work.

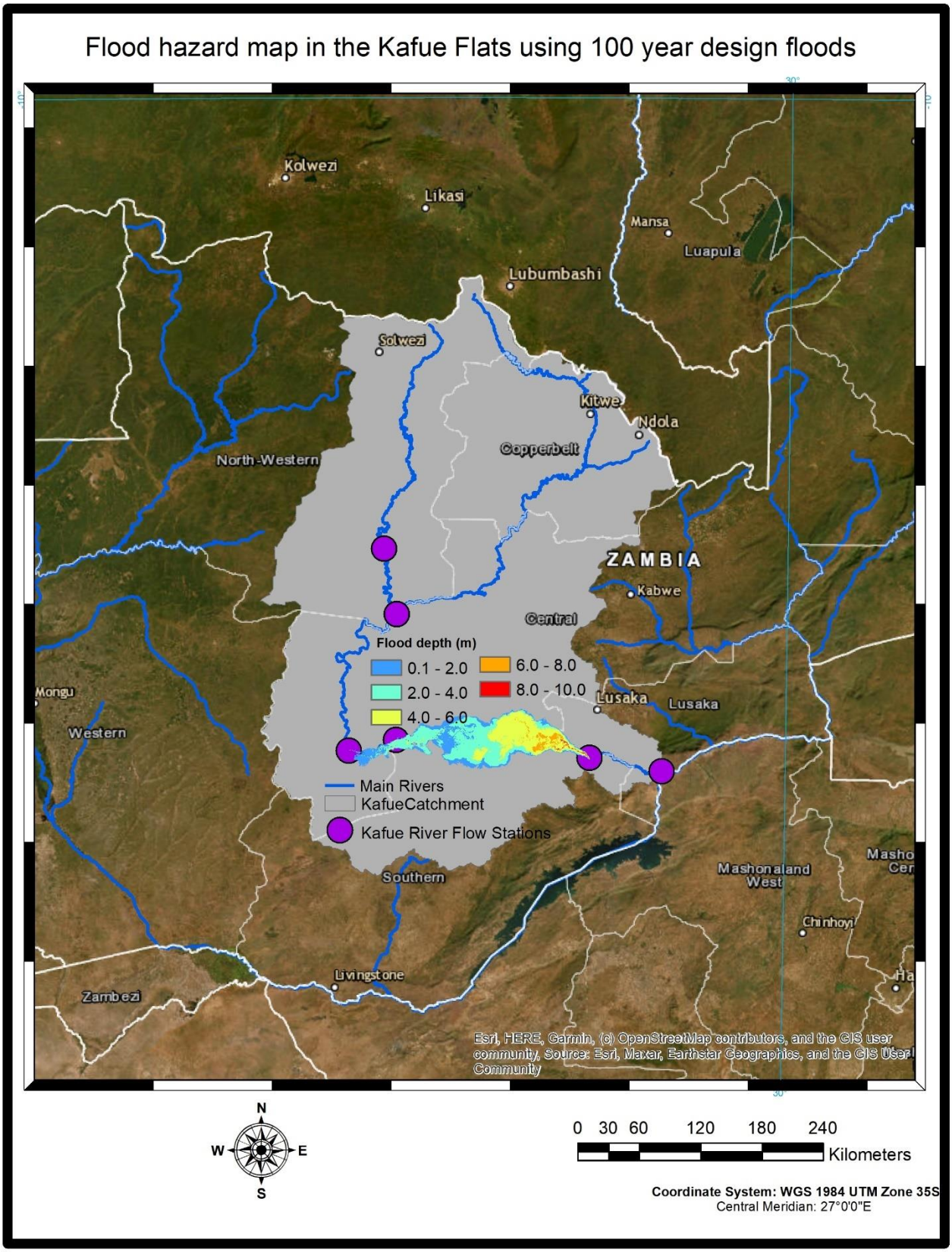

Figure 8. *Model results of flood depths produced using design floods of 1 -in -100-year return period.*

6.0 Conclusion

The study focuses on the district-level consultation, site prioritization, and flood model development for index-based flood insurance in Zambia. Muti-stakeholder consultation has been conducted – at national level, District level, and the community level aiming at laying the direction on the co-development and co-implementation of the index-based flood insurance, selecting the implementation site, and perception of the community on the district-level development, respectively.

Based on satellite flood maps and district-level stakeholder engagement, Namwala District has been selected as the test site for index-based flood insurance product development. A flood inundation model has been developed for the main Kafue River reach, downstream of Itezhi-tezhi dam, to map flood inundation from the river. The calibration and validation of the model is in progress. The flood inundation maps due to flash will be developed based on the information from rainfall and soil characteristics, which is planned to be done in 2024. In the end, we aimed to incorporate multiple triggers and parameters to develop efficient index-based insurance that will cover the diverse flood types.

7.0 References

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