Development of a Flood Index Insurance Product for Zambia

15 December 2023
Zambia

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CGIAR
INITIATIVE ON
Climate Resilience

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Suggested Citation

Batra, N.; Amarnath, G. 2023. *Development of a flood index insurance product for Zambia.* Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Initiative on Climate Resilience. 18p.

Acknowledgments

This work was carried out with support from the CGIAR Initiative on Climate Resilience, ClimBeR and CGIAR Initiative on Diversification for Resilient Agribusiness Ecosystems in East and Southern Africa, Ukama Ustawi. We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund.

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Learn more about ClimBeR here: https://www.cgiar.org/initiative/climate-resilience/

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SUMMARY

Weather Risk Management Services Pvt Ltd (WRMS) is collaborating with the International Water Management Institute (IWMI) as part of the CGIAR Initiative on Climate Resilience (ClimBeR) to develop financial solutions for post-extreme climatic events. The focus is on creating parametric insurance solutions to aid vulnerable populations in managing and mitigating loss and damage caused by natural disasters, with a primary emphasis on floods.

The project's scope involves a comprehensive approach to enhance community resilience through financial solutions for flood. It begins with identifying vulnerable locations using secondary data sources. The subsequent steps include developing parametric insurance products, setting triggers and damage ratios based on past events, and evaluating community vulnerability.

Zambia is particularly prone to seasonal floods from November to April. Major rivers like Zambezi, Kafue, and Luangwa can lead to widespread inundation, impacting lives, displacing communities, damaging infrastructure, and disrupting agriculture. The project focuses on flood risk in specific regions, the Kafue flats area in Lusaka and Southern Provinces.

Data sources crucial for assessing flood severity include river water level, dam discharge data, and rainfall. The study utilizes historical data from 1980-2023 for water level and discharge, and 2000-2020 for rainfall, collected from multiple locations in the Kafue plains area.

The development of the flood index-based insurance product involves analyzing data to determine triggers for flash floods and riverine floods. The shortlisted region experienced severe flooding in the past, and detailed analysis has been done to validate if the collected data sets capture both the intensity and duration of those extreme events.

The proposed index insurance product features triggers based on water level and rainfall data, offering fast and transparent settlement with low administrative costs. For riverine floods, payouts depend on the increase in daily water level from a set benchmark, considering the number of days above the threshold. For flash floods, compensation is triggered by excess rainfall over a specified period.

Ultimately, the project aims to offer a combined flood coverage product addressing both flash and riverine floods, contributing to the overall goal of strengthening disaster resilience through integrated risk analysis, financial solutions, and actionable protocols.

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1. INTRODUCTION

WRMS (Weather Risk Management Services Pvt Ltd) is supporting IWMI under the CGIAR Initiative on Climate Resilience (also known as ClimBeR) to develop financial solutions that can help provide relief post an extreme climatic event. Financial solutions such as parametric insurance solution can help vulnerable population in managing and/or mitigating the loss and damage.

The scope of work involves a comprehensive approach to enhance community resilience through financial solutions for disaster management. The initial phase focuses on identifying vulnerable locations through a concise feasibility review, leveraging secondary data sources. Once the locations and major risks are identified, the work involves development of financial solutions, encompassing the creation of parametric insurance and other mechanisms. This process includes setting triggers and corresponding damage ratios based on the impact assessments of past events, and evaluations of community vulnerability to natural hazards.

Furthermore, the identification of early action protocols for various agencies is crucial to facilitate proactive measures for mitigating losses. The deliverables of this initiative encompass a catalogue of historical flood events, development of trigger settings and protocols utilizing seasonal forecast data, and the handover of index settings and methodologies for incorporation into the AWARE platform. This multifaceted approach seeks to strengthen disaster resilience by integrating risk analysis, financial solutions, and actionable protocols.

Early Warning Systems play a pivotal role in facilitating timely and effective actions, and ex-ante insurance solutions can be helpful in pre-disaster efforts. Likewise, Index based insurance on actual data can be helpful in precisely determining payouts post the flood event occurrence. In response to the critical need for innovative financial solutions to enhance community resilience against natural disasters, particularly floods, the focus of this report centers on the development of a flood index-based insurance product based on proxy flood indicators.

2. ZAMBIA RISK PROFILE

Zambia, located in Central and Southern Africa, exhibits a tropical climate influenced by its varied altitudes. The Köppen climate classification categorizes most of the country as humid subtropical or tropical wet and dry, with pockets of semi-arid steppe in the southwest as shown in figure 1. Zambia experiences two primary seasons: the rainy season (November to April) corresponding to summer, and the dry season (May to October/November) aligning with winter. Altitude moderates the climate, providing a subtropical climate for much of the year.

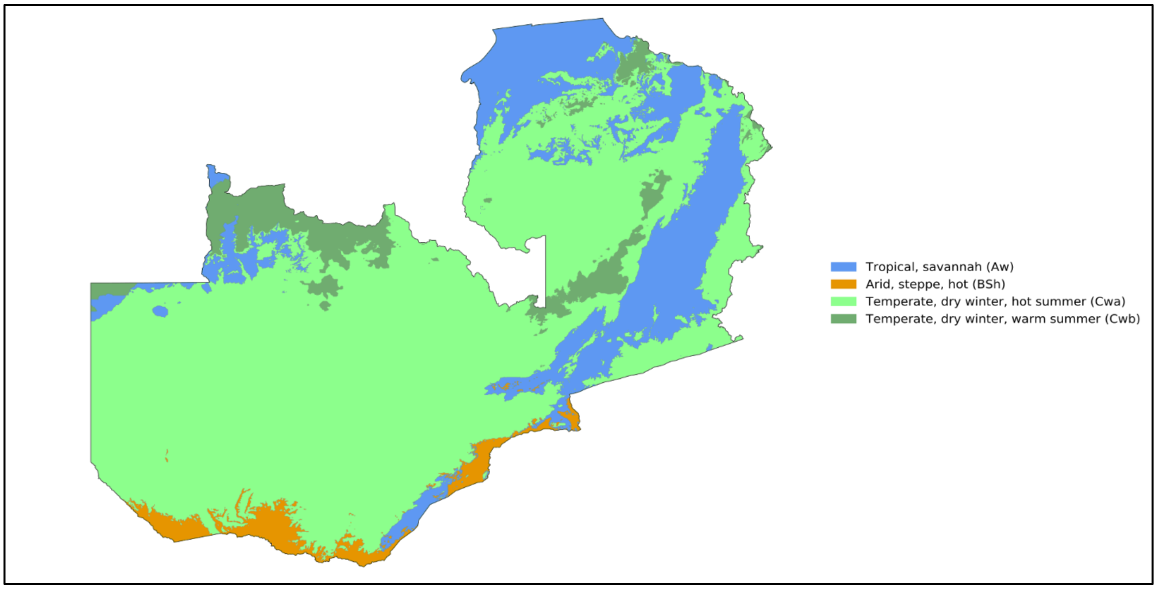

***Figure 1: Koppen-Geiger climate classification map for Zambia (1980-2016)*[1]**

During the rainy season, precipitation ranges from 500 to 1,400 mm per year as shown in figure 2. Notably, June, July, and August observe minimal to no rainfall. The onset and cessation of the rainy season significantly impacts economic, cultural, and social activities. Rainfall is brought by the Intertropical Convergence Zone (ITCZ), accompanied by thunderstorms and occasional hail. In some years, the ITCZ moves south of Zambia, leading to a brief dry spell in the north. The north experiences the highest rainfall, while the far south and certain river valleys are comparatively drier.

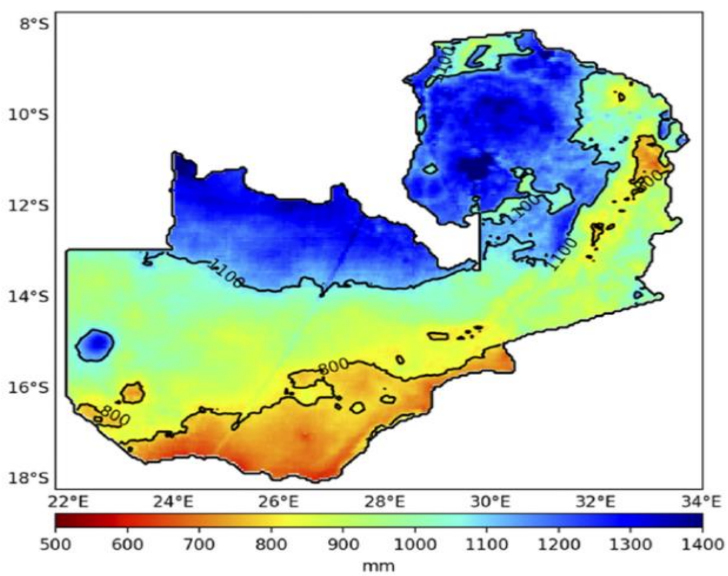

***Figure 2: Mean Annual Rainfall map of Zambia for the period 2000-2016*[2]**

[1] [Climate of Zambia - Wikipedia]
[2] [(PDF) Cognitive Biases about Climate Variability in Smallholder Farming Systems in Zambia (researchgate.net)]

Historically, Zambia is frequently inundated with seasonal floods and flash floods with increased severity and frequency in recent decades. Inadequate infrastructure paired with the fact that a large proportion of the population is rural and poor, makes Zambia highly vulnerable to natural hazards, especially floods. The losses due to the climatic risks are significant. For instance, in 2020 floods affected almost 1 million people and caused significant damage to infrastructure and crops. These climatic risks have also led to increased food insecurity, malnutrition, and poverty among communities that depend on agriculture for their livelihoods.[3]

As shown in below figures 3 & 4, Flood is the most frequent occurring event in Zambia, percentages of these are given in the table 1 below.

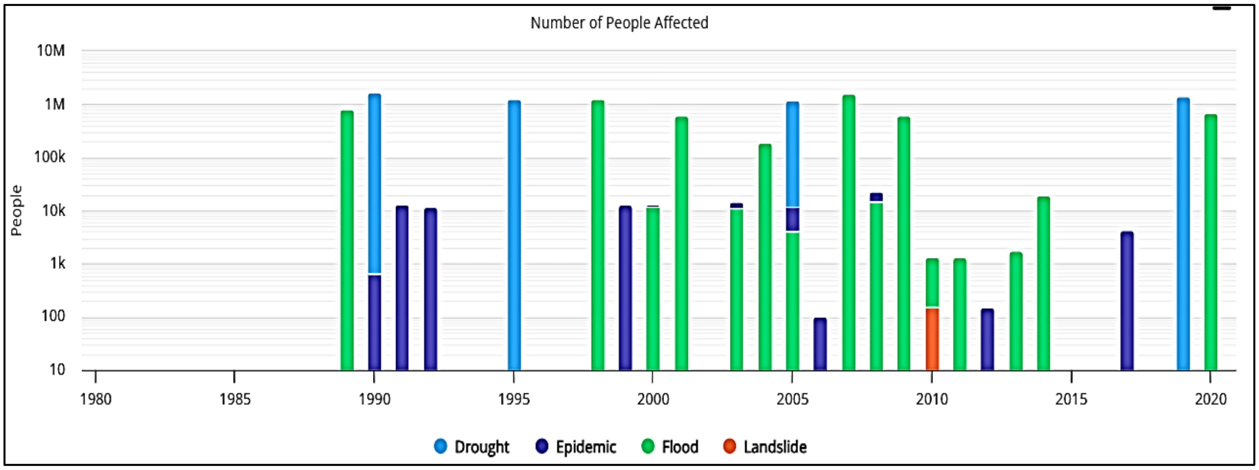

Figure 3: Zambia's Key Natural Statistics from Year 1980-2020

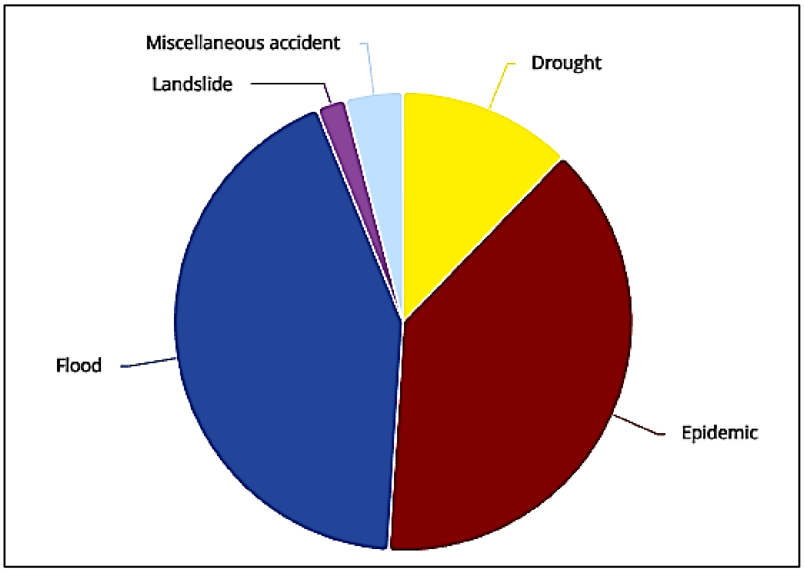

Figure 4: Average Annual Natural Occurrence from Year 1980-2020[4]

[3] Zambia - Vulnerability | Climate Change Knowledge Portal (worldbank.org)
[4] Zambia - Vulnerability | Climate Change Knowledge Portal (worldbank.org)

Table 1: Hazard wise % incidences 1980-2020

Natural Hazard	Contribution in %
Flood	43
Epidemic	39
Drought	12
Landslide	2
Misc. accidents	4

Zambia experiences seasonal floods, primarily during the rainy season from November to April. The country's many rivers, including the Zambezi, Kafue, and Luangwa, can overflow their banks, leading to widespread inundation of low-lying areas. Flooding can result in loss of life, displacement of communities, damage to infrastructure, and disruptions to agriculture, which forms a significant part of Zambia's economy. Two types of floods are prominent in Zambia i.e., River and Urban Flood, as shown in figures 5 and 6. Major flood years in Zambia are mentioned in table 2 below (source see footnote 5).

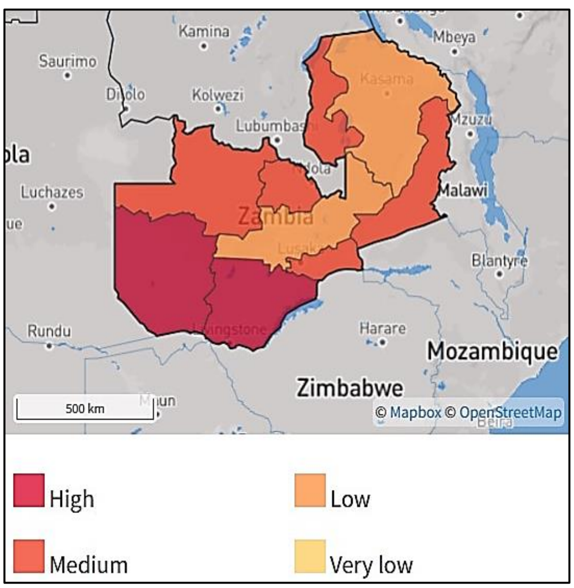

Figure 6: Province wise Hazard Profile of Urban Flood

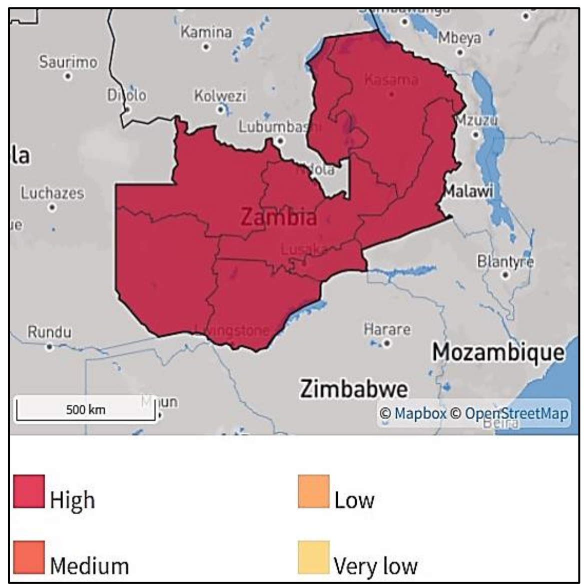

Figure 5: Province wise Hazard Profile of River Flood

Table 2: Major Flood years

Year	No. of people affected from Flood
1989	8,00,000
1998	13,00,000
2000	12,000
2001	6,17,900
2003	11,000
2004	1,96,398
2005	4,000
2007	15,53,521
2008	15,000
2009	6,14,814
2010	1,200
2011	1,375
2013	1,800
2014	20,000
2020	7,05,772

Figure 7 captures the area flooded between 1997 and 2007 in Zambezi River basin. Major floods were recorded in parts of the Zambezi basin during the rainfall seasons of 1999-2000, 2005-06 and 2007[5]. In addition to destruction of homes and infrastructure, and loss of crops and livestock, flooding also inundates land, decreases soil fertility and destroys fodder resources, limiting agricultural production.

[5] Zambezi River Basin flood areas | GRID-Arendal (grida.no)

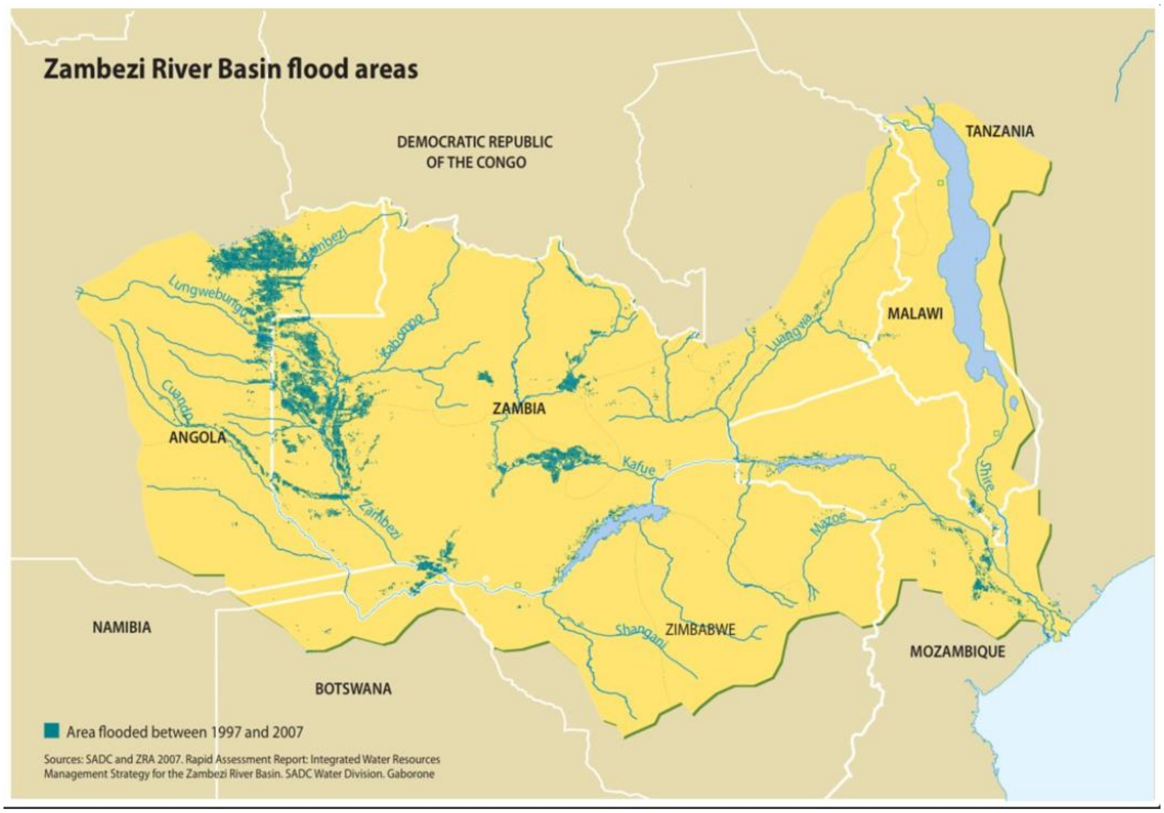

Figure 7: Area flooded between 1997 and 2007

In Zambia, floodplains and associated habitat include:

1) the Barotse Flood plain on the Upper Zambezi River in Western Province;
2) the Kafue Flats and Lukanga Swamp in the Kafue River Basin;
3) the Bangweulu swamps around Lake Bangweulu;
4) the Mweru Wantipa swamps;
5) Lake Mweru- Luapula Swamp in Luapula Province

3. DATA SOURCES

The important data sets which are helpful in assessing the event severity are river water level, dam discharge data and rainfall. The river water level and discharge data are very important data sets to understand riverine floods. However, flash floods incidences can be checked using rainfall data. In case of insufficient surface data, rainfall data can also be taken from satellite/ reanalysis sources. Other proxy flood indicators are flood extent captured in satellite images.

To design flood index insurance product the study has been conducted on Kafue flats area highlighted in below figure 8. The Kafue River is the longest river lying wholly within Zambia at about 1,576 kilometres 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. This area is in Lusaka Province adjacent to Southern Province. Both Southern and Lusaka Province have high risk profile of urban/ flash flood and riverine flood.

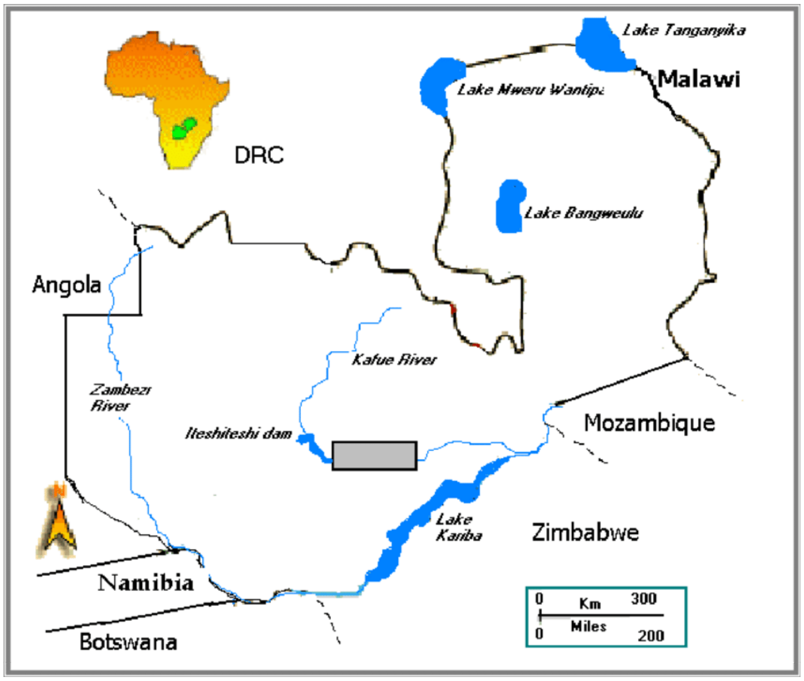

Figure 8: Map of Zambia showing the location of the Kafue Flats study area.

Water level and discharge data from 4 locations for the period 1980-2023 (table 3) and rainfall data of 6 stations for the period 2000-2020 (table 4) was collected for the purpose of designing flood insurance product, locations are highlighted in figure 9.

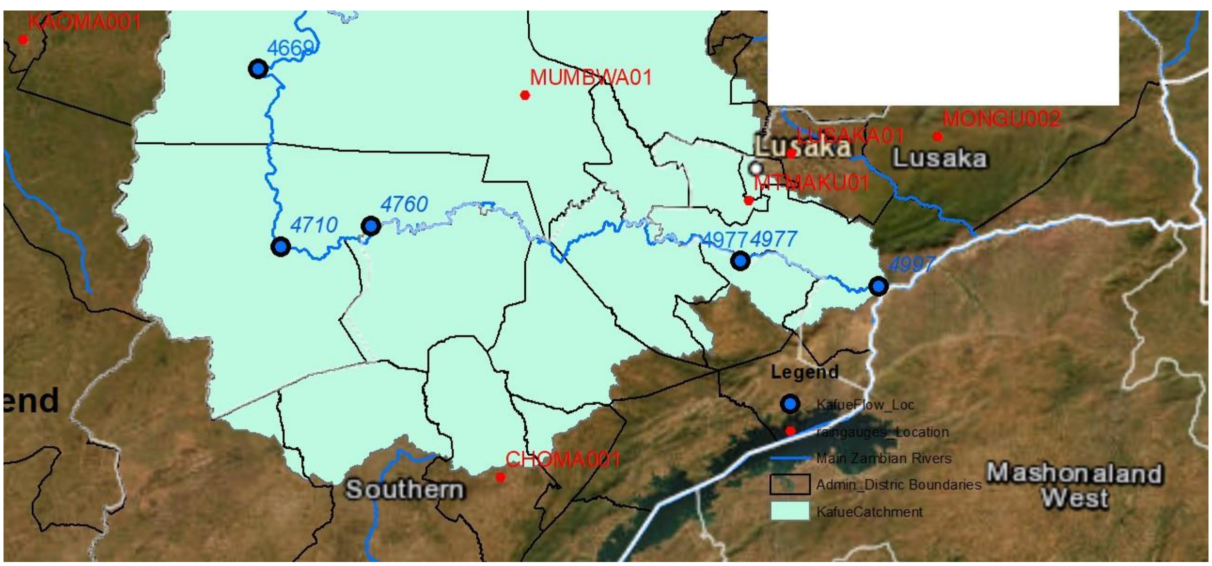

Figure 9: Location and Station map

Historically whenever exceptionally high rainfall has happened across Southern Africa, the main rivers have expanded significantly impacting the surrounding areas. In case of continuous rainfall, the lakes/dam reaches their maximum storage capacity and dam management has to discharge more water which causes flooding downstream. The Zambezi, a flood-plain river that crosses the continent has three major dams. Opening of the Itezhi-Tezhi dam flood gates raises the water level downstream.

Table 3: Water Level locations in Kafue flats area

Kafue River at	location	Lat	Long
4710	Itezhi-Tezhi	15.8	26.0
4760	Namwala Pontoon	15.7	26.5
4977	Kasaka	15.8	28.2
4997	Chiawa Pontoon	15.9	28.9

Table 4: Station in Kafue flats area

Station List
Choma
Koama
Lusaka
Mongu
Mtmaku
Mumbwa

4. DEVELOPMENT OF INDEX INSURANCE PRODUCT

Index Insurance based products settlement is fast and transparent with low administrative costs. Considering there can be more than one relevant parameter for flood, the designed product can either have one or multiple triggers to initiate a claim payment.

In case of a flash flood, rainfall recorded over a continuous spell act as a good proxy to check the event occurrence and severity. However, for riverine floods, the river water level is the best flood indicator. Therefore, a combination of two triggers is required to capture both flood types – Flash & Riverine.

Water level and rainfall data sets collected for Kafue plains were analyzed to check if moderate to severe flood events are captured in the data. Below figure 10 captures the daily week wise maximum water level data and rainfall data for the monsoon period November 2007 to April 2008. In February 2008 intense flooding[6] was reported in certain areas. A significant increase in the water level data is visible for the month of February which is consistent for more than 7 days. Maximum River Water level of 9.3 meters was recorded in Feb second week.

[6] Floods on the Kafue River, Zambia (nasa.gov)

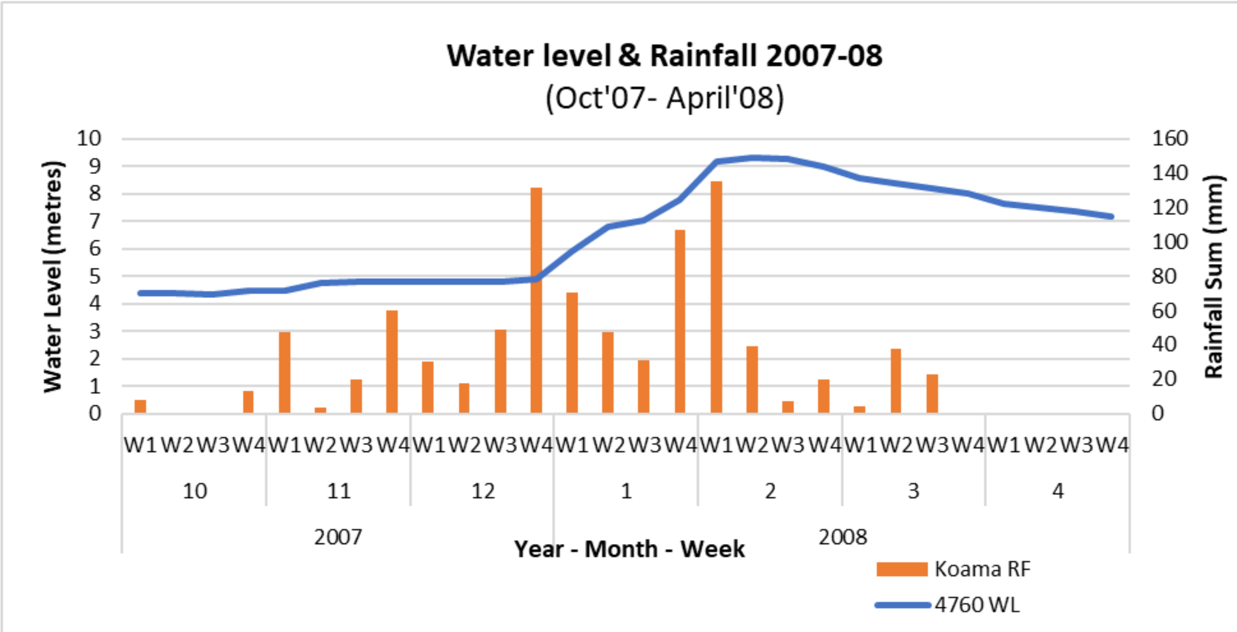

Figure 10: Weekly Water level and Rainfall data for 2007-08 monsoon season

Similar events have also been recorded in other monsoon seasons – 2006-07, 2008-09, Due to the exceptionally early and heavy rainy season in late 2006 (December 2006 - February 2007). Houses collapsed, roads were submerged, bridges got washed away, crops and household food stores had been affected by flooding in February 2007. Below figure 11 captures the week wise sum rainfall of Koama station and corresponding water level recorded at the nearest location (4760). Consistent rainfall coupled with very heavy rainfall incidences in a short spell [7]. Maximum water level of 8.6 meters was recorded in 4760 location and 8.5 meters in 4977 location.

[7] Chambeshi River Floods, Zambia (nasa.gov)

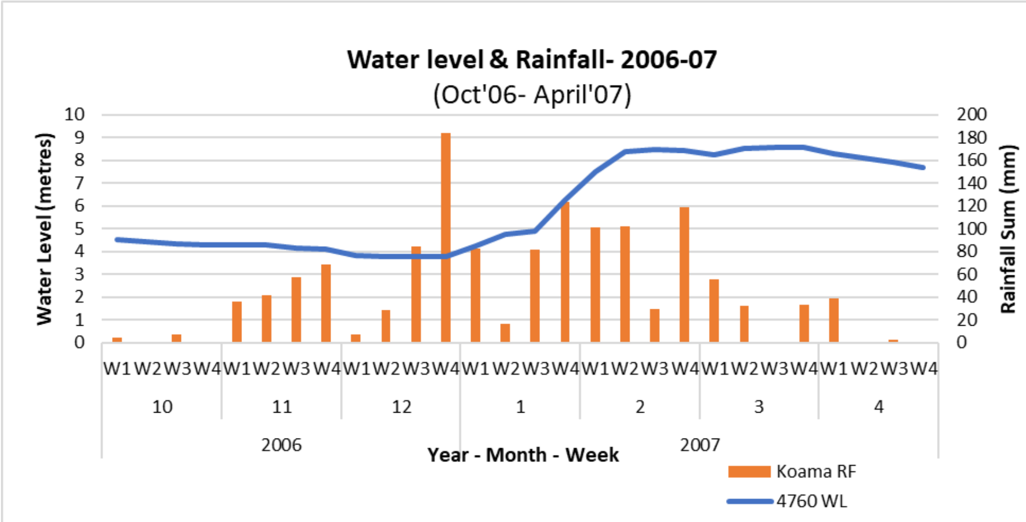

Figure 11: Weekly Water level and Rainfall data for 2006-07 monsoon season

In 2008-09 monsoon season, torrential rainfall during Nov'08 – Jan' 09 resulted in flooding in March 2009[8]. It was one of the worst flood events in the last 40 years. Floods affected more than 20,000 households in Southern province. The week wise rainfall sum and increase in water level during the monsoon season is captured in below figure 12.

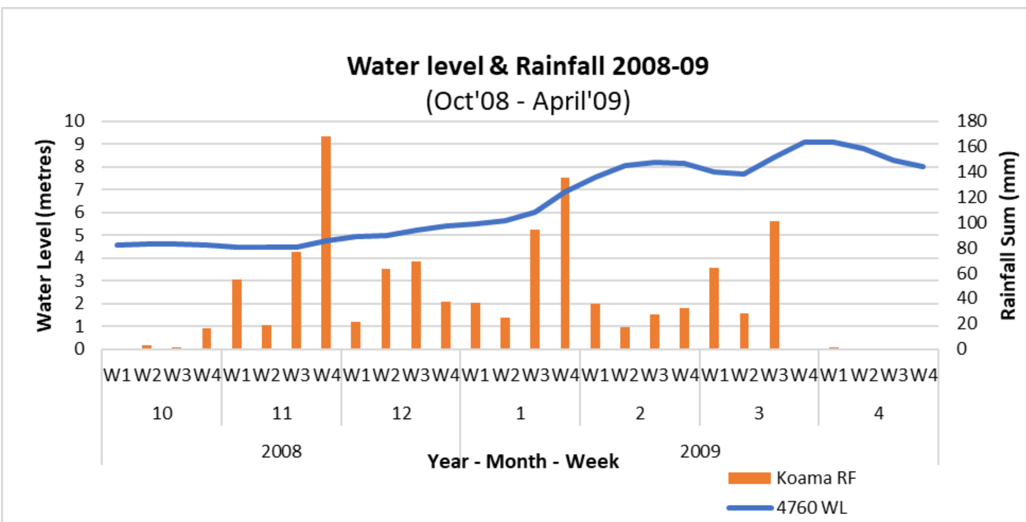

Figure 12:Weekly Water level and Rainfall data for 2008-09 monsoon season

In addition to the above incidences, there have been flash flood events where a single day rainfall resulted in flash floods. One such event occurred in January 2020 which is not captured in water level data as shown in figure 13. A bridge was washed away by the flood waters in Monze district and significant agriculture area was damaged due to this event[9].

[8] Zambia and Namibia face worst floods in 40 years | Reuters
[9] Zambia – Floods in Southern Province – FloodList

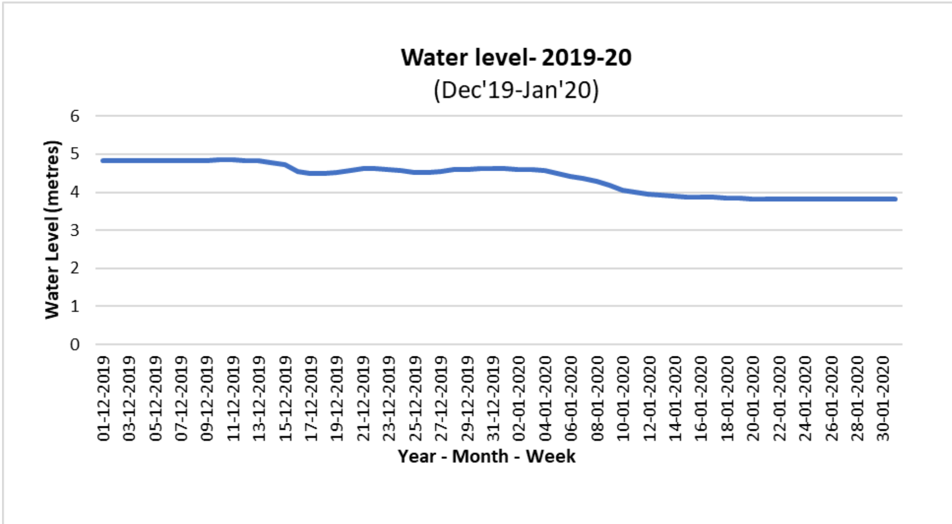

Figure 13: Weekly Water level data for 2019-20 monsoon season

Another such flash flood event happened due to very heavy rainfall in the two weeks of December'2013 in Mazabuka district of Zambia's Southern Province[10]. Figure 14 below captures the incidence in week 3 and week 4 sum rainfall of December 2013. Corresponding to this event though there is an increase in water level, but it is not around the danger level.

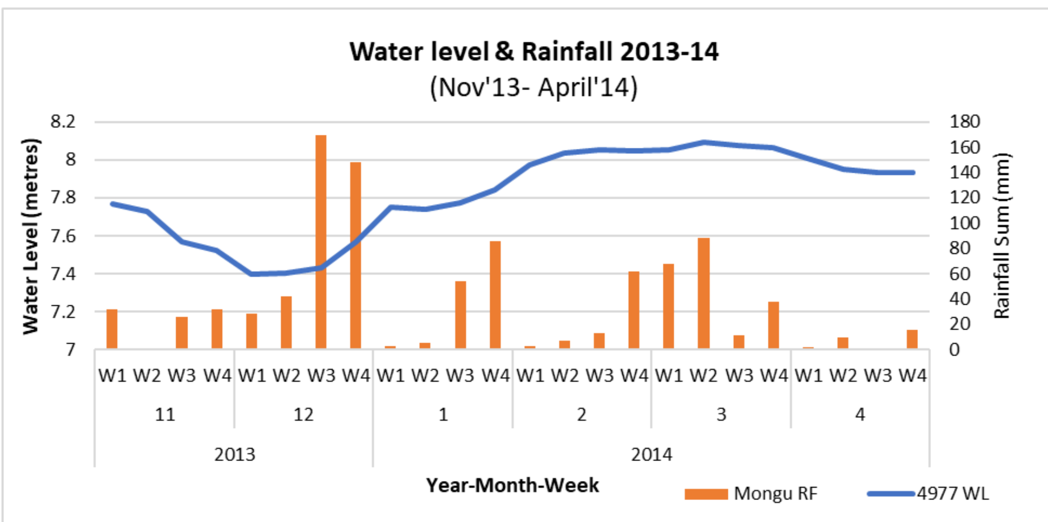

Figure 14:Weekly Water level and Rainfall data for 2013-14 monsoon season

Historical catalogue and proxy indicators

In the below table 5 the flood catalogue has been compared with River water level of two locations and upward rainfall deviation of nearby stations. High deviation indicates an abnormal surge in rainfall, which

[10] 20,000 Homeless After Floods in Zambia – FloodList

leads to high water levels. In some cases, the flood events correspond to flash flood wherein event was validated using daily rainfall data of the corresponding month. The upward deviation of rainfall for the monsoon duration refers to the increase in precipitation compared to the long-term average (taken as 950 mm).

Table 5: Archive Comparison with Historical data

	Water Level (metres)		Nov - April Upward Rainfall Departure (%)						
Monsoon Season	**4977**	**4760**	**Koama**	**Lusaka**	**Mongu**	**Mtmaku**	**Mumbwa**	**Event Month**	**Event Captured**
2000-01	8.6	5.7		15%			11%	Jan-01	WL & RF
2001-02	7.8	5.3							
2002-03	8.3	4.6						Mar-03	*Mar-03 RF*
2003-04	8.5	7.9			10%			Mar-04	*Dec-03 RF*
2004-05	8.2	5.4							
2005-06	8.6	8.0	-					Mar-06	Water Level
2006-07	8.5	8.6	39%				18%	Feb-07	WL & RF
2007-08	8.9	9.3		12%		13%	14%	Feb-08	WL & RF
2008-09	8.2	9.1	17%		24%		-	Mar-09	WL & RF
2009-10	8.8	8.9	-	10%	42%	19%	-	Mar-10	WL & RF
2010-11	8.3	8.3					-		
2011-12	8.2	7.0	-		-		48%		
2012-13	8.7	5.5	-					Feb-13	WL
2013-14	8.1	7.0	-			-	-	Jan-14	*Dec-13 RF*
2014-15	7.9	4.8	-	-			-		
2015-16	7.1	4.8	-		-	-	-		
2016-17	8.5	8.2	-		34%	-	-	Feb-17	WL & RF
2017-18	8.7	5.0	-			-	-		
2018-19	8.2	5.9	-	-	-	-	-		
2019-20	7.1	6.2	-		-	-	-	Jan-20	*Jan-20 RF*
2020-21	8.2	8.6	-	-	-	-	-		
2021-22	8.3	5.4	-	-	-	-	-		
2022-23	8.5	7.1	-	-	-	-	-	Jan-23	WL & RF

Sample Product

For riverine floods the sample product given in table 6 below can be offered to a household in the risk zone, wherein the product payout is based on the increase in the daily water level from the set benchmark. The payoff is a function of daily deviation and also takes into consideration the number of days with water level above the set threshold. The threshold is subject to change as per the targeted community and their vulnerability profile. Based on the risk profile, required risk coverage, and danger level set by the Disaster Management the threshold can be changed. Also, the compensation rate in sample product below is subject to change as per the actual loss experience, economic damage in the past flood events and corresponding severity level.

Table 6: Index Product based on Water Level

Index: Water Level	
Index	Daily upward deviation of Water level from the threshold
Threshold (Meters)	8.5
Strike 1 (> metres)	0.0
Strike 2 (> metres)	1.0
Strike 3 (> metres)	2.0
Payout Rate 1 (ZMW/ metre)	125.0
Payout Rate 2 (ZMW/ metre)	250.0
Payout Rate 3 (ZMW/ metre)	500.0
Maximum Sum Insured (ZMW/ Policy)	10,000

For flash flood events, the excess rainfall product shown in table 7 below can be used to settle losses. This product allows for compensation against multiple events. Whenever the rainfall of 3 consecutive days period exceeds the strike, the insured is eligible for a payment. However, total payout will be capped to Sum Insured.

Table 7: Index Product based on Rainfall amount

Excess Rainfall Index	
Excess Rainfall Index: Multiple of consecutive 3 days cumulative rainfall greater than the strike(mm)	
Strike 1 (>=)	100
Strike 2 (>=)	125
Strike 3 (>=)	150
Strike 4 (>=)	200
Strike 5 (>=)	250
Payoff 1 (in ZMW)	500
Payoff 2 (in ZMW)	1,000
Payoff 3 (in ZMW)	2,000
Payoff 4 (in ZMW)	3,500
Payoff 5 (in ZMW)	5,000
Maximum Sum Insured (ZMW/ Policy)	10,000

Both the above products can be combined together to offer complete Flood coverage against both flash and riverine floods.

5. CONCLUSION

The study is on the vulnerable Kafue flats area, providing a detailed examination of the region's susceptibility to both riverine and flash floods. In case of a flash flood, rainfall recorded over a continuous spell act as a good proxy to check the event occurrence and severity. However, for riverine floods, the river water level is the best flood indicator. Therefore, two triggers are required to capture both flood types – Flash & Riverine.

Collected data sources daily river water level and rainfall taken for assessing flood risk and designing flood index insurance product have proved to be reliable flood parameters. The sample product designed on the water level and rainfall as proxy indicators has been validated for all extreme flood events recorded in the recent 30 years.

By incorporating multiple triggers and parameters, the proposed index-based insurance product is efficient for coverage of diverse nature of flood events.