Beth Tellman
Earth Institute and International Research Institute for Climate and Society
AcToday Bangladesh
Potential collaboration with WFP Oxfam, SBC, Green Delta, Saiful Islam from BUET, BMD, FFWC, IMWI
2/6/19

Draft Scoping Document:
Flood Index Insurance in Bangladesh: examining data for indices for five types of floods

Introduction:

As a part of Actoday Bangladesh (Objective 2: Develop and Tailor Priority Climate Service in Bangladesh), we are conducting a flood landscape analysis (objective 2.2.1). The analysis proposed to scope flood insurance initiatives in Bangladesh to better understand existing partners, state of the science, and identify needs. Participants in the data for insurance workshop in Dhaka in November (objective 2.1.3) identified the need to assess and compare different types and quality of datasets, to be able to build and verify flood indices for insurance. Actoday team members Beth Tellman, Dan Osgood, and Colin Kelley also met with 12 actors in Bangladesh as part of the landscape analysis. Actors were consulted in a series of meetings in November 2019 including one government (FFWC), one university (BUET), one private sector research institute (IWM), three insurance companies (Green Delta, Willis Towers Watson, SBC), three national or local NGOS (Oxfam Bangladesh, WFP Bangladesh, Red Cross Bangladesh), and four international agencies (InsuResilience, UNDP, WFP, IWMI). We also reviewed documents of climate risk financing, including insurance and forecast based financing in Bangladesh to understand the landscape.

The following draft plan is an outcome of the initial landscape analysis we determined in discussions with local actors. We hope to refine this plan in consultation with partners.

Bangladesh experiences five types of major flooding 1)flash; 2)river (related to monsoon rains); 3) river erosion; 4)surge; 5) urban (see figure 1 a and b for maps of types 1-4, figure 1c for urban areas in Bangladesh). Each of type of floods may have different causes, damage, drivers, and data associated with them. Thus while a general approach for identifying data regarding flood damages and variables describing flood dynamics can be developed, an index correlated with different types of flooding will be required.

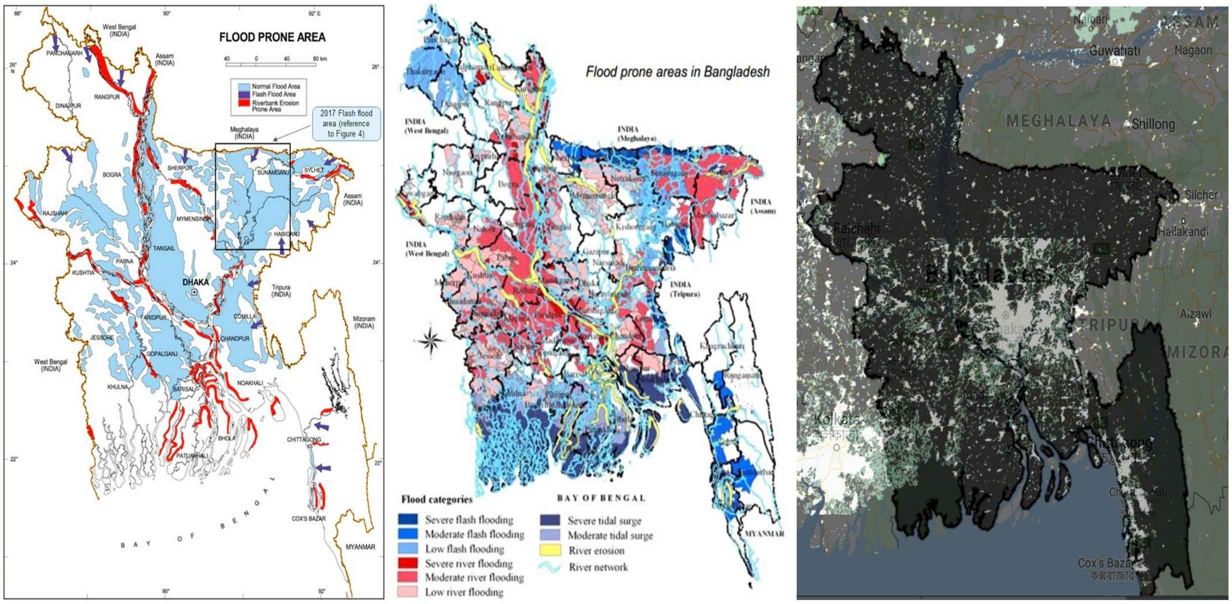

Figure 1. A)right-Types of flood, erosion, and flash flood areas in Bangladesh (from Kamal et al 2018). **B)** middle-Expanded flood types including cycle and storm surge floods (from Dastagir et al 2015). **C)** Urban Areas from the GHSL dataset. Areas in white are high or low intensity urban areas (map made in Google Earth Engine by Beth Tellman).

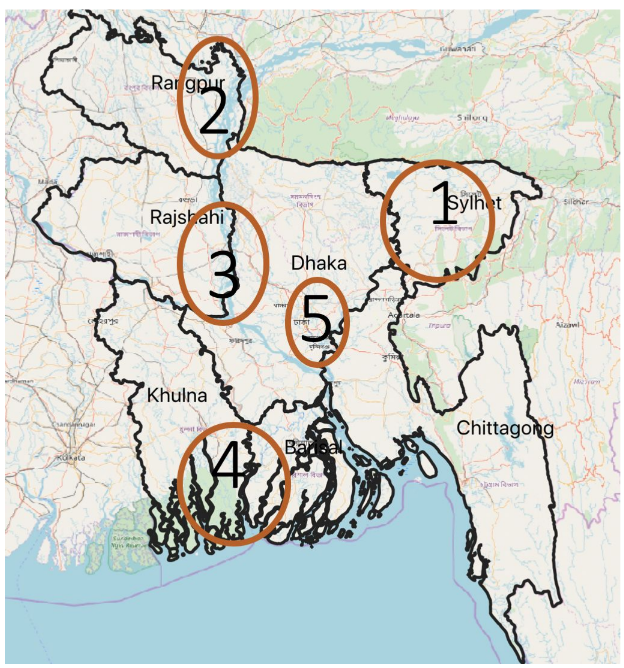

Figure 2. Potential case study sites to be selected in consultation with partners. Likely to be in these regions to represent each type of flooding: 1)flash (in the Haor region, to coincide with the SBC pilot); 2)river (in Kurigram, to coincide with the World Food Program Pilot); 3) river erosion (Srirajhang and Gaibandha, to conicide with the Green Delta Project); 4)surge; 5) urban (in Dhaka).

Through the 2019 microinsurance conference, the 2019 data for insurance workshop by IRI and meetings with stakeholders in side meetings by the IRI team, we identified existing or proposed insurance pilots for both monsoon flood areas (Figure 4-2) and the flash flood areas in the haor region (Figure 4-1). Existing or proposed projects are in Bogra, Gaibandha, Srirajgang (Rashashi region), and Sylhet (Sunamganj upazila) by Green Delta, SBC, and Oxfam. These regions encompass river erosion, monsoon flooding, and flash floods. The 2017 floods in the Sylhet region that destroyed the boro rice crop is a major driver of new insurance initiatives directed at farmers in this region and supported by the government (as announced in the Microinsurance conference by the Prime Minister).

Efforts in past initiatives to develop index insurance include two main data approaches: rainfall data and flood modeling. Oxfam piloted a flood modeling based insurance project in collaboration with IWM, but the method was difficult to scale due to high model calibration costs. SBC and Green Delta have both used rainfall data to develop extreme rainfall trigger, but rainfall data quality and spatial resolution has been an issue. Sometimes farmers receive crop damage not correlated with rainfall readings.

Scaling index insurance for floods in Bangladesh will require an approach that can enable a shared vision of risk between both clients (farmers) and reinsurers. This requires an approach that is financially sustainable in terms of data cost and is transparent to both reinsurers and clients, who must agree on risk levels and established premiums and triggers. Index validation can reduce basis risk and premium price by reducing uncertainty for all parties.

IRI could support the flood index insurance development in Bangladesh by testing different types of data to serve as a flood proxy, and validating them against different types of damage data, across five types of floods in Bangladesh. We propose to select 5 locations (at the district or upazila level) for this assessment.

Objectives:

1. Test different types of data to serve as a flood proxy, validated against different types of damage data, across five types of floods in Bangladesh.

2. Collect flood indicators: rainfall, satellite, and stream gauge products (table 1).

3. Collect flood damage data from the field (in collaboration with partners who have damage data), the media, and official sources to create binary (e.g. bad years) time series of damaging flood events and continuous time series (table 2)

4. Prepare information for potential stakeholders so they can evaluate flood indicators across key performance indicators (e.g. latency, price, length of record, stability,

correlation with observed damage, etc), and if this varies by flood type. This will potentially be an effort to support a training/planning workshop.

Data:

Table 1. Potential Flood Indicators (this is the long list, we may reduce to the short list later)* see appendix for explanation of satellites with their advantages and disadvantages

Type	**Source**	**Spatial,Temporal Resolution and Record Length**	**Flood Type it could work with**
Discharge	Bangladesh Water Development Board, maybe BUET has some	various	River erosion, monsoon
Tidal Gauges	Bangladesh Inland Water Transportation Authority (Chiu and Small, 2016)	15 gauges, ~2 hours, 1997-2010	Storm surge
Windspeed	Joint Typhoon Warning Center	1977, present ~6 hour for 77 cyclones	cyclones/storm surge?
Rainfall	ENACTS (IRI data library)	.05 degree, daily, 1971-2017	All except storm surge?
MNDWI from optical data	Needs to be made, could use Sentinel-2, Landsat, could use Du et al (2016) for MNDWI (Modified normalized difference water index)	~every 2 weeks 1984-20 (30m), then every 3 days (30m- fusing Sentinel-2 and Landsat) 2017-present	River erosion, monsoon, flash flood
Monthly surface water	JRC Water occurrence dataset (Pekel et al 2016) using Landsat	30m, monthly, 1985-2016,	River erosion, monsoon, flash flood
Satellite: Radar Backscatter	Need to be made, could use Sentinel-1, e.g. Cian et al (2018) normalized flood difference index	10m, every 6 days, 2014-present	All but urban
Satellite: Microwave Emissivity	Brightness temperature (or work with AER or make our own algorithm to estimate surface water fraction)	**25km** (3km enhanced product, and 90m AER product)	Monsoon flood
Satellite: Daily surface water	Using MODIS (from Ji et al 2018)	500m, daily, 2001-2016	All but urban
Satellite: IWMI surface water flood product	8-day MODIS composite LSWI (Land Surface Water index- Matheswaran 2018)	500m, 8 days, 2001- present	Monsoon, river erosion, storm surge
Satellite: Cloud to Street recurrence flood product (inundated area)	Monthly or yearly inundated area using daily Landsat and MODIS (Tellman et al 2019)	250m and 30m; monthly; 1984-present and 2001-present	All except urban

Table 2. Damage Indicators

Type	Source	Spatial,Temporal Resolution and Record Length	Flood Type it could work with
Ready-made garment time series	Export Promotion Bureau (EPB)	Monthly? 2000-present	urban
Agricultural damage data (estimated from crop area and yield data)	Yield from Bangladesh Bureau of Statistics (BBS), damage estimates from Allaire et al (2017)	2008, 2012-2015 from BBS, according to Allaire et al 2017	Flash, monsoon, maybe storm surge
fatalities	Bangladesh disaster management Bureau	Not available	all
people affected	Bangladesh disaster management Bureau	Not available	all
Media reports- analyzed with Lamont 2020 summer intern	Analyst codes (or trains NLP algorithm) for Lexis Nexus, GDELT, or local papers to extract flood damaging event and variables (people affected, agricultural and infrastructure losses, etc)	Depends on digital archives of papers, but usually daily	All, especially urban
Field data	Gps points of flood height and dates for damaging floods	Depends on partners	all
Bad Years	Farmer or other source reporting bad years	Depends on partners- like since 1980? Annual time step	all
Loan Fluctuations	Payback for microfinance loans	Depends on partners	all

Methods:

1. We will analyze the damage data in table 2 to determine potential areas, districts, and scales that support analysis. We plan to select one case study for each flood type.

2. Time series data will be generated for each index in table 1. Earth Engine will be used to process satellite data and generate time series data for each variable at a daily, monthly, or yearly time step. R or the Climate Data Library at IRI will be used to process ENACTS data. All time series data will be made public with the publication for transparency.

3. Time series data will be generated for damage in table 2. Some data require extensive processing, such as media data. IRI will work closely with partners to collect additional field and bad years data.

4. Assess key performance indicators to compare datasets in table 1 to datasets in table 2 (e.g. latency, length of record, stability, false positive rate, overall accuracy, or others using methods that may include Bayesian probabilities or frequentist regression analyses). We may aggregate different scales and to test the effect of uncertainty on each.

5. Stakeholder meetings with key actors engaged in flood insurance in Bangladesh (reinsurers, insurance companies, government, NGOs, and flood affected populations/potential clients) to discuss analysis results and what key performance indicators for different datasets imply for index construction.

Expected Results:

We expect results will assess potential data sources that can be used as a flood insurance index for each type of flood. We will report all results, key performance indicators, correlations, and uncertainty associated with each potential flood index for different sources of damage data. We hope to discuss with stakeholders the results of this analysis. We will provide recommendations, based on feedback from the stakeholders, of potential datasets that could be used to build indices for each type of flood, with the strengths and weaknesses of each. We will publish these results in one article. The media analysis may be published as a stand alone piece, especially if NLP works well.

Confirmed Collaborators:
Mike Steckler
Marco Tedesco
Upmanu Lall

Potential Collaborators:
Saiful Islam, BUET
Green Delta
Oxfam
Red Cross
SBC
IWMI
Cloud to Street
WFP
ICCCAD

Timelines:

Objective	Jan -Mar 2020	April-June 2020	July-Sept 2020	Oct-Dec-2020	Janu-Mar 2021
1.Case study selection based on damage data quality and availability					
1.2 Trip to Bangladesh (mid March for data follow ups)					
2. Time series processing for flood indicators					
3. Time series processing for damage data (need to collect all field data by June)					
3. Key performance indicators of flood proxy data, results categorized by flood type					
4. In country workshops					
5. Publish results					

Appendix:

Table 1. Main sensors categories with advantages/disadvantage for flood mapping- from Tellman et al NASA Terrestrial Hydrology 2019 Proposal

Sensor Type	Advantages	Obstacles	Example Sensors	Common Methods
Optical (Public)	Long history (~1980s), can identify assets such as roads, fields, and major infrastructure	Cannot map floods through clouds or under vegetation, and only 3 day revisit for <30m resolution	MODIS, Landsat, Sentinel-2	Thresholding, band ratio, or normalized differencing on short wave infrared(Coltin et al. 2016)
Radar (active)	Identify inundation through clouds, and assets such as roads, fields, and major infrastructure	More difficult to map flooded vegetation, urban flooding, short history, low revisit (>6 days))	Sentinel-1, ALOS PALSAR	Thresholding or change detection of backscatter, loss in coherence(Matgen et al. 2011, Mason et al. 2012)
Passive Microwave	Long history (~1990s), Identify temporal pattern of inundation through clouds over large areas	Very coarse resolution, degraded signal in urban areas	SMAP, SMOS, AMSR	Change in brightness temperature or soil moisture.

Very high resolution commercial (optical or radar)	Identifies floods in urban areas and assets including homes, cars, sidestreets	Cannot map floods through clouds or under vegetation, short history, and data requires purchase	Planetscope, Iceye, Terra-SARX, UAVs	Various- machine learning, band thresholding, backscatter change

References:

Allaire,Bavandi, Ceccato, Cian, Haraguchi, Lall. GFDRR, Columbia Water Center, IRI, and the World Bank. 2017. Building Capacity for Rapid Financial Response to Natural Hazards: with a focus on Floods in South and S. E. Asia. Report.

Dastagir, M. R. (2015). Modeling recent climate change induced extreme events in Bangladesh: A review. *Weather and Climate Extremes*, *7*, 49–60. https://doi.org/10.1016/j.wace.2014.10.003

Kamal, A. S. M. M., Shamsudduha, M., Ahmed, B., Hassan, S. M. K., Islam, M. S., Kelman, I., & Fordham, M. (2018). Resilience to flash floods in wetland communities of northeastern Bangladesh. International Journal of Disaster Risk Reduction, 31(December 2017), 478–488. https://doi.org/10.1016/j.ijdrr.2018.06.011

Tellman, B, Sullivan, J.S, Doyle, C.S. 2020. Global Flood Observation with Multiple Satellites: Applications in Rio Salado, Argentina, and the Eastern Nile Basin. *Global Drought and Flood: Monitoring, Prediction, and Adaptation.* Eds. Huan Wu, Dennis Lettenmaier, Philip Ward and Qiuhong Tang

Cian, Fabio, Mattia Marconcini, and Pietro Ceccato. “Normalized Difference Flood Index for Rapid Flood Mapping: Taking Advantage of EO Big Data.” *Remote Sensing of Environment* 209 (May 2018): 712–30. https://doi.org/10.1016/j.rse.2018.03.006.

Pekel, Jean-François, Andrew Cottam, Noel Gorelick, and Alan S Belward. “High-Resolution Mapping of Global Surface Water and Its Long-Term Changes.” *Nature*, 2016.

Chiu, S., & Small, C. (2016). Observations of Cyclone-Induced Storm Surge in Coastal Bangladesh. *Journal of Coastal Research*, *321*, 1149–1161. https://doi.org/10.2112/jcoastres-d-15-00030.1

Uddin, K., Matin, M. A., & Meyer, F. J. (2019). Operational flood mapping using multi-temporal Sentinel-1 SAR images: A case study from Bangladesh. *Remote Sensing*, *11*(13), 1–19. https://doi.org/10.3390/rs11131581

Matheswaran, Karthikeyan, Niranga Alahacoon, Rajesh Pandey, and Giriraj Amarnath. “Flood Risk Assessment in South Asia to Prioritize Flood Index Insurance Applications in Bihar, India.” *Geomatics, Natural Hazards and Risk* 10, no. 1 (January 2019): 26–48. https://doi.org/10.1080/19475705.2018.1500495.

Du, Yun, Yihang Zhang, Feng Ling, Qunming Wang, Wenbo Li, and Xiaodong Li. “Water Bodies’ Mapping from Sentinel-2 Imagery with Modified Normalized Difference Water Index at 10-m Spatial Resolution Produced by Sharpening the SWIR Band.” *Remote Sensing* 8, no. 4 (April 22, 2016): 354. https://doi.org/10.3390/rs8040354.

Ji, Luyan, Peng Gong, Jie Wang, Jiancheng Shi, and Zhiliang Zhu. “Construction of the 500-m Resolution Daily Global Surface Water Change Database (2001-2016).” *Water Resources Research* 54, no. 12 (December 2018): 10,270-10,292. https://doi.org/10.1029/2018WR023060.