# FINAL REPORT

Selection 1259359

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## Towards impact-based forecasting: upgrading InaSAFE and GeoSAFE to enable forecast-based action

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KARTOZA
OPEN SOURCE GEOSPATIAL SOLUTIONS

Climate Centre

# Forecast Based Financing with InaSAFE : Final Report

Dear funders

It is with great pleasure that we provide you with this fiinal report outlining the implemention for our challenge fund project to bring the InaSAFE platform to Forecast based Financing and Forecast based Action.

The development of the application described in this report has been driven by the needs expressed by and opportunities presented by our organisation partners in Indonesia, and the expertise brought to the project by the Kartoza and Climate Centre teams.

If you have any questions or queries about this report, please feel free to enter into contact with us at your convenience.

With Kind Regards

| | | | |
|---|---|---|---|
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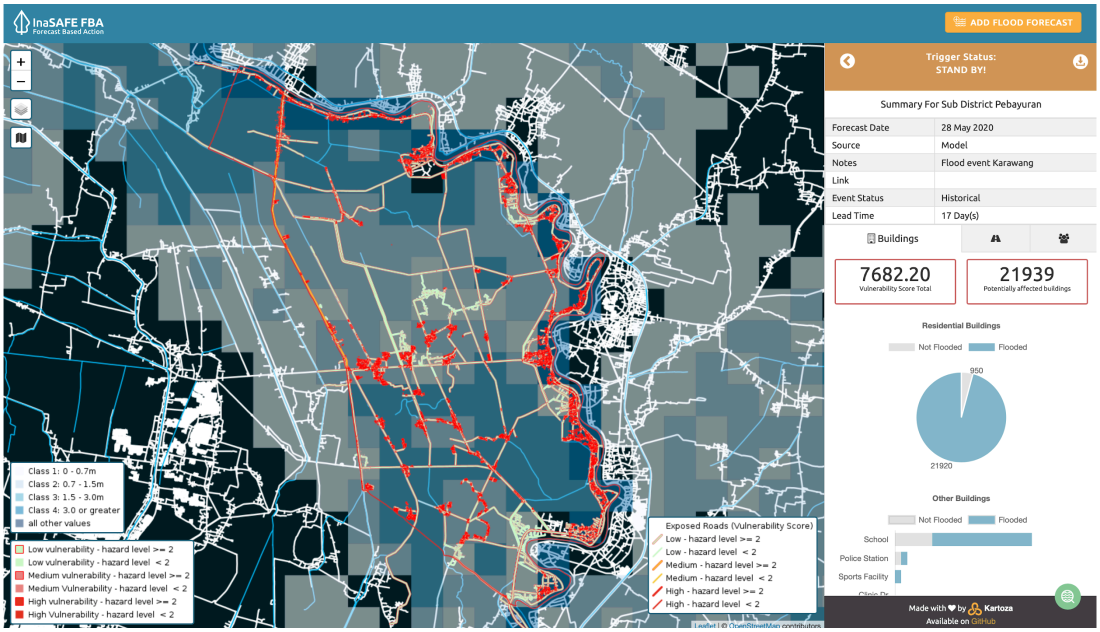
# Contents


1 Executive Summary ..... 2
2 Introduction ..... 5
2.1 Background on FbF and a demand for Impact-based forecasting ..... 5
2.2 Rationale and goal ..... 5
3 The Project ..... 8
4 Partner Engagement: an iterative step by step process ..... 20
4.1 Local Partner Engagement ..... 20
4.2 Global Partner Engagement ..... 22
5 Technical Decisions ..... 24
5.1 Framing risk ..... 24
5.2 Finding the data ..... 24
5.2.1 Exposure and vulnerability ..... 24
5.2.2 OpenStreetMap and International support ..... 25
5.2.3 Vulnerability Indicators ..... 26
5.3 Inventory of forecasts ..... 29
5.4 Mutually reinforcing data and outputs ..... 29
5.5 Hazard magnitudes: Historical analysis and return period ..... 30
6 Monitoring and Evaluation ..... 32
7 Next Steps ..... 34
7.1 The broader landscape of Impact based Forecasting ..... 34
7.2 Next steps for the Indonesia Red Cross FbA process ..... 35
7.3 Next steps for InaSAFE-FbA team ..... 35
7.4 Next steps for the project ..... 36
8 Conclusion - Key Messages for Future Projects ..... 37
9 Source code ..... 38

**Acronyms**

BMKG - National Meteorological and Climatology Agency
BNPB - National Disaster Management Agency -
CSO - Civil Society Organizations
ECMWF - European Centre for Medium-Range Weather Forecasts
GLOFAS - Global Flood Awareness System
HOT - Humanitarian OpenStreetMap Team
IFRC - The International Federation of Red Cross and Red Crescent Societies
ITB - Bandung Institute of Technology
MoEF - The Ministry of Environment and Forestry
PMI - Indonesian Red-Cross
LAPAN - Indonesian Aerospace Agency
SIDIK - Vulnerability Index Data Information System
WFP - World Food Program

# 1 Executive Summary




Impact-based forecasting (IbF) is taking forecast-based action one step further; if we can predict the impacts of the hazard as well as the event itself, we can act early, in a more precise and concerted way to minimise the shock where it occurs.

However, the concept for IbF is still in its infancy and its tools have yet to be fully developed. This project presents one of the first of these tools, through the development of an impact-forecast platform in Indonesia called InaSAFE-FbA, that combined with a current RCRC FbF program for flooding, hopes to be one of the first functional examples of IbF in the world. This report candidly describes the tools and development of this project up until May 2020, presenting lessons learned throughout this process in order to guide thoughts and future programs around the world. This project answered the following questions.

| **Question** | **Summary Answer** |
|---|---|
| • *Can an existing information management system, such as InaSAFE, that is already used for contingency planning be transformed into an IbF* | By applying the FbF trigger methodology and principles of Impact based Forecasting, a prototype has been developed, using a global flood forecast (GloFAS) and OpenStreetMap, |

| | |
|---|---|
| *tool that integrates real-time weather forecasts?* | as key datasets in the system |
| *• How can an InaSAFE-like platform enable a trustworthy and effective decision-making process for early action?* | The key for success in order for users to trust InaSAFE-FbA is the co-production at all the stages of the development. Working together in the step-by-step process, Kartoza, Climate Centre and Indonesia Red Cross developed a solid cooperation framework that will be crucial for the sustainability of the system. There are still aspects that should be addressed beyond the scope of the project to move from a prototype to a fully developed system. |
| *• Can a GIS-based tool that is used by disaster managers and government planners foster interdisciplinary collaboration? Specifically, can it enable dialogue between the two groups and create an easy way to set triggers for early action?* | A dialogue about impact-based forecasting offers an opportunity to bring in the same place a multidisciplinary group of people and organizations. IbF requires that hydro-met services, scientists, risk information management experts and humanitarian actors be at the same table, agree on data, objectives and processes to co-produce an IbF services. Centring discussions around the transformation of an existing Government-le GIS-based tool is an opportunity to engage a variety of people to provide feedback, ideas and recommendations on the key steps to develop a useful and impactful IbF tool. |

**Key Elements**

Achieving the development of an InaSAFE inspired Impact based Forecasting tool for Early Action was possible by:

(1) Introducing support for more sophisticated impact analysis curves based on vulnerability data, historical events and the impacts of those events.

(2) Conducting forecast analysis to identify which flood forecast models are feasible to use.

(3) Enabling users to convert these to risk data in near real time to show quantifiable potential impacts of the forecast event.

(4) Implementing InaSAFE-FbA as a web application so that there is a minimal knowledge ramp up needed to use it.

# 2 Introduction

## 2.1 Background on FbF and a demand for Impact-based forecasting

To reduce the impact of disasters, the Red Cross Red Crescent is establishing Forecast-based Financing (FbF) systems with its National Societies; there are currently more than 30 countries working on such systems. These FbF systems allow humanitarian assistance to reach the people most vulnerable to climate shocks globally, in the window between a forecast and a likely disaster. Acting in anticipation in this way decreases the impact of the shock by increasing preparedness and building resilience.

However, the implementation of FbF in comprehensive ways can be quite difficult, particularly because traditional hydro meteorological forecasts do not indicate to humanitarians the type of impact to expect in order to properly plan and act before for a shock. In order to plan for the right early actions in the right places, humanitarians require information about where to expect potential impacts. For instance, useful information includes location of the impact and the differential impact on different communities, as well as quantitative measures such as the number of houses that could be destroyed and roads that could be closed.
In recent years, the concept of Impact based Forecasting (IbF) has been developed by the World Meteorological Organization, aming to move from the traditional way for forecasting "what the weather will be" to a new type of service focused on "what the weather will do". IbF combines a weather or climate forecast of a hydro-meteorological hazard with information about people and places at risk, to anticipate sector-specific and context-specific impacts. IbF breaks the silos of forecasting that exist between hydro-meteorologists and people who can take early action, allowing for the development of more efficient sectoral responses. By focusing on impacts and communicating these, it is expected that the population at risk and the responding professionals will have a better understanding of potential disruptions, which can be used to develop triggers to identify when and where to take appropriate early actions.

## 2.2 Rationale and goal

Currently, there exist few tools and approaches for Impact-based Forecasting. Notably, the World Meteorological Organization is promoting a shift toward the production of IbF services by hydro-met services which, in synergy with existing tools that allow people to analyse disaster impacts, could be a game changer towards the creation of IbF services.

InaSAFE (http://InaSAFE.org) is one of these tools, used in many countries, with active projects in Indonesia, Fiji, countries of the South Pacific, India, Mozambique, Tanzania and Philippines. The platform allows users to combine information about extreme events with vulnerability and exposure information and thus allow decision makers to analyse risk, therefore making preparedness and emergency response more effective. It is used by disaster managers and responders to understand the potential impacts of disasters through reports which tabulate the counts of people, humanitarian needs, and infrastructure such as roads and buildings. Users can query the software about potential extreme events to understand what is at risk and what has been affected. For example, a user could ask: "In the event of a flood, how many structures might be affected?", and the software will combine actual flood hazard information with exposure data (e.g. data from OpenStreetMap) to show the affected structures.

In Indonesia, the InaSAFE platform has been developed by the Disaster Risk Management Agency (BNPB) with the technical guidance from Kartoza and funding from the Australian Government and GFDRR. This platform is used in Indonesia for contingency planning and emergency response. The InaSAFE-FbA project has been developed by Kartoza and the Red Cross Red Crescent Climate Centre, allowing for the exploration of how a risk information management platform can be a driver for Impact based Forecasting that can be used as a trigger of Forecast-based Financing systems. The exploration has been focussing on Indonesia as a case study, however it can have a global use.

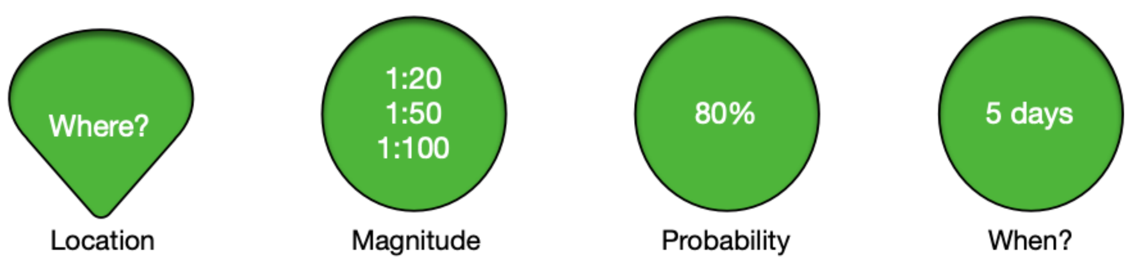
Building on this existing experience, the InaSAFE-FbA project developed a new platform to provide an Impact based Forecasting decision making tool for FbF. Real-time forecasts of actual extreme events were incorporated into the InaSAFE-FbA platform. This will allow users, in particular the Indonesia Red Cross, to see which areas, people and assets are likely to be impacted by a real flood event that is forecasted to happen in the coming days. With this Impact-based Forecasting information, they can activate early action protocols to conduct early actions in the places that might need it the most. The goal achieved by this project was to support the roll-out, prototyping and sustainability of Impact-based Forecasting to enable Forecast based Financing in Indonesia. This can be a transformative tool to leverage large amounts of GIS information such OpenStreetMap and vulnerability datasets to help people before disaster strikes.

# 3 The Project

InaSAFE-FbA is implemented as an in-database application. We built a platform from modular components that process flood events and dynamically generate a flood impact report at different spatial scales: the entire flood, the impacted districts, sub-districts and villages. The main components of the system are:

- A relational database that stores the data consisting of:
  - Population data from WorldPop and census data from Potes (Indonesian national census data)
  - Building footprints from OpenStreetMap (OSM)
  - Road networks from OSM
  - Administrative boundaries (including district, subdistrict, village) from OSM
  - Pre-computed hazard models for 1:50, 1:20 etc. year flood maxima
  - Glofas measuring points
  - Flood event data downloaded from Glofas
- A tool that continually updates the database with the latest data additions from OpenStreetMap
- A tool that fetches flood events from GloFAS and generates reports in the database based on the event location and severity
- A restful API that is served directly from PostgreSQL (PostGREST)
- A tool that regularly fetches event data from Glogas (PG-CRON)
- A static web page that presents information and maps to our users

There are four key questions the system needs to know about an impending flood:




1. **Location**: Where will the event occur? We use the location of a Glofas reporting station to determine this.

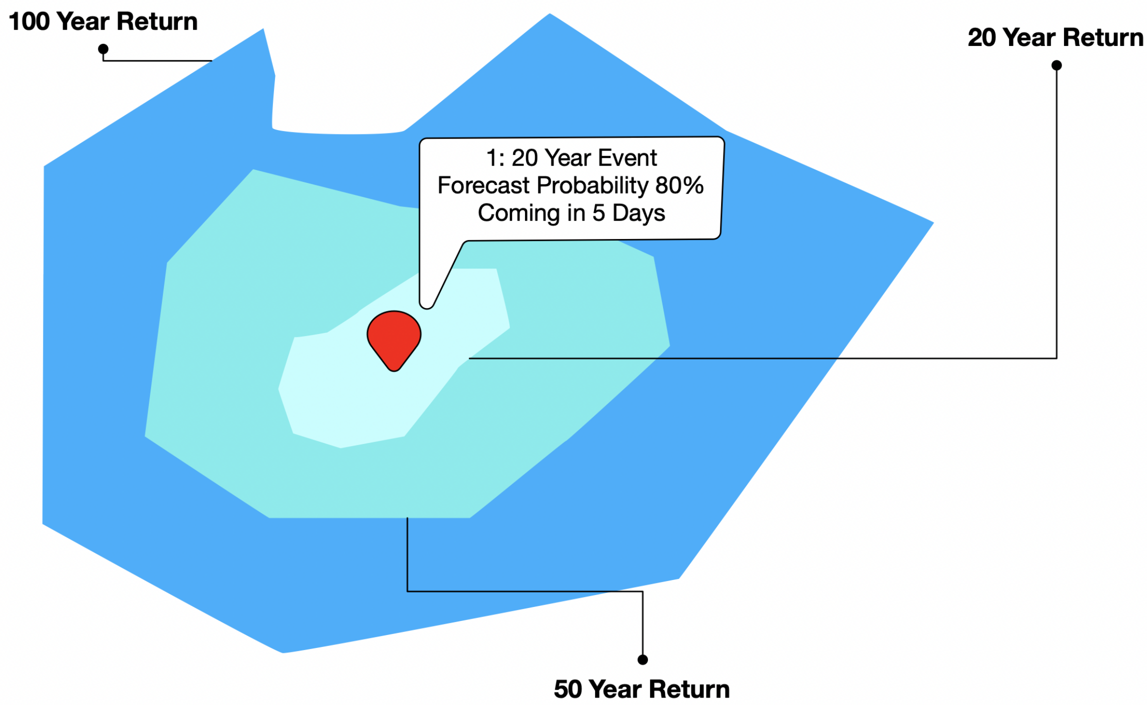
2. **Magnitude**: Is the scale of the impending flood no larger than an annual event or does it approach the scale of a 1:100 year event? (Return period analysis)
3. **Probability**: How likely is the forecast flood to actually occur?
4. **When**: Is the impending flood tomorrow or 10 days into the future?

These questions follow the logic of the Forecast-based Financing Trigger Methodology.

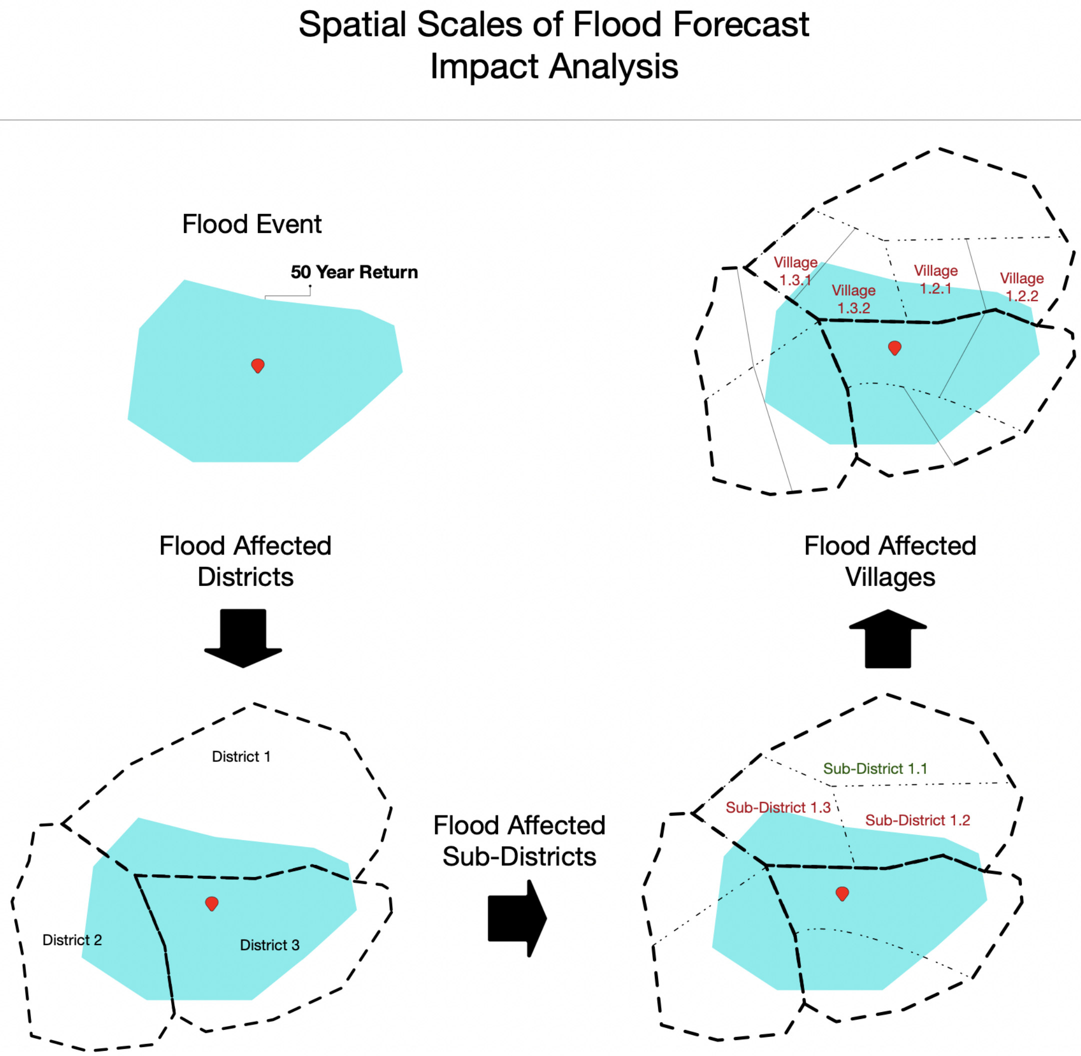
During this project we looked for different sources of data that can answer these questions - from our institutional partners and from online resources such as GloFAS. For our prototype we chose to use GloFAS, although the system can be extended to include data from sources other than GloFAS.

Converting a forecast into a spatial dataset required that there should be pre-computed flood extent boundaries available. We found that there are many complexities involved in obtaining such spatial flood maxima datasets:


In our project we used both models derived from our field trips and data shared by institutional partners, and data published by the JRS. When an event occurs, our system uses the event location and return period to select the appropriate flood extent for the predicted return period:




That flood extent is then used to select all of the districts, subdistricts, villages, buildings, roads, population records and census areas that intersect with the forecast flood area to produce reports at different spatial scales.




The buildings and roads within flood affected districts, sub districts and villages are given a vulnerability score according to an extensible scoring matrix. Each entity is scored according to this matrix and these vulnerability scores are accumulated into village, subdistrict, district and flood event level.

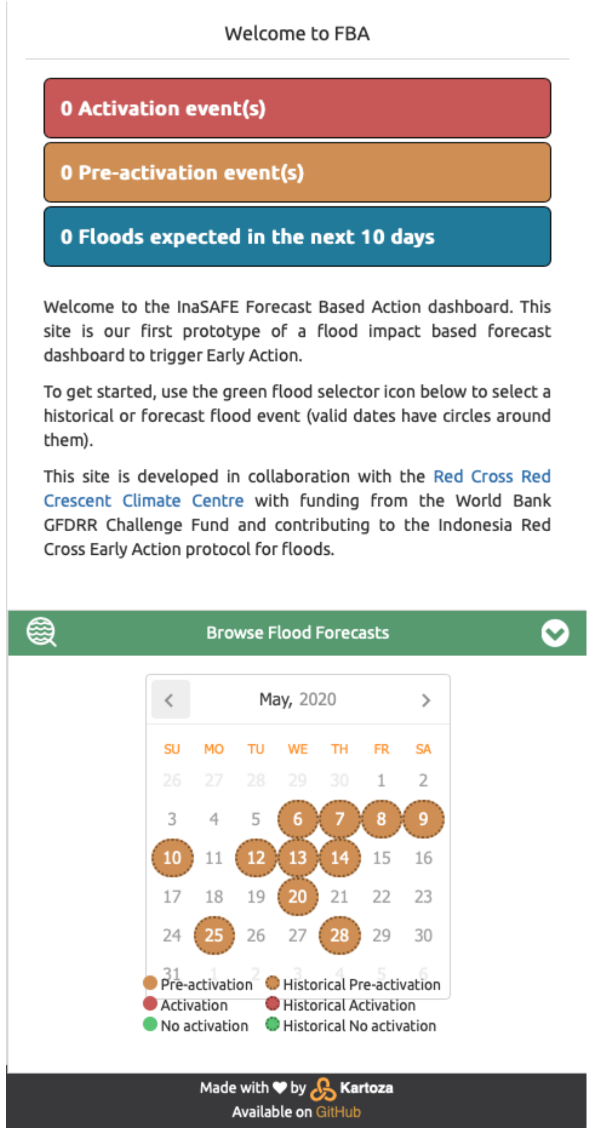
| Factor | Type Scores (1) | Material Scores (2) | Building Area (3) | Road Network Density (4) | Vulnerability Score (Sum of factors / factor count) |
|---|---|---|---|---|---|
| Building 1 | House = 1 | Mud = 1 | 60m = 0.5 | 500m = 0.5 | 3 / 5 = **0.75** |
| Building 2 | Office = 0.5 | Mud = 1 | 60m = 0.5 | 500m = 0.5 | 2.5 / 4 = **0.625** |
| | | | | | 0.728 + 0.625 = **1.375** |

Village 1 Buildings

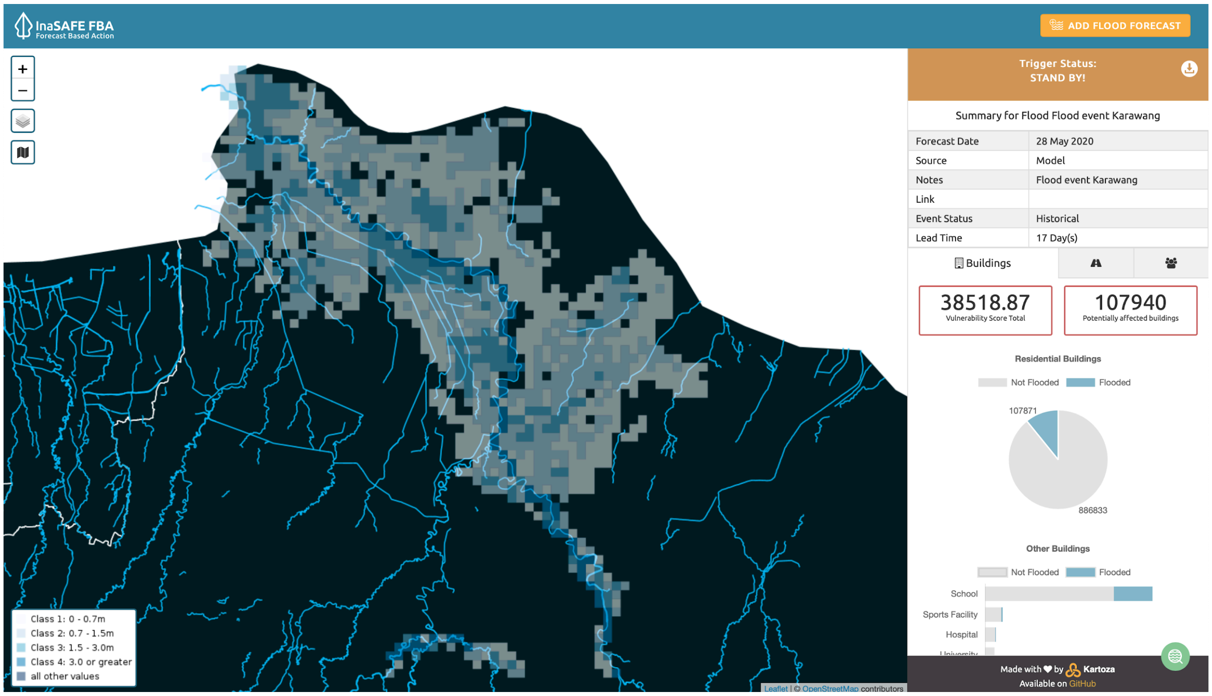
Village 1 Vulnerability Score

These capabilities are presented to users by means of a simple web interface that requires minimal training to use. The following screenshots illustrate the web interface we developed.

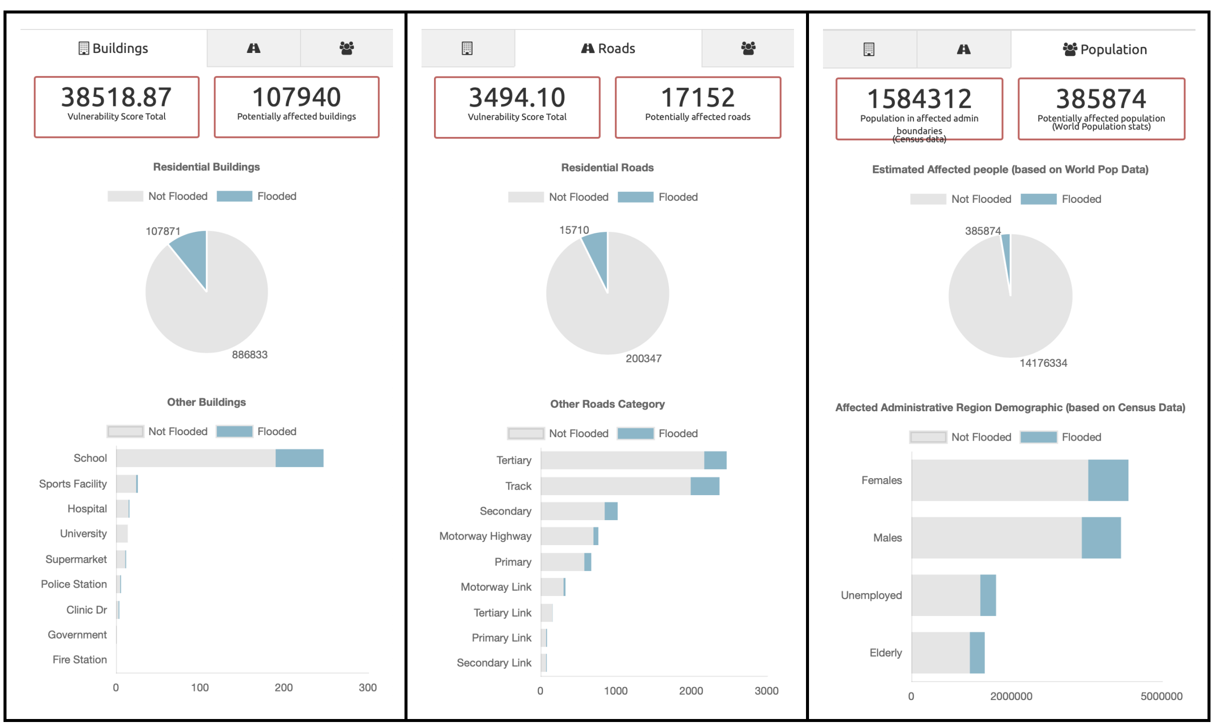
The user  starts by selecting an upcoming or past event from the calendar.




When an event has been selected, they are presented with a dashboard for the flood event.

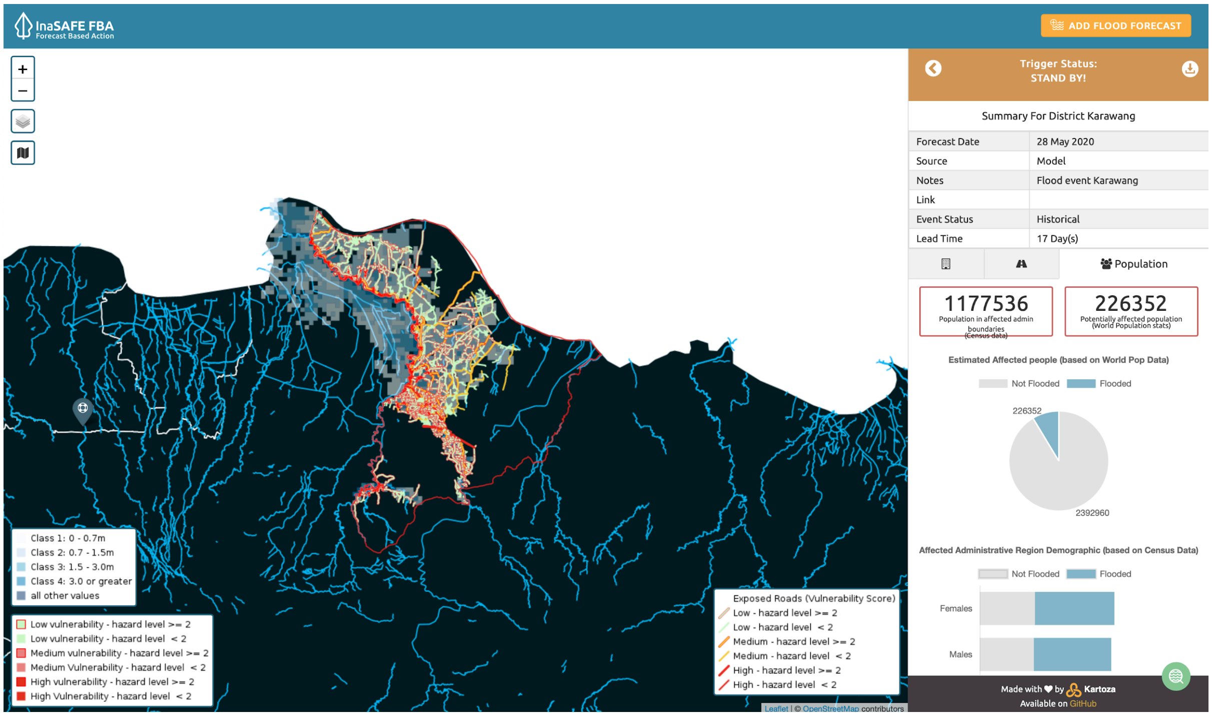



The dashboard has three tabs for buildings, roads and population. As you drill down to district, sub-district and village level, these tabs are updated to reflect the anticipated effect on that administrative unit.

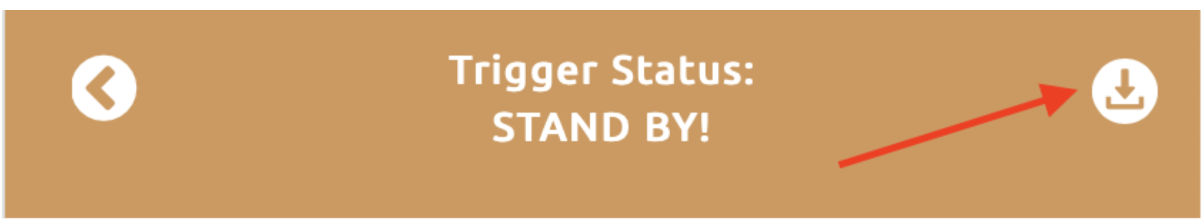


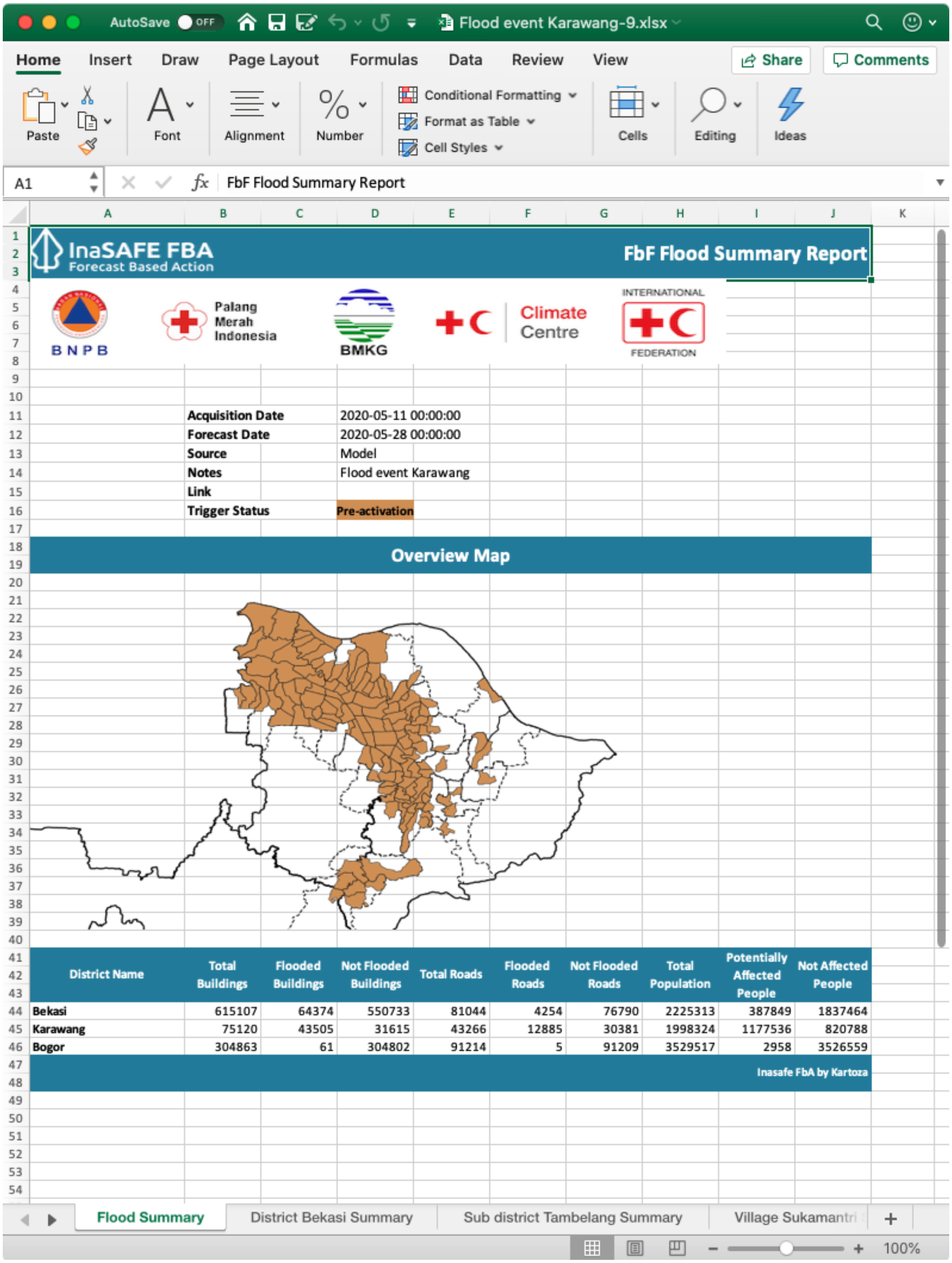
Beneath the charts, a summary is listed for each of the subordinate administrative units. The icon next to each is colour coded according to the trigger status status.


Clicking the icon next to an administrative area lets you drill down into the sub administrative areas. As you select areas, the map updates to display the buildings and roads indicated in the dashboard.




A bivariate legend is used to show the interplay between hazard level and vulnerability level. The entire report can be downloaded as a spreadsheet for offline analysis:






In terms of application, this tool can be used by the Indonesia Red CRoss (or other actors) to activate their Early Action Protocols (plans that allow the organization to implement early actions in the window of time between the forecast and the shock). For example, once PMI identifies which are the districts, sub districts and villages that are more likely to be impacted by the flood, they can proceed to prioritize which are the ones where they can deploy their teams to conduct Early Actions with the respective local authorities and the community. In the case of the Red Cross Red Crescent, having this decision making system to identify when and where to trigger early action is one of the prerequisites to be eligible to access automatic funds to conduct the pre-agreed early action (for more information see the FbA by DREF financing mechanism).

# 4 Partner Engagement: an iterative step by step process

## 4.1 Local Partner Engagement

The development of this project necessitated the work of many partners at all scales, from government, the humanitarian sector, and research and development experts. The identification of these partners was done from the early stages as buy-in and collaboration is fundamental to the development and sustainability of Impact based Forecasting services.

| **Government Partners** | **Humanitarian Sector** | **Research & Development, private sector** |
| --- | --- | --- |
| • BNPB<br>• BMKG | • Indonesia Red Cross (PMI)<br>• Red Cross Red Crescent Climate Centre<br>• International Federation of Red Cross and Red Crescent Societies (IFRC)<br>• Australian Red Cross<br>• British Red CRoss<br>• Humanitarian OpenStreetMap<br>• American Red Cross (Missing Maps) | • Kartoza<br>• AVIVA Insurance<br>• GloFAS (ECMWF) |

**Partnership Process**

**July 1, 2019: The Kick-off Event**

*Goal*: Bring on board all key partners with the idea of the project, explore opportunities of collaboration.
*Participants*: Key Government agencies and Red Cross Red Crescent partners (other partners included IRI and NASA)
*Outcome*: All partners agree on the relevant to develop IbF services for Forecast based Financing by using an existing risk information management platform. The initiative was welcomed by partners.

**July 2019 to February 2020: Bilateral Meetings**

*Goal*: In constant discussions with key partners identify how the InaSAFE FbA system could be developed in a sustainable way.
*Participants*: Indonesia Red Cross, IFRC, BNPB, BMKG. Additional partners to have discussions are Deltares, Ministry of Public Works (Water Management subdivision), UK Met Office, British Red Cross, AVIVA, American Red Cross (Missing Maps), Humanitarian OpenStreetMap, among others.
*Outcome*: Information was gathered on what data is currently available and possible collaboration between different existing information systems.

**February 2020 - May 2020**

*Goal*: In closer discussions with key partners identify how the InaSAFE FbA system could be developed in a sustainable way and present the latest state of the software to PMI.
*Participants*: Indonesia Red Cross, IFRC, British Red Cross
*Outcome*: Identification of possible support from PMI and IFRC to ensure the sustainability of the project.

PMI has significant influence with government agencies. The requests for a meeting were responded to quickly by BNPB and BMKG. That would be the strength for implementing the FbA approach. The challenge is in having intergovernmental collaboration and having collaboration officially reflected in written-agreement. Existing dynamics with inter-governmental relations are usually unknown and significantly influence the process. In addition to that, emerging disaster events such as the large Forest Fire at the end of 2019 and COVID19 are significantly taking attention of key persons both at BNPB and PMI from InaSAFE-FbA's process.

**The InaSAFE-FbA project started earlier than the PMI broader FbA program, and this broader program will continue past the end of the InaSAFE project to continue the development of an institutionalized FbF system that can use this functionality.** For the first few months, IFRC/Climate Centre staff in Jakarta was in front in communicating the InaSAFE initiative to BMKG and BNPB. Meanwhile, both the end-user and representation of the project in Indonesia is PMI. Given this strategic cooperation between the InaSAFE-FbA project and the Australian funded FbA project of PMI, the prototype developed under the GFDRR funded project will ideally be fully integrated by PMI for further development.

## 4.2 Global Partner Engagement

In addition to the in-country Indonesian activities, we have put a considerable amount of effort into introducing our work to interested parties around the world. This included demonstration sessions with the World Food Programme international office, Medicin Sans Frontiers (Canada) and the GeoCRIS project in the Carribean. In the latter case we are in the process of deploying a local instance of the InaSAFE-FbA platform for testing in that geography, and also for testing with other hazard forecasts such as cyclones. We have also had interest in deploying the system in Africa through the socialisation work we have carried out with the broader Climate Centre team. We also presented the platform and promoted our work at three international conferences - the Regional FbF Dialogue platform held in the Philippines (June 2019), the Humanitarian OpenStreetmap Team Summit held in Heidelberg,Germany (September 2019) and the Global FbF Dialogue platform held Berlin, Germany (November 2019).

**Lessons Learned about Partnerships and Policy**

- Concept: The idea of InaSAFE-FbA as an impact based forecasting tool is yet a very new concept for Government partners. The policy environment for data sharing across different departments is still not in place, it is expected that the more the Indonesia Government moves towards Open Source policies, the better the exchange will be.

- Synergies between two projects: having a research-application oriented project (InaSAFE-FbA) side by side to a humanitarian FbA project has been essential to ensure the user buy-in and capacity to engage and apply the research-application outcomes.

- Number of stakeholders engaged: It was realized that it would have been better to limit the number of stakeholders engaged at the beginning. BNPB, BMKG, Ministry of Public Work, one provincial DM Agency and OpenStreetMap Community were sufficient at the beginning. As lessons learned for other similar projects, it is recommended that the Ministries Social Affairs, Environment, and Home Affairs be involved at some point in the dialogue process for more specific collaboration, especially on data integration and action.

# 5 Technical Decisions

## 5.1 Framing risk

Knowing which risks could be addressed by doing early action is an essential step in the forecast-based action process. Given the often short window of time between a forecast and a shock, people doing early action should know what risk(s) can feasibly be reduced (e.g. reduction of mortality of people, reduction of damage of crops, reduction of morbidity of children etc). Understanding risk is therefore a fundamental part of the process, as knowing those risks helps to identify which are the vulnerability and exposure indicators that could be used in the IbF decision making tool, in this case in the InaSAFE-FbA tool.
After a detailed risk analysis for floods, the Indonesian Red Cross prioritized these disaster risks:

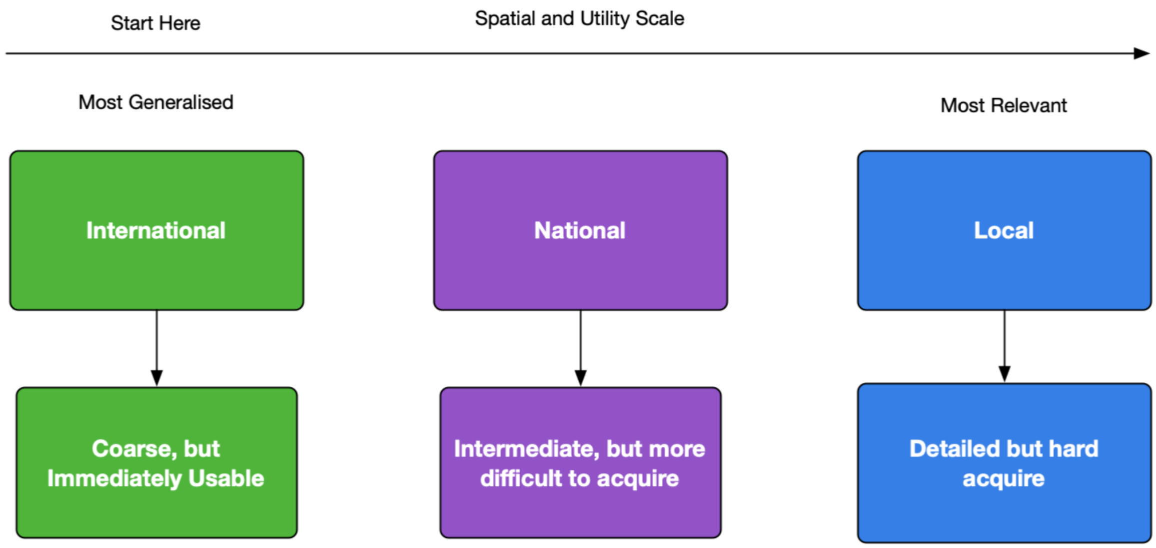
- Mortality of exposed population
- Damage of household assets
- Mortality of exposed livestock

The InaSAFE-FbA project has aimed to address the first two risks given the available information. While mortality of livestock is extremely relevant, the InaSAFE FbA project is not offering a solution to this, given the lack of access to livestock related data, including historical impacts of floods in livestock and current exposure and vulnerability data related to it.

## 5.2 Finding the data

### 5.2.1 Exposure and vulnerability

Based on these definitions, the limited amount of vulnerability and exposure data in Indonesia sets is a challenge for impact-based forecasting. Although information management systems are improving over time, there is still a lot of investment that should be done to ensure that vulnerability and exposure data are recorded with quality standards, are granular enough (recorded at the largest scale / admin level), and that are updated on a regular basis. In Indonesia, such information exists at different Government department levels and systems such as InaRisk and the newly launched InaWARE will change radically the way how risk data is managed. However, transforming data sharing protocols is still a challenge. For InaSAFE-FbA, sharing vulnerability and exposure data between agencies (e.g from the Ministry of public works to BNPM) will be very relevant when InaSAFE is in full use. Navigating these data sharing challenges was a key priority for the project.




**Lesson Learned**

An important outcome of this project has been the development of the methodology to quickly on-ramp a new geographical area. To do this we follow a 'good, better, best' approach as shown in the diagram above. It is clear that obtaining institutional data, even with partnerships and buy-in as we had on this project can be a time consuming process in many communities.

### 5.2.2 OpenStreetMap and International support

For the time being, the most sustainable way forward was identified to use OpenStreetMap to fill these gaps . This system offered the opportunity to access exposure data and develop proxy vulnerability indicators out of it. Its database has grown exponentially in recent years in Indonesia, the national Humanitarian OpenStreetMap team for example has lead recently (2019) one of the most advanced data enhancement process using machine learning to map the road network of the country and BNPB has a national plan to increase OSM data in the next 4 years.

For IbF, this means that the more complete, comprehensive and at scale OSM data, the better the decision-making process for Early Action could be.
Here, again, is highlighted the importance of partnerships. It was crucial to discuss with the Humanitarian OpenStreetMap team (Global and Indonesia), as it was realized at the early stages of the projects that information sharing from

Government agencies on socio-economic indicators would be a challenge due to different bureaucratic process, therefore, the project team concluded that using OpenStreetMap data was a way not only to capture exposure (as planned from the beginning), but also as a proxy for vulnerability information which would be crucial for the project.

BNPB has a plan to increase OSM data in the next few years and different partners were interested to contribute to the increase of the mapping of key areas. For this, the American Red Cross' missing maps team lead a Mapathon focused on Indonesia flood risk areas, the areas identified by Indonesia Red Cross as high risk areas where the FbA system is likely to be activated. In addition, the project team has leveraged the contribution from AVIVA Insurance as part of their social responsibility framework in partnership with the British Red Cross. Aviva dedicated hours of their staff to map flood risk areas of Indonesia. This has contributed to the framework of the project to increase the existing OSM data.

Based on the risks identified by Indonesia Red Cross, the project team identified a set of indicators that would give a proxy of where the most impacted people might be, and where households and roads are likely to be affected. Overall, the common denominator and assumption is that people and households most likely to be impacted are the ones living within the exposed area (in the historical flood print) and with vulnerability characteristics that would increase their suffering.
In addition to OSM data, we also use other sources of exposure data for population. We use local census data available from the Ministry of Internal Affairs.

To make the system applicable to global dataset, we also decided to support World Population datasets. The overall idea is to use a global dataset to make the platform easily accessible anywhere in the world, but also incorporate local dataset if available. Population data are used as exposure and vulnerability indicators because PMI is directly interested to see the possible human impact from the system. This will help them focus on prioritizing which area that has the most vulnerable populations.

### 5.2.3 Vulnerability Indicators

Vulnerability indicators associated with this are extracted from OSM data, World population, and local census data. Such indicators are one of the key elements to identify what are the areas of the river basin that are likely to be impacted and more vulnerable in case of flood. Vulnerability indicators can be used to prioritize the aid. Some areas might be equally impacted, but aid can be targeted to the most vulnerable group.

| **Category** | **Explanation** | **Indicators Chosen** | **Vulnerability/Exposure** |
|---|---|---|---|
| Buildings | Buildings exposures contain possible proxy indicators to represent vulnerability. The distribution and existence of buildings are directly related to indicate if the area has some degree of human activity | Building area | The bigger the area of the building, the more likely it is that the building is not a house (and therefore less vulnerable to flooding). |
| | | Building material | We declare building material with associated vulnerability score |
| | | Building type | Some types of buildings are more vulnerable to flood impacts. For example, the impacts of flooding on houses and hospitals is particularly high. |
| Roads | Road exposure might indicate the importance and population density of an area. | Road type | Some highly used roads are more exposed to high water levels and vulnerable to impacts. . |
| Census data attached in | Although it will not be possible to use census data directly as | Population count | Communities with higher population densities are more |

| | | | |
|---|---|---|---|
| administrative boundaries<br><br>World Population data as raster exposures | exposure, we can estimate which administrative boundaries are more vulnerable to help prioritize from a bird's eye view. Whenever census data is not available yet, world population data can be easily integrated for early estimation of population numbers. | | exposed and vulnerable to floods. |
| | | Gender breakdown | In general, women are considered more vulnerable to flooding as they are more likely to have dependents and, for instance, are less likely to be able to swim. |
| | | Age breakdown | In general, children and the elderly are more vulnerable to flooding. |
| | | Unemployment count | Unemployed people are more vulnerable to flood impacts. |

In the future, when data sharing protocols and agreements are in place, it will be possible to integrate additional vulnerability indicators in the system **from different sources** in order to improve even more the accuracy of the selection of areas likely to be impacted. The following table presents a few options:

| Indicators | Source |
|---|---|
| Vulnerability: | |
| 1. Vulnerable groups breakdown (senior citizen, minors, disable group) | Ina-Risk |
| 2. Income | SIDIK-The Ministry of Environment and Forestry (MoEF)/BPS |
| 3. Poor Group | PKH-Ministry of Social Affair |
| 4. Main source of living | SIDIK-MoEF/BPS |
| 5. Number of houses at river bank, and number of family living in slum area | SIDIK-MoEF/BPS |

| | |
|---|---|
| Exposure: | |
| 1.House Material of Poor Family | PKH-Ministry of Social Affair |

## 5.3 Inventory of forecasts

Indonesia does not yet have a government-owned and operational hydrodynamic forecast - however, there exist many privately owned models and high capacity to create such a system for the Indonesian hydro-met service. Additionally, there are many limitations to data and information availability in Indonesia:

1. Hydro-meteorological measurement is sparsely available and therefore there is little information with which to calibrate any flood forecast and validate decisions on triggers
2. Historical flood data is also limited, and therefore there are gaps in understanding the impacts of different return-periods, and validate the choice of thresholds
3. Impact curve data computation remains schematic and hypothetical, and limits must be determined on a basin-by-basin scale where there is no uniform provision of impact data.

The ongoing InaSAFE-FbA project has set the stage for future data sharing plans. With regards to forecast data, the primary focus has been on leveraging the forecast data sharing in a way that signature forecast from BMKG can be part of the InaSAFE-FbA prototype. This process is more of a long term process that would be achieved l in the framework of the larger FbA project of Indonesia Red Cross.

## 5.4 Mutually reinforcing data and outputs

In the meantime, the project team concluded that the use of a global forecast product could be the most effective way to demonstrate the IbF functionality of the InaSAFE platform. Bilateral discussions with the flood experts at the European Centre for Medium-Range Weather Forecasts (ECMWF) lead us to the conclusion that it is possible to integrate the flood forecast produced by the Global Flood Forecasting Systems (GloFAS) into InaSAFE-FbA. Despite the forecast limitations of GloFAS for Indonesia, after several technical analyses, it was concluded that this could be complementary in the future to the inclusion of the national level

Signature forecast, and on its own could be better suited to other geographies where the forecasts are better calibrated.

The GLOFAS system has been widely used for FbF projects around the world, and there is therefore much experience with using and interpreting its products. GLOFAS also presents another advantage for anticipatory action since its forecasts are given at much longer lead-times than are generally available in national products. It is important to note here, however, that with these longer lead times come greater uncertainty, and a coarser spatial resolution. When presented with the option to work with InaSAFE, GLOFAS expressed strong interest in joining. In particular, they were keen to improve the skill of their model in Indonesia - as yet, it does not have enough observation points in the country to provide a robust forecast, and no measure of skill has been undertaken.

For them, the InaSAFE-FbA project therefore presents an interesting win-win situation to which they are eager to contribute.  Using GLOFAS to set triggers in InaSAFE-FbA requires answering two major questions: 1) when (i.e. at what level) is the forecasting crossing a pre-establish impact limit or threshold and 2) where (i.e. in what areas) will these thresholds be crossed?. For this project, the first step was to identify all nodes in the project areas where hydro meteorological measurements were taken and transfer this information to GLOFAS who then determine whether or not this information is sufficient or appropriate for their model. It is important to note here however, that, even assuming the 1 in 5 and 1 in 10 year return-periods provided by current models such as GLOFAS are accurate, we are missing the "in-between" of these probabilities (eg. what happens in a 1 in 7 year flood?) and there are many gaps between the telemetry and the forecast that, once filled, will greatly increase the accuracy of the prediction.

## 5.5 Hazard magnitudes: Historical analysis and return period

The historical analysis of flood related humanitarian impacts was conducted through an analysis of past DREF appeals for the areas of interest. In these were identified the minimum percentage of damage highlighted by the national society at the time. Then, these damages were compared with the corresponding years flood hydrographs.

Once information was exchanged between the national hydromet BMKG and GLOFAS, the question then remained on the empirical differences between the 1-5 year and 1-10 year floods presented by GLOFAS? This was answered through a field visit and expert assessment of the hydrology and, the 1-5 year flood was determined as the threshold for InaSAFE-FbA, shown by research to be the first point of outbank flow. However, this choice is only provisory - until data and systems are tested, it remains hypothetical. Further field visits and model verification might determine that this return period could be longer and still capture major flood impacts. Additionally, hypothetical impact hazard curves were created based on data from a field visit that included key informant interviews and observations. This data must be validated further through surveys and analysis over future flood seasons, this process would be undertaken under the larger Indonesia Red Cross project on Forecast based Action.

**Key Technical Lessons Learned**

- Data sharing: This is one of the most complex aspects of setting up a IbF service. Realistic expectations and backup use of open source data was crucial to continue delivering the project outcomes.
- Flood forecasting: In Indonesia, flood forecasting is still in very early stages, although it is a critical hazard, there is still a lot of flood modeling that needs to be further developed to be able to include an reliable forecast into InaSAFE-FbA. The possibility of using a global forecast model offered the opportunity to develop the prototype as an interim solution.
- Global scope: It was realized during the project that by using OpenstreetMap and GloFAS data, it is possible to apply the InaSAFE-FbA system to other countries that are faced with data scarcity.

# 6 Monitoring and Evaluation

Fundamental to the planning and implementation of any project, M&E provides us with the opportunity to measure the success of programs. Notably, the following elements are central to highlight at this time.

- *Number of local policies, plans or investments informed by the project:* PMI's Early Action Protocol for Forecast based Financing will integrate the project outputs (trigger) into the EAP official document that is submitted to the IFRC to obtain access to funding for early action. If this approach is successfully adopted, it will have informed PMI and BNPB policies though it is still perhaps too early to report this. At local level, PMI has been in dialogue with local government units to explore how disaster risk reduction and management funding could be allocated by them for early action. Although there is interest in the FbA concept, there is still need for further advocacy and proof of concept.
- *Number of local partnerships formed:* Partnerships formed with PMI, British, and Australian Red Cross. BMPB and BMKG were very involved in the dialogue process, but formal partnership with the government would be done between PMI and BMKG and BMPB. The InaSAFE-Fba project has been catalytic for strengthening those relationships in the framework of early action decision making and planning.
- *Number of local actors benefiting from the innovation:* There is high potential for local government units to benefit from this project. Once PMI adopts the trigger process within its EAP, it will be possible for municipal/district offices to use these triggers to enable early action. A similar process is already happening in the Philippines. It is not possible to estimate the exact number of local government units that can benefit from this system. However, there would be at least 6 NGOs and UN agencies actively involved in early action that could make use of the system (the World Food Programme, Food and Agriculture Organization, and members of the start Network such as World Vision, Oxfam, and CAR, among others) Dialogue with all this organizations will continue in the framework of PMI's FbA project.
- *Number of local champions developed to enable further access or use of the innovation:* PMI staff and Kartoza staff are currently the key local actors.

- *Number of local actors trained:* These will be PMI and BNPB staff. We should also mention the 10.000 volunteers of American Red Cross that will do the Mapathons focused on the 30 districts + the AVIVA mapathon for 3 districts. The HOT team is supporting our work through their mapping process in the areas that are likely to be impacted, where FbF could be activated. British and Australian Red Cross members will also be trained.
- *Gender situation (e.g. disaggregation by gender of indicators c,d and e if relevant):* We provide below, summary tables by organisation and gender from our social engagement workshops to show gender representation at different times in the project.
    - November 2019 meetings: 4 female, 7 male
    - November 2019 field work: 2 male, 1 female
    - Glofas meeting: 5 male, 1 female
    - PMI meetings: 1 female (Atik)
    - November meeting at Deltares: 3 male, 2 female
    - November 2019 BMKG meeting : 4 female, 7 male
    - PMI meetings: 1 female, 7 male
    - BMKG meetings, 4 female, 7 male.

# 7 Next Steps

## 7.1 The broader landscape of Impact based Forecasting

Moving towards a production impact based forecasting service requires us to rethink and redefine how different institutions need to collaborate. This is an approach that requires co-production between National Hydrological and Meteorological Services, Disaster Risk Management agencies, information management experts, humanitarian and development organizations among others. IbF sustainability depends on the way it is institutionalized into existing Disaster Risk Management strategies, for this, the use of existing risk information management platforms, such as InaSAFE, offer an opportunity to create services that build on existing systems rather than duplicating them. Through the project, the project team has been able to advocate for this new type of thinking in key forums, including:

- World Meteorological Organizations, Multi-hazard Impact based Forecasting Symposium. UK December, 2019: An event that gathered key stakeholders from the hydrometeorological world who are developing IbF services.
- Forecast based Financing Global and Regional Dialogue platforms (Manila July 2019 and Berlin November 2019): These events are the main opportunities of dialogue for the anticipatory community of practice. Impact based Forecasting sessions, with emphasis on InaSAFE-FbA were organized in order to present the project ideas, process as well as to advocate to move towards these types of approaches.
- SHEAR annual meeting (London, September 2019): the main UK funded research programme on Science for Humanitarian Emergencies and Resilience in the framework of its Forecast-based Financing research projects, offered the opportunity to share with the community of researchers, the ideas and process of InaSAFE-FbA.
- Humanitarian OpenStreetMap summit (Heidelberg, September 2019): InaSAFE-FbA was highlighted in different sessions related to the future of anticipatory action as one of the approaches to IbF that can contribute to effective early action. From this event, Missing Maps has led several

maphatons to map specific flood risk prone areas in Indonesia, link to the project.

- Impact based Forecasting methodology: A joint methodology of the UK Met Office and the Climate Centre in order to bring together the WMO and the humanitarian approach to IbF. This new methodology for National Hydro-Met Services will make reference to the InaSAFE-FbA prototype.

## 7.2 Next steps for the Indonesia Red Cross FbA process

PMI is planning to use the new InaSAFE functionality as part of their FbA system. Conversation has been raised on follow-up action to further-update the InaSAFE once the project is completed in May 2020. Draft agreement with BNPB includes joint management and updating InaSAFE in future. Although at this moment, river-based food forecasts are not yet included into the application updates, PMI is considering including these after the completion of Challenge Fund funded-InaSAFE project. The proposed PMI-BNPB agreement includes collaboration between PMI and BNPB on managing and further updating InaSAFE in the long term. After the completion of this project in May 2020, further steps should explore the availability of Indonesia-based Kartoza staff and mode of collaboration with PMI.

## 7.3 Next steps for InaSAFE-FbA team

The development of the InaSAFE-FbA prototype has been a learning opportunity that will contribute to the future of Impact based Forecast globally. It is expected that in some years, the production of such services will be mainstreamed, having public IbF services in our phones by providers such as google and apple, to tailored services for specific sectors produced by National Hydro-logical services, DRR agencies and the private sector.

The InaSAFE-FbA project is demonstrating that integrating weather forecast information with historical impact data, vulnerability and exposure indicators, using an existing risk management platform offers an opportunity to build in already existing systems and to develop services that can be sustainable and efficient. The Indonesian Red Cross will continue developing further the existing prototype towards a service that can be fully adapted to their Forecast-based Action systems. Furthermore, the project team will continue exploring how other partners around the world could benefit from the project thinking and architecture to apply the same knowledge and lessons learnt in countries where such systems for anticipatory action could flourish ultimately to protect the lives and livelihoods of the most vulnerable people.

On the technical aspect, the next steps to this project is clearly to transition to using the Indonesian hydrometeorological "in-house" forecasts into the system, perhaps replacing GLOFAS gradually or using both forecasts as other FbF projects in the world are doing. This is key to bolstering the sustainability of the system. Under the PMI FbA project, the facilitation of data sharing is a key objective, dialogues between PMI and BMKG will continue further in order to determine the modalities for sharing flood forecast data. As an exit strategy from the InaSAFE-FbA project, PMI will continue counting with the technical support from the Climate Centre and Kartoza in such a way that when data is available the system will be updated. Furthermore, trainings will include a full set of information for PMI on the technical aspect of integrating new forecasts and new vulnerability data when this becomes available.

## 7.4 Next steps for the project

The potential for InaSAFE-*FbA* to be used in many different contexts is one of the conclusions of this project. Indeed, this is opening the doors to explore how such systems can be transformed into decision making tools to trigger early action. Notably, the platform is being piloted in Granada for the GeoCRiS project and there are also discussions to use it with Australian Red Cross. The platform has also been demoed to Médecins Sans Frontières Canada, the World Food Program GIS group, and the team at large at the Red Cross Red Crescent Climate Centre.

# 8 Conclusion - Key Messages for Future Projects

The future of forecasting relies on the capacity to integrate weather and climate information with information about people's susceptibility to be affected by it, the InaSAFE-FbA project is a preliminary contribution to the enormous efforts that should be done at all levels to have a future in which early action can be done based on a sound understanding of risk and forecast.

This projects is a test of how silos can be broken to join efforts between organizations that often do not work together, in this case, joining forces between the Red Cross Red Crescent and Kartoza, is testament that those silos can be broken and that we can co-produce ideas and project  that can change the world.

# 9 Source code

All of the source code we have developed is open source and freely available at:

https://github.com/kartoza/fbf-project

The spreadsheet writer routines we developed are at:

https://github.com/kartoza/smartexcel-fbf