What is a hazard?

In the context of InaSAFE a hazard is any natural or human caused event or series of events that may negatively impact the population, infrastructure or resources in an area.

Some examples of natural hazards:

a flood (caused by overflowing rivers, storm surge etc, localised precipitation that cannot drain effectively, or by engineering failure such as a dam or levee breach)

- an earthquake and the resulting ground shaking that is produced by it
- a volcano and the resulting lava flow from a volcano
- ash fall from a volcano
- a tsunami
- Some examples of non-natural hazards:
- a chemical spill
- a nuclear plant failure
- an industrial fire / explosion
- It is important to note that InaSAFE is **not a hazard modelling tool**. That means that you need to source your hazard data from elsewhere and bring it along ready to use in InaSAFE. In this training course we will be focussed on flood hazards, so we will take a moment here to explain how one goes about creating hazard datasets.

There are three primary mechanisms that can be used to generate flood hazard datasets:
Remote sensing

i. Local knowledge
ii. Modelling
iii. Remote sensing
iv. This is done using remote sensing equipment (e.g. a drone, airplane or satellite based sensor) that overfly the flooded area taking images. With remote sensing or GIS software these images can be mosaicked (combined) into a single aerial image and the flooded areas captured. The capture process can either be:
v. **manual** - by digitising the flooded polygons as a polygon layer by tracing over the image

- **semi-automated** - a remote sensing specialist could use software to classify the image and extract the flooded area.
- Typically the process for calculating flooded areas would include taking a pre-flood ‘control’ image and then an in-flood image. The extents of water each stage would be extracted from the imagery and then subtracted from each other. This result will be a flood footprint. In other cases it may be sufficient to simply have the current flood situation mapped during a disaster and perform analysis based on that.
- Remote sensing can be extremely fast and effective for capturing large areas, but it also has potential issues. For example during flood events there is often a lot of cloud over the flooded area making the process difficult. It is also possible to use non-visible spectrum (e.g. radar) remote sensing techniques to detect flood waters,

but there is an issue with costs associated with this approach - it is often prohibitively expensive. For a nice presentation about using SAR (RADAR) data for flood mapping see:

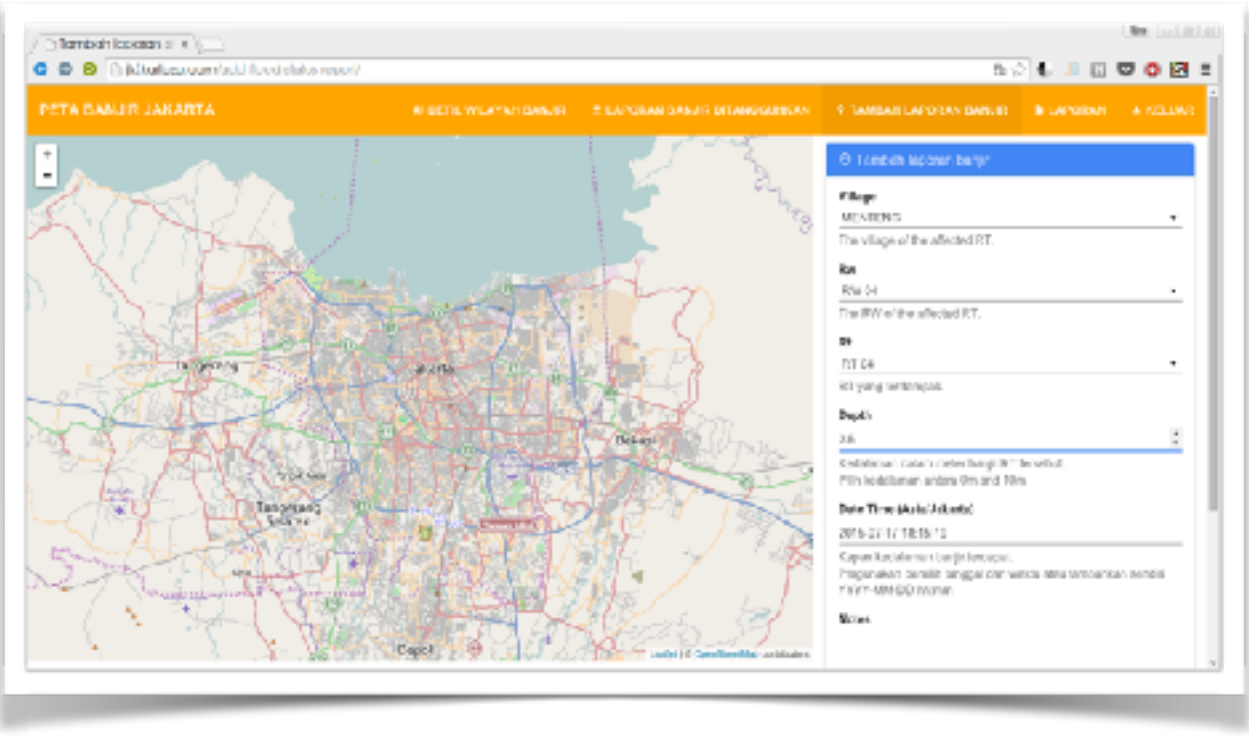
- http://earth.eo.esa.int/download/eoedu/Earthnet-website-material/to-access-from-Earthnet/2009_ROSA-ESA-DLR-Radar-Remote-Sensing-Course/Flood_detection_principles_TSX.pdf

Summary	
Single event usage?	Yes - each dataset is typically for a single event
Multi event usage?	Yes, by combining flood areas from two or more events
Accuracy	Can be very good
Pros	Can cover large areas
Cons	May not work due to cloud cover, can be expensive to circumvent this.

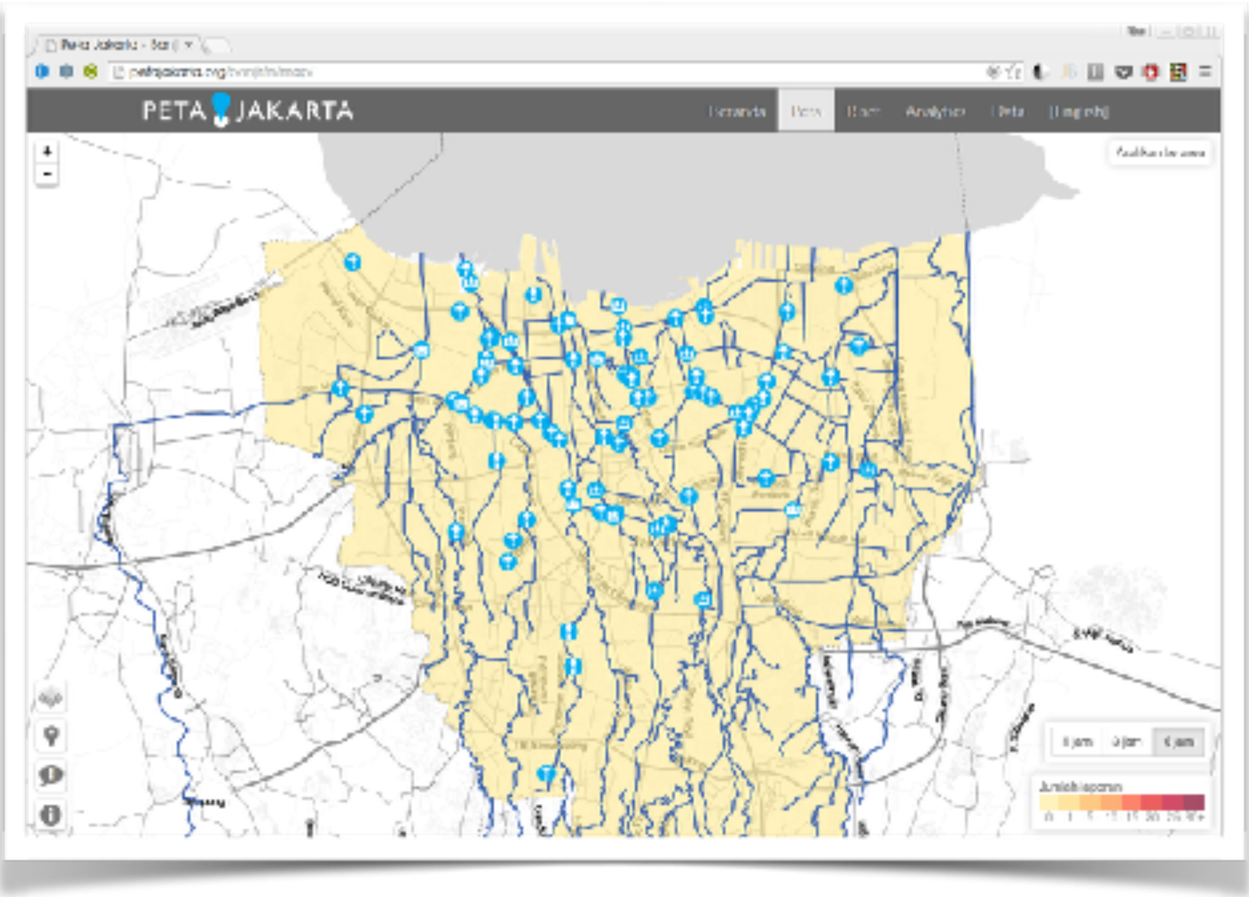
Local Knowledge

This is probably the most practical way to gather flood data fast, though with lower precision than using remote sensing techniques. One approach that has been effective in Indonesia is to hold mapping workshops where village chiefs / local officials are invited. The officials are asked to indicate which wards / sub-wards within their responsibility area flood regularly.

Instead of simply mapping which wards are flooded, it is also possible to take another approach and map per event, using the same boundaries (wards or subwards). During the event a help desk environment can be used to call out to an official from each ward and query the status of the flood waters in their ward. This approach can also be used via a website (if internet accessibility permits) or by using social media such as twitter. Two examples of this are shown below.



Jakarta Flood Mapper - http://jkf.kartoza.com



Peta Jakarta - http://petajakarta.org/

A key requirement for these local knowledge based processes is that there are suitable mapping units available to use for deciding if an area is flood prone or not. In some cases participants may need to capture these, in other cases ward or sub-ward boundaries can be used. Using sub-ward boundaries may not always be ideal since the flood extents most likely do not align well with the boundaries, but it may be sufficient for broad planning purposes.

Summary	
Single event usage?	Yes
Multi event usage?	Yes, local knowledge typically will span multiple events
Accuracy	Typically only accurate to subward level
Pros	Fairly quick to create the data, does not require sophisticated technology
Cons	Susceptible to human error and coarse accuracy

Modelling

Modelling floods is an entire discipline in its own right. Flood modelling can be carried out by combining factors such as precipitation, geology and runoff characteristics, terrain etc. to derive a model of impending or current flood. Modelling can use data interpolation techniques - e.g. by taking flood depth readings manually or using telemetry from various sites around the flood prone area, flood depths can be interpolated to estimate the depth at places that were not sampled.

Another modelling approach used by engineers is to install depth sensors upstream of the catchment and then try to model how much water is coming into the catchment area based on depth and flow rates. This has the potential advantage of giving early warning before floods enter the flood prone area, although it also has the disadvantage that localised rainfall may not be accurately considered in the model.

Using a digital elevation model (DEM) and a stream network, it is also possible to generate a simple model of which areas might be inundated by a water rise in the river network of a certain amount. DEM cells adjacent to the stream network which are below the flood-rise threshold will be considered flooded and then those cell neighbours can in turn be considered so as to ensure that only contiguous areas in the DEM are flagged as inundated. There are various other approaches that can be used to model flood potential that involve using a DEM.

One advantage of using a modelling approach is that it allows us to do forecasting for abnormal events. For example, there may not be localised knowledge about 50 or 100 year flood events and their impacts, but these can be estimated using modelling techniques.

Summary	
Single event usage?	Yes
Multi event usage?	Yes
Accuracy	Accuracy may be very variable depending on the datasets used the the algorithms employed.
Pros	Does not require large amounts of human input, may provide insight into the impact of extraordinary events such as 100 year floods.
Cons	A large number of techniques available make it difficult to choose an appropriate one. Algorithm parameters need to be carefully tuned and a high confidence in the input data used for modelling is needed.

Single versus multi-event hazards

Hazard data used in InaSAFE can be either single event or multi-event. Single event hazards are useful when you want to estimate scenarios like ‘how many people would be affected if we had another flood like in 2007’. A single event hazard covers a short span of time - like a single flood or earthquake event. Single event data is also the most suitable to use for events which are stochastic e.g. earthquakes which seldom occur at the same place and with the same intensity more than once.

Multi-event data are useful when you would like to plan for disasters that repeatedly affect the same area. For example over the course of 10 years, the same wards or sub-wards may get flooded, though not on every event. Flood and volcano eruptions may be good candidates for using multi-event data in your contingency planning.

Some tools that can be used for flood modelling

The techniques that are available in GRASS for modelling floods are:

- r.hazard.flood which is an extension in grass and the instructions on how to do that are accessed on the grass wiki. http://grass.osgeo.org/grass70/manuals/addons/r.hazard.flood.html
- r.lake and r.rake.series. r.lake is available in grass and can also be accessed via the processing interface in qgis and run for each simulation. r.lake.series is a grass extension only available in grass 7 which also supports simulation through the nviz module in grass.
  http://grass.osgeo.org/grass64/manuals/r.lake.html
- r.terraflow. Mainly used for flood modelling for rasters that are big. There are two variations of r.terraflow which stem from the type of data the dem has. For cell type data there is r.terraflow.short which is used for this and is available in grass 6. http://grass.osgeo.org/grass64/manuals/r.terraflow.html
- Techniques available in QGIS:
- Using the processing module in QGIS one can access the modules in SAGA,OTB and GRASS. Installing a plugin named Geospatial Simulation also enables different flood modelling techniques to be visible in the processing toolbox. The instructions on how to undertake these processes can be accessed at their respective website/wiki or any other blog articles that describe the processed carried out.
- Requirements for using flood data in InaSAFE

Key notes for floods	
Format	Vector polygon data or raster data
Required fields	Applies to vector flood data only: A field representing whether the polygon is flood prone or not. We recommend calling this field **‘FLOODPRONE’** and using a value of ‘**YES**’ to indicate that it is flood prone.
Notes	InaSAFE does not need ‘engineering quality’ data. When provided in raster format, each cell value will typically represent a flood depth in meters.
Sourcing	Can be sourced from community mapping efforts, from your national mapping agency.