DFID – GFDRR Challenge Fund

Version	Date	Author	Initials	Review	Initials	Approval	Initials
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Note: This report has been reviewed and approved by the reviewer following the Deltares Quality Management System. This is part of our ISO 9001 quality certification.

PHASE II FINAL REPORT TEMPLATE: INCLUDING MONITORING SELF-ASSESSMENT

Please address the following in narrative form, as applicable, to your project.

I. Name of project, target country(ies), USD amount and time frame of Phase II grant

Name of project:	Participatory terrain data and modelling
Target country:	Tanzania
USD amount:	$ 150,000
Time frame:	Contract signature: 13 October 2016

"Accurate digital elevation models (DEMs) created using airborne lidar have transformed regional flood modelling and forecasting. At continental and global scales, however, the best-available DEMs come from satellite images and are too crude for simulating flooding — and its related risks to public health, biogeochemical cycling and wetland ecology.[…] Current global DEMs cannot resolve the detail of terrain features that control flooding." (Source: Schumann et al., Nature 2014)

II. **Description of tool, approach, toolkit**

a. Was it demand-led? If yes, how?

b. Did you work with local beneficiaries in Phase II to develop your tool? If yes, how many local beneficiaries and how were they involved?

c. What is 'new'? In other words, what did Challenge Fund monies support in Phase II?

In many world regions, there is a strong need for high resolution terrain data as a basis to enable hydrological and flood modelling. Although lidar and stereo imaging techniques such as Structure-from-Motion are capable to establish high resolution terrain data from airborne platforms, these techniques require a large investment (to fly Dar Es Salaam: about USD 2,000,000) and do not capture the details of under and overpassing structures. The limitations of currently available global terrain datasets have also been mentioned in the "Solving the Puzzle" report by GFDRR as a high priority avenue. In phase I of our project, we piloted a prototype tool that enables a user to establish a high resolution terrain dataset with locally collected information on roads, water ways and buildings, stored in OpenStreetMap (OSM). Details about the features can be included during a stakeholder workshop with members of the communities that know how roads are built, how buildings are protected and which water ways function properly and which not. The result is a terrain dataset that includes detail, and where blockage and conveyance of water through or under structures is preserved. The results can then be used for hydraulic flood modelling.

A clear need for tools that use OSM data to derive data and schematizations for flood modelling exists in Dar Es Salaam. This city is rapidly growing and improved knowledge of probabilistic flood risk is needed. As the drainage system consists of highly detailed features including channels of less than 1 meter wide, detail is needed to fully comprehend flood risk. Recently the Tanzania Urban Resilience Program was started (DFID funded) to answer to the needs for increased resilience to floods in the context of its rapid urbanization and climate change. To answer to the lack of data, two community mapping projects "Ramani Huria" and "Zuia Mafuriko" organized by the World Bank and the Tanzania Red Cross Society were performed to map the city's most vulnerable wards. These data are stored in OSM and provided a solid basis to test our methods and apply these in the city.

In Phase II we wished to bring the method as well as the dataset to scale, by developing a user-friendly tool based on the pilot routines. Furthermore we wished to build further on the Ramani Huria / Zuia Mafuriko data (hereafter referred to as OSM data) as to come to a community informed flood impact assessment. We discovered that during the community mapping, attention was already paid to direct impacts of flooding, but no attention was paid to the indirect and cascading effects of Critical Infrastructure. Therefore, our focus was on assessing impacts of failing critical Infrastructure. We did this in a gender and inclusiveness informed way, in order to identify the groups, most vulnerable to flooding, through failure of different critical infrastructures.

This requires a strong commitment from stakeholders and community members within the focus neighbourhood. To make this possible, we have teamed with the Tanzania Red Cross Society in Phase II, and we have involved TRCS volunteers. We decided to focus on Manzese Ward in Dar Es Salaam for rolling out our activities, because a strong group of TRCS volunteers is present in Manzese. Below we summarize the outcomes of this Challenge Fund extension.

From prototype to web service:

We established an online web service "OSM-terrain" that can synthesize the details of urban terrain, using an OpenStreetMap (OSM) dataset as input. The web service uses Google Earth Engine as a back-end for calculations, but the user does not need to have knowledge of Google Earth Engine. In short the user can filter features from the OpenStreetMap dataset geographically as well as by means of tags. The tool is now freely available through the webservice http://osm-terrain.appspot.com/.

Community informed risk assessment

> *"It is magical how CIrcle-Bao clearly shows the relations among the Critical Infrastructure. I am very thankful that our ward Manzese was chosen for this training." (Quote from a Tanzania Red Cross Volunteer).*

A first step in flood impact modelling and scenario assessment is to establish a hydraulic model. We prepared scripts to automize and ease the process of model setup from the terrain data and the OSM data. The terrain data, synthesized from OSM-terrain was used to prepare the 2-dimensional domain of the model, while the 1D model network was setup by scripting. We inventoried which stakeholders should be targeted for a training on setting up and running a flood model. The target was to ensure that stakeholders are aware what is possible with the OSM data, and how models can be used to assess flood problems. For instance, we demonstrated what happens when a bridge is blocked by solid waste and reduces the ability of water to be conveyed under the bridge. The training was used by some of the people to get acquainted with modelling, for some people to observe what is possible with the OSM data, and for some (in particular staff from University of Dar Es Salaam and Ardhi) to go in-depth with flood modelling. We trained 20 people with an equal balance in gender.

Finally, we developed a non-digital (fully physical) tool and workshop form that allows for doing a Critical Infrastructure cascading risk assessment in a neighbourhood. The tool was inspired by the traditional East-African game "Bao" and was based on the existing digital tool CIrcle which stands for "Critical Infrastructures

- Relations and Consequences for Life and Environment".

The target of our method was to empower local end users to perform an assessment of critical infrastructure within their own environment, using knowledge from stakeholders that manage or are involved with management of the respective identified critical infrastructures. Therefore we conducted a 2-day training, in which we trained 23 TRCS volunteers, and 2 students to convene a CIrcle-Bao by themselves. After the training, we selected 5 volunteers to conduct a CIrcle-Bao session themselves (2 women, 3 men). During this session, we kept our influence to a minimum. The final session had several targets:

- To provide a platform for the trained TRCS volunteers to experience their first CIrcle-Bao workshop.
- To find out if we have developed a method that can be transferred to TRCS for further use.
- To allow stakeholders to speak up and learn how their infrastructure depends on each other. This awareness may lead to recognition of possible interventions, and evidence (collected during the workshop) to support and prioritize further action.
- To evaluate if the method indeed can enable a group of stakeholders to collect their own knowledge and inventorize cascading impacts of critical infrastructure during flooding.

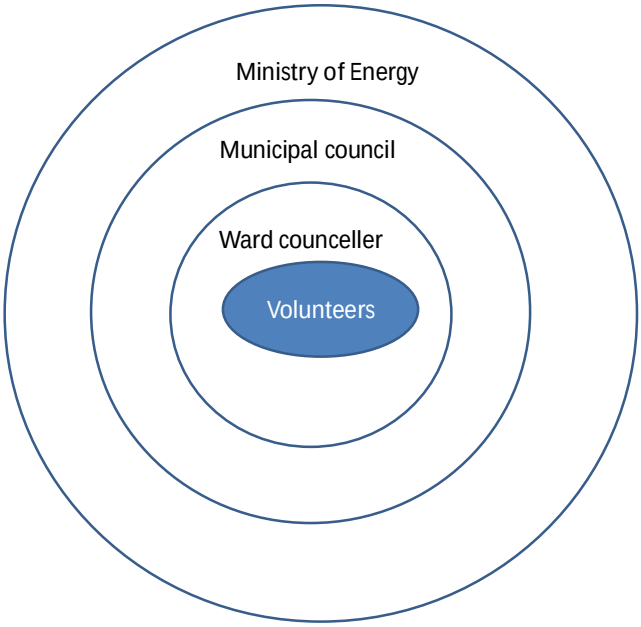
The results of this workshop are further described in section IV.

d. How does it support risk identification and decision-making?

e. Discuss how it enables (or will enable) users to make more effective disaster management and resilience decisions.

Through Phase II, we have established a workflow that can go from openly available data sources, to high resolution terrain data, to flood hazard simulations to critical infrastructure cascading impacts, including assessment of specific vulnerable groups.

Through the training, TRCS volunteers came to the conclusion that electricity fall outs caused by flooding can have significant impacts on other critical infrastructure (see Box 2). Furthermore, its direct impacts are also severe, as transformator blow outs during floods can cause dangerous situations like potential electrification hazard, and loss of income by the power company. This led to the conclusion that the building of new transformation stations should be informed by the Ramani Huria OSM data and should not be positioned in the flood zone, according to the community mapped data. The CIrcle-bao session provides the community members with evidence that poorly designed energy infrastructure may have serious consequences throughout the ward. The Circle of influence from the volunteers' perspective is given below. Volunteers may for instance unite under a community group and as a group bring this forward during community meetings with the ward councellor. The ward councellor is member of the municipal council, which is consequently in contact with the Ministry of Energy. The ministry of energy finally works with the power company, TANESCO and they together influence decisions on new energy infrastructure in the ward and elsewhere in Dar Es Salaam. To enable better decision making, we will present the results of the CIrcle-Bao session to stakeholders in our next visit in December 2017.



Box 1. Circle of influence of TRCS volunteers. This box demonstrates how a CIrcle session may lead to improved decision making.

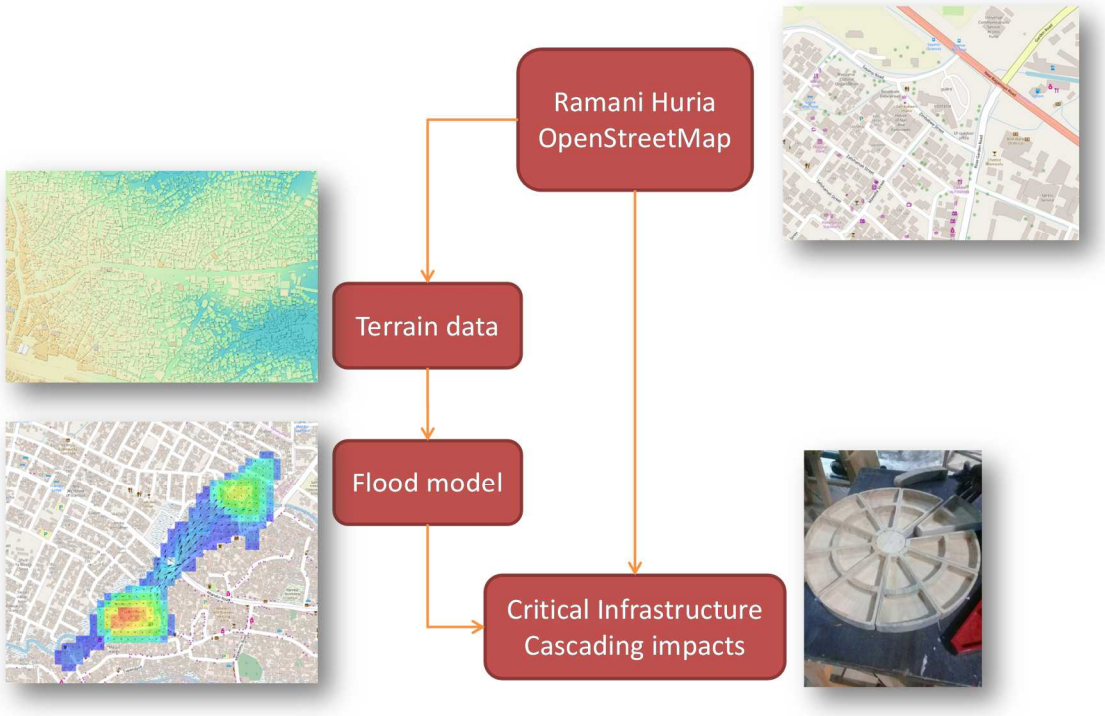


Figure 1. Steps realized in this Challenge Fund project

This process is shown in Figure 1. In particular at the last step (impact identification), we give community members first evidence what infrastructure causes the most severe impacts, and which infrastructure is hit the hardest by cascading impacts. In Manzese ward, we were able to identify that in particular water points and roads cause many cascading impacts, and that schools and hospitals are hit the hardest. Furthermore the volunteers collected additional information at what flood levels these infrastructures could be failing and which groups in society are disproportionally vulnerable to their failure. The results of the training were used to make TRCS volunteers more aware which infrastructure (upon failure) may cause the most impacts of their risks. We used the results of their analysis to identify which interventions, targeted to which infrastructure are the most promising. We furthermore investigated at which level decision-making is required and how volunteers, from their own position in the community, may influence this decision-making. We give an example of this process in Box 1. This circle of influence was drawn during our session with TRCS volunteers.

Finally, the World Bank has been supportive about our efforts to introduce flood modelling abilities with Ramani Huria OSM data in Dar Es Salaam. The most important gap still to establish a sustainable uptake is short course or curriculum development around the established methods and tools. Although many users are aware of the methods, the period of training is too short to leave these tools behind in a sustainable manner. We are currently considering proposals to prepare curricula with ITC Twente and Ardhi University to sustainably use the CIrcle-Bao method (contact through TRCS: Professor Kiunsi). TRCS has two CIrcle boards to work with and they can be easily replicated locally for low costs (USD 150,- per board). Curricula activities may also be

developed with university staff of UDSM to increase the capacity to perform flood modelling (in particular the department of Water Resources Engineering (contact through Deltares: Dr. Felix Mtalo).

f. Describe the degree to which it is openly-available and how users can access it.

All methods and tools are publicly available. Below we have listed the respective locations for use or download.

OSM-terrain website	http://osm-terrain.appspot.com/
Hydro-OSM tools (MIT license)	https://github.com/openearth/hydro-osm/
Code for OSM-terrain website	https://github.com/openearth/parterra/
Guidelines for CIrcle-Bao	http://www.deltares.nl/circle

III. **Description of partnerships (active in Phase II, but which could have started in Phase I), in particular those involving local partners.**

Did you work in partnership(s) with a local partner(s)? If yes, please provide the name(s) of the local partner(s) and the nature/strength/sustainability of the partnership.

The partnership with the Tanzania Red Cross Society has been very important. Their network with stakeholders is impressive and through their volunteering network we were able to connect to governmental level as well as community level. In particular the connection with the community through the TRCS volunteering network, was very important. Through the volunteering network, the CIrcle-Bao method could be positioned at the level where the impacts of flooding are felt most. TRCS (together with RCCC) co-developed the CIrcle-Bao method. Furthermore, TRCS assured that any materials we used are reproducible locally.

The collaboration with TRCS started during Phase II of our project and lasts until October 2017. However, the groundwork has been set for a longer term collaboration in which the focus will be on better embedding of flood modelling and risk assessments method in Dar Es Salaam through capacity building, as well as improved early warning and response, by embedding the models and methods developed in this project in a forecasting and early warning system.

It should be noted that these new developments require a number of additional partners in Tanzania. The mandate for forecasting and early warning lies with the government (Tanzania Meteorological Agency, TMA), and therefore our partnership should be extended to include TMA. The Prime Minister's Office – Disaster Management Department is keen to improve early warning by means of impact warning. With our methods, the opportunities to establish flood impact warning systems are increasing and we are at the moment trying to secure funds to make steps in this direction. We submitted a concept note for this for a WISER project to the UK Meteorological Office.

During the process of this project, TRCS also made very clear that there is a strong need to further embed the models and methods generated in this project, to ensure the results would be uptaken and used. TRCS is urging us to make sure that this happens, as to prevent that results simply end up in a dusty cabinet. We believe that the solutions should lie in setting up new curricula at the universities. As TRCS as well as the World Bank have a very good and long standing relationship with both UDSM and Ardhi University, we are trying to work through them to get such curricula around our tools developed.

Finally, we should mention that the World Bank – Tanzania has been extremely supportive of our ideas and methods. They have provided staff to get our workshops organized and provided feedback on methods. Their keen interest is to improve capabilities for flood modelling and give this a role in Disaster Risk Management and Urban Resilience. To introduce this topic, we were invited to the closing workshop of Ramani Huria, as well as the UR Tanzania event. They furthermore hosted a UNESCO-IHE student, who worked on further development of automated model setups with the OpenStreetMap data (Ms. Eskedar Gebremedhin, currently employed by Deltares). Finally, we received an additional project from them to improve mapping of drainage data in the Ramani Huria community mapping initiative and support this with Quality Assurance tools.

IV. Description of capacity building of local stakeholders.

Did you conduct training in Phase II for local communities or beneficiaries in the use of your tool? If yes, please describe the type of the training and the number/type of beneficiaries trained. Did you measure change in knowledge as a result of your training? If yes, please provide results. Did you follow up in any way after the training to see if what you discussed was put into practice? If yes, please explain.

We have had many training elements in our Phase II Challenge Fund. We describe two training events: a) training of various stakeholders in use of OpenStreetMap data in flood inundation modelling; and b) training Red Cross volunteers in the use of CIrcle-Bao, a physical (non-digital) tool to assess the cascading impacts of failure of critical infrastructure on society. We describe both training events, along with measurable impacts in this paragraph:

Flood inundation modelling with OpenStreetMap data

A three day training was organised focussing on flood inundation modelling with OpenStreetMap data (21-23 February 2017). The training was aimed to inform a wide audience representing very different stakeholders and was meant to start the process of model building and data improvement. We conducted a survey to inventory the needs for flood modelling with 15 professionals working with Non-Governmental Organizations, Government Institutions, Research institutions, Universities, private sector and others. This survey led to a list of requested training subjects that we could cover during the training. The topics requested were.

- What features in a city are important in a flood inundation model?

- GIS Tools and methods to convert OpenStreetMap data in flood inundation model layers.
- Detect where OpenStreetMap data should be improved.
- Make your own ward-scale flood inundation model.
- How to prepare/run events (discharge and rainfall).
- A field trip to improve OpenStreetMap data for flood modelling.

Concepts of flood inundation processes were partly conveyed through serious games, organised by the Red Cross Climate Centre, and by conducting a field trip to recapitulate these concepts in the real-world. We demonstrated to the audience, how the community data in OpenStreetMap can be used to model the dynamic genesis of floods, using the tools developed in this project

The training was therefore not only technical but was particularly meant to have interaction between typical stakeholders that may acquire or improve data (i.e. local community members and mappers), stakeholders that may use data to establish models (e.g. university staff, and advanced consultants from companies or World Bank staff) and stakeholders that should understand what a flood model can be used for, in order to improve decision making (e.g. Red Cross and NGOs). The training helped to let stakeholders, knowledgeable about hydrology and hydraulics interact with stakeholders in the mapping community to provide feedback where details in the mapping material were missing or should be rechecked in order to improve any flood models derived from them. This is one of the essential elements of this Challenge fund project and is meant to start an iteration loop on data improvements. This procedure of mapping, modelling and improving data with a central role for the community rather than the expert is emphasized in Figure 2.

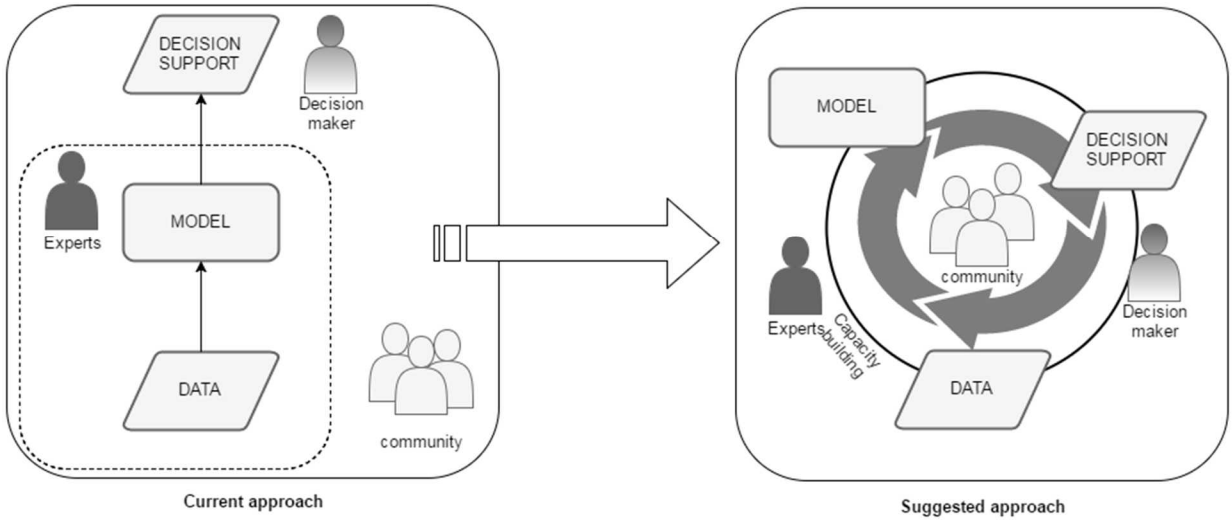


Figure 2 Moving to a community centered approach in flood modelling and data collection

Measuring the impact of the workshop

Conveying urban flooding concepts and modelling
First of all and very concrete, the workshop led to training in the concepts of urban flooding of a group of about 20 people. This group included a very wide audience ranging from ward officers to disaster managers and planners. We noticed that a smaller portion of this group, in particular the members of academic institutes, were very engaged in the technical part of the training, whilst others, with less technical background were engaged in finding out what is possible. For instance, ward manager Osigili Losai (Kigogo Ward) mentioned that he would very much like to do the same for his own ward. We are therefore proposing in a follow-up proposal (submitted to the "Partners for Water" programme of the Ministry of Foreign Affairs, The Netherlands), to establish a flood model from the OSM data in this particular ward and use this in a flood early warning system.

Stakeholder dialogue
Furthermore, the workshop led to a further dialogue between stakeholders, knowledgeable in mapping the city, stakeholders, knowledgeable in hydrology and stakeholders requiring flood information for planning and disaster management. For instance, this was the first time that participants in the hydrology domain (Water Resources Engineering Department of University of Dar Es Salaam) were connected to the already existing network of community mapping. This group can now be approached for follow-up work in flood modelling. The dialogue led to an improved understanding on what is required for a sound flood model.

Increased focus on data quality
During the workshop (and further analysis of the OSM data by the project team), we also concluded that many data was collected, but in particular data related to water was in some cases quite incomplete in terms of the drainage network itself, and the collected profile information of the drainage network. The two mapping projects were not particularly aimed for collecting details on the drainage network, which may partly explain this. Our routines included a set of first data quality checks to assess whether network elements were properly connected, whether profile information (width and depth) was mapped or not. Water elements were color coded to see these quality issues and used as guidance to decide where to check the data in the field and to improve it, so as to improve the basis for a good flood inundation model. This led to a request from the World Bank to increase capacity to check how well the agreed data model was followed, how well the river network is connected and whether over- and underpassing structures are mapped or not. This is reported under a separate contract modification, under the same contract number P7180930.

Training Red Cross volunteers to investigate cascading impacts of failing Critical Infrastructure – CIrcle-Bao.

As part of the proposed activities, we have converted an existing method to investigate with stakeholders what the impacts are of cascading failure of Critical Infrastructure (CI) on society.

The original method is called CIrcle[1] and works with a touch table or as a webtool. We have adapted the method such that it can be reproduced locally and can work without electronic equipment. It is loosely based on the local well-known Swahili game "Bao". It uses a number of basic tools being prepared printed maps, the board game version of CIrcle called CIrcle-Bao, and a number of colored pawns and card material. We have prepared a guideline for facilitators which can be freely downloaded from http://www.deltares.nl/circle and which can be used to produce and prepare the materials and conduct the workshop.

Our target was to *enable local community members*, in our case represented by volunteers from the Tanzania Red Cross Society, all living in Manzese ward, to conduct a CIrcle workshop themselves. After the training, we have organized a session with stakeholders from Manzese, all representing different Critical Infrastructure in the neighbourhood. After this training and workshop, we have concluded that the method is very useful, and the highly engaged volunteers came very far in conducting the workshop themselves. We believe that full uptaking would require embedding of the method in curricula, for instance in the study Disaster Risk Management at Ardhi university.

Figure 3. Tanzania Red Cross volunteers, in training on CIrcle-Bao

During the training, one of the volunteers stated that "It is magical how CIrcle-Bao clearly shows the relations among the Critical Infrastructure." We noticed that even during the training, Red

[1] https://www.deltares.nl/en/software/circle-critical-infrastructures-relations-and-consequences-for-life-and-environment-2/

Cross volunteers were very well capable of identifying cascading relationships within their own neighbourhood.

Results of CIrcle-Bao workshop

13 stakeholders representing various infrastructure of Manzese ward participated in the workshop. They mapped out missing Critical Infrastructure (CI) on a paper map. These missing locations have been digitized. The list was categorised and after discussion among all the stakeholders 10 most important CI were selected for further identification of direct impacts of flooding on CI and cascading effects of CI disruption or failure on other CI networks.

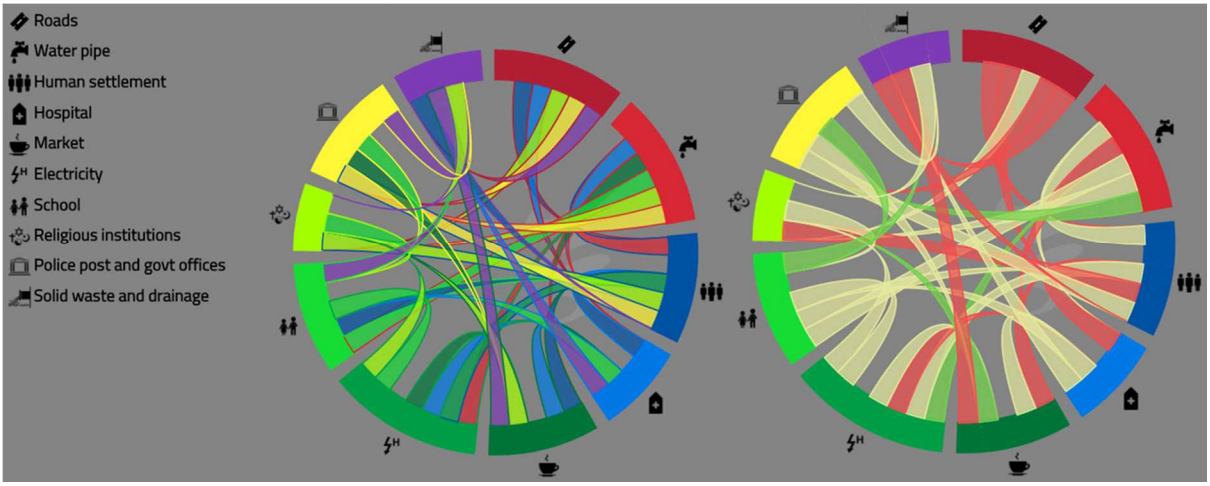


Figure 4 Result of interdependencies of CI network in Manzese ward

First, the direct impacts of flooding on different critical infrastructure were discussed. The water levels when the CI would start getting affected and when it would fail were identified. The measurements of the water levels were taken as “ankle level”, “knee level” and “waist level”. The stakeholders were more comfortable discussing the water levels with these units rather than in meters or centimeters. It was also discussed what the impacts associated with affected and failure were. In addition, the vulnerable groups (based on age, gender, income group and people with disability) in the ward were also identified.

We here name a number of examples of outcomes, that typically required inputs from local stakeholders. We limit ourselves to examples, a full report on the session is provided in our background report, which will be released shortly.

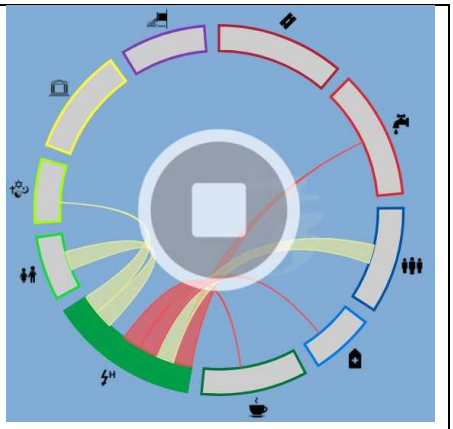
Direct impacts

Interesting outcomes are that the electricity network is usually not directly affected. However, TANESCO (the power supply company) halts the electricity services during flooding as a preventive measure. In fact during recent events (26 October 2017), electricity outages were reported to us by our group of volunteers and students. The group identified that adults above 18 years might be the ones who are mostly affected due

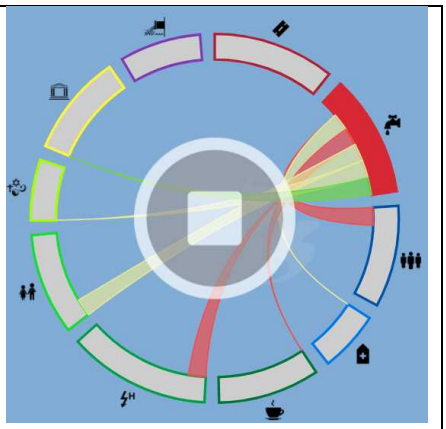
to electricity outage because they are the ones mostly consuming electricity for various purposes in Manzese ward.

Cascading impacts

After the round of direct impacts, cascading impacts were treated following the guidelines of CIrcle-Bao. This resulted in the conclusion that **failure of electricity** and **water points** cause many cascading impacts to other CIs. Electricity failure also causes disruption of water points as water points with pumps also require electricity to function. These relationships are demonstrated through the boxes below (from our background report).

Electricity (Umeme) Electricity was identified as the CI that causes the highest number of cascades when it is disrupted. Hospitals and health centres for example need electricity to operate computers, operation machines and other devices, leading to inability of providing health services to the patients. This will particularly impact the patients who need urgent operation and special care. The patients may also have to be shifted to another hospital which can provide those facilities. Manzese ward uses two sources of water, water points and water taps. Water taps are relatively far from the ward; therefore, even if there is no electricity in Manzese, the water taps are still usable. However, the water points that use pumps cannot function in absence of electricity, leading to difficulty in fulfilling the water demand. This will impact the people will low income groups, since they rely only on the water points for water supply. Also, women will be extremely affected since they are responsible for bringing water to their households. Therefore, they will have to move further for water and the water points still available will need to be shared by more people. The schools also use electricity mostly for pumping drinking water in the tanks. The stakeholders mentioned that there will be economic loss, if the schools and human settlement are disrupted. Since the consumption of electricity will be lesser.	

Box 2 Cascading impacts of electricity failure in Manzese ward

Water supply (Bomba wamaji) Disruption or failure of water supply will have impacts on five CI networks. Hospitals and health centres mostly require water for drinking and cleaning. Additional money has to be spent to fulfil the demand of water at the hospital. Therefore, this will increase the expenses of the hospital. If there is no water supply in the school, the toilets will have no water. The students in these cases defecate in the open, which increases the possibility of eruption of epidemic diseases. Though the religious institutions are affected, the impacts will not be high since they can use bore holes (only with permission) to fulfil the water demand. The extension of lack of water supply in police posts will cause problems in drinking water supply and water for the toilets. They might have to purchase water, which will increase the costs of the police authorities.	

Furthermore, roads and settlements receive the most cascading impacts, meaning that these CIs are the most vulnerable. These also lead to a heavier burden on infrastructure for relief (in particular health centres and religious institutions that are used for evacuation purposes) and cause security issues. Homes that are abandoned are prone to theft and vandalism.

Measuring the impact of CIrcle-Bao training

In order to measure the impact of the training, we have performed a pre and post-survey to assess how knowledgeable red cross volunteers are on Critical Infrastructure. We asked them the following questions to measure their knowledge:

- What is Critical Infrastructure? Please give some examples.
- Which critical infrastructure in Manzese ward could be affected by flooding and how? Give some examples.
- Who or what would be affected by your examples above and how?
- Do you know about possible dependencies between the critical infrastructures in Manzese ward?
- What role do stakeholders play in increasing flood resilience of Manzese ward?

Most of the trainees were able to distinguish some forms of critical infrastructure (most mentioned were roads and drainage) before our training, but many did not really describe what these mean to society (only 7 out of 21 respondents). After, the training most elaborated on the meaning of critical infrastructure and described it as physical assets that help society function (15 out of 20 respondents). The CI mentioned before the workshop were sewerage, drainage, roads and bridges. These already are very clear examples of CI in Manzese. In many occasions, volunteers also mentioned the cause of flooding, being rainfall in combination with poor drainage due to accumulation of solid waste. After the workshop, some also mentioned electricity, schools, police stations, government offices and mosques. Interestingly, for the question who or what would be affected, before the workshop only 6 people mentioned one or more vulnerable groups. After the training, 16 out of 20 mentioned specific vulnerable groups and why these are hit more than others. Some particular groups to mention are women (during the training and workshop mentioned in relation to water points and in case of pregnant women due to lack of health centres), children (during training and workshop often mentioned in relation to flooding of school buildings). The question about possible dependencies were even beforehand already answered by mentioning a set of CIs. In principle this proves that volunteers were already quite well aware of the CIs, but the CIs were only mentioned in isolation, and not with their relationship. Probably our question was difficult to understand or to translate in Swahili. Some attendants did not even answer the question. The last question gave us a good impression that volunteers had a better idea what the next steps could be. Before the training, almost all answered in a very general sense, for instance “more education”, “improve infrastructure”, “work together to improve cleanliness”. After the workshop, at least some (definitely not all) started becoming more concrete. Some mentioned themselves as actor (“stakeholders should cooperate more with citizens and organize meetings”). Some also mentioned specific attention points (medical sector and electricity were mentioned).

Impact of workshop on Red Cross volunteer facilitators

We held a post-survey amongst the Red Cross volunteers that facilitated the stakeholder workshop. The most tangible responses are summarized below.

- Receiving information on cascading impacts from one CI to another was seen as the most challenging part of the workshop
- CIrcle-Bao was mentioned by most as the most interesting part of the workshop.
- The facilitators were happy to be with a group of 5 with clear responsibilities. This enabled them to help each other when challenges were found
- The most important critique to bring along is that the amount of training received is limited. A 2-day training is enough to explain concepts and do first rounds of role-playing, but it will require more practice and training to smoothly run a session without the Challenge Fund team present.

Impact of workshop on stakeholder participants

We held an anonymous post-survey after the stakeholder workshop to inventory how the perception of stakeholders on cascading CI impacts changed. The most important observed changes are listed below:

- In general, people found results which they did not expect and realized that one failing CI can be a mechanism for failure of others. This by itself means that discovery took place.
- People became aware that the police play a role in evacuations during a disaster, and thus have other responsibilities than making sure the law is followed.
- People clearly identified which CI causes the most impacts (electricity and water points) and which receive the most impacts from other failing infrastructure (roads and settlements)
- People were very grateful towards the Red Cross volunteers for convening this session and letting them gain insight in failure of CI.

Reflections on the workshop were made as well. Most positive feedback concentrated around the way CIrcle-Bao gives insight (the board itself and in particular the color coding used was mentioned as positive), but many also referred to the discussions that were triggered by the systematic rounds made. A number of participants also mentioned that they think more CIrcle-Bao workshops should be organized. A critical remark was that the session took a lot of time from morning until the afternoon and that we should keep better track of this or simplify in order to make the workshop fit in one day part. We are currently discussing with the World Bank and ITC if the method can be built into a short course or eventually taken up in the curriculum of Disaster Risk Management – Ardhi University. ITC is presently preparing cookbooks with methods in collaboration with Ardhi University.

Figure 5 Stakeholder workshop with CIrcle-Bao, facilitated by trained Tanzania Red Cross Society volunteers.

V. ***Did you leverage private or public sector resources****? If yes, please describe the source of the leverage as well as the total USD amount of combined cash and in-kind contributions. If relevant, please describe the nature of your relationship with the source(s) of leverage.*

The project was leveraged with the following contributions and follow-up studies.

Organisation	Contribution in-kind	USD amount On basis daily fee $1,250	Description
NL Ministry of Infrastructure and Environment	24 days	30,000	Subsidy contribution to establish the web service http://osm-terrain.appspot.com/ A mockup design of the tool was established in the first Phase of Challenge Fund based on a survey. The subsidy was used to design and establish the service.
NL Ministry	20 days	$ 25,000	Subsidy contribution to design and

of Infra and Environment			prepare the CIrcle-Bao tool.
World Bank	32 days	$ 45,000	Extension project funded by World Bank – Tanzania. On the basis of our automated flood modelling procedures, we were asked to establish detailed quality control methods for hydrological data quality assurance of the Ramani Huria data. Within this extension, we prepared a set of data quality assurance routines, an improved protocol for data collection and data model, and a report on the hydrological data quality of Ramani Huria.
World Bank	28 days	$ 35,000	Member of Ramani Huria 2.0 consortium (lead: Humanitarian OpenStreetMap Team). In this project we ensure that the new community mapping project collects the right attributes for drainage in the right way. This contract is to improve the data quality so that the tools developed in Challenge Fund can be applied better.
UKMO / DFID	*In proposal stage*	GBP 500,000	Weather Information Services for East-Africa. We have submitted a concept note in this call in which we intend to use tools and methods from this project, to establish early warning systems in the region.

VI. **How did your project consider gender in any aspect of project planning or implementation? Was a gender analysis or assessment conducted?** If yes, did your project address any gap identified in the assessment? If yes, please describe how. All Phase II projects are required to integrate gender into their work. *Please use what you wrote in your inception report on gender as the starting point for this section.*

Here we would like to broaden the term “gender” to “inclusiveness” following the Sustainable Development Goals. We have targeted inclusiveness and gender in two ways:

1. First of all TRCS is by definition an inclusive organization, working through all layers of societies, including all races, ages, gender and other contrasting groups. This can be exemplified by the fact that we have trained 23 volunteers, which ranged from young people to old, ***included a total of 13 females***. These volunteers are inhabitants of Manzese Ward, which is one of the wards targeted under the Ramani Huria project. We organized a survey to inventorize what people were keen on to learn about flood modelling, as to ensure the training was demand-led.
2. Second, other than classical flood impact assessments which are in many cases focused on direct economic impacts, we have focused on cascading infrastructure failure, and how this ***impacts on different vulnerable groups in society***. We have identified ***gender, income group, age, and physical disabilities*** as groups potentially having different vulnerabilities. As such, the target of CIrcle-Bao is to reveal and collect evidence of vulnerabilities to flooding of specific groups in society such as men women, elderly young etc. and map out where these vulnerabilities occur. Note that per application area, the vulnerable groups representative for that area should be identified. These could be different per target area. For instance, in the Netherlands young mortgage owners are typically very vulnerable, as there is no flood insurance and their mortgage is the certainty of having a place to live in.

Important evidence about vulnerable groups affected was collected by our group of Red Cross volunteers. From the four different societal divisions, the following particular vulnerable groups were identified and their particular vulnerabilities described from the session results:

Age: The most vulnerable age group was identified to be children and elderly. Their vulnerability was explained to be due to the lack of capacity to deal with the flooding situation. For example, when there is flooding, the stakeholders mentioned that the children cannot balance themselves if the water level is higher. Also, elderly people are not physically strong enough to cope with flooding.

Gender: Women were identified as the most vulnerable gender. Their direct vulnerability was mostly linked to relatively lesser physical strength compared to males. They are in charge of carrying water from water points. Failure of water points therefore disproportionally affects women. They were also considered to be more unprepared to react during flooding. Another important reason behind their increased vulnerability is linked to their responsibility to take care of elderly and children at home. One example when female are most vulnerable was specified to be because of the type of clothes they wear (skirts). This limits their mobility.

Income groups: Most vulnerable income groups were recognized to be the people from lower income groups because they are the ones who cannot afford to opt for alternatives during the times of emergency. For example, when their settlement areas are uninhabitable, it is more challenging for them to leave all their properties at stake and move to another place.

Physical disabilities: People with disability related to mobility were recognized as the most vulnerable people. For instance, a representative of school mentioned that people who require a wheel chair are more vulnerable because it is difficult to move them out of the classroom. People usually panic during flood situations; therefore, people with disabilities may be forgotten and not receive any help, which can result in loss of life.

VII. Discussion of how tool or approach can be brought to scale in the future

- Guidelines for drainage data collection. An important outcome of this study is that, although a lot of OSM data may have been collected for the city of Dar Es Salaam in the Ramani Huria project, the quality and completeness of drainage features is still quite limited. Drains were not adequately connected and many attributes were missing and limited in their description of the drainage network. We were able to make first steps in automated model setup but a better data collection protocol was required to make the automated generation of flood models feasible. As a result, we were asked to improve this and prepare a new data model for use in Ramani Huria 2.0. To guarantee upscaling potential, this new data model and mapping protocol should be uptaken elsewhere. It can be found on https://wiki.openstreetmap.org/wiki/Dar_es_Salaam/Ramani_Huria.
- Short-course and eventually curriculum development of CIrcle-Bao. This would cost approximately 100,000 USD. For this amount, we would convert the guideline into a cookbook along with course materials for lecturers and attendants of a short course. Furthermore, we would train the trainers in using the tools, and organize 3 CIrcle sessions with students and lecturers together to gain experience and refine the course materials. We would do this together with ITC Twente. ITC is already working on curriculum development in Dar es Salaam and this would make the connection more smooth. The costs would roughly entail the man-hours to prepare and refine course material, 3 trips to roll out the course materials and train the trainers, and conduct the pilot sessions.
- More use cases around the tools are required. We are currently proposing to nest the simulation model develpoments in a forecasting system within the WISER call (submitted concept note on 3 November 2017).
- More exposure of the tools on the GFDRR website. We would like very much to provide links to the tools on the GFDRR website as well as expose the tools and methods during Understanding Risk 2018. We have proposed a side-event for the CIrcle-Bao tool during UR 2018, and have proposed to apply the method on Mexico City during this event.

VIII. What were main points of learning from this phase of the project?

Relationships with Universities are very important to embed methods

The capacity to perform flood modelling is still very weak in Dar Es Salaam. To improve this situation, a more long lasting relationship with the "champion" institutes is required. We believe now that UDSM – Department of water resources engineering would be a good starting point for this. Connecting this group to the Ramani Huria initiative would open doors to establish a more sustainable group on urban flood modelling, utilizing the OSM data directly.

Ex-ante determination of monitoring and evaluation measures

Understanding in what way impacts of the Challenge Fund projects are measured and what is valued by the funder, helped considerably in shaping the approach to Phase II. We have been able to put much more emphasis on gender and inclusiveness and we have paid attention to monitoring of progress in knowledge in our CIrcle-Bao session. We have ensured that women were not only well represented in our training sessions, but we have also shaped CIrcle-Bao such that it can reveal impacts of flooding on specific vulnerable groups in society, something that is deemed very important to DFID and GFDRR.

Timeline and local presence

We learned that local presence is extremely important to guarantee continuity, build trust and a sustainable relationship and to show results after these are worked on at home. This project only offered us a limited amount of travel to Dar Es Salaam, but new projects have emerged which enable us to also present results of analysis following from the use of our tools. Nyambiri Kimacha from Tanzania Red Cross Society raised the issue, that it would be a pity and a loss of momentum if we would leave our results from flood modelling and CI impact in our reports. Therefore we decided to use time in our next visit in December 2017 to do two things: first we will present our Challenge Fund findings and the possibilities to conduct modelling and gain insights into flood impacts with our tools in a BBL at either TRCS or the World Bank. Furthermore, we will present the results of the CIrcle-Bao session to a number of stakeholders and decision makers. The aim of this presentation is to start conversations about interventions, that are informed by the results of the CIrcle-Bao session and the insights gained by the TRCS volunteers.

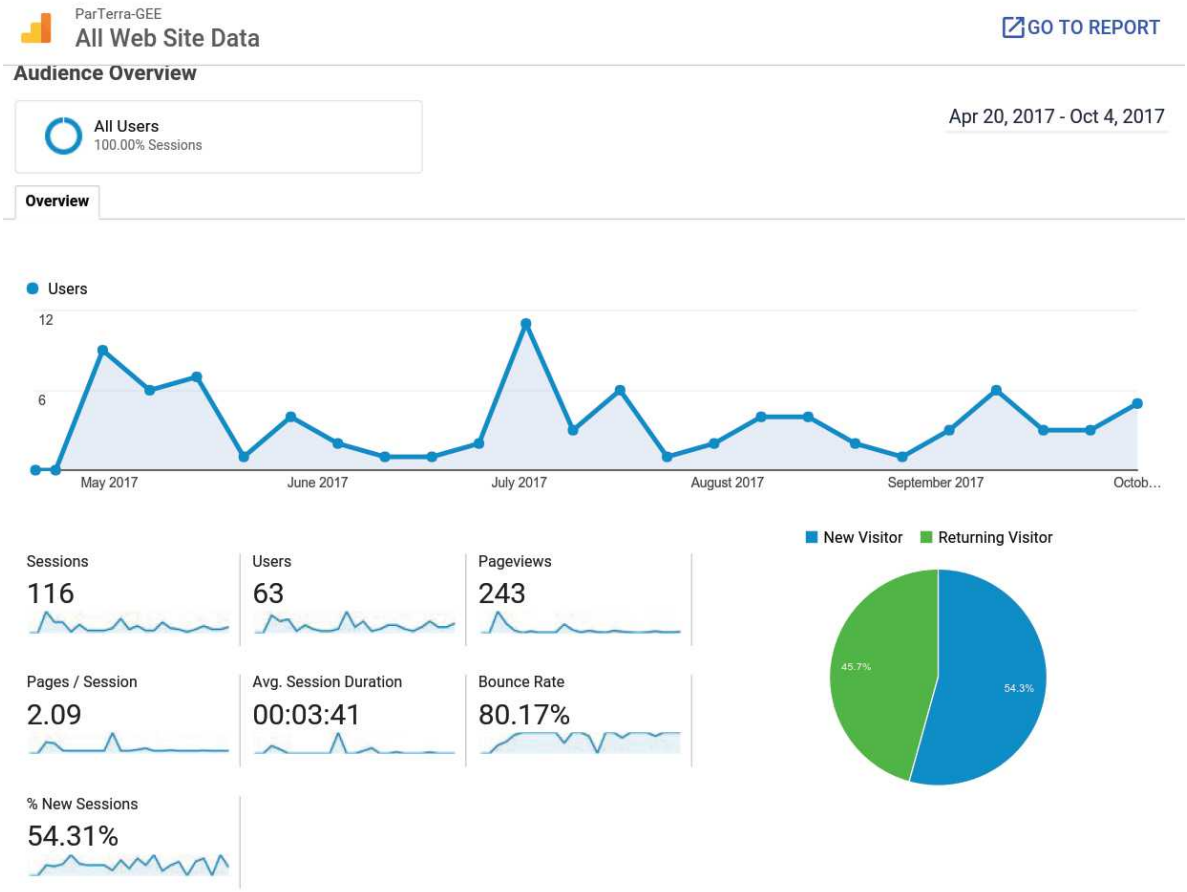
IX. Additional Monitoring Data regarding Tool Uptake

a. *Is your tool openly available to the broader user community? If yes, please provide the name of the platform.*
b. *How many downloads of your tool have occurred throughout both Phase I and Phase II? How is this being measured?*

We have released two tools in the open. The PARTERRA tool is a service, and hence we are not measuring its use in downloads, but rather in page views. We measure this with Google Analytics. Below, the overview of the page views is provided. We would like to explore if we can post a link or a blog about the tool on the GFDRR website for more uptake.

CIrcle-Bao has only just been released on our website and we are not really monitoring specific downloads and link clicks there. Instead, it is a physical tool, accompanied by guidelines. The tool can be locally fabricated for $ 150 USD (Tanzania price) and we are therefore sure that replication elsewhere should be easy. The World Bank office in Tanzania already indicated that they would like to have a board themselves.

Finally, we are planning to organize a UR 2018 side event with TRCS and RCCC to introduce CIrcle-bao to a wider audience. We have submitted a request for a side event to GFDRR on 13 October 2017.



	Country	Sessions	% Sessions
1.	Netherlands	59	50.86%
2.	Tanzania	12	10.34%
3.	United States	8	6.90%
4.	Brazil	5	4.31%
5.	Indonesia	5	4.31%
6.	Portugal	4	3.45%
7.	Thailand	4	3.45%
8.	India	3	2.59%
9.	Russia	3	2.59%
10.	Italy	2	1.72%

c. *How many decision makers have accessed your tool throughout Phase I and Phase II? Of these, how many access your tool on a regular basis? How is this measured? (it can be through conversations, email, direct observation or another way)*

The tools are not tools that are used for real-time purposes. They are used within a risk framework, to establish hydrological models and impact assessments at urban scale. The most uses that can really be monitored are web users of PARTERRA (see our Google Analytics overview above).

d. *Have any policies, plans or investments been informed/influenced by your tool? If yes, please provide a bit more detail on how your tool has informed/influenced investment/policy/plans; if possible, provide USD amounts of local budgetary changes or other investments. If the influence was policy-based, please describe the policy change your tool informed. If the influence was in planning, please provide detail.*

Yes. Due to our work, and the limitations we found in the Ramani Huria 1.0 drainage data, the community mapping efforts done in Ramani Huria 1.0 were revisited, and quality assessed in terms of drainage information. As a result, we were asked to provide new data model and data collection protocols for Ramani Huria 2.0 and construct hydrological data quality assurance checks that can be regularly performed on collected drainage information. We reported about this in an extension report of this challenge fund, and the new data collection protocol is now being implemented in Ramani Huria 2.0.

Furthermore, TRCS and Deltares are planning a meeting with decision makers in the week of 11-15 December 2017. In this meeting, we will demonstrate the outcomes of our CIrcle session and have a round table discussion on possible next steps. We cannot guarantee that this will lead to better informed decisions, but it is our intention to at least influence and inform decision makers.

Other policies, plans and investments are not yet informed by our tools, but we expect that in the Tanzania Urban Resilience Program (DFID fund, currently implemented in Tanzania), the developed tools will be further enhanced, used and transferred to local organizations.

e. *Was your sustainability goal for the project achieved? Please provide the metric used and explain the results achieved.*

The strongest and most direct measure for sustainability is the amount of people that were informed and/or trained. In total we have trained 43 people, from which 21 work in the community itself.

Furthermore, we believe that tools are much more sustainable if they are kept open-source and openly available. The tools we developed are all freely and open-source available and can therefore be used, as well as changed by anyone that requires it. In total, 3 tools can be mentioned in this regard: PARTERRA (code released on github with MIT license), Hydro-osm (also released on github with MIT license) and guidelines for CIrcle-Bao (downloadable from our website).

f. *Do you have an exit strategy for your project? If yes, please explain.*

As described before, we have the following activities that should leave our tools in a good state and open doors to further uptake:

1. Present our project in Dar Es Salaam (December 2017)
2. Present results of CIrcle-Bao to decision makers, start conversation about interventions (December 2017)

3. UR 2018 CIrcle-Bao demonstration case
4. Movie on CIrcle-Bao in Dar Es Salaam

X. Please detail how the budget was spent through the course of phase II?

	GFDRR Funding	*In kind Funding*	*Other Funding*	**Total Funding**
CONSULTING SERVICES (fees, travel, per diem)	USD 70,000	USD 50,000		USD 120,000
TASK TEAM SUPERVISION (List key personnel and their related expenditure)	USD 20,000 Team led by H. C. Winsemius (Deltares)	USD 5,000		USD 25,000
DISSEMINATION* (Translation, editing, publication, etc.)	USD 37,500			USD 52,500
LOGISTICS (Training, workshops, consultations, etc.)	USD 12,000			USD 12,000
GOODS AND WORKS				
OTHER (please specify): Indirect Cost	USD 5,500 Per diems attendants and hire venue			USD 5,500
TOTAL				USD 205,000

** We assumed that "dissemination" should include development of training materials and preparing CIrcle-Bao session. All translations were done at TRCS.*

XI. Please attach any additional project related documents you may have to the final report.