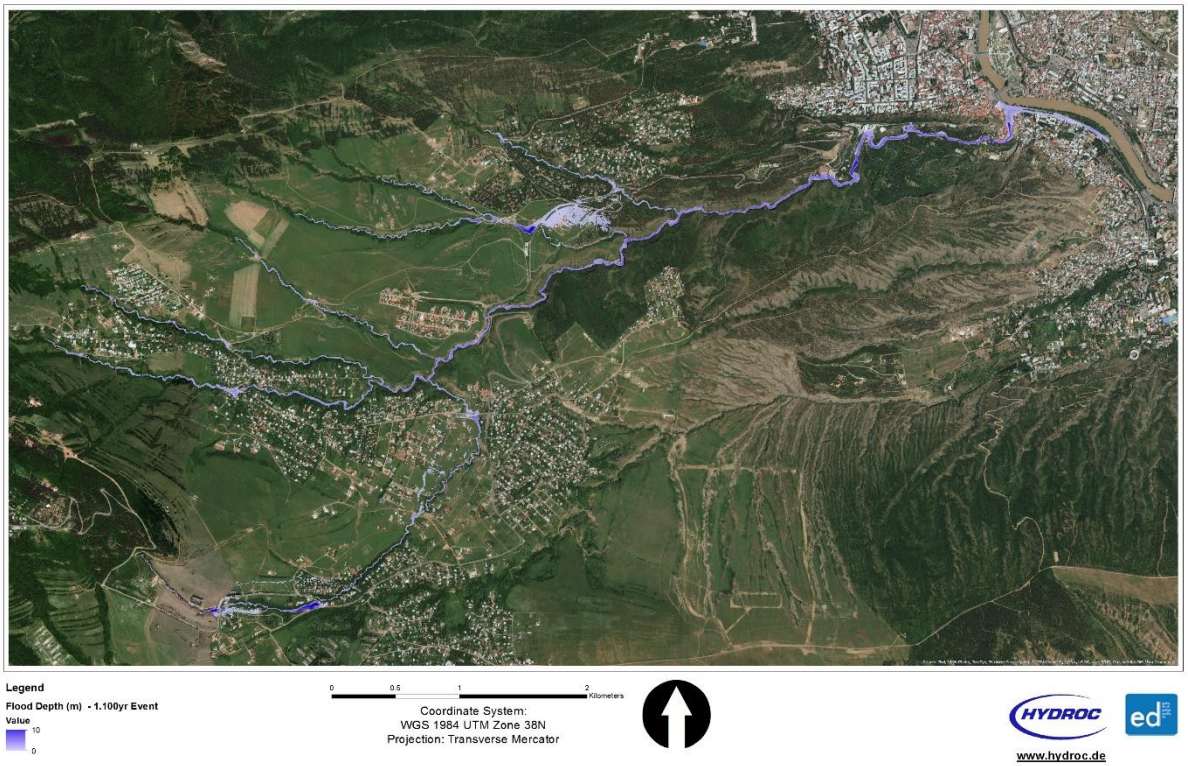
P170526

Final Report

Assessment of Suitable Flood Mitigation Measures (based on Dukniskhevi River Extreme Flood Analysis) in Tbilisi, Georgia

CTCN REFERENCE NUMBER: 2016000043



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Contact
HYDROC GmbH
Siegum 4
24960 Siegum
Germany

Tel - +49 172 450 91 49
Email - info@hydroc.de

Table of Contents

Table of Contents 3

1 Introduction 4

2 Basic information 5

3 Summary of all activities, outputs and products 6

4 Lessons learnt 11

5 Illustration of the TA and photos 13

6 Information for TA impact description 20

ANNEX 23

Annex 1 (for internal use in donor and UN reporting) 24

Annex 2 (for internal use – to be filled in by the CTCN) ..... **Error! Bookmark not defined.**

1 Introduction

The main objective of this consultancy is to improve the flood risk management in the Leghvtakhevi River basin in Tbilisi (Georgia). This has been accomplished through the implementation of a modelling framework, the inclusion of climate change impacts, the definition of flood maps and the designation of flood mitigation and adaptation measures. Capacity building and technological transfer activities were undertaken too, and are at the core of the project.

The technical assistance started in August 2017 and was finished in August 2018 (duration of 12 months). The contract between UNIDO and HYDROC had been signed on the 14th of August 2017.

The technical assistance is managed by the CTC-N, the National Designated Entity is the Ministry of Environment and Natural Resources Protection of Georgia, while key stakeholders are the National Environmental Agency (request applicant), the Tbilisi Municipality and the Emergency Management Agency under the Ministry of Internal Affairs.
This report describes the methodology that is followed during the implementation of this technical assistance.

The technical assistance closure report is designed to communicate publicly a summary of progress made and lessons learned under the technical assistance towards the anticipated impact and to compile TA-specific information required for internal use in donor and UN reporting.

2 Basic information

Basic information

Title	Assessment of Suitable Flood Mitigation Measures (based on Dukniskhevi River Extreme Flood Analysis) in Tbilisi
Country / countries	Georgia
NDE focal point and organization	Ministry of Environment and Natural Resources Protection of Georgia
Proponent focal point and organization	National Environmental Agency of Georgia
Sector(s) addressed	Disaster
Technologies supported	Hydrological modelling, hydraulic modelling, flood management, flood mitigation
Implementation period and total duration	August 2017-August 2018, 12 months
Total budget for implementation	216,050 USD

3 Summary of all activities, outputs and products

Summary of all activities, outputs and products that contribute to the expected impact of the technical assistance.

Description of delivered outputs and products as well as the activities undertaken to achieve them. In doing so, review the log frame of the original Response Plan and refer to it as appropriate.	Deliverables - Activity 1 • Skype Kick-off meeting (minutes from the meeting) • Report on data acquisition • Description of suitable methodology and technology for flood modelling & mapping Deliverables - Activity 2 • Report on hydrological modelling • Report on climatic scenarios • Report on hydraulic modelling Deliverables - Activity 3 • Report on flood mapping • Flood hazard maps • Report on adaptation and flood mitigation measures Deliverables - Activity 4 • Protocol about delivered software tools • Technical training material and presentations • Summary report and list of participants from trainings • Summary report of evaluation and dissemination seminar • Final report of the project
Partners organizations	The National Environmental Agency of Georgia supported the project with conducting topographical surveys in the field
Beneficiaries	Ministry of Environment Protection and Agriculture National Environmental Agency Emergency Management Agency Tbilisi City Hall National Botanic Garden of Georgia
Methodologies applied to produce outputs and products	- Literature research considering previous flood events - Stakeholder interviews considering current problems, plans and best practice as well as data availability - Data collection of both national and public domain datasets

	- Field visits for obtaining a system understanding - Topographic surveys of structures and complex topography - Climate data analysis and preparation of scenario modelling inputs based on CMIP5 RCP 8.5 data and 2030-2050, and 2070-2090 time slices - GIS data analysis (ground precipitation, rainfall radar data, land related spatial information) - Numerical modelling using HEC-HMS for a paired catchment approach to understand the hydrology and overcome sparse data situation. Result analysis and export into HEC-RAS - 2D HEC-RAS numerical model runs for flash flood simulation in the ungauged catchment based on defined river cross sections developed from ground survey and LiDAR DEM data. - Flood risk analysis based on spatially interpreted HEC-RAS results, overlaid on DEM and aerial/satellite imagery data for 1:5, 1:25, 1:50, 1:100 and 1:500 return period baseline and climate change scenarios - Expert judgement was used during data interpretation, model calibration, conducting plausibility checks and hotspot identification (bottleneck structure identification), as well as defining flood risk management recommendations
Deviations	n/a
Achieved or anticipated gender benefits from the TA	Benefits will be for male and female population alike
Achieved or anticipated co-benefits from the TA	Stakeholders exposed to broad understanding of data analysis including radar data use in flood risk management and flood modelling. Social, environmental and economic benefits are expected from increased planning possibility and related reduced flood related damage and loss of production and livelihoods
Anticipated follow up activities and next steps	Implementation of flood risk management measures, closure of data gaps as highlighted in the reports, upscaling to other catchments. Detailed activities will be agreed and implemented by the applicant organization and other involved stakeholders following the project. This is expected to include amendment of masterplans and emergency response plans,

	dissemination of flood maps and utilization of the same for decision making, improving bottleneck infrastructure, development planning and other activities as recommended in the flood mitigation report. Overall recommendations have been provided throughout the whole TA, and in this section a summary of all recommendations can also be found: • It is recommended that an appropriate database for enhancing the reliability of flood modelling in the region is obtained. This can be accomplished through the installation of sub-hourly and long-term, gauge-based precipitation observations, installation of sub-hourly and long-term water level and discharge observations, a longer overlapping time period of radar data and gauged rainfall data • It is recommended that the Leghvtakhevi regime is observed, recording information about how often and when certain paths in the Leghvtakhevi gorge are unpassable or when, where and under which conditions pedestrian infrastructure becomes damaged. • It is recommended the formation of a Flood Risk Management Committee with representatives from the Tbilisi City Council, NEA and EMA. It should be noted that these stakeholders have shown interest on the formation of this committee. • It is recommended that mechanism are implemented in order to fully consider residual flooding in the flood risk management of the catchment, especially considering evacuation. • It is recommended that the some structural measures are undertaken within the catchment in order to mitigate flooding. This includes the opening of the second culvert in the downstream end of the Leghvtakhevi and the increase in hydraulic capacity under some of the road crossings. It should be noted that Tbilisi City Hall has express its interest in considering these recommendations in the Tbilisi City Hall 2019 budget planning. • It is recommended that these recommendations are fully embedded into new Master Plan of Tbilisi. This master plan is already developed and approved by the Tbilisi City Council and the Tbilisi City Hall has shown interest in including this recommendations as amendments to the master plan.

	• It is recommended that NEA takes full ownership of the flood modelling products yielded by this technical assistance, and they are updated and reviewed periodically in order to ensure that the flood hazard maps are up to date. • It is recommended that similar studies, replicating the approach, in all the relevant catchments in Tbilisi are undertaken. It should be noted that on this topic Tbilisi City Hall is soon announcing the development of master (sub) plans for specific territories of Tbilisi by next year and that one of the requirements for master (sub) plans will be development of the flood maps. • It is recommended that the work and lessons learnt within this technical assistance by the stakeholders are applied within the future GCF project (Scaling-up Multi-Hazard Early Warning System and the Use of Climate Information in Georgia). • It is recommended that a full flood forecasting early warning system is implemented in the Leghvtakhevi catchment. It is recommended that this system is implemented following the typical four components of a people-centred early warning system (risk knowledge, monitoring and warning, communication and dissemination and response). It should be added that stakeholders have already expressed their interest in such a system being implemented and that the results from this technical assistance can be used as the basis for this implementation. Within this recommendation there are several additional recommendations: - It is recommended that the flood modelling results and mapping are disseminated further within the affected population. There is interest within the stakeholders to disseminate the flyer produced within this technical assistance. - It is recommended that mechanisms are implemented in order to ensure that risk knowledge exercises are periodically repeated. This should be addressed by the new legislation being put into place in Georgia regarding disaster risk management plans. - It is recommended that meteorological forecasting, meteorological monitoring and hydrological forecasting capabilities within this catchment are enhanced.

	- It is recommended that the warning criteria and definition for flood events in this catchment are developed and agreed among relevant stakeholders. - It is recommended that a communication and dissemination system within this catchment is implemented, including the implementation of a common alerting protocol. - It is recommended that the response component is fully implemented and embedded into the full EWS. - It is recommended that flood evacuation routes and centres are defined. - It is recommended that flood emergency response plans are implemented in all the communities (or neighbours) within the flood prone area. - It is recommended that flood awareness campaigns are undertaken within this catchment too.

4 Lessons learnt

Lessons learnt

This table describes the lessons learnt, indicating which stakeholder has benefitted from what activities and what lessons as compared to the original ToR. At the same time, these lessons are recommendations for future implementation and improvement.

	Lessons learnt	Recommendations
Lessons learnt in the area of the TA	1. The combined 1D/2D modelling approach considered initially in the study proved to be unsuitable for the very rapidly changing topographic conditions. The approach was adjusted for full 2D to ensure model stability and plausible results. 2. The scarce data situation was challenging and was only overcome utilizing alternative data, here rainfall radar data. 3. Ground surveys in the rough terrain have been challenging. Appropriate technologies had to be used. Decision on methodology was made considering various aspects and finally total station based ground surveys were used to obtain river cross sections. 4. Measures in this TA have been designed considering the capabilities of the local government for implementing measures.	1. Ensure modelling approach fits data situation, ensure plausibility checks and result driven adjustments of approach where necessary. 2. Ensure a full overview of all available data, check for coverage and quality and decide for optimum approach 3. Ensure evaluating the full scale of options for data acquisition. In the case of topographic data this can include classical ground surveys using theodolite or total stations, tachymeters or differential GPS. Alternative options include drone based photogrammetry, laser scans or satellite altimetry in sufficient resolution. Especially for drone- or aerial surveys, the need for permissions needs to be considered 4. While a broad range of possible measures may be

	5. Significant efforts have been spent involving stakeholders in the project. This has shown to be important for acceptance and ownership.	recommended, detailed proposals need to consider implementability based on technical, economical and financial aspects. 5. Stakeholders need to be taken on board as early as possible to ensure full involvement, acceptance and ownership of results and to ensure implementation.
Lessons learnt related to climate technology transfer	Considering projected increases in rainfall intensity the TA has developed a detailed understanding of the flooding conditions and respectively for options for flood risk management and situational improvements. The TA has shown that an individual approach tailored to the catchment by considering available data and the specific conditions leads to plausible results that can be further utilized for flood management and planning.	Ensure success of a project by using an individual approach, developed based on an understanding of the natural conditions and designing a suitable methodology.
Lessons learnt related to the CTCN process for TA	Good stakeholder involvement.	Ensure significant stakeholder involvement.

5 Illustration of the TA and photos

Illustration of the TA and photos

TA process

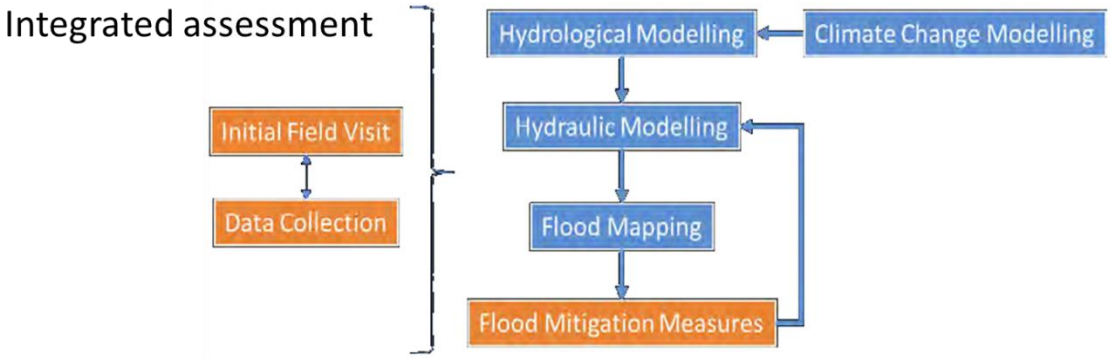
Power Point Slide 1:

Activity 1 - Initial analyses and support

Activity 2 - Modelling of flooding scenarios

Activity 3 - Adaptation measures

Activity 4 - Technology and knowledge transfer



Power Point Slide 2:

Project overview and goals

- Make use of state of the art approaches and intensive analysis for understanding the flood behaviour of Dukniskhevi River
- To improve flood risk management and provide a best practice example for flood analysis in Georgia

Power Point Slide 3:

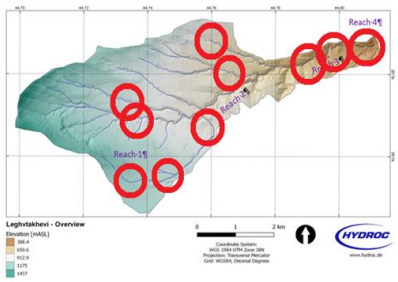
Process

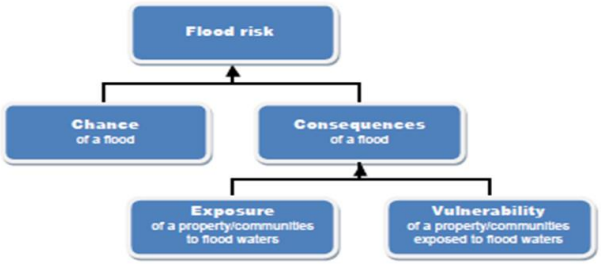
- Data collection
- Involvement of relevant institutions
- Data analysis for situational understanding
- Climate change impact assessment
- Hydrological modelling
- Hydraulic modelling
- Flood management and adaptation measures development
- Mapping and dissemination

Power Point Slide 4

Outputs and results

- Full analysis of hydrometeorological conditions and flood risk
- Identified flood hotspots
- Mitigation and adaptation measures detailed
- Stakeholders trained and results disseminated
- Upscaling recommendations provided





TA photos

Figure 1: Catchment area

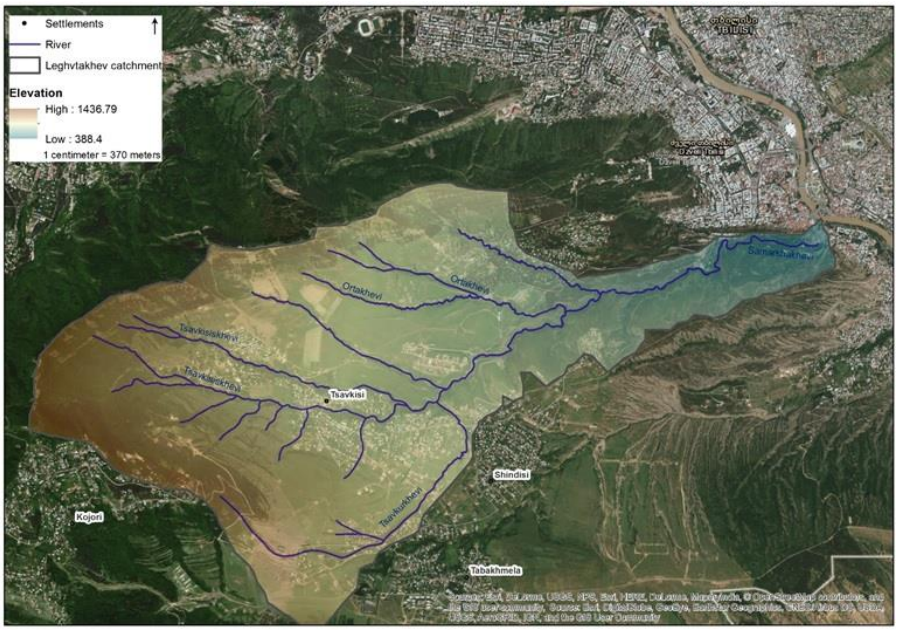


Figure 2: Catchment visit

Figure 3: Cross section surveys

Figure 4: Climate change assessment

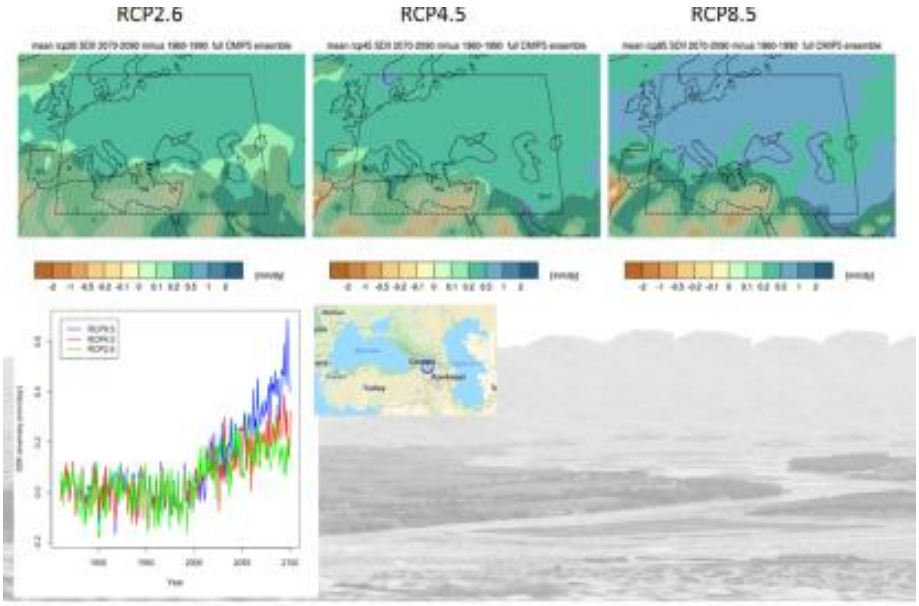


Figure 5: Catchment physiographic analysis

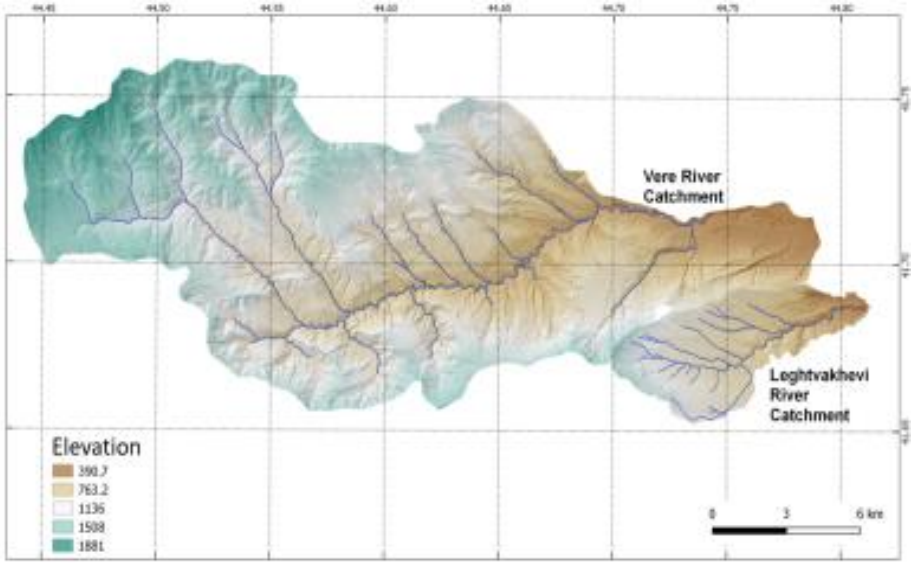


Figure 6: Rainfall radar data analysis

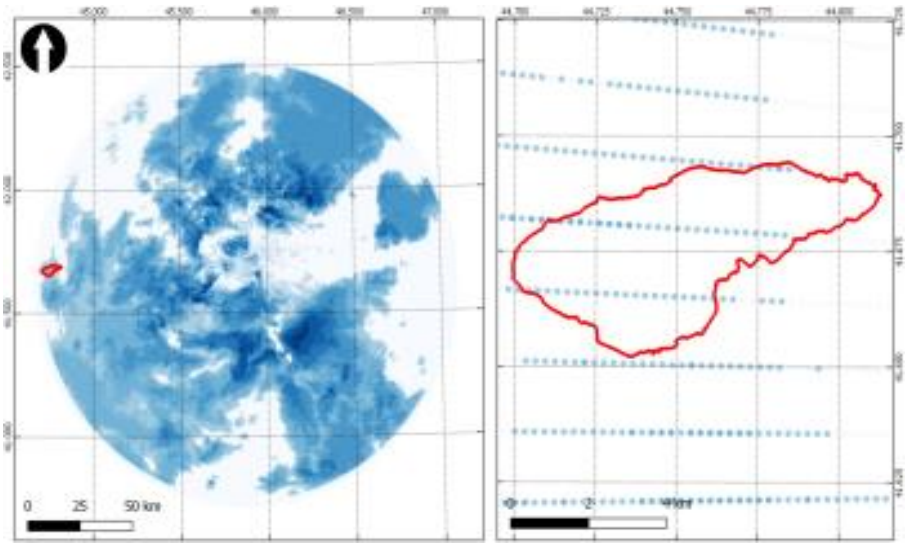


Figure 7: Flood modelling

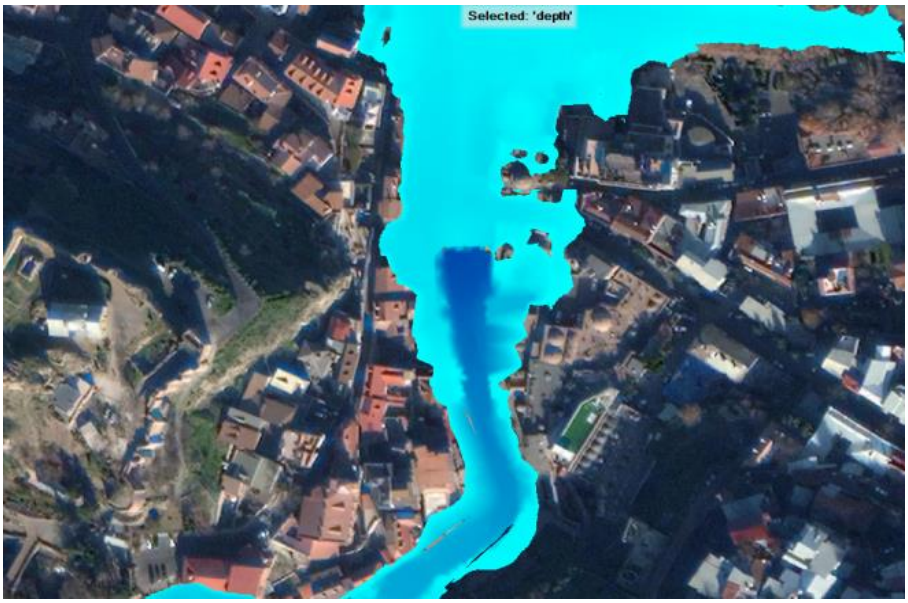


Figure 8: Dissemination workshop

6 Information for TA impact description

Information for TA impact description (for public use)

Challenge (approx. 500 characters with spaces)	Flooding is a major problem in the steep Leghvtakhevi River basin, especially considering the fast catchment response in combination with the significant damage potential downstream. At the same time data as well as analysis results to fully understand the catchment are very limited, leading to the need to apply new approaches for flood risk analysis and planning. This is a typical problem in many areas of the city of Tbilisi
CTCN Assistance (2 to 4 bullet points. Approximately 450 characters with spaces)	The CTCN technical assistance project provides Georgia and the city of Tbilisi with the opportunity to conduct cutting edge flood risk analysis and mitigation planning, providing a pilot case for upscaling also in other catchments. The project allows for a very detailed study of a small catchment with varying conditions and significant flood risk downstream, making it an ideal study case. The project also aims to build capacities for application of the allied methodologies on a broader scale.
Anticipated impact (2 to 4 bullet points. Approximately 250 characters with spaces). As a minimum, please include: Number of people with increased capacity to adapt to the impacts of climate variability and change.	This will in return allow for broad benefits regarding peoples livelihoods and Georgia's (and Tbilisi's) productivity through reduction of flood damages and related losses that are other ways expected to be exacerbated by climate change but will in this way be mitigated through increased resilience

Linkages and contribution to NDC (2 to 4 bullet points. Approximately 350 characters with spaces).	• Objective of the government to improve country's preparedness and adaptive capacity by developing 5 climate resilient practices that reduce vulnerability of highly exposed communities, including to growing frequency and intensity of floods, flash floods, landslides and mudflows • Establishment of Early warning systems for climate related extreme events is considered as priority measures Commitment to sustainable forest and protected area management that will have multiple benefits including catchment management
The narrative story (Approximately 1200 characters with spaces)	Based on recent extreme flood events with significant losses, the technical assistance has recommended suitable flood mitigation measures in Tbilisi using state of the art approaches in the Leghvtakhevi River catchment. This aimed to improve flood risk management and provide a best practice example for flood analysis in Georgia and was implemented jointly with the National Environmental Agency (NEA). Flooding risks were analysed considering projected climate change impacts with the aim to reduce the vulnerability of the Tbilisi community to flooding by a combination of reducing their exposure and reducing the consequences of a flood event. This considered both structural and non-structural interventions, including upstream-downstream relations.

Contribution to SDGs (to the extent possible, please include contribution to +/- 3 SDGs) , describing the contribution with a few sentence for each SDGs concerned). A complete list of SDGs and their targets is available here: https://sustainabledevelopment.un.org/partnership/register/.	13. Climate Action 11. Sustainable cities and communities 9. Industry, innovation and infrastructures A better planning of the catchment and implementation of the most appropriate technologies and infrastructures will lead to a reduction of flood risks and impacts and support the city and country's adaptation to climate change

ANNEX

Annex 1 (for internal use in donor and UN reporting)

A. Standardised CTCN performance indicators for donor and UN internal reporting

CTCN standardised performance indicators	Quantitative value	Qualitative description *List the various elements corresponding to the quantitative value*
1. Overview		
Number of active person-days (not full duration) of assistance provided to counterparts or stakeholders by international experts and consultants	236	Consultant
Number of active person-days (not full duration) of assistance provided to counterparts or stakeholders by national experts and consultants	55	Consultant
Number of for external communication and outreach activities conducted to showcase the assistance (news release, newsletters, articles on website, etc.)	1 1	Television news Set of flyers in Georgian and English language
2. Events (other than trainings) held as part of the assistance		
Number of international and multi-country (at regional or sub-regional level) technology and knowledge sharing events	n/a	
Number of participants in the events above	n/a	
Number of national technology and knowledge sharing events	1	Dissemination workshop in July 2018
Number of participants in the events above	22	Ministry of Environment Protection and Agriculture, National Environmental Agency, Georgian Amelioration, Emergency Management Agency, Tbilisi City Hall, National Botanic Garden of Georgia, Parliament of Georgia
Number of public-private events related to technologies	n/a	

Number of participants in the events above	n/a	
3. Training and capacity building activities conducted during the assistance		
Number of training sessions and capacity strengthening activities	2	Hydrological modelling training Hydraulic modelling training
Number of people who received the training	31	National Environment Agency, Emergency Management Agency, Ministry of Defence, Ilia State University
Number of men	22	
Number of women	9	
Total number of organizations trained	4	National Environment Agency, Emergency Management Agency, Ministry of Defence, Ilia State University
Number of research organizations, laboratories and universities	1	Ilia State University
Number of private companies		
Number of cities and local government		
Number of communities		
Number of ministries	1	Ministry of Defence
Number of specialized governmental institutions	2	National Environment Agency, Emergency Management Agency
Number of non-profit organizations		
Level of satisfaction of participants after the training (from training feedback form). *From very satisfied, satisfied, not really satisfied, not satisfied at all*	very satisfied	
Percentage of participants that increased their capacities thanks to the training (from training feedback form) *From significantly, very, moderately, to none*	significantly	
Percentage of men	all	
Percentage of women	all	
4. Tools, technical reports and information material supported by the assistance		

Total number of tools, technical reports and information material supported by the assistance (excluding mission, progress and internal reports)	15	
Number of tools strengthened, revised or developed	2	Tool for accessing radar rainfall data A flood modelling framework
Number of technical reports strengthened, revised or created	12	Technical reports
Number of other information materials strengthened, revised or created	1	flyer with project information/ summary
5. Policies, laws and regulations supported by the assistance		
Number of policies, strategies, and plans drafted addressing climate change adaptation	n/a	
Number of policies, strategies, and plans drafted addressing climate change mitigation	n/a	
Number of documents developed to inform other policies, strategies, and plans on climate change adaptation (sectoral strategies, national development plans, etc.)	1	Report on adaptation and flood mitigation measures, can be used to inform city masterplan, catchment management plans, development plans, and/or emergency management planning
Number of documents developed to inform other policies, strategies, and plans on climate change mitigation (sectoral strategies, national development plans, etc.)	1	Report on adaptation and flood mitigation measures, can be used to inform city masterplan, catchment management plans, development plans, and/or emergency management planning
Number of laws, agreements, or regulations drafted addressing climate change adaptation	n/a	
Number of laws, agreements, or regulations drafted addressing climate change mitigation	n/a	
Number of documents developed to inform laws, agreements, or regulations on climate change adaptation	n/a	

Number of documents developed to inform laws, agreements, or regulations on climate change mitigation	n/a	
6. Institutional strengthening supported by the assistance		
Number of institutional arrangements in place to coordinate near and long-term national adaptation plans (NAPs)	n/a	
Number of organizations with increased technical capacity to advance near and long term national adaptation plans (NAPs) which integrate EbA	3	Tbilisi City Council National Environmental Agency Emergency Management Agency,
Number of organizations with increase awareness and knowledge among countries to better own and drive national adaptation planning processes	3	Tbilisi State University Ministry of Defence Ilia State University
7. Partnerships and cooperation		
Number of private companies directly engaged in the assistance (that partnered with the proponent, the beneficiaries or the CTCN to implement the assistance)	1	ED
Number of South-South collaboration enabled during or through the assistance, when stakeholders from other countries were involved in the assistance	n/a	
Number of North-South collaboration enabled during or through the assistance, when stakeholders from other countries were involved in the assistance	n/a	
Number of Triangular collaboration enabled during or through the assistance, when stakeholders from other countries were involved in the assistance	n/a	

B. Indicators of anticipated impacts that may occur after the TA is completed

CTCN standardised performance indicators	Quantitative value *Insert the request value and unit*	Content *List the elements included in the number provided*	Expected timeline *Indicate when the indicator and value are*	Responsible institution *Indicate the institution(s) that will play leading role in enabling*

			expected to be achieved	*the indicators and anticipated values to be achieved*
16. Anticipated finance mobilised				
a) Anticipated amount of public/donor investment mobilized (in USD) from the beneficiary country for climate change activities as a result of the TA	Waiting input from stakeholders			
b) Anticipated amount of public/donor investment mobilized (in USD) from international and regional sources for climate change activities as a result of the TA	Waiting input from stakeholders			
c) Anticipated amount of private investment mobilized (in USD) from the beneficiary country for climate change activities as a result of the TA.	It is estimated that at least 500,000 USD are required (bulk estimate)			
d) Anticipated amount of private investment mobilized (in USD) from international and regional sources for climate change activities as a result of the TA.	n/a			
17. Policies				
a) Anticipated number of policies, strategies, plans, addressing climate change mitigation officially proposed, adopted, or implemented as a result of the TA.	it is expected that the Tbilisi city masterplan will be adjusted based on the TA			
Anticipated number of policies, strategies, plans, addressing climate change adaptation officially proposed, adopted, or implemented as a result of the TA.	n/a			
b) Anticipated number of laws, agreements, or regulations addressing climate change mitigation officially proposed,	n/a			

adopted, or implemented as a result of the TA.				
Anticipated number of laws, agreements, or regulations addressing climate change adaptation officially proposed, adopted, or implemented as a result of the TA.	n/a			
c) Anticipated laws, policies, regulations, strategies and plans where climate change mitigation will be mainstreamed as a result of the TA	n/a			
Anticipated laws, policies, regulations, strategies and plans where climate change adaptation will be mainstreamed as a result of the TA	n/a			
18. Anticipated number of public-private partnerships created	n/a			
19. Anticipated twinning arrangements created as a result of the TA	n/a			
20. Anticipated number of technology projects prepared and implemented to support action on low emission and climate-resilient development	Waiting input from stakeholders			
21. Anticipated strengthened National Systems of Innovation and technology innovation centres in CTCN recipient country.	1 (Ilia State University)	Flood analysis and adaptation		
22. Anticipated Clean Energy Generation Capacity Clean supported by the TA that has achieved financial closure	n/a			
23. Anticipated and projected GHG reductions Quantity of greenhouse gas (GHG) emissions, measured in metric tons of CO2e, anticipated to be reduced or	n/a			

sequestered as a result of projects supported by the TA.				
10. Clean Energy Generation Capacity Clean energy generation capacity supported by the TA that has achieved financial closure.	n/a			
24. Anticipated and projected GHG reductions to 2030 Projected greenhouse gas emissions reduced or avoided through 2030, in metric tons of CO2e, from adopted laws, policies, regulations, or technologies related to clean energy/sustainable landscapes as a result of the TA.	n/a			
25. Anticipated co-benefits Number of people receiving livelihood co-benefits as a result of the TA.	47,649 (basin population)			
26. Anticipated technology types effectively deployed in the country	n/a Rainfall radar use, hydrological modelling, climate change modelling, hydraulic modelling, flood risk mapping, flood management intervention			

	and mitigation options (structural/ non-structural			
27. Anticipated UNFCCC processes implemented as a result of the TA (NAMA, NAPA, NDC, etc.)	n/a			
28. Anticipated Technology Needs Assessments (TNA) and technology Action Plans (TAP) as a result of the TA	n/a			
29. Anticipated cooperative research, development and demonstration programmes within and between developed and developing country Parties facilitated as a result of the TA	n/a			
30. Anticipated improved climate change observation systems and related information management in developing country Parties.	n/a			