Using simple mobile technologies to scale up digital collection & processing of climate observation for adaptation actions in Malawi

UNEP CTCN Project: 2022000048

Cost Analysis of the Technology System at Scale

March 2025

Draft for review and not for disclosure

ADAPTATION FUND

UN environment programme

CTCN UN Climate Technology Centre & Network

Table of Content

A. Scope 3

B. Methodology 3

Cost categories 3

C. Implementation of the Technology System at Scale 4

Technology system and scale 4

D. Key Findings and Insights 6

E. Initial (year one) Investments and Activities 9

Capital equipment costs 9

Materials and maintenance tools and equipment 10

Management and staffing expenses 11

Year one operating costs 12

Total year one Costs 13

F. Operating and Capital Maintenance Costs (year two to Five) 13

Ongoing operating and capital maintenance costs (year two onwards) 13

Management, staffing and training costs 14

Data collection and equipment maintenance 14

Software and mobile communication and maintenance 15

Personal and maintenance equipment replacement 16

Total ongoing operating costs, years two through five 16

Periodic capital equipment replacement costs 17

Appendix A. Operating expenses for the 15-year projection period 18

A. Scope

As part of the project "Using simple mobile technologies to scale up digital collection & processing of climate observation for adaptation actions in Malawi", supported by UNEP CTCN, this document analyzes the costs of the technology system expanded nationwide in Malawi for the monitoring of lakes, rivers and rainfall as fundamental water and weather parameters.

This chapter is the outcome of Activity 5.1 under the Output 5, Designing a financial mechanism that would make the technology concept sustainable in the context of Malawi. The chapter estimates and projects capital expenditures and operating costs of the technology concept and its different components. It covers replacement and refurbishment of manual water, weather and climate observations equipment and capacity building, through to system management and software running costs.

The associated deliverables in Output 5 are:

- Deliverable 5.1 Cost analysis of the new mobile technology system
- Deliverable 5.2 Business Models for 15 years financial sustainability
- Deliverable 5.3.a Minutes: Business Model Validation Workshop
- Deliverable 5.3.b Final Business Model

B. Methodology

The cost analysis estimates the cost implications of establishing, scaling and running the technology system over 15 years. The cost analysis informs the development of the project's business model(s). This write-up summarises the results of that exercise and provides the team's best estimates of initial and ongoing costs.

The consulting team's economist first prepared detailed cost estimates for the initial (year one) investments and activities and then projected ongoing (years two through fifteen) operating costs, with the aim of understanding, in particular, the ongoing revenues required to ensure consistent collection of hydrometeorological observations, the maintenance and, where needed, replacement of equipment, as well as resources required to ensure the processing and availability of the quality controlled data.

Costs were estimated based on real costs encountered in the ongoing project in 2024 and market research, as well as lessons from earlier prototyping by Water in Sight Ltd in Malawi between 2021 and 2023. Costs include general assumptions on inflation. The cost analysis was done using a financial model developed for the project.

Cost categories

The following major components of the technology system were assessed:

- Capital equipment costs: to replace and rehabilitate broken or missing monitoring equipment at manual river and lake level, and rainfall monitoring stations. Note: prices for monitoring equipment that meet WMO-standards differ depending on supplier, country of origin, materials etc. Costs used in the analysis are based on best market knowledge available for compliant and durable equipment. Should the technology be scaled to additional water and climate variables, the financial model can accommodate adjustments based on government preference.

- Materials and maintenance tools and equipment: for accurate and consistent daily monitoring of manual water and weather observations, the persons responsible for a monitoring station - i.e., the hydrological Gauge Readers taking manual river and lake level measurements, and meteorological Observers taking manual rainfall and synoptic weather observations - require a basic set of equipment and tools. In addition, stations require yearly physical maintenance and calibration. The associated costs are in two categories: materials and tools, and maintenance of stations and equipment.

- Management, staffing & operational capacity and training expenses: management and skills development are required to scale the technology and train Gauge Readers and Observers collecting observations and Government staff using the software. After scaling the system nationwide, management resource needs decrease for the 15 year duration but are still necessary to ensure software and equipment maintenance, certain software uses (e.g., the application of water and weather observations into forecast and hazard models), and communications across key climate services stakeholders - from university researchers to disaster risk agencies. Training is included as an essential enabling intervention to first, ensure 330 Gauge Readers and Observers have the hydrological and meteorological skills in collecting observations and maintaining the equipment; second, to provide recurrent training of government users and administrators of the software to ensure technology skills transfers as the software capabilities advances; and third, to provide operational government staff the opportunity to advance their ICT, software/AI and hydrological and meteorological modelling skills through international trainings.

- Software, mobile communications and flood-hazard mapping: maintenance and the continuous and development of the mobile communications technologies and software that collects, digitizes, processes, and transfers manual river, lake and rainfall observations, whilst also integrating observations from physical sensors and satellites. In addition, to generate actionable application and analysis of the multiple sets of observation data, the group of costs includes modelling and mapping of flood hazards, and building integration of risk analysis into early warning protocols and disaster risk planning.

C. Implementation of the Technology System at Scale

Technology system and scale

Country wide adoption of the technology system in Malawi – 330 manual monitoring stations, covering 150 lake and river-level monitoring stations of the Department of Water Resources (DWR) and National Water Resources Authority (NWRA) and 180 rainfall and synoptic stations of the Department for Climate Change and Meteorological Services (DCCMS) – requires:

1) Purchasing and installation of necessary capital assets. This includes physical equipment at stations needing both an assessment and rehabilitation – i.e., the rain gauges and river/lake level gauge plates (along with updated cross-section measurements to derive discharge estimates). In addition, Gauge Readers and Observers require personal protection equipment (PPE, e.g. raincoats and gumboots) as well as spades and slashers to keep stations clean of vegetation and siltation. Some Gauge Readers require a replacement of their phone. In all, first-year expenditures are higher in year one in order to put in place the equipment to enable nationwide high-quality and efficient collection of water and weather observations;

2) Managerial and operational staff time, supported with capacity building, for the establishment of systems and processes. The UNEP CTCN project confirmed what earlier piloting and similar international innovation projects in hydromet encounter - that operations require a collective effort of national government staff (supported with training), and national and international experts in the diverse aspects of the hydrometeorological monitoring (from software through to effective collaboration of national stakeholders);

and

3) Operational expenditures to ensure high-quality and sustained data management - from the point of collection through to processing (mobile communication, cloud computing and AI integrated as a software) as well as application of modeling and forecasting (e.g., flood hazard mapping, APIs etc.). The operational expenditures also cover the necessary salaries/remuneration of the data collection by hydrological Gauge Readers through to mobile communication, high-capacity computing, and software maintenance.

The cost analysis incorporates all necessary aspects of technology adoption and operations (figure 1), and not just the purchase of mobile communication technology and software.

This cost analysis presentation focuses on an initial five-year time-period – deployment and operations – because it offers insights into two key aspects of the technology adoption: First, installation and rehabilitation costs of approximately 30% of monitoring stations in year one, and second, the subsequent operational and lower capital expenses in years two through five. For the remaining 10-year time horizon, operational costs (from station and software maintenance to training and project management) are consistent. However, the cost estimates for the full 15 years include annual capital replacement set-aside requirements that are needed to finance the replacement of river and rainfall level monitoring equipment by the end of their estimated lifespan (15 to 25 years).

Figure 1. Cost analysis scope of hydrometeorological system and the technology adoption

D. Key Findings and Insights

The UNEP CTCN technology system is far more cost-effective than conventional methods for purchasing, importing and installing automated water and weather observation sensors to address climate data gaps. Modernizing 330 stations with automated sensors would cost US$11.5 million ($35,000 per station), excluding maintenance costs (around 15% of capital expenditure[1]) and high replacement costs from theft or damage during extreme events. These factors often lead to sensor failure, making initial investments unsustainable. Unlike conventional equipment, the UNEP CTCN system combines hardware and software investments with government staff capacity building. It also integrates maintenance solutions and offers incentives for using the software and collecting observation data.

Nationwide adoption of the new UNEP CTCN technology system and innovations – operating at 330 water and weather observation stations at national scale in Malawi and for a total five year period – is estimated to cost a total of US$2.3 million in capital and operational costs.

Year-one, total costs are approximately US$683,500, as shown in figure 2 and 3, reflecting the need for higher capital expenses, human-resource requirements, training, flood hazard mapping integration, and in-field station assessments than subsequent years.

[1]https://documents1.worldbank.org/curated/en/099060623121033174/pdf/P168556001b11f0360b1cb06ac775da70fe.pdf?utm_source

Figure 2. Year-One Costs of Country Wide System with 330 stations

150 Lake & River Monitoring Station + 180 Rainfall & Synoptic Stations

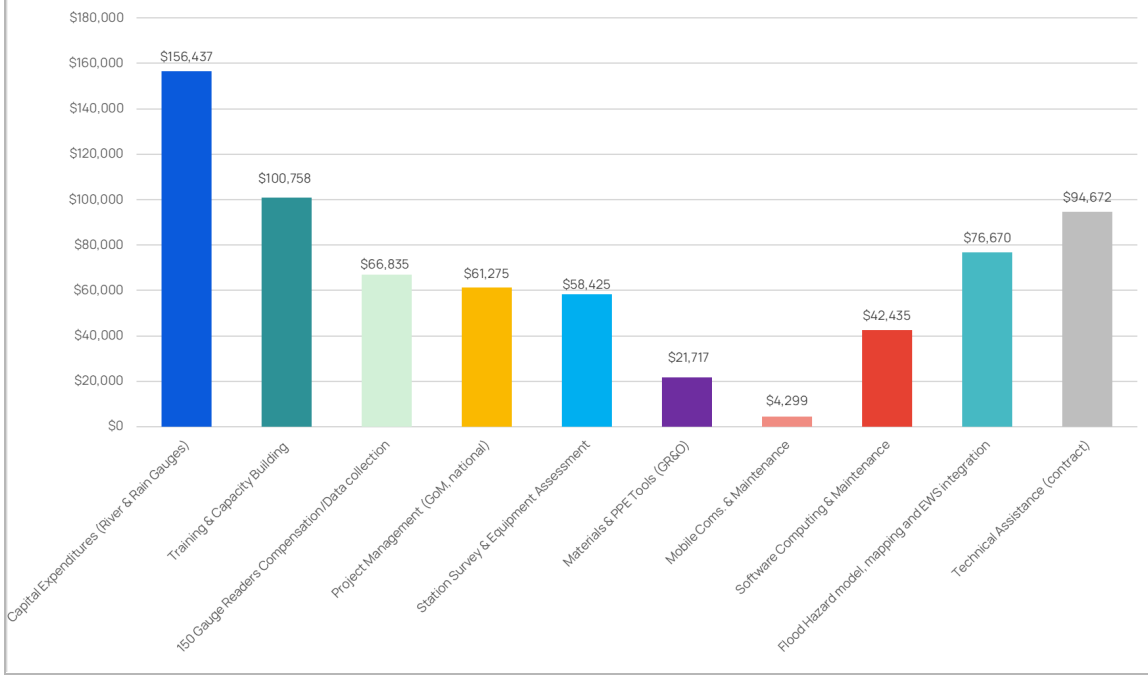
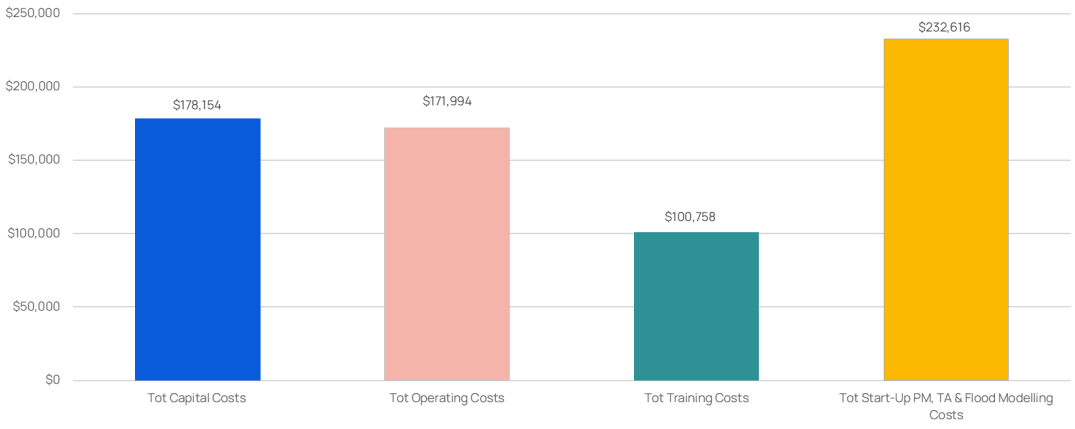


Figure 3. Year-One Capital, Operating, Training, and Startup/TA Costs of Country Wide System

150 Lake & River Monitoring Station + 180 Rainfall & Synoptic Stations

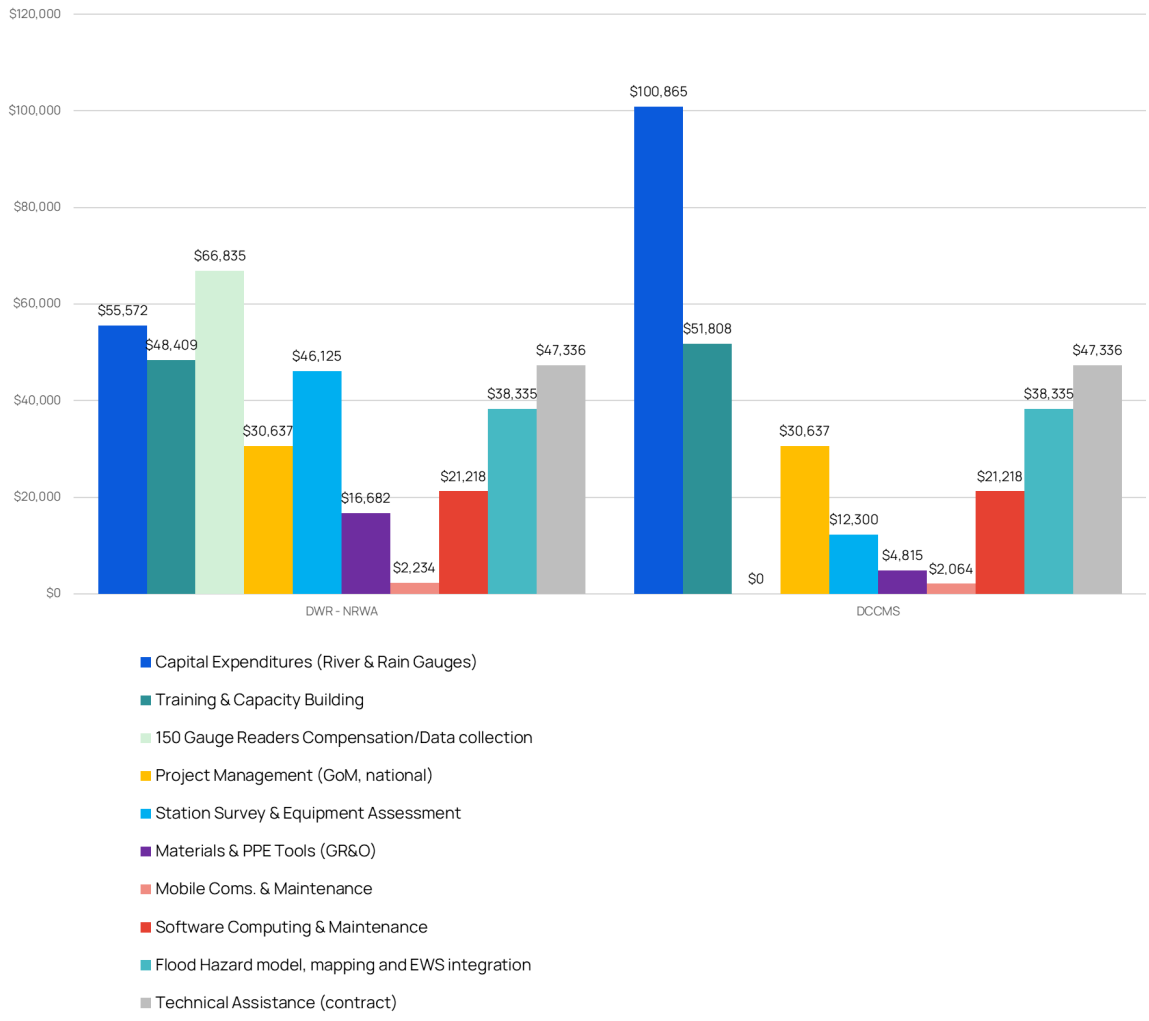


The cost analysis illustrates a balanced split between operational elements of the project led by Government and suppliers (figure 2 and 3) as well as capital and operational costs over a five-year implementation period (figure 5). In year one, for example, capital expenditure for rehabilitating and installing new equipment of approximately a third of all stations alongside materials, tools and PPEs - sourced both nationally and internationally - constitutes 26%

(US$178,000) of the total year one budget. Start-up, national project management, technical assistance, and advancement of flood mapping costs, amount to US$ 233,000 (34%).

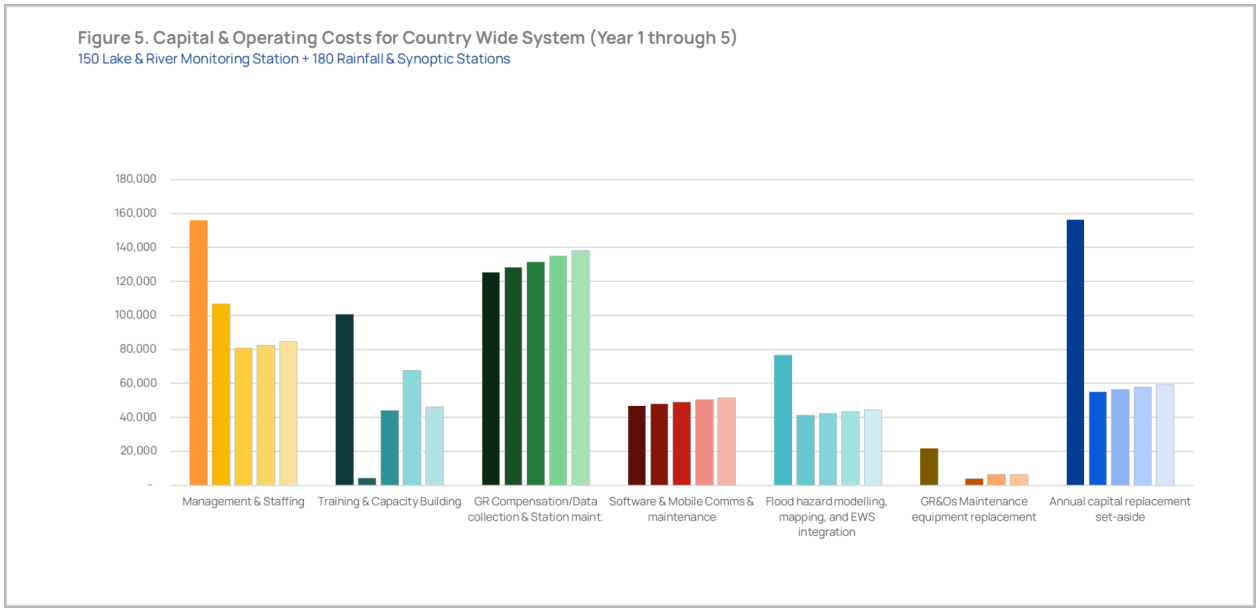
The scope and needs within hydrology and meteorology are different, as shown by the costs broken down by implementing agencies (figure 4) - DWR, NWRA, and DCCMS.

Figure 4. Year-One Costs of Country Wide System with 330 stations by agency
150 Lake & River Monitoring Station + 180 Rainfall & Synoptic Stations

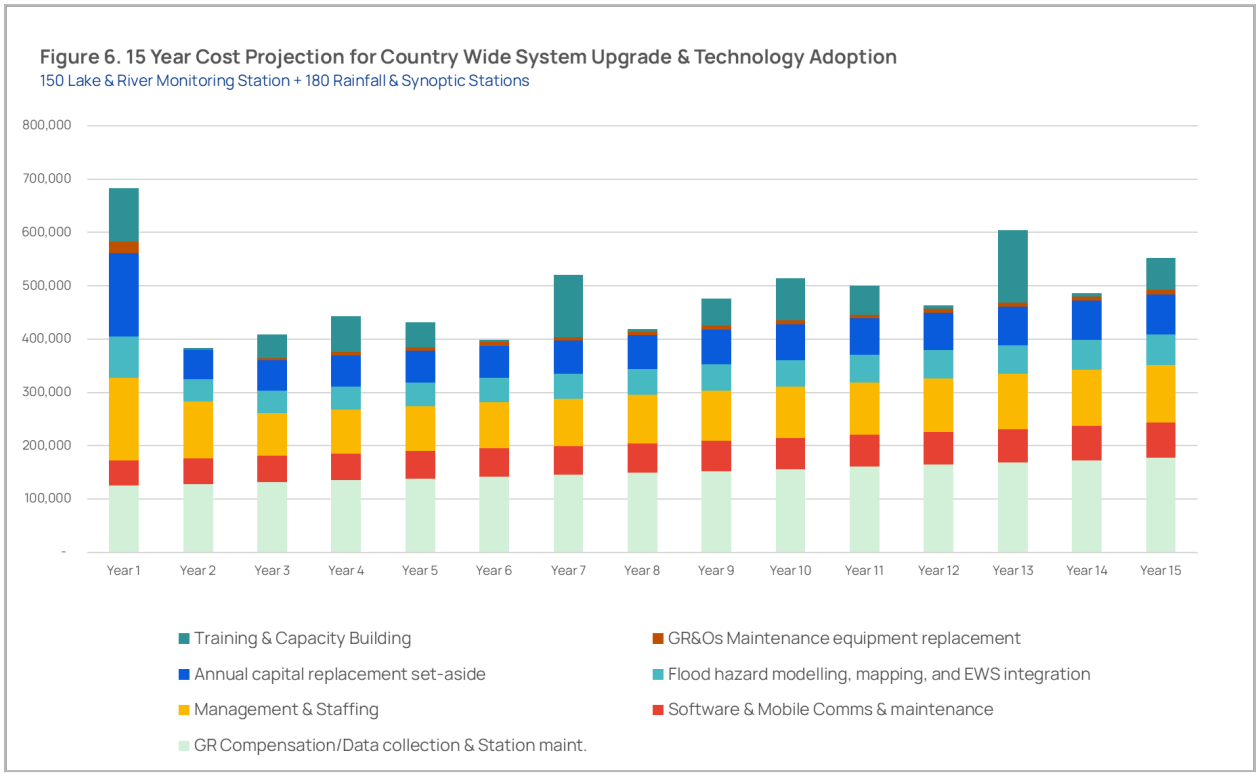


In year two, the total annual cost drops to approximately US$377,000. The decrease is due to lower capital expenditure costs and human resources related to technical assistance.

The cost-split demonstrates how the technology is an integral part of a system of both capital and operational elements of hydro-meteorology - from investment to maintenance - that underpin successful adoption.



Technology adoption in Malawi at 330 of the government's manual monitoring stations, operating for the full 15 years, is estimated to cost a total of approximately US$7.3 million, including capital replacement expenditures. Figure 6 shows costs over the 15-year period with the annual capital replacement expenditure set-aside requirements allocated yearly starting in year two. Variations in annual total costs are due to the timing of recurrent training of government staff and gauge readers and observers at regional level. Annex A presents the detailed cost analysis for 15 years.



E. Initial (year one) Investments and Activities

Section E presents cost estimates with a 2.5% inflation adjustment from the base year (Year 0) costs.

Capital equipment costs

The estimated initial cost of equipment for the project totals approximately $156,000 with details provided below.

The scaled technology system was based on a system design of 150 lake and river gauging stations and 180 rainfall and synoptic stations across Malawi. The scale of the system was based on best knowledge of the Government of Malawi's current network of stations and their operating status.

The equipment at the stations for which capital cost estimates were analysed pertains to the water-level gauging plates and rainfall-level gauges. This equipment is used to collect daily river and lake level measurements, as well as 24-hr rainfall levels. These were the primary hydro-meteorological parameters monitored in the UNEP CTCN-piloted technology. At synoptic weather stations, daily observations were transmitted using the technology for additional parameters: relative humidity, wind speed, wind direction, maximum temperature and minimum temperature. The cost for associated monitoring equipment, as well as the need for replacement of such equipment, was not included in the cost analysis.

Should the Government wish to scale the system further, the cost can be estimated using the financial projections developed. It is important to note that the different stations are managed by separate ministries and departments; the cost projections analyze the costs as a unified system. The software technology can be applied and adjusted to serve departments individually or for multiple departments stations and data collection collectively. For example, the platform shows rainfall and river lake data alongside each other, despite the stations themselves and the legal mandate for the stations and observations is with separate agencies.

Specific administrative rights can be given to one or more staff members in departments who are tasked with controlling which department stations are visible for specific users. Through a cross-departmental memorandum of understanding, one department can also be mandated as a focal point of the overall system. In addition, administrative access management functions of the system adds value through enabling external access when actors, such as students, request access to observation data. Table 1 summarises capital equipment costs for the scaled and rehabilitated system of stations.

Table 1. Capital equipment costs (year one)

Rain Gauges	Number of units	Cost per unit	Year 1 Costs 2.5% inflation
Rain Gauge PVC with brass rim 127mm, 75mm collecting bucket - 25 year lifespan	60	$250	15,375
Rainfall measuring cylinder Borosilicate mm graduated (50 mm) - 5 year lifespan	180	$40	7,380
Fence 3 x 3 meters - 25 year lifespan	60	$865	53,198
Concrete stand for rain gauge Cement - 25 year lifespan	25	$185	4,741
Installation of rainfall gauges (fuel and per diem)	60	$228	14,022
Community consultation with District Council and Police	60	$100	6,150
Water Level Gauges (rivers, lakes)			
Water level gauging plates Six metal plates (0 - 750 cm) with angle irons, paint, nuts and bolts - 15 year lifespan	50	$2,214	37,823
Replacement of plates, angle irons, bolts and washers - 5 year lifespan/station	50	$55	940
Installation of plates (fuel and per diem)	50	$228	11,685
Community consultation with District Council and Police	50	$100	5,125
Total Initial Capital Costs			156,437

Materials and maintenance tools and equipment

In addition to the above purchases, while the following are not considered capital investments (due to their shorter lifespan and need to be periodically replaced), various materials and tools for the gauge readers and rainfall observers will need to be purchased, as well as maintenance equipment for access to and maintenance of the stations. Mobile phones (simple) is the basic requirement to send a manual observation into the software for digitization and data processing using free SMS. Protective gear in the form of gumboots and a raincoat is for the safety and comfort of both gauge readers and observers during the rainy season (October to April). A slasher and spade is critical for maintaining the station, to prevent siltation and vegetation that obscure the water level against the gauging plate measuring the water depths. The costs are presented in table 2.

Table 2. Materials and maintenance tools and equipment (year-one)

Materials/Tools	Number of units	Unit cost	Year 1 costs 2.5% inflation
Mobile phones For Gauge Readers - 3 year lifespan	150	$60	9,225
Gumboots For Gauge Readers and Observers - 5 year lifespan	330	$20	6,765
Rain coat For Gauge Readers and Observers - 3 year lifespan	330	$6.75	2,283
Subtotal - materials/tools			18,273

Maintenance equipment			
Slasher	150	$12	1,845
For Gauge Readers - 5 year lifespan			
Spade	150	$10.40	1,599
For Gauge Readers - 5 year lifespan			
Subtotal - maintenance equipment			3,444

Management and staffing expenses

Year one (and year two, to a lesser extent) establishment and management of the scaled technology system requires a noticeably higher level of effort than ongoing operations; for example, ongoing management is likely to require technical assistance services of 30 days in year three onwards from the international Project Manager, Full-Stack Developer, and Hydrologist/Meteorologist. In year one, the level of effort is in contrast 85 days and for year two, 65 days.

In addition, a team of a project manager, project officer (both national hires) and government staff counterparts are required at a higher level of effort in year one, from coordinating rehabilitation of stations and equipment and training of users, as well as ensuring compliance with WMO standards, appropriate registration of the scaled system in the software, and application of observations into forecasting and analytical models, such as flood hazard mapping. The substantial management and staffing need is reflected in higher costs during the first year, as presented in table 3.

Table 3. Management and staffing expenses (year one)

Management and Staffing	Unit	Number of units	Cost per unit	Year-1 (& 2) costs 2.5% inflation
Project Manager (intl)	days	45	$700	32,288
Full-Stack Developer (intl)	days	20	$800	16,400
Hydrologist/Meteorologist (intl)	days	20	$700	14,350
Operations Manager (national)	days	50	$475	24,344
Operations Officer (national)	month	12	$550	6,765
PM Desk officer, government (national)	yearly	2	$7,200	14,760
International travel	yearly	4	$2,600	10,660
National travel	monthly	24	$250	6,150
National office & admin	monthly	12	$215	2,645
National office IT (3 laptops, 3 phones)	yearly	1	$6,450	6,661
Communication and awareness raising	yearly	2	$3,750	7,688
Audits	yearly	1	$3,500	3,588
Overhead, administration (7%)	monthly	1	7%	9,699
Subtotal - management and staffing				155,946

Year-one training and capacity building costs

During implementation of the UNEP-CTCN project, technology piloting at scale and enabling efforts to transfer the technology use to government counterparts, the importance of training at different levels was apparent.

First, an annual workshop is proposed to ensure that the skills of administrators and users of the technology at the government, as well as other key stakeholders involved in hydro-meteorology (e.g., Red Cross), are updated - estimated at 40 individuals. This is important to address any shortcomings of the technology, and ensure that when new software and AI capabilities are developed in the technology, users have full capacity to understand and use them. The estimated total cost of the workshop in year one is approximately $4,200.

A shortcoming in the pilot design was discovered during the fieldwork and training with manual gauge readers and observers, and with the rehabilitation of monitoring and station equipment. The training was focused on gauge readers and observers' ability to transmit their manual observations using their phones - but not on the actual lake, river, rainfall or synoptic measurement itself. Particularly DWR raised the issue that training of the 330 gauge readers had been overlooked for a long time, and there is a need to train them in the hydrological observation techniques and in the maintenance and on-site rehabilitation needs of the equipment. Both DWR and DCCMS propose that such training is done at a regional level, where gauge readers and observers travel to the location for the training - rather than individual visits and training. The training is proposed to recur every 2 years. The estimated total cost for training gauge readers and observers in year one is approximately $38,000.

As the technology software advances, AI capabilities rapidly enable improved use of hydro-meteorological data and satellite observations, the government counterparts expressed the need for advancing technical skills in AI and forecast modelling (e.g., particularly flood hazards). The training would be done abroad for nine individuals and recur every three years. The estimated total cost for training DWR, NWRA and DCCMS staff in year one is approximately $59,000.

The training and capacity building costs for year one are presented in table 4.

Table 4. Training and capacity building costs (year one)

Training & capacity building	unit	Number of units	Cost per unit	Year-1 cost 2.5% inflation
Training of government staff (1-day workshop)	venue	1	$1,000	1,025
Training of government staff (1-day workshop, 40 ppl.)	per-diem	40	$60	2,460
Training of government staff (1-day workshop)	fuel (4ppl/car)	10	$65	666
Training of GR & Os at regional level (3 regions)	venue	3	$1,000	3,075
Training of GR & Os at regional level (3 regions)	per-diem	360	$60	22,140
Training of GR & Os at regional level (3 regions)	fuel/transport	120	$65	7,995
Training of GR & Os - organizer, materials, logistics	lump sum	1	$4,500	4,613
Training of government staff (tech, international, 5 days)	per-diem	45	$410	18,911
Training of government staff (tech, international, 9 pp.)	flight	9	$1,600	14,760
Training of government staff (training program, logistics)	lump sum	1	$24,500	25,113
Subtotal - training & capacity building				100,758

Year-one flood hazard modelling, mapping and EWS integration costs

Towards the end of the piloting period, sufficient manual observations were collected to enable a small correlation analysis between the in-situ observations of river levels on the main stem of the Shire River (tributary to the Zambezi River) and satellite observations. Comparison of manual in-situ observations at the Mangochi station, for example, with NASA SWOT and Sentinel 3 mission observations showed strong correlation. This means that the in-situ observations are not only credible but also valuable as they are frequent and consistent, compared to satellite observations with set return periods (e.g., 10 days for NASA SWOT) and their challenge to collect data during cloudy conditions, such as during cyclones.

With the above insights and with the software capabilities to map, illustrate and analyse observations, the need to enable application of observations for climate adaptation and monitoring of extreme conditions is clear and there is a leveraging and cost effective pathway to build on the technology to deliver an easy way for government to understand flood risks and the application of observation into flood management strategies and early warning protocols.

The cost analysis therefore includes an estimate of establishing flood risk modelling and mapping into the software as well as integration into early warning protocols in year one ($76,700) followed by upgrades and maintenance in subsequent years ($41,200 in year two).

The associated costs are presented in table 5.

Table 5. Flood hazard modelling, mapping & EWS integration costs (year one)

Flood hazard modelling, mapping & EWS	unit	Number of units	Cost per unit	Year-1 cost 2.5% inflation
Flood risk modelling & hazard mapping integration	lump sum	1	$40,500	41,513
Flood hazard integration into EWS protocols	lump sum	1	$34,300	35,158
Subtotal - flood hazard modelling, mapping & EWS				76,670

Year-one operating costs

Operating costs for the scaled technology system include payments to the hydrological gauge readers for data collection, station assessments and updating of river cross-section measurements (to derive discharge estimates), software maintenance and data transfer expenses, flood hazard mapping, and data management and processing.

The team has included the potential for a full year of these costs in the first year, although in all likelihood operations will not start until sometime mid-year, or with a gradual roll-out. Full-year operations would be expected in year two.

Importantly, the form of employment and remuneration are different between hydrological gauge readers and rainfall observers or meteorologists. Gauge readers are volunteers for the government, and the policy is to remunerate them for their daily observations and station maintenance with a monthly honorarium. There is, however, ongoing policy dialogue in Malawi to transition volunteers as staff of local government. Observers, on the other hand, are commonly employed as meteorologists for Malawi's Department of Climate Change and

Meteorological Services or employed by the Ministry of Agriculture and provide a cross-ministerial service to Agricultural Research Centers. Observers receive a monthly salary through their department; these salaries are not considered part of the project cost and are not included in the cost analysis. .

Piloting since 2021 in Malawi and international research has shown that voluntary environmental, water and climate data collection (e.g., 'community based monitoring', 'citizen science') is commonly not sustained past an initial phase of practice. One of the main reasons why people stop collecting data is a lack of incentives, competing livelihood priorities, and the absence of an institutional context (such as schools and academic research where data collection becomes routine within a program of activities etc.). Gauge readers in several low-income countries are predominantly subsistence farmers whose livelihood priority is to farm for household and income needs or to seek financial income from paid work. They perform their daily river and lake monitoring as a part-time activity. For their sustained work, financial remuneration - whether as salary or honorarium - is a critical aspect of sustainability and proper compensation for the long-term work performed for the government. Piloting by Water in Sight has found in two preceding pilots that within a few months of the end of financial remuneration to gauge readers, so did data collection. In summary, the cost for gauge readers' work in daily data collection and maintenance and protection of the station equipment needs to be put into a wider context of hydro-meteorological monitoring where their labour is an essential part of any technology system.

Operating costs are estimated as follows in table 6, with payments for data collection the largest cost component.

Table 6. Operating costs (year one)

Data Collection	unit	Number of units	Cost per unit	Year-1 cost 2.5% inflation
Gauge Readers financial remuneration (150)	month	12	$35	64,575
Payment fees for mobile payment service			3.50%	2,260
Subtotal - GR hydrological data collection remuneration				**66,835**
Station & Equipment Survey/Maintenance				
DCCMS (1/3 of stations)	yearly	1	$12,000	12,300
DWR - NWRA (1/3 of stations)	yearly	1	$15,000	15,375
Cross section updates (priority 30 stations)	yearly	1	$30,000	30,750
Subtotal - Station & Equip. Survey/Maintenance				**58,425**
Mobile Communication & Maintenance				
Shared short-code maintenance	month	12	$18.00	221
Individual SMS messages	SMS messages	462,528	$0.0086	4,077
Subtotal - mobile communication & maintenance				**4,299**
Software Management				
Cloud and AI computing	month	12	$1,500	18,450
For national scale technology system				
Software maintenance (performance and upgrades)	month	12	$1,950	23,985
Subtotal - software management				**42,435**

Total year one Costs

Table 7. Total year one costs

Year one Costs	
Capital Expenditures (River & Rain Gauges)	156,437
Training & Capacity Building	100,758
150 Gauge Readers Compensation/Data collection	66,835
Project Management (GoM, national)	61,275
Station Survey & Equipment Assessment (including cross section updates)	58,425
Materials & PPE Tools (GR&O)	21,717
Mobile Communications Technologies & Maintenance	4,299
Software Computing, AI, & Maintenance	42,435
Flood Hazard model, mapping, and EWS integration	76,670
Technical Assistance (contract)	94,672
Total year one Costs	683,522

F. Operating and Capital Maintenance Costs (year two to Five)

Ongoing operating and capital maintenance costs (year two onwards)

For ease of presentation, expected operating expenses are presented in this section showing years two through five. Appendix A presents operating expenses for the 15-year projection period. Costs are presented in US Dollars, with inflation assumed at 2.5 percent per year.

Ongoing operating costs include the following cost groups:

- Management, staffing, and training costs
- Data collection and equipment maintenance costs
- Software, mobile communication and flood hazard application maintenance costs
- Personal and maintenance equipment replacement costs

Because the main components of the rain gauges and the river gauges have 15-year expected lifespans, and given that existing equipment is at various points along their lifespans, periodic replacements will be necessary. Those capital replacements are budgeted to take place on 5-year schedules (during which approximately one-third of components would be replaced). Operational cost projections therefore show "lumpy" periodic expenses year 10 to 15.

Management, staffing and training costs

As presented previously, the team expects that initial program set-up will require additional managerial and training costs in both year one and year two. Starting in year three, however, the time requirements of the international technical team are reduced, with the national team taking on most of the responsibilities. Table 8 and 9 summarises projected costs over years two through five (subsequent-year costs are assumed to increase at an inflation rate of 2.5 percent.)

Table 8. Management and staffing (year two through five)

Management & Staffing	unit	No. of units	Cost/ unit**	Year 2	Year 3	Year 4	Year 5
Project Manager (intl)	days	10	$700	25,740*	7,538	7,727	7,920
Full-Stack Developer (intl)	days	10	$800	12,608*	8,615	8,831	9,051
Hydro./Meteorologist (intl)	days	10	$700	11,032*	7,538	7,727	7,920
Operations Manager (national)	days	25	$475	12,476	12,788	13,108	13,435
Operations Officer (national)	month	12	$550	3,467	3,554	3,643	3,734
PM Desk officer, gov (national)	yearly	2	$7,200	15,129	15,507	15,895	16,292
International travel	yearly	1	$2,600	2,732	2,800	2,870	2,942
National travel	monthly	24	$250	6,304	6,461	6,623	6,788
National office & admin	monthly	12	$215	2,711	2,778	2,848	2,919
Communication & awareness	yearly	1	$3,750	3,940	4,038	4,139	4,243
Audits	yearly	1	$3,500	3,677	3,769	3,863	3,960
Overhead, administration (7%)			7%	6,987	5,277	5,409	5,544
Subtotal - management and staffing				106,802	80,665	82,681	84,749

*year two days: 35 (Project Manager), 15 (FS Developer), and 15 (Hydro./Meteorologist); **adjusted with 2.5% inflation

Table 9. Training and capacity building (year two through five)

Training & capacity building	unit	Number of units	Cost per unit**	Year 2	Year 3	Year 4	Year 5
Training gov (1-day workshop)	venue	1	$1,000	1,051	1,077	1,104	1,131
Training gov (1-day workshop)	per-diem	40	$60	2,522	2,585	2,649	2,715
Training gov (1-day workshop)	fuel (4ppl/car)	10	$65	683	700	717	735
Training of GR & Os (region)	venue	3	$1,000		3,231		3,394
Training of GR & Os (region)	per-diem	360	$60		23,261		24,438
Training of GR & Os (region)	fuel/transport	120	$65		8,400		8,825
Training of GR & Os (organ.)	lump sum	1	$4,500		4,846		5,091
Training gov (inter.)	per-diem	45	$410			20,365	
Training gov (inter.)	flight	9	$1,600			15,895	
Training gov (inter.))	lump sum	1	$24,500			27,043	
Subtotal - training & capacity building				4,255	44,099	67,774	46,331

**adjusted with 2.5% inflation

Data collection and equipment maintenance

Data collection for the lake and river level gauges – the regular collection and transmittal of data – is the highest ongoing operating cost of the program. In addition, the program has included in the budget the per-diem and fuel costs of the cost of the annual inspections and cross section measurements of river beds to ensure that the realignment of gauging plates takes place. Hydrological monitoring technicians are employees of the Department of Water Resources and National Water Resources Authority with transitioning and/or shared monitoring mandate to the National Water Resources Authority. However, due to difficulties in fund allocation, travel to gauge sites often does not take place, leading to system-wide reduction in observation data quality over time.

The ongoing costs for the gauge readers and station inspection and realignment labour, and cross-section updating measurement, is presented in table 10.

Table 10. Data collection and equipment maintenance (years two through five)

Data Collection	Unit	Number of units	Cost/ unit*	Year 2	Year 3	Year 4	Year 5
Gauge Readers 150 readers	month	12	$35	66,189	67,844	69,540	71,279
payment fees for mobile payments			3.50%	2,317	2,375	2,434	2,495
Subtotal - data collection labour				68,506	70,219	71,974	73,773
Station & Equipment Survey/Maintenance							
DCCMS (1/3 of stations)		yearly	$12,000	12,608	12,923	13,246	13,577
DWR - NWRA (1/3 of stations)		yearly	$15,000	15,759	16,153	16,557	16,971
Cross section updates (priority 30 stations) fuel and per-diem		yearly	$30,000	31,519	32,307	33,114	33,942
Subtotal - station & equipment survey/maint.				59,886	61,383	62,917	64,490

*adjusted with 2.5% inflation

Personal and maintenance equipment replacement

As presented previously, the program requires personal tools and materials for gauge readers and observers, such as personal protection equipment (PPE) that have limited lifespans, and therefore need regular replacement. These include basic mobile phones for data transmission (with an estimated 3-year lifespan), gumboots (5-year lifespan), and raincoats (3-year lifespan), as well as spades and slashers to ensure access to the rain and water level gauges (estimated 5-year lifespan). The replacement costs of these items are assumed on a rolling basis, starting in year 3, as presented in table 11.

Table 11. Personal and maintenance equipment replacement (years three through five)

Personal Protection Equipment (for gauge readers and observers)	Units	Cost per unit*	Year 3	Year 4	Year 5
Mobile phones					
For Gauge Readers - 3 year lifespan	150	$60	3,230	3,311	3,394
Gumboots					
For Gauge Readers and Observers - 5 year lifespan	330	$20		1,457	1,493
Rain coat					
For Gauge Readers and Observers - 3 year lifespan	330	$6.75	800	820	840
Subtotal – personal equipment			4,030	5,588	5,728
Maintenance equipment replacement (Gauge Readers)					
Slasher					
For Gauge Readers - 5 year lifespan	150	$12.00		397	407
Spade					
For Gauge Readers - 5 year lifespan	150	$10.40		344	353
Subtotal – personal equipment			-	741	760

*adjusted with 2.5% inflation

Software and mobile communication and maintenance

The cost of cloud computing and software maintenance comprise the majority of the cost of data management and processing, AI analytics, access control, and the vital application of observation data into modelling and forecasting processes. The current base cost is $1,500 per month for cloud computing and $1,950 per month for software maintenance services. The corresponding cloud computing capacity is predicted to be necessary for the data volume, quality assurance and protection anticipated. If the technology adoption expands – including to new countries – that cost will be spread across the larger program.

The primary data entry technology using mobile communication is "free SMS" that is piloted in the UNEP CTCN project consists of two parts (the technical term is shared short code/2-way SMS service with API and reversely billed SMS services). First, a maintenance fee of $18 per month, and a fee per SMS sent by gauge readers and observers and the software back to them. Notably, the shared short code service requires the user to include "WS" at the start of the SMS. This code allocates the data from the SMS to the API for transmission into the correct software. Free SMS service can be offered as a "dedicated shortcode", but costs for setting it

up and maintaining are far greater (e.g., $175 per month in maintenance). The complimentary data entry technology of WhatsApp is a cloud computing service built into the previous cost category. The ongoing costs for software and mobile communication is in table 12.

Table 12. Software and mobile communication and maintenance (years two through five)

Software	Unit	Number of units	Cost/ unit*	Year 2	Year 3	Year 4	Year 5
Cloud and AI computing cost scale with project size	month	12	$1,500	18,911	19,384	19,869	20,365
Software maintenance	month	12	$1,950	24,585	25,199	25,829	26,475
Subtotal - software				43,496	44,583	45,698	46,840
Mobile Communication & Maintenance							
Shared short-code maintenance	month	12	$18.00	227	233	238	244
Individual SMS messages	SMS	462,528	$0.0086	4,179	4,284	4,391	4,500
Subtotal - mobile communication and maintenance				4,406	4,516	4,629	4,745

*adjusted with 2.5% inflation

Flood hazard modelling maintenance

To maintain advanced capabilities of the software and its integration into climate information applications, there are operating costs to maintain the flood hazard modelling, mapping and integration into early warning protocols, table 13. This includes, among others, regularly updating the underlying flood hazard mapping that alters with changes in the environment, and changes in the Shared Socioeconomic Pathways used for predicting climate change.

Table 13. Flood hazard modelling and EWS integration maintenance

Flood hazard modelling, mapping & EWS maintenance	Unit	Number of units	Cost/ unit*	Year 2	Year 3	Year 4	Year 5
Flood risk model & map upgrades	yearly	1	$25,500	26,791	27,461	28,147	28,851
EWS integration maintenance	yearly	1	$13,750	14,446	14,807	15,177	15,557
Subtotal - flood model/EWS maint.				41,237	42,268	43,325	44,408

Total ongoing operating costs, years two through five

The table 14 below summarises the projected operating costs in the initial 4 years adjusted by inflation of 2.5% per year.

Table 14. Total ongoing operating costs (years two through five)

	Year 2	Year 3	Year 4	Year 5
Management and Staffing	106,802	80,665	82,681	84,749
Training & Capacity Building	4,255	44,099	67,774	46,331
Data collection and equipment maintenance	128,392	131,601	134,891	138,264
Personal and Maintenance equipment replacement	-	6,330	6,488	6,650
Software and mobile communication and maintenance	47,902	49,099	50,327	51,585
Flood hazard modelling & EWS maintenance	41,237	42,268	43,325	44,408
Operating Costs	328,587	351,763	385,328	371,824

Periodic capital equipment replacement costs

Key components of the rain and water-level gauges, as well as the gauges themselves, will need to be replaced periodically. These include:

- Rain gauge components:
    - Rainfall measuring cylinder (5-year lifespan, including international shipping, customs and distribution).
    - Funnel (15-year lifespan, including international shipping, customs and distribution).
- Lake and river level gauge components:
    - Water level gauge stations (15-year lifespan, including assessment and installation).
    - Plates, angle irons, bolts, and washers (5-year lifespan, installation and calibration).

The technology system at national scale anticipates capital replacements on a periodic, rolling basis – i.e., one-third of the rain gauge funnels (60 funnels) will need replacement every five years, and one-third of the lake and river level gauge stations (50 gauge stations) will need replacement every five years. The river gauge bolts, and washers will need to be replaced every five years on those stations that are not newly installed – i.e., 100 sets every five years. The associated costs are presented in table 15.

Table 15. Periodic capital equipment replacement costs (years five and six)

Rain Gauges		Total units	Cost per unit*	Year 6
Rain gauge - 15 year life span		60	$250	17,395
Rainfall Measuring cylinder - 5 year lifespan		180	$40	8,350
Fence 3 x 3 meters - 25 year lifespan		60	$865	60,188
Installation of gauges (fuel, per diem)		60	$228	15,865
Int. shipping and Installation cost	per 5 stations	5	$4,600	64,015
Community consultation		60	$100	6,958
Sub-total - rain gauges				172,771
Lake and River Level Gauges				
Water level gauge station 6 angle irons with plates - 15 year lifespan		50	$2,214	128,378
Replacement of plates, bolts and washers - 5 year lifespan/station		50	$55	3,189
Installation of plates - Installation cost - fuel and per diem		50	$228	13,221
Community consultations		50	$100	5,798
Subtotal - lake and river level gauges				150,586
Total Capital Equipment Replacement Costs				323,357

*adjusted with 2.5% inflation

The capital replacement costs would be expected as well in years nine and ten, and 14 and 15, with adjustments according to inflation.

For budgeting purposes, the team recommends taking an annual average of the capital equipment replacement costs – $54,927 in a year and then adjusted annually for inflation – and budgeting that amount each year. This results in annual capital replacement set-asides as shown in table 16.

Table 16. Capital replacement set-aside

	Year 2	Year 3	Year 4	Year 5
Capital Replacement Set-Aside	54,927	56,301	57,708	59,151

This strategy does require disciplined budget management – i.e., setting aside these funds every year in a reserve account and not using them for operational expenses so that they are available when needed for the purchase of replacement equipment and their installation costs. Following this methodology, expected total annual revenue needs are presented in table 17.

Table 17. Expected annual revenue needs (years two through five)

	Year 2	Year 3	Year 4	Year 5
Management and staffing	106,802	80,665	82,681	84,749
Training and capacity building	4,255	44,099	67,774	46,331
Data collection, equipment & station maintenance	128,392	131,601	134,891	138,264
GR&O Maintenance equipment replacement	-	4,030	6,330	6,488
Capital Replacement Set-Aside	54,927	56,301	57,708	59,151
Software and mobile coms. maintenance	47,902	49,099	50,327	51,585
Flood model, map, EWS maintenance	41,237	42,268	43,325	44,408
Operating Costs	383,515	408,063	443,037	430,975

Appendix A. Operating expenses for the 15-year projection period

Operating and Capital Replacement Expenses																		
US$				2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
		Year		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		Inflation	2.5%	1.025	1.051	1.077	1.104	1.131	1.160	1.189	1.218	1.249	1.280	1.312	1.345	1.379	1.413	1.448
	unit	number	cost/unit															
Management and Staffing																		
Project Manager (TA contract)	days	10	$700		25,740	7,538	7,727	7,920	8,118	8,321	8,529	8,742	8,961	9,185	9,414	9,650	9,891	10,138
Full Stack Developer (TA contract)	days	10	$800		12,608	8,615	8,831	9,051	9,278	9,509	9,747	9,991	10,241	10,497	10,759	11,028	11,304	11,586
Hydrologist/Meteorologist (TA contract)	days	10	$700		11,032	7,538	7,727	7,920	8,118	8,321	8,529	8,742	8,961	9,185	9,414	9,650	9,891	10,138
International travel (TA contract)	yearly	1	$2,600		2,732	2,800	2,870	2,942	3,015	3,091	3,168	3,247	3,328	3,411	3,497	3,584	3,674	3,766
Operations Manager (national)	days	25	$475		12,476	12,788	13,108	13,435	13,771	14,116	14,469	14,830	15,201	15,581	15,971	16,370	16,779	17,199
Operations Officer (national)	monthly	6	$550		3,467	3,554	3,643	3,734	3,827	3,923	4,021	4,121	4,224	4,330	4,438	4,549	4,663	4,779
Project Manager, government (national)	yearly	2	$7,200		15,129	15,507	15,895	16,292	16,700	17,117	17,545	17,984	18,433	18,894	19,366	19,851	20,347	20,855
National travel	monthly	24	$250		6,304	6,461	6,623	6,788	6,958	7,132	7,310	7,493	7,681	7,873	8,069	8,271	8,478	8,690
National office & admin	monthly	12	$215		2,711	2,778	2,848	2,919	2,992	3,067	3,143	3,222	3,303	3,385	3,470	3,557	3,645	3,737
Communication and awareness raising	yearly	1	$3,750		3,940	4,038	4,139	4,243	4,349	4,458	4,569	4,683	4,800	4,920	5,043	5,169	5,299	5,431
Audits	yearly	1	$3,500		3,677	3,769	3,863	3,960	4,059	4,160	4,264	4,371	4,480	4,592	4,707	4,825	4,945	5,069
Overhead, administration (7%)			7%		6,987	5,277	5,409	5,544	5,683	5,825	5,971	6,120	6,273	6,430	6,590	6,755	6,924	7,097
Subtotal - Management and Staffing					**106,802**	**80,665**	**82,681**	**84,749**	**86,867**	**89,039**	**91,265**	**93,547**	**95,885**	**98,282**	**100,739**	**103,258**	**105,839**	**108,485**
Training & Capacity Building																		
Training of Gov staff (1-day workshop)	venue	1	$1,000		1,051	1,077	1,104	1,131	1,160	1,189	1,218	1,249	1,280	1,312	1,345	1,379	1,413	1,448
Training of Gov staff (1-day workshop)	per-diem	40	$60		2,522	2,585	2,649	2,715	2,783	2,853	2,924	2,997	3,072	3,149	3,228	3,308	3,391	3,476
Training of Gov staff (1-day workshop)	fuel (4ppl/car)	10	$65		683	700	717	735	754	773	792	812	832	853	874	896	918	941
Training of GR & Observers - venue	Every 2 years	3	$1,000			3,231		3,394		3,566		3,747		3,936		4,136		4,345
Training of GR & Observers - per diem	Every 2 years	360	$60			23,261		24,438		25,676		26,975		28,341		29,776		31,283
Training of GR & Observers - fuel	Every 2 years	120	$65			8,400		8,825		9,272		9,741		10,234		10,752		11,297
Training of GR & Observers - Organizer and materials	Every 2 years	1	$4,500			4,846		5,091		5,349		5,620		5,904		6,203		6,517
Training of Gove staff in Computing technologies & Application - DSA	Every 3 years	45	$410				20,365			21,931			23,618			25,434		
Training of Gove staff in Computing technologies & Application - flights	Every 3 years	9	$1,600				15,895			17,117			18,433			19,851		
Training of Gove staff in Computing technologies & Application - Logistics	Every 3 years	1	$24,500				27,043			29,123			31,362			33,774		
Subtotal - Training & Capacity Building*					**4,255**	**44,099**	**67,774**	**46,331**	**4,697**	**116,848**	**4,935**	**51,141**	**78,597**	**53,730**	**5,447**	**135,508**	**5,723**	**59,308**
Data Collection																		
Gauge Readers (150 readers)	month	12	$35		66,189	67,844	69,540	71,279	73,061	74,887	76,759	78,678	80,645	82,661	84,728	86,846	89,017	91,243
Payment fees for mobile payments			3.50%		2,317	2,375	2,434	2,495	2,557	2,621	2,687	2,754	2,823	2,893	2,965	3,040	3,116	3,193
Subtotal - Hydrological Data Collection Remuneration					**68,506**	**70,219**	**71,974**	**73,773**	**75,618**	**77,508**	**79,446**	**81,432**	**83,468**	**85,555**	**87,693**	**89,886**	**92,133**	**94,436**
Station & Equipment Survey/Maintenance																		
DCCMS (1/3 of stations)	yearly	1	$12,000		12,608	12,923	13,246	13,577	13,916	14,264	14,621	14,986	15,361	15,745	16,139	16,542	16,956	17,380
DWR - NWRA (1/3 of stations)	yearly	1	$15,000		15,759	16,153	16,557	16,971	17,395	17,830	18,276	18,733	19,201	19,681	20,173	20,678	21,195	21,724
Cross section updates - as needed scale H,M, L priority (30 stations)	yearly	1	$30,000		31,519	32,307	33,114	33,942	34,791	35,661	36,552	37,466	38,403	39,363	40,347	41,355	42,389	43,449
Subtotal - Station & Equipment Survey/Maintenance					**59,886**	**61,383**	**62,917**	**64,490**	**66,103**	**67,755**	**69,449**	**71,185**	**72,965**	**74,789**	**76,659**	**78,575**	**80,540**	**82,553**
Materials/Tool Replacement (gauge readers and rainfall observers)																		
Mobile phones (3-year lifespan) (for gauge readers)		150	$60			3,231	3,311	3,394	3,479	3,566	3,655	3,747	3,840	3,936	4,035	4,136	4,239	4,345
Gumboots (5-year lifespan)		330	$20				1,457	1,493	1,531	1,569	1,608	1,648	1,690	1,732	1,775	1,820	1,865	1,912
Rain coat (3-year lifespan)		330	$6.75			800	820	840	861	883	905	927	950	974	999	1,024	1,049	1,075
Subtotal - Materials/Tool Replacement						**4,030**	**5,588**	**5,728**	**5,871**	**6,018**	**6,168**	**6,322**	**6,480**	**6,642**	**6,808**	**6,979**	**7,153**	**7,332**
Maintenance equipment replacement (gauge readers)																		
Slasher (5-year lifespan)		150	$12.00				397	407	417	428	439	450	461	472	484	496	509	521
Spade (5-year lifespan)		150	$10.40				344	353	362	371	380	390	399	409	420	430	441	452
Subtotal - Maintenance equipment replacement							**742**	**760**	**779**	**799**	**819**	**839**	**860**	**882**	**904**	**926**	**950**	**973**
Mobile Communication and Maintenance																		
Shared short-code maintenance	month	12	$ 18.00		227	233	238	244	250	257	263	270	276	283	290	298	305	313
Individual SMS messages	SMS messages	**462,528**	$0.0086		4,179	4,284	4,391	4,500	4,613	4,728	4,846	4,968	5,092	5,219	5,350	5,483	5,620	5,761
Subtotal - Mobile Communication and Maintenance					**4,406**	**4,516**	**4,629**	**4,745**	**4,863**	**4,985**	**5,110**	**5,237**	**5,368**	**5,503**	**5,640**	**5,781**	**5,926**	**6,074**
Software																		
Cloud computing (cost will scale with size of the project)	month	12	$1,500		18,911	19,384	19,869	20,365	20,874	21,396	21,931	22,480	23,042	23,618	24,208	24,813	25,434	26,069
Software maintenance	month	12	$1,950		24,585	25,199	25,829	26,475	27,137	27,815	28,511	29,223	29,954	30,703	31,470	32,257	33,064	33,890
Subtotal, Software					**43,496**	**44,583**	**45,698**	**46,840**	**48,011**	**49,212**	**50,442**	**51,703**	**52,996**	**54,320**	**55,678**	**57,070**	**58,497**	**59,960**
Flood hazard modelling & mapping																		
Flood risk modelling & mapping upgrades	yearly	1	$25,500		26,791	27,461	28,147	28,851	29,572	30,311	31,069	31,846	32,642	33,458	34,295	35,152	36,031	36,932
Flood hazard EWS integration maintenance	yearly	1	$13,750		14,446	14,807	15,177	15,557	15,946	16,344	16,753	17,172	17,601	18,041	18,492	18,955	19,428	19,914
Subtotal - Flood hazard modelling & mapping					**41,237**	**42,268**	**43,325**	**44,408**	**45,518**	**46,656**	**47,822**	**49,018**	**50,243**	**51,499**	**52,787**	**54,107**	**55,459**	**56,846**
Total Operating Costs					**328,587**	**351,763**	**385,328**	**371,824**	**338,327**	**458,819**	**355,455**	**410,425**	**446,863**	**431,202**	**392,356**	**532,090**	**412,219**	**475,967**

Capital Equipment Replacement Costs																
Raingauges																
Rain gauge - 15 year life span		60	$250					17,395				19,681				
Borosilicate Rainfall Measuring cylinder - 5 year lifespan		180	$40					8,350				9,447				
Fence (3 x 3 meters) - 25 year lifespan		60	$865					60,188				68,097				
Installation of rainfall gauges - Installation cost (fuel and per diem)		60	$228					15,865				17,949				
Int. shipping and Installation cost (Rain Gauge)	per 5 stations	5	$4,600					64,015				72,427				
Community consultation with District Council and Police		60	$100					6,958				7,873				
Sub-total - Raingauges								**172,771**				**195,475**				
River-Level Gauges																
River-level gauge station (6 plates) - 15 year lifespan		50	$2,214					128,378				145,248				
Replacement of plates, bolts and washers - 5 year lifespan/station		50	$55					3,189				3,608				
Installation of plates - Installation cost (fuel and per diem)	per 5 stations	50	$228					13,221				14,958				
Community consultation		50	$100					5,798				6,560				
Sub-total - River-Level Gauges								**150,586**				**170,374**				
Total Capital Equipment Replacement Costs					-	-	-	-	**323,357**	-	-	-	-	**365,849**	-	-	-	-
To calculate annual capital replacement set-aside, revert cap expenditure to base year:				*836,490*				-	*278,830*				-	*278,830*				-
Annual Capital Replacement Set-Aside					**54,927**	**56,301**	**57,708**	**59,151**	**60,629**	**62,145**	**63,699**	**65,291**	**66,924**	**68,597**	**70,312**	**72,069**	**73,871**	**75,718**
Total Operating and Capital Replacement Budget					**383,515**	**408,063**	**443,037**	**430,975**	**398,957**	**520,964**	**419,154**	**475,716**	**513,787**	**499,799**	**462,668**	**604,159**	**486,090**	**551,685**

SUMMARY	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
Management & Staffing	155,946	106,802	80,665	82,681	84,749	86,867	89,039	91,265	93,547	95,885	98,282	100,739	103,258	105,839	108,485
Training & Capacity Building	100,758	4,255	44,099	67,774	46,331	4,697	116,848	4,935	51,141	78,597	53,730	5,447	135,508	5,723	59,308
GR Compensation/Data collection & Station maint.	125,260	128,392	131,601	134,891	138,264	141,720	145,263	148,895	152,617	156,433	160,344	164,352	168,461	172,672	176,989
Software & Mobile Comms & maintenance	46,734	47,902	49,099	50,327	51,585	52,875	54,197	55,552	56,940	58,364	59,823	61,319	62,851	64,423	66,033
Flood hazard modelling, mapping, and EWS integration	76,670	41,237	42,268	43,325	44,408	45,518	46,656	47,822	49,018	50,243	51,499	52,787	54,107	55,459	56,846
GR&Os Maintenance equipment replacement	21,717	-	4,030	6,330	6,488	6,650	6,817	6,987	7,162	7,341	7,524	7,712	7,905	8,103	8,305
Annual capital replacement set-aside	156,437	54,927	56,301	57,708	59,151	60,629	62,145	63,699	65,291	66,924	68,597	70,312	72,069	73,871	75,718
Total Year Costs	683,522	**383,515**	**408,063**	**443,037**	**430,975**	**398,957**	**520,964**	**419,154**	**475,716**	**513,787**	**499,799**	**462,668**	**604,159**	**486,090**	**551,685**
5 YEAR TOTAL	**2,349,111**														
15 YEAR TOTAL	**7,282,089**														