THE REPUBLIC OF UGANDA

MINISTRY OF WATER AND ENVIRONMENT




Climate and Vulnerability Risk Assessment for Water and Sanitation in Uganda

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FOREWORD

The Ministry of Water and Environment (MWE) is committed to ensuring that the existing and planned water and sanitation systems and facilities are more Resilient to climate change and more likely to withstand shocks and stress. In order to achieve this MWE with support from UNICEF and Stockholm International Water Institute (SIWI) in carried out climate and vulnerability risk assessment for water and sanitation services in Uganda.

Assessing vulnerability to climate change is important for defining the risks posed by climate change and provides information for identifying measures to adapt to climate change impacts. It enables practitioners and decision-makers to identify the most vulnerable areas, sectors and communities. This is fundamental for informing the prioritisation of climate action and investment in adaptation and mitigation actions.

On behalf of MWE, let me express my gratitude to members of the task force who participated and worked tirelessly to ensure successful completion of this assessment. I therefore, implore all the sector players to use the report in their endeavour in shifting to climate resilient WASH by adopting the recommendation of the report which are 1) designing and implementation of adaptation strategies for the most vulnerable groups of the population, 2) focusing on the financial sustainability of service providers. 3) increase resilience of Wash infrastructure, and 4) implementing Integrated Water Resources Management (IWRM) principles.

For God and my country

Alfred Okot Okidi
Permanent Secretary

EXECUTIVE SUMMARY

Uganda has historically been hit by hazards of distinct nature, intensity, and range. Heavy rains and drought events, storms, and landslides are some examples of climate related episodes that had and still have a strong impact over almost all economic sectors, regions, and population. Hazards have directly impacted water and sanitation services as well, affecting access to safe water, damaging WASH facilities, contaminating water sources, and compromising the population's health and the country's environment. They will continue to do so and will probably become more intense and frequent, due to climate change. The need to cope with these issues is urgent. New approaches and new strategies are needed to ensure that Uganda is able to secure availability and sustainable management of WASH services for all and to realize the human rights to water and sanitation.

The country's commitment to the United Nations Convention on Climate Change has been translated into policymaking aiming at establishing mitigation and adaptation strategies. Recently, the Government of Uganda has launched a multistakeholder process to update its Nationally Determined Contribution (NDC). The NDC sets mitigation and adaptation targets related to climate change and describes measures to be pursued towards the achievement of these targets, paying special attention to the impacts of climate change over the water sector and water-related services, including sanitation. In this context, the assessment of climate risks and vulnerability related to water and sanitation, the main objective of the present study, comes to be of extreme strategic relevance and is aligned with Uganda's agenda. The underlying rationale for this analysis resides in the fact that WASH systems that are informed by risk assessments will be more resilient and more likely to withstand shocks and stresses caused by climate change.

The present document used the risk assessment methodology of the GWP and UNICEF Strategic Framework for WASH Climate Resilient Development, which is based on a step-by-step participatory assessment procedure, aimed at involving government planners, decision-makers, and practitioners responsible for WASH service delivery in Uganda. The analysis' ambition is to determine the nature and extent of risk by understanding how **climate and environmental hazards** affect and impact **exposed population groups, critical infrastructure**, **water sources**, and other relevant assets, while integrating the **underlying causes of vulnerability** in Uganda, such as poverty, education, and human development.

The study discusses separately these three elements – i.e., hazards, exposure, and vulnerability, and then bring them together to provide an overall scoring of risks, according to the following risk formula: ***Risk = Hazard x Exposure x Vulnerability***. The first step in the analysis was the identification of those climate and environmental hazards with highest impact on WASH services and facilities. In consultation with sector stakeholders, the following hazards were prioritised: **drought**, **flooding**, **landslides**, **land degradation**, **water pollution** and **water overexploitation**. All these hazards were characterized, based on an assessment of their main features: frequency, duration, intensity, geographical extent, and time of year. After characterizing them, mainly through a desk review that was validated and fine-tuned in a series of workshops with stakeholders, these hazards were scored using a simple traffic-light system. The second step of the methodology consisted of the exposure analysis for these prioritized hazards, focusing on three different elements: population, critical WASH infrastructure, and water sources. A set of exposure indicators was defined in relation to each of these elements, for all hazards. They were assessed using again a traffic-light system (i.e., high, moderate, or low exposure). The third step was the analysis of vulnerability. A number of criteria were developed and assessed in relation to six vulnerability areas: human, social, physical, financial, environmental, and political. In the last step, hazard, exposure, and vulnerability were combined to come up with an overall score, resulting in the prioritization of climate and vulnerability risks for the WASH sector in Uganda.

The list of prioritized risks that resulted from the analysis showed that drought, flooding, and water pollution are the hazards that hit the Ugandan WASH sector the most, both in the present and in the future. Some of them are localized phenomena, such as landslides that occur in mountainous areas, while others are diffuse and affect larger areas, such as water pollution and land degradation. The northeastern region for instance is at risk of being hit by several hazards at once, with severe consequences over the local population. Rural areas are also vulnerable to several hazards, such as landslides, land degradation and water overexploitation.

In terms of exposure, specific population groups can be simultaneously affected by more than one hazard and are thus the most vulnerable. It is the case of women and children, which are often in charge of searching for alternative sources and for fetching water. In performing this task, they not only miss school or work, but they expose themselves to all kinds of risks (e.g., attacks, gender-based violence, etc.). Promoting the delivery of water on premises will significantly reduce these risks. Since most of Ugandan farmers rely on rain-fed crops for subsistence, changes in precipitation and water availability will impact their livelihood, with possible income losses, worsening their WASH situation. Finally, people that live in informal settlements are also exposed to water pollution, since they typically access water through unimproved sources. Often, the immediate impact of a hazard is that the affected population is diverted to lower service levels and incur in severe health-related risks. Therefore, special attention should be given to these most exposed and vulnerable groups, even more so considering that most hazards tend to become more intense in the coming years due to climate change.

Regarding WASH infrastructure and services, major concern relates to pit latrines, which are used by more than 80% of the population. If forecasts of more concentrated rainfalls leading to more frequent and intense flooding events in the future are correct, resilience of these sanitation solutions must be improved in order to better cope with climate risks. The second aspect relates to service provision. Hazards often lead to fluctuating water levels in networks, which might damage the distribution systems and pumping stations alike, challenging delivery of water services. A third aspect has a financial dimension. Service providers are financially exposed due to a combination of poor revenue collection during and after the occurrence of hazards and increased costs of service provision due to infrastructure damages. Although the Ugandan national government makes resources for rehabilitation available, service providers' capacities to endure hazards should be strengthened to better face emergencies and react timely and properly, without compromising services' sustainability. As for water sources, the analysis shows that shallow wells are particularly exposed to hazards such as drought, water pollution and landslides. This makes them the most vulnerable source of water, followed by protected springs and deep boreholes, which better endure longer dry periods and contamination coming from the surface. Considering that shallow wells serve nearly one out of four Ugandans, special measures should be implemented to ensure both the protection of these sources, so that the sanitary conditions in the affected areas are improved, and redundancy in sources where possible.

The prioritized risks that are the essence of the study's findings constitute the base for the next phase of the work, which consists of proposing climate resilient solutions adapted to the identified concerns. It is recommended that in such process the following aspects are taken into consideration:

- Design and implementation of adapted strategies for the most vulnerable groups of the population: women, children, farmers, among other groups are affected differently by hazards and climate resilient WASH solutions should consider such differences and address the respective challenges.

- Focus on the financial sustainability of service providers: if cost recovery through tariffs is hindered by the occurrence of hazards, emergency response should include timely and adequate support by other actors, so that the effects of hazards over infrastructure are dealt with and service provision is normalized as soon as possible. Assess current levels of cost recovery and identify the extent to which hazards will impact those costs in the future might be needed. In parallel, a vulnerability index including the issue of affordability could be developed to support policy design and prioritization.

- Increasing resilience of WASH infrastructure: considering the high vulnerability of pit latrines and widespread use of this type of facility, it is crucial for adaptation to a scenario of more concentrated rainfalls and increased flooding occurrence that latrines are improved so that the impacts of hazards are minimized. At the same time, alternatives should be evaluated also in terms of mitigation. Facilities at schools and health care centers in the priority areas should be also assessed in detail, so that tailor-made solutions are proposed. On the other hand, redundancy of water sources should be encouraged, especially in the areas affected by drought.

- Further implementation of IWRM principles and tools: the current situation of water sources could benefit from more integrated management approaches, so that the mutual effects of water allocation and land management at basin level are considered in decision-making processes, with better outcomes in terms of tackling water overexploitation and pollution issues. It is also recommended to use a river basin approach for prioritization and implementation of WASH climate resilient solutions, especially those related to the improvement of sanitation facilities, so that their impact can be assessed both in terms of public health and quality of water source.

1. INTRODUCTION

Uganda has historically been hit by hazards of distinct nature, intensity, and range. Heavy rains and drought events, storms, and landslides are some examples of climate related episodes that had and still have a strong impact over almost all economic sectors, regions, and population. Between 2010 and 2014, estimates count for a 3.5% reduction of GDP performance due to disasters[1]. Moreover, non-climate hazards negatively influenced society, economy, and the environment.

Hazards have directly impacted water and sanitation services as well, with estimate losses of 23.8 billion shillings between 2019 and 2020[2] (nearly 7 million USD). Hazards damage water and sanitation facilities, contaminate water sources, and challenge services provision in different ways, which directly impact on access to safe water, sanitation and hygiene, and compromise the population's health and the country's environment. The need to cope with these issues is urgent. New approaches and new strategies are needed to ensure that Uganda is able to secure availability and sustainable management of WASH services for all, thus realizing the human rights to water and sanitation.

Uganda has committed to the United Nations Convention on Climate Change and this commitment has been translated into policymaking aiming at establishing mitigation and adaptation strategies. For the past years, the Government of Uganda (GoU) has reviewed several sector policies, regulations and practices and enshrined in the country's National Development Plan III the adaptation objective of promoting inclusive climate resilient development at all levels. More recently, in order to comply with Article 4 of the Paris Agreement, Uganda has launched a multistakeholder process to update its Nationally Determined Contribution (NDC). The NDC sets mitigation and adaptation targets related to climate change and describes measures to be pursued towards the achievement of these targets. It is noteworthy that the NDC draft pays special attention to the impacts of climate change over the water sector and water-related services, including sanitation. The NDC considers water as the main priority sector for adaptation[3], with special attention given to water, sanitation and hygiene. To support the implementation of NDC targets, the GoU is in the process of elaborating the Third National Communication to the United Nations Framework Convention on Climate Change, the National Adaptation Plan and the Long-term Strategy for Climate Change, among other crucial documents and policies.

In 2020, the GoU also published the National Risk and Vulnerability Atlas of Uganda[4], an important tool for public authorities and other stakeholders to gain understanding of the level and extent of national vulnerability and risk
associated with major natural hazards in the country. In this context, the assessment of climate risks and vulnerability related to water and sanitation comes to be of extreme strategic relevance and is aligned with Uganda's agenda. The underlying rationale for this analysis resides in the fact that WASH systems that are informed by risk assessments will be more resilient and more likely to withstand shocks and stresses caused by climate change.

The present document analyses the characteristics and exposure elements of prioritized hazards that could derive from or be exacerbated by climate change and thus affect the Ugandan WASH sector. It uses the risk assessment methodology of the GWP and UNICEF Strategic Framework for WASH Climate Resilient Development[5]. This methodology is based on a step-by-step participatory assessment procedure, aimed at involving government planners, decision-makers and practitioners responsible for WASH service delivery in Uganda. The methodology serves to set out the rationale and concepts for WASH climate resilient development, as well as improve understanding of how to ensure that climate resilience is considered in WASH strategies, plans and approaches.

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[1] Government of Uganda (2019) National Risk and Vulnerability Atlas of Uganda, p. iv.

[2] Government of Uganda (2020) Annual State of Disaster Report.

[3] Government of Uganda and UNDP (2021) Updated Nationally Determined Contribution (NDC) Draft version.

[4] Government of Uganda (2019) National Risk and Vulnerability Atlas of Uganda.

[5] GWP and UNICEF (2017). *WASH Climate Resilient Development. Guidance Note. Risk Assessments for WASH.* Global Water Partnership and UNICEF.

Gathering relevant information from different sources, this document provides evidence (i.e., data and knowledge) for the climate risk and vulnerability assessment. The next section presents methodological aspects of the analysis conducted herein. Each step of the assessment (hazard characterization, exposure, and vulnerability) and the respective validation and scoring procedures are described. The third part of the document is dedicated to the analysis and characterization of the most relevant hazards in Uganda. The fourth section discusses the main elements exposed to climate hazards (e.g., specific population groups, critical water and sanitation infrastructure, and water sources) and presents the exposure indicators for their assessment. In the fifth section, vulnerability is analysed based on six different components (social, financial, physical, environmental, human, and political) and also scored. Section six presents prioritised hazards, which are then comprehensively discussed in the seventh section. The conclusion summarizes main findings and recommendations. In the annex, more detailed information that supported the whole analysis is included.

2. METHODOLOGY

A climate risk assessment aims at determining the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, including specific groups. The focus of this exercise is on main impacts of climate risks on water and sanitation infrastructure and services, including water sources. It applies the methodology proposed by GWP and UNICEF[6], in which risks result from the interaction of hazard, vulnerability, and exposure. Capacity also influences risk: high capacity reduces risk while low capacity does not[7].

Table 1: key definitions

Hazard	Exposure	Vulnerability	Capacity
The term hazard can be defined as "a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage".	The term exposure can be defined as "people, property, systems or other elements in places or settings that could be adversely affected by hazards and that are thereby subject to potential losses".	The term vulnerability can be defined as "the characteristics and circumstances of a community, system or asset that make them susceptible to the damaging effects of hazard". There are many aspects of vulnerability, arising from various social, physical, economic, and environmental factors.	The term capacity includes "infrastructures and physical means, institutions, societal coping abilities, as well as human knowledge, skills and collective attributes such as social relationships, leadership and management". Capacity is the ability to prepare, respond, recover, and learn.

Source: GWP and UNICEF (2017)

Therefore, the methodology assesses separately hazard, exposure, and vulnerability, and then bring these aspects together to provide an overall scoring of risks[8], according to the following risk formula:

Risk = Hazard x Exposure x Vulnerability

In terms of method, the analysis has been conducted through a desk review exercise, which has then been improved, fine-tuned, and validated through a set of participatory workshops with the Climate Task Force (CTF), a group of sector stakeholders representing main water-related institutions and organizations in Uganda, such as the Ministry of Water and Environment, UN agencies (UNICEF, UNDP, UNCDF), networks of experts (Global CAD), and independent consultants (see Annex 2).

In detail, the step-by-step approach is shown in Figure 1 and briefly outlined below.

[6] GWP and UNICEF (2017), op. cit.

[7] For simplicity purposes, capacity is not included in this analysis.

[8] Capacity is not included in this first part of the exercise, but assessed separately when identifying and appraising solutions to address prioritized risks

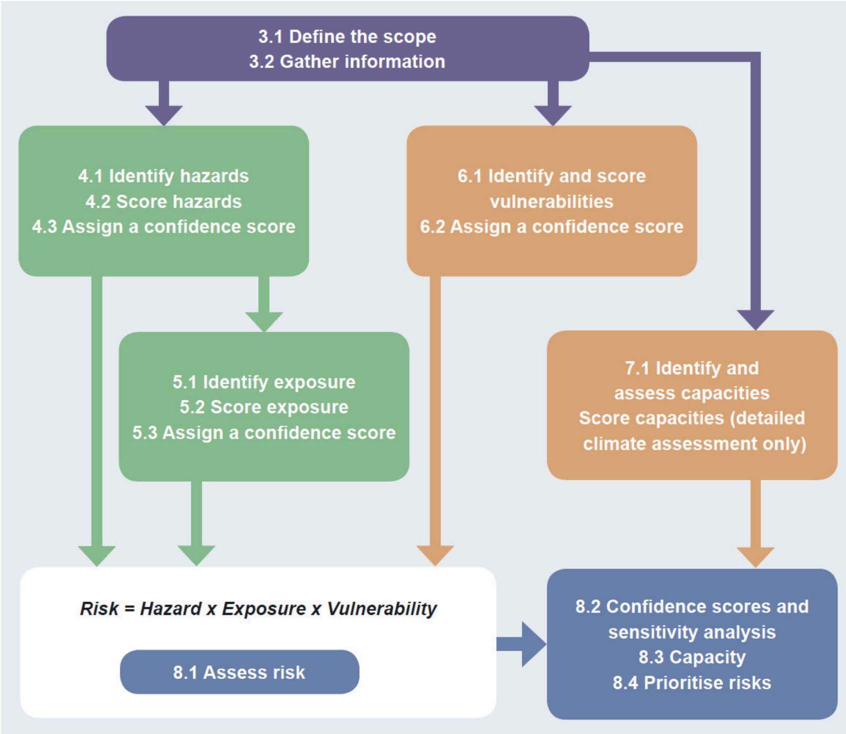

Figure 1 Assessment approach in detail. Source: GWP and UNICEF (2017)

2.1 Hazards assessment

The first step in the analysis was the characterization of hazards that affect the WASH sector, which is based on an assessment of their main features, according to the table below.

Table 2: description of analysed features for hazards

Feature	Description
Frequency	The frequency of the hazard includes details on how the hazard is expected to change in the future: • How frequently the hazard has occurred in the past (with historical trends) • How the frequency of the hazard is expected to change in the future
Duration	Describes how long the hazard lasts: • How long the hazard typically lasts (with historical trends) • Whether duration of the hazard is likely to decrease or increase in the future due to climate change
Intensity	Describes the magnitude of the hazard, i.e., if flooding is identified as a hazard, is it shallow, slow moving flood water; or deep, fast-moving flood water: • Magnitude of the hazard • Historical/current and future intensity changes due to climate change
Geographical extent	Describes the extent of the geographical area affected by the hazard: • Historical and current extent of the geographical area affected by the hazard • Future projections of changes in geographical extent affected by the hazard
Time of year	Describes whether the hazard occurs at a particular time of year – for example, during the wet seasons: • Whether hazard occurs at a particular time of year • Whether current/historical time of year is projected to change due to climate change

Source: GWP and UNICEF (2017)

In the next step, all prioritized hazards were scored. The way to do this is to consider the main characteristics of each hazard and provide a simple scoring chart so that they can be easily scored using a traffic light system. In Uganda, first focus was on determining the geographical extent of all hazards, as shown in Table 3 below.

Table 3: classifying hazards – example for present day and expected future geographical extent

Class	GEOGRAPHICAL EXTENT		Score
	Present day frequency	Expected future frequency	
High	Affects a large area	Expected to continue to affect a large area or an even larger area	3
Medium	Affects a small area	Expected to affect a larger area	2
Low	Not a problem	Not expected to increase	1

Second, each hazard was scored based on one further characteristic or two, depending on available data. For each characteristic or combination of characteristics, a simple classification is defined so that a specific score can be assigned. Figure 2 shows the scoring system based on frequency and intensity, while a scoring system based on frequency and intensity, for both the present day and the expected future, is given in Table 4. This scoring mechanism was adopted for the scoring of drought, flooding and landslide. For the scoring of degradation, water pollution, and water overexploitation, only intensity was used, for both present-day and expected future occurrence.

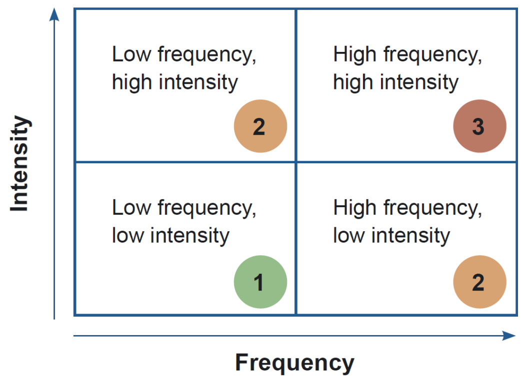

Figure 2 scoring system based on frequency and intensity

Table 4: classifying hazards according to frequency and intensity, for present day and expected future

Class	FREQUENCY AND INTENSITY		Score
	Present day frequency and intensity	Expected future frequency and Intensity	
High	High frequency, high intensity	High frequency, high intensity	3
Medium	High frequency, low intensity	High frequency, low intensity or high frequency, intensity expected to increase	2
Medium	Low frequency, high intensity	Low frequency, high intensity or expected to occur more frequently, high intensity	2
Low	Low frequency, low intensity	Low frequency, low intensity or not expected to occur in the future	1

Finally, the arithmetic mean of criteria 1 (geographical extent) and criteria 2 (Frequency & Intensity / Intensity) was computed to obtain the final score for each hazard.

2.2 Exposure assessment

After characterizing hazards, the second step of the methodology was the exposure analysis. Exposure levels and characteristics being different for the different hazards, each one of them was analysed according to the set of features listed in Table 5. In terms of geographical scope, the analysis focused on those areas previously identified as the most affected or prone to each hazard:

Table 5: description of analyzed features for exposure

Feature	Description
Population	Describe how each hazard affects particular groups of the population • How each hazard affects specific groups of the population both currently/historically • How groups of population are expected to be affected in the future due to climate change
WASH infrastructure	Describe how WASH infrastructure is affected by each hazard • How WASH infrastructure is affected by each hazard both currently/historically • How infrastructure is expected to be affected in the future due to climate change
Water sources	Describe how and if the hazard affects water sources • How and if the hazard affects water sources both currently/historically • How infrastructure is expected to be affected in the future due to climate change
Other	Describe any other types of assets in the area

Source: adapted from GWP and UNICEF (2017)

The methodology aimed at identifying separately the exposure of all hazards, considering that hazards may have different exposures in different settings (i.e., countries, regions, etc.), as shown in Table 6. It is observed, for instance, that flooding affects population and critical infrastructure (latrines) in country A; while in country B, it affects critical infrastructure (latrines). Similarly, fluoride affects population and water sources in both countries. However, it only affects primary water sources in country B.

Table 6 Examples of hazards and their exposures for two countries

Country A		Country B	
Hazard	**Exposure**	**Hazard**	**Exposure**
Flooding	Population	Flooding	Critical infrastructure – latrines
Flooding	Critical infrastructure – latrines	Fluoride	Population
Fluoride	Population	Fluoride	Water sources, including primary
Fluoride	Water sources, not primary	Political instability	Population
Political instability	Population	Cryptosporidium	Water sources
Cryptosporidium	Water sources	Cryptosporidium	Population
Cryptosporidium	Population	Desertification	Population
		Desertification	Water sources

Source: GWP and UNICEF (2017)

In addition, exposure elements can be assessed in relation to six different components, as described in the next Figure.

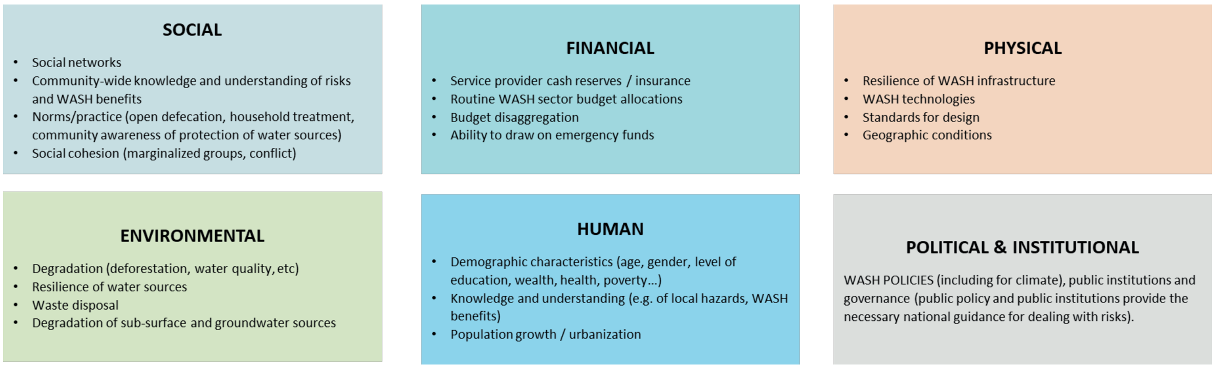

Figure 3: description of six components of exposure. Source: adapted from GWP and UNICEF (2017)

The linkages between exposure elements and these six components are shown in the table below.

Table 9: guidance for matching exposure and component levels

Exposure	Most likely component among the 6 to choose from
Population	Human / Social
Critical infrastructure – latrines	Physical / Financial / Institutional
Water sources	Environmental / Institutional /Political

Source: adapted from GWP and UNICEF (2017)

To score exposure, some indicators were defined (see some examples in Table 8 for four of the components). Indicators may cover all six components, or they may only cover one or two of the components. For example, a hazard may affect water sources only, so will therefore only cover the environmental component. In addition, there may be more than one exposure for some of the hazards, and they need to be recorded separately. Other hazards may have the same exposure, but these would also be recorded and scored separately. By way of example, population might be recorded as an exposure for both droughts and degradation.

Table 7: possible indicators of exposure to help scoring

Component	Possible indicators of exposure
Physical	Percentage of critical infrastructure affected
Environmental	Number of water sources affected Percentage of a certain land type affected
Human	Percentage of population affected Number/percentage of communities disrupted/affected
Financial	Percentage of GDP Income from livelihoods according to sector, e.g. agriculture, fishing, etc.

Source: GWP and UNICEF (2017)

Finally, in order to come up with a score for each exposure, simple scoring classification systems were developed (see Table 8). Since individual voting by participants for all indicators was proposed, an average value was computed. However, one important aspect to review was the confidence level of the final score, and the level of consensus among participants. By applying a simple rule[9], it was proposed to remove all exposure indicators showing low level of consensus or low confidence.

[9] A low confidence level is assigned when less than 70% of responses score "High" and "Medium" or "Medium" and "Low", which happens when a significant number of responses are obtained for both "Hight" and "Low" exposure.

Table 8: possible classification of exposure

Component	High	Medium	Low
Physical	>20% of critical infrastructure affected	5–20% of critical infrastructure affected	0–5% of critical infrastructure affected
Environmental	>20% of water sources affected	5–20% of water sources affected	0–5% of water sources affected
Human	>5% of population affected	0.5–5% of population affected	<0.5% of population affected
Financial	Costs – major damage and disruption	Costs – moderate damage and disruption	Costs – minor damage and disruption

Source: GWP and UNICEF (2017)

2.3 Vulnerability assessment

The third step in the methodology was the assessment of vulnerability, from a WASH perspective. While vulnerability is in general hazard-specific, certain factors, such as poverty, education, and the lack of social networks and social support mechanisms, will aggravate or affect vulnerability levels irrespective of the type of hazard. The analysis therefore focuses on the “underlying causes of vulnerability” and considers the six main components defined in previous section: human, social, physical, financial, political, and environmental. A very important issue here is inequity: more vulnerable groups are generally more exposed and more affected by hazards of any sort.

The vulnerability assessment was conducted in a participatory way, using tools, approaches, and questions adapted from the GWP and UNICEF Guidance Note. As an example, the Table below shows the list of different vulnerability factors that can be assessed in relation to the Social component (similar tables are available for the rest of components). For each of the factors, there is a number of elements and questions to consider and assess. All these tables have been adapted to the Ugandan context.

Table 8: possible classification of vulnerability

Social		
Factor	Element	Question
Social networks (access to social networks such as informal social safety nets)	Access to social networks	Is there adequate access to social support networks such as informal social safety nets?
Community-wide knowledge and understanding of risks and WASH benefits	Community-based risk assessments	Are there any community-based risk assessments?
	Engagement in early warning systems	Is there sufficient engagement in early warning systems?
Norms/practice	Open defecation	What is the level of open defecation/ use of improved toilets?
	HWTS	What is the level of safe household water treatment and safe storage?
	Community awareness of protection of water sources	Is there good awareness in communities of the need to protect water sources?
Social cohesion	Conflict	Are there (strong) conflicts between different groups / community members?
	Marginalised groups	Are there marginalised groups / population?

Source: GWP and UNICEF (2017)

For the assessment, the aim was to get a single score of 1, 2 or 3 for each component, depending on whether the vulnerability is low, medium, or high. In order to promote common understanding among participants in relation to what the scores should be, a scoring system can be used for the elements or questions used for each of the factors. Examples of scoring systems are given in Table 9. For some of the factors it may be possible to assign quantitative thresholds that define the ranges of high, medium, and low; however, this will depend on the type of factor and available information. The final score of each component is given by the average of the scores assigned to all related factors.

Table 9: examples of vulnerability scoring systems for the Social component

Social: social networks such as informal social safety nets	Social: community-wide knowledge and understanding of risks and WASH benefits	Social: community-wide knowledge and understanding of risks and WASH benefits
Is there adequate access to informal social safety nets? ■ High: there is limited access to social networks ■ Medium: there is some access to social networks ■ Low: there is good access to social networks	Are there any community-based risk assessments? ■ High: there are very few or no community-based risk assessments ■ Medium: there are some community-based risk assessments ■ Low: there are many community-based risk assessments	Is there sufficient engagement in early warning systems? ■ High: there is limited engagement in early warning systems ■ Medium: there is some engagement in early warning systems but this could be improved ■ Low: there is sufficient engagement in early warning systems

Source: GWP and UNICEF (2017)

2.4 Risk prioritization

The last step in the methodology combines hazard, exposure, and vulnerability to come up with an overall score for risks, according to the standard risk formula:

Risk = Hazard x Exposure x Vulnerability

These scores were then used to rank the risks to determine priorities, identifying which of the risks need to be taken forward to the next discussion about appraisal of climate solutions. Some examples of risk are provided in the next Table. The risk column shows the overall score of country X, while the rank column can be used to order the risks. In this example, the top scoring risks are:

- flooding of latrines, considering the financial vulnerability component
- fluoride affecting water sources, considering the environmental vulnerability component
- political instability affecting the population, considering the human vulnerability component
- cryptosporidium in water sources, considering the environmental vulnerability component.

The risks have been reordered (according to rank). In addition, a threshold has been applied to determine which should be taken forward to the identification and appraisal options. The threshold used in this example is rank four – i.e. all of those that fall within ranks one to four.

Table 10: examples of vulnerability scoring systems for the Social component

Hazard		Exposure		Vulnerability		Risk score	Rank
Description	Score	Description	Score	Description	Score		
Flooding	3	Critical infrastructure – latrines*	3	Financial	2	18	1
Fluoride	2	Water sources, including primary	3	Environmental	3	18	1
Political instability	3	Population	3	Human	2	18	1
Cryptosporidium	2	Water sources	3	Environmental	3	18	1
Cryptosporidium	2	Population	3	Human	2	12	2
Flooding	3	Critical infrastructure – latrines*	3	Physical	1	9	3
Fluoride	2	Population	2	Human	2	8	4
Flooding	3	Critical infrastructure – wells	1	Financial	2	6	5
Flooding	3	Critical infrastructure – wells	1	Physical	1	3	6
Desertification	1	Water sources	1	Environmental	3	3	6

**Exposure has more than one vulnerability component to consider*

Source: GWP and UNICEF (2017)

3. HAZARDS

This Section focuses on the analysis of hazards. As proposed by UNISDR, the term hazard can be defined as "a dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage"[10].

Based on a comprehensive review of climate hazards in Uganda, an initial list was identified and then prioritised by the Climate Task Force, taking into consideration the potential impact of each hazard on the WASH sector. The prioritised hazards are briefly outlined in the following table.

Table 12: Short description and rationale for prioritized hazards

Hazard	Description / High level rationale
Drought	Meteorological drought is the most pronounced type of drought in Uganda. Depending on rainfall deficiencies and duration, drought intensities range from extremely wet conditions to extremely dry. Several regions of the country endure moderate, severe, and extreme drought events. **High level rationale**: Drought caused by low rainfall can lead to less water resources availability and therefore exacerbate water stress and scarcity. It also increases the demand on water services and thereby builds up more stress on WASH infrastructure. Higher temperatures due to climate change might exacerbate the effects of drought.
Flooding	Depending on rainfall, land cover, soil porosity and other factors, flooding episodes can occur in different parts of the territory, especially in areas close to large water bodies and during the wet seasons. Densely populated and mountainous areas are at risk from more intense flood episodes. **High level rationale**: Flood is linked to heavy or longer durations of rainfall, soil sealing and loss of riparian vegetation. It might damage WASH infrastructure, especially sanitation, making it temporarily or permanently non-functional, leading to lower service levels and to contamination of drinking water sources, increasing the risk of waterborne diseases. Climate change might exacerbate the consequences of flooding.
Landslide	Landslides can be triggered by heavy rainfalls, earthquakes, volcanic activities, among other natural or man induced factors. Landslides' speed is affected by slope and water quantity. The areas that are normally more prone to landslides are steep hills, mountains, and other landscape figures of sharp downward slopes. **High level rationale**: Climate change is likely to alter slope and bedrock stability through changes in precipitation and temperature. This could lead to increased land/mud slides, rockfalls which could damage WASH infrastructure and pollute water resources.
Water pollution	Water resources pollution occurs when harmful substances – often chemicals or microorganisms – contaminate a stream, river, lake, aquifer, or other water body. It is a growing concern Uganda, especially due to industrial and urban discharges and poor sanitation conditions. **High level rationale**: Climate change might worsen water quality due to changes in precipitation patterns, higher temperatures, and evaporation, which are factors that increase contaminants concentration.
Land degradation (including riverbank erosion)	Land degradation is the reduction or loss of the biological or economic productivity and complexity of soil resulting from natural processes or human activities. An indicator of the intensity of land degradation is erosion. Nearly half of Uganda is affected by severe land degradation characterized by soil erosion and nutrient depletion. **High level rationale**: Climate change features, such as more concentrated rainfalls and higher temperatures, together with poor land management might increase degradation in the future.
Water overexploitation	Overexploitation occurs if a water resource is used and extracted at a rate that exceeds its recharge capacity. Although Uganda is reputedly well endowed in water resources, there are several areas of

[10] UNISDR (2009) UNISDR Terminology on Disaster Risk Reduction.

	water stress, where water demand is superior to offer. **High level rationale**: Climate change might exacerbate water stress and scarcity, through changes in precipitation patterns, higher temperatures, and evaporation. Population growth will increase demand for drinking water, and together with other users (e.g., agriculture, industry, and electricity), will put more stress on already low availability of water resources.
Earthquake[a]	Earthquakes are seismic waves provoked by the sudden release of energy in the Earth's crust and manifest themselves at the surface by shaking and sometimes displacement of the ground. Uganda lies within two of the most active seismic epicentres of East Africa and has experienced events in recent years. **High level rationale**: If triggered by geological forces, earthquakes will be less influenced by climate change than other hazards. Nevertheless, its occurrence could have catastrophic consequences over WASH infrastructure.
Windstorm[a]	Wind is the perceptible air movement and windstorms are strong wind events. Its intensity and geographical occurrence change in the different seasons. Several regions in Uganda are affected by windstorms, especially in the Eastern and Western regions and around Lake Victoria. **High level rationale**: Higher temperatures and changes in precipitation patterns provoked by climate change might increase frequency and intensity of windstorms. Nevertheless, the impacts of its occurrence over the WASH sector are less pronounced than those of other hazards.
Hailstorm[a]	Hail is a form of solid precipitation that consists of balls or irregular lumps of ice measuring between 5 mm and 15 cm in diameter. Broadly, hailstorms occur at the beginning of the wet seasons and close to large water bodies. 75,300 km^2 of the country's surface is prone to hailstorms. **High level rationale**: Hailstorm events might be exacerbated by climate change, especially by higher temperatures and changes in precipitation patterns. It might affect WASH infrastructure, both in urban settings and rural areas.
Lightning[a]	Lightning happens when electrical discharges occur from a charge centre in a cloud either to the induced charge on the earth, to the charge centres of the same or of another cloud. Uganda has one of the highest rates of lightning strike deaths in the world. **High level rationale**: Higher frequency and intensity of lightning could be the consequence of climate change. Nevertheless, its effects over the WASH sector are less pronounced than those of other hazards.
Note: a) Despite the potential impact of this hazard on WASH facilities and services in Uganda, these hazards were not prioritised and are therefore analysed together.	

All prioritized hazards are briefly outlined in following sections, and key climate aspects are analysed and presented in a synthesis table: frequency, intensity, duration, geographical extent, and time of year.

3.1 Drought

Drought is defined as a condition of insufficient moisture caused by a deficit in precipitation over some time period[11]. The National Risk and Vulnerability Atlas of Uganda (henceforth Atlas) defines it as a recurrent feature of climate that occurs when there is an extended period of abnormal deficiency in precipitation (relative to what is considered normal). Among the different types of droughts, Uganda being an agrarian country, meteorological drought is the most pronounced, characterized by rainfall deficiencies (15% less than the annual average of 1,168 mm), reduced soil moisture and water supplies[12]. A zonation of the probability of intense drought events in the different regions was established using available data on precipitation, resulting in intensities ranging from extremely wet to extremely dry. For the purposes of this document, only intensities of moderately dry, severely dry and extremely dry are considered. Table 5 below provides a zonation of the

[11] McKee TB, Doesken NJ, Kleist J. (1993). The relationship of drought frequency and duration to time scales. In Preprints, 8th Conference on Applied Climatology, 17–22 January, Anaheim, CA; 179–184.

[12] Government of Uganda (2019) National Risk and Vulnerability Atlas of Uganda, p. 27.

probability of moderate to extreme drought events in the country. The red, orange, and yellow areas indicate very high, high, and moderate probability of occurrence, respectively.

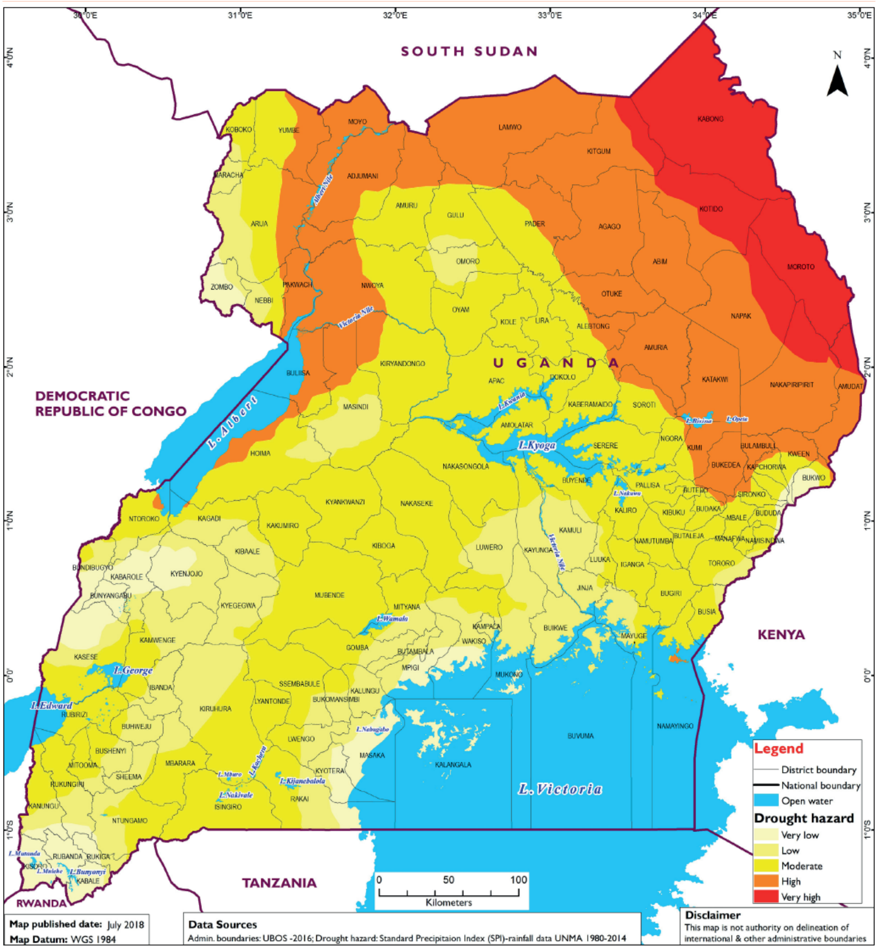

Figure 4 Integrated drought hazard zonation map. Source: (Atlas, p. 31)

Seasonality is a very important factor in the assessment of drought hazard. Its frequency, duration, intensity, and geographical extent vary extremely in the different times of the year. Shorter droughts tend to occur in the months of December, January, and February; while the long events are experienced in June, July, and August. Since this pattern might change in the different regions, detailed information on affected areas in each period is provided in the annex. Generally, the droughts experienced in Uganda can be categorized into the 4 seasons:

Table 13: Seasonality of droughts in Uganda.

N°	Seasons	Months	Remarks
1	Short dry season	December, January, February	All regions in Uganda
2	Short wet season	March, April, May	All regions in Uganda
3	Long dry season	June, July, August	Wet in Northern Uganda
4	Long wet season	September, October, November	All regions in Uganda

Source: National Risk and Vulnerability Atlas of Uganda, p. 27

Almost the whole territory is susceptible to drought events. Nevertheless, the Northern (specially the Northeast), the Eastern and Western regions are most susceptible to severe events (special attention to the North, which is very exposed to drought hazards of high and very high intensities). The most drought prone districts are located in the Karamoja subregion and include Kaabong, Moroto, Kotido, Napak, Amudat, Nakapiripirit and Kitgum (in Acholi sub-region).

Additional information on duration, frequency and intensity of drought events has been also found in the literature. Najjuma et al. (2021)[13] analyse the incidence of drought events in Bukomansimbi and Mubende, in the Central region of the country, and provide historical information on the duration and intensity of the events. They show that events last generally from 1 to 4 months, with a peak of 22 months in the long drought of 2005-2007. Even though patterns change geographically, this information might be used as a proxy for the other regions.

Mulinde et al. (2016)[14] analyse drought incidence for the whole territory and, using a similar methodology of that of the Atlas, establish a zonation of drought prone areas. Although the results are slightly different, both studies coincide that the North-eastern and Western regions are very sensitive areas. They indicate also that it takes approximately 12,5 years for all drought prone zones to experience events simultaneously, while the average drought event interval in any drought prone zone is 1-6 years with an average dominancy in occurrence of 1 year. This oscillation of events coincides with El Niño and La Niña episodes. According to the authors, there was an increase in drought events in the country, both in frequency and intensity, recurring at an interval of 10 to 15 drought events per 5-years, where the deficit in rainfall has increased hence precipitation becoming more often classified as 'much below normal' than 'below normal'.

The trend for the future is reflected in the high uncertainty in onset and cessation of rainfall seasons. Depending on source and climate change scenario, results are often different and even contradictory[15]. While some projections indicate that precipitation averages are expected to decrease, others foresee an increase in some areas of the country (western shores of Lake Victoria, central western region, Mount Elgon region, and the region extending from Mount Rwenzori to the southern parts of Lake Kioga), with deceases in others (the northern and north-eastern areas)[16]. Models consistently project overall increases in the proportion of rainfall that falls in heavy events[17], i.e., more concentrated rainfall patterns[18]. Nevertheless, warmer temperatures (more hot days and nights and less cold days and nights) could accelerate the rate of evapotranspiration and reduce potential benefits of increased rainfall. Despite differences in projections, drought events are expected to become more frequent and more intense, especially in the already arid and semiarid areas, affecting the availability of surface water and groundwater. The annex provides more information on precipitation patterns and possible trends.

3.1.1 Characterization of drought

The next table provides a synthesis of the most relevant features of droughts as climate hazard in Uganda.

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[13] Najjuma et al. (2021). Characterization of Historical and Future Drought in Central Uganda Using CHIRPS Rainfall and RACMO22T Model Data. In. International Journal of Agriculture and Forestry 11(1) 9-15. Available at http://article.sapub.org/10.5923.j.ijaf.20211101.02.html.

[14] Mulinde et al. (2016). Meteorological drought occurrence and severity in Uganda. In. Disasters and climate resilience in Uganda: processes, knowledge and practices. Edited by Nakileza et al., Kampala. Available at https://www.researchgate.net/publication/316701990.

[15] GoU (2021) Updated NDC Draft 1.0.

[16] World Bank (2021) Climate Risk Country Profile Uganda, p. 13.

[17] According to http://www.inpe.br/webelat/homepage/menu/infor/tempestades/tipos.php, the occurrence of tempests is more frequent in the afternoon (4 to 6 pm). In mountainous regions, this peak tends to occur earlier (around 1pm).

[18] McSweeney et al. (2010) UNDP Climate Change Country Profiles Uganda.

Table 14: Characterization of drought

HAZARD: Drought	
Frequency	According to available information, 10-15 events occur per 5 years in average. It takes 1-6 years (1 year in average) for an event to occur in any of the prone regions and 12,5 years for an event to occur simultaneously in the majority of the prone regions. Studies indicate that drought frequency is increasing[19] and is expected to increase even more in the future[20].
Duration	Over the past 20 years, longer-lasting drought conditions have been experienced in several regions (Western, Northern and North-eastern)[21]. According to the study by Najjuma et al. (2021), since 1980 droughts have lasted from 1-4 months in Central Uganda (peak of 20 months in the drought of 2005-2007). This data can be used as a proxy for other regions.
Intensity	Historically, Uganda has suffered from drought hazards of moderate, severe and extreme intensities (prevalence of moderate events, according to available data), although intensity varies drastically in the different regions and seasons. The intensity classification is normally based on the precipitation index (in some cases, duration is also considered) and is measured as a function of the deviation from the average. The annex provides more information on this aspect. Projections indicate a tendency of increased drought intensity, especially in the already arid and semiarid areas[22]. For 87% of Ugandans, drought has gotten "somewhat" or "much" more severe[23].
Geographical extent	Drought affects virtually all climatic zones, but its characteristics and impact differ from one region to another. 40% of the territory is moderately susceptible, 25% is highly susceptible and 7% is very highly susceptible to droughts. The most drought prone regions in the order of severity include Northern, Eastern and Western regions. The most drought prone districts are in the Karamoja subregion and include Kaabong, Moroto, Kotido, Napak, Amudat, Nakapiripirit and Kitgum[24]. Some studies suggest increased rainfalls in some areas (Center and South) and decreased rainfalls in others (North and Northeast)[25].
Time of year	Drought events occur the whole year round in the different regions of the country. Seasonality affects the incidence of drought events drastically: - December to February: Moderate / Severe (Lake Victoria, North and West) - March to May: Moderate (East) and Severe / Extreme (North) - June to August: Moderate (Centre) and Severe (whole territory except North) - September to November: Moderate (Centre) and Moderate / Extreme (North) Changes in the seasonal rainfall incidence are expected and will impact the occurrence of droughts.

3.1.2 Scoring drought

Two different scorings were proposed. First scoring focused on the geographical extent, while second included frequency and intensity. The following tables were employed for the scoring of droughts, according to these characteristics, for present day and expected future. The table shows the results of the assessment, which was conducted through simple voting system. For each scoring, values for high – medium – low classification indicate the number of Climate Task Force members that score that option.

[19] Mulinde et al., op. cit.

[20] WB, op. cit., p. 13.

[21] WB, op. cit., p. 6.

[22] WB, op. cit., p. 13.

[23] Msafiri D. and Makanga R. (2019) Afrobarometer Dispatch No. 303. Available at https://afrobarometer.org/sites/default/files/publications/D%C3%A9p%C3%AAches/ab_r7_dispatchno303_climate_change_makes_life_worse_in_uganda.pdf.

[24] GoU, Atlas, p. 31.

[25] WB, op cit., p. 13

Table 15: Classifying and scoring droughts for present day and expected future geographical extent

Class	GEOGRAPHICAL EXTENT		Score	No. votes
	Present day frequency	Expected future frequency		
High	Affects a large area	Expected to continue to affect a large area or an even larger area	3	7
Medium	Affects a small area	Expected to affect a larger area	2	2
Low	Not a problem	Not expected to increase	0	0

Table 16: Classifying and scoring droughts according to frequency and intensity, for present day and expected future

Class	FREQUENCY AND INTENSITY		Score	No. votes
	Present day frequency and intensity	Expected future frequency and Intensity		
High	High frequency, high intensity	High frequency, high intensity	3	5
Medium	High frequency, low intensity	High frequency, low intensity or high frequency, intensity expected to increase	2	4
Medium	Low frequency, high intensity	Low frequency, high intensity or expected to occur more frequently, high intensity	2	0
Low	Low frequency, low intensity	Low frequency, low intensity or not expected to occur in the future	1	0

3.2 Flooding

Flood is defined as a temporary overflow of water onto land that is normally dry. It can happen during heavy rains[26], when snow melts quickly, when dams break, when see comes to shore or water bodies overflow. According to the Atlas, flood in Uganda can be characterized as riverine and flash floods. Riverine floods are caused by overflowing of rivers, while a flash flood is caused by sudden, excessive rainfall that exceeds the ability of the ground to absorb it. As it combines the destructive power of a flood with high speed, flash flood is the most dangerous type. Areas near water bodies are at risk from flood. Densely populated and mountainous areas are at risk from flash flood, because of increased runoff rates caused by soil sealing and hills steepness. Although flood's triggering factor is natural (heavier rainfalls than usual), other factors that might induce its occurrence include clearing of riparian vegetation, gravel extraction in the river channel, urban soil sealing, etc.

Flooding has various adverse social, economic and environment consequences, such as life losses, people displacement, health damages, destruction of houses, roads and other infrastructure, lower crop yields. Each year, the impact of floods in Uganda is estimated at USD 62million in GDP, directly affecting 50,000 people, and between 1993-2018, flood had destroyed 65,458 houses[27]. Its occurrence has affected the WASH sector directly. In most parts of the territory, floods contaminated water sources, submerged safe water points and

[26] According to http://www.inpe.br/webelat/homepage/menu/infor/tempestades/tipos.php, the occurrence of tempests is more frequent in the afternoon (4 to 6 pm). In mountainous regions, this peak tends to occur earlier (around 1 pm).

[27] ASDR (2020), p. 6.

filled and washed away pit latrines. Protected springs and deep boreholes were also affected by flood episodes. A flood episode in 2013 affected two piped water supply systems for Kilembe mines and Kasese Municipality, 817 latrines and one sewage treatment unit[28]. Following flood events, access to safe water becomes a challenge and sanitation is compromised with people having no alternative but to opt for open defecation[29]. Poor sanitation and lack of access to safe water increase the risk of water-borne diseases, like cholera.

Generally, floods occur in the wet seasons, especially in the months of April-May and September-November of each year. They can last for a few hours or even days. The Atlas reports the case of a flash flood in the Rwenzori sub-region that had a peak of 3 days. Sometimes the same district is hit by floods twice within a year. In the Kasese District for instance, heavy rainfalls caused flooding episodes in May 2021 and November 2020. In this case, exposed areas in both episodes did not coincide[30]. Flood related disasters have reportedly increased in recent years. Nevertheless, for 88% of Ugandans, flood intensity did not change in the past years[31]. This apparent discrepancy might be the consequence of more information being currently available than it used to be, and also of flood frequency being so high, that affected people only consider floods to be the events with a water depth above the knee[32].

Flood intensity can be measured in terms of depth, speed, duration, and content of debris. Using the depth criteria, the Atlas defined flood inundation areas in 17 watersheds for different return periods of 5, 10 and 50 years. Flood depths for the inundated areas were categorized into a flood intensity scale (<0.5m; 0.5-1.0m; 1.0m-1.5m; 1.5m-2.0m; >2m). Deeper flood extents tend to be larger in long-term return period compared to short-term return period, which is a reflection of the risk phenomenon, i.e., the most devastating extreme events occur less frequently. The Northern and Eastern regions are the most flood prone areas in all three return periods. The figure below presents a flood zonation map that integrates the results for the three return periods.

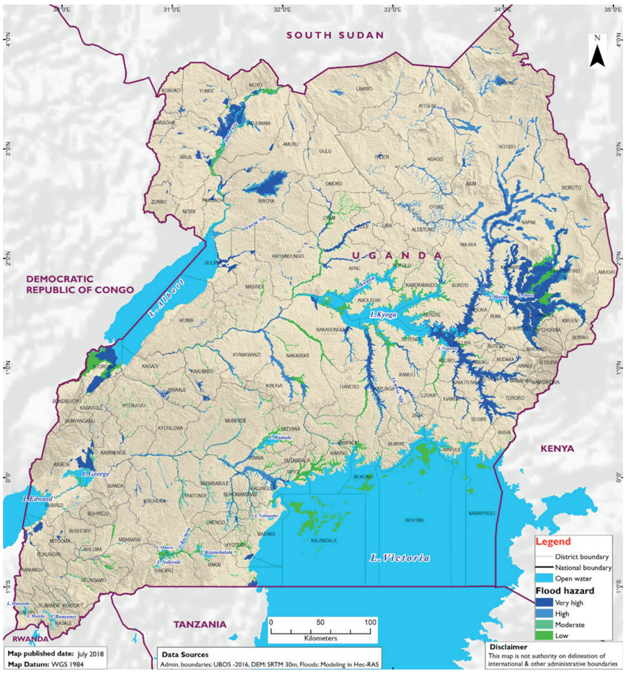

Figure 5 Integrated flood hazard zonation map of Uganda. Source: Atlas, p. 38.

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[28] IFRC (2014) DREF Preliminary Final Report Uganda: Kasese Floods. Available at: https://www.ifrc.org/en/publications-and-reports/

[29] ASDR (2020), p. 27.

[30] According to https://floodlist.com/tag/uganda

[31] Msafiri and Makanga (2019), op. cit.

[32] Cecinati, Francesca (2013) Precipitation Analysis for a Flood Early Warning System in the Manafwa River Basin, Uganda. MIT Department of Civil and Environmental Engineering. Available at https://core.ac.uk/download/pdf/18321903.pdf

Flood prone areas in Uganda are generally located alongside rivers and major water bodies, seasonal and permanent wetlands, and low-lying areas. At the regional level, the eastern and northern regions are more prone to floods of more than 1m depth. According to the Atlas, the districts prone to floods of more than 2.0m depth include: Pallisa, Bulambuli, Butaleja, Kibuku, Ntoroko, Ngora, Katakwi and Bukedea. The Teso and Bugisu areas are more likely to suffer from destructive floods them the other regions of the country. Historically, Lake Kyoga is one of the worst flood affected regions. Floods in the Rwenzori area[33] and in Kampala[34] are also common. In the Northern region, winter is the rainy season. That is why the flood prone period for this part of the country comprises the months from June to August. The figure below shows the flood prone areas of each region of the country in the 10-year return period (potentially impacted areas vary only slightly in the three return periods).

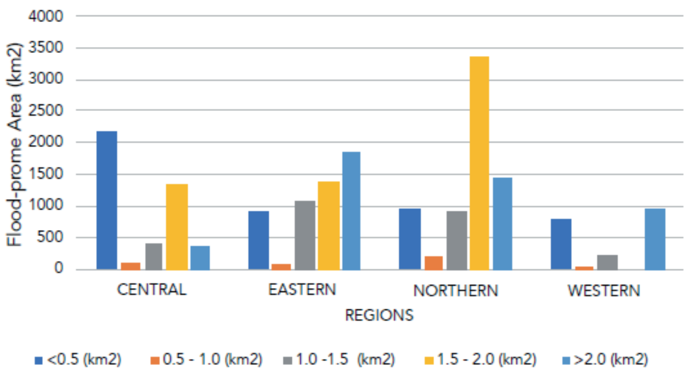

Figure 6 Flood prone area of each region. Source: Atlas, p. 35

There is very strong model agreement that mean annual precipitation, runoff, precipitation during extreme storm events, and precipitation intensity will increase in Uganda. Despite models' uncertainty, some of the largest increases will likely occur in months that already receive substantial rainfall (e.g., April and October). Most climate models project that the months outside summer (June-August) could also experience precipitation increases[35]. If forecasts are correct, precipitation increases will have a direct impact over intensity, duration, and frequency of flood hazards. Nevertheless, even in areas where average precipitation might decrease, flood events could become more intense because of higher rainfall peaks, loss of land cover, soil porosity and urban soil sealing.

3.2.1 Characterization of flooding

The next table provides a synthesis of the most relevant features of flooding as climate hazard in Uganda.

Table 17: Characterization of flooding

HAZARD: Flooding	
Frequency	Floods occur every year, in both wet seasons. Sometimes, the same district is hit twice by flood episodes within the same year. Considering projections of increased rainfalls for the future, flood frequency is expected to increase.
Duration	Floods last generally for several hours but can last longer depending on the intensity (3 days peak period reported for an episode in the Kasese region).

[33] World Bank (2011) Uganda Water Assistance Strategy, p. 34.

[34] Staudt M. et al. (2014) Production of Multi-Geohazard Maps for the Uganda Geological Mapping Project. Special Paper - Geological Survey of Finland. Available at: https://www.researchgate.net/publication/273136521

[35] WB (2021), p. 18.

Intensity	Flood intensity is measured according to the following 5 level depth scale: below 0.5m; 0.5-1m; 1-1.5m; 1.5-2m; more than 2m. More intense floods varying from moderate to very high (1m depth or more) occur for most of the territory between March and May and between October and November, except for the North where winter is normally wet (July to August) and thus flood prone. Although flood intensity has reportedly increased, only 12% of Ugandans consider that flood events have worsened in the past 10 years. Forecasts of increased rainfall averages and peaks might worsen flood intensity.
Geographical extent	Flood prone areas in central, eastern and northern Uganda are generally located alongside rivers and major water bodies, seasonal and permanent wetlands, and low-lying areas (e.g., Lake Kyoga). The Central region is more prone to lower depths floods, while the East and the North are prone to higher intensity floods. According to the Atlas, the districts prone to floods of more than 2.0m depth include: Pallisa, Bulambuli, Butaleja, Kibuku, Ntoroko, Ngora, Katakwi and Bukedea. The Teso and Bugisu areas are more likely to suffer from destructive floods them the other regions of the country. Due to the topography, the Rwenzori and Mt. Elgon areas are also susceptible to floods of higher intensity.
Time of year	The wet seasons are generally those that are more flood prone. In the periods from March to May and October to November, there is a higher incidence of intense floods in most of the affected area. In August, there are more moderate events. The seasonal occurrence of floods in the North respects the regional rainfall regime, thus, being the period from June to August also flood prone.

3.2.2 Scoring flooding

As for drought, two different scorings were proposed for flooding. The first focused on the geographical extent, while second included frequency and intensity. The following tables were employed for the scoring of flooding, according to these characteristics, for present day and expected future. The number of votes for high – medium – low options of each scoring is also presented.

Table 18: Classifying and scoring flooding for present day and expected future geographical extent

Class	GEOGRAPHICAL EXTENT		Score	No. votes
	Present day frequency	Expected future frequency		
High	Affects a large area	Expected to continue to affect a large area or an even larger area	3	3
Medium	Affects a small area	Expected to affect a larger area	2	5
Low	Not a problem	Not expected to increase	1	0

Table 19: Classifying and scoring flooding according to frequency and intensity, for present day and expected future

Class	FREQUENCY AND INTENSITY		Score	No. votes
	Present day frequency and intensity	Expected future frequency and Intensity		
High	High frequency, high intensity	High frequency, high intensity	3	6
Medium	High frequency, low intensity	High frequency, low intensity or high frequency, intensity expected to increase	2	2
Medium	Low frequency, high intensity	Low frequency, high intensity or expected to occur more frequently, high intensity	2	0

Low	Low frequency, low intensity	Low frequency, low intensity or not expected to occur in the future	1	0

3.3 Landslide

Landslides are defined by the Atlas as the sudden movement of soil material down a slope. They vary in size, speed, and content of debris. Landslides can be triggered by heavy rainfalls[36], earthquakes, volcanic activities, snowmelt, changes in water level and in groundwater, erosion, or any other factor, natural or man induced, that increases the effects of downhill forces. Speed is affected by slope and quantity of water. Landslides last generally only seconds to few minutes, but it may take longer for the material to stabilize completely. The areas that are normally more prone to landslides are steep hills, mountains, and other landscape figures of sharp downward slopes.

Being rainfalls, also according to the Atlas, one of the main causes for landslides in Uganda, the simultaneous occurrence of both hazards, flooding and landslides, is not uncommon and their combined effects can be disastrous[37]. It affects every year 250 people with 20 casualties in average and costs the country USD 1,2 million in infrastructure, education, health, and transport damages[38]. Landslides have serious social, economic and environment consequences. They take lives, cause people displacement, destroy homes and other infrastructure, leave scars on the landscape rendering the sites unproductive for farming activities. They impact the WASH sector as well. Since landslides might have an enormous destruction potential, every WASH infrastructure such as wells, boreholes, water points, latrines, facilities, networks, etc., that is on their way, might be temporarily or permanently damaged. Water resources might also be polluted by runout depositions of large slides.

Landslides occur due to a ´combination of three kinds of factors[39]:

(i) conditional factors: existing conditions of the area, such as topography and lithology, that induce slope instability and are more stable in time;

(ii) preparatory factors: generally human interventions that prepare the slope for failure and are more dynamic in time, such as deforestation, disturbances for constructions, etc.;

(iii) triggering factors: external stimuli that actually initiate the mass movement, such as rainfall incidence or seismic activity.

Nakilesa and Nedala (2020) conducted a study focusing on Mont Elgon region and associate landslide occurrence with rainfalls (concentration of events in the wet seasons, from August to November and March to May), moderately steepness (15°-25°) and mid altitudes (1500-1800 m.a.s.l.)[40]. Another study on the Rwenzori region, showed similar results[41]: rainfall as the most important trigger factor; the incidence of events therefore being more concentrated in the wet seasons and associated with heavy rains. Not only heavy rainfalls trigger landslides, but prolonged low intensity rainfalls do also it as well[42]. Jacobs et al. (2016) indicate that an obstacle for understanding the frequency of events is lack of information. They show, for instance, that, for 255

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[36] According to http://www.inpe.br/webelat/homepage/menu/infor/tempestades/tipos.php, the occurrence of tempests is more frequent in the afternoon (4 to 6 pm). In mountainous regions, this peak tends to occur earlier (around 1pm).

[37] WB (2011) op. cit., p. 89.

[38] GFDRR (2019) Disaster Risk Profile Uganda. The World Bank Group, available at https://www.gfdrr.org/sites/default/files/publication/uganda_low.pdf.

[39] Jacobs, L., et al., Landslide characteristics and spatial distribution in the Rwenzori Mountains, Uganda, Journal of African Earth Sciences (2016), http://dx.doi.org/10.1016/j.jafrearsci.2016.05.013.

[40] Nakilesa B.R. and Nedala S. (2020). Topographic influence on landslides characteristics and implication for risk management in upper Manafwa catchment, Mt Elgon Uganda. Geoenvironmental Disasters volume 7, Article number: 27, available at https://geoenvironmental-disasters.springeropen.com/articles/10.1186/s40677-020-00160-0.

[41] Jacobs et al. (2016), op. cit.

[42] GFDRR (2019), op. cit.

out of 371 events in their study area, the year of occurrence was registered, for 106 the month could be determined and only for 40 landslides the day of occurrence was known. Although most of them reportedly occurred after 2000, this does not necessarily mean an indication for an increased landslide frequency in the past 15 years.

The Atlas establishes 4 different maps of landslide susceptibility combining this set of criteria. A first susceptibility scenario is proposed for the sole conditional factors, followed by two maps combining these factors with rainfall and earthquakes separately. An integrated susceptibility map generated from the combination of the three aspects is also developed. The results are similar for all four scenarios: the most landslide prone areas are those close to mountains or hills with susceptibility increasing with the combination of one or two triggering factors. At the regional level, the Western and Eastern regions are the most susceptible to landslides, regardless of the criteria, especially the areas around Mount Elgon and the Rwenzori Mountains. Hilly areas or areas located along steep slope terrain are the most prone to rainfall-induced landslides, which include Mufumbiro volcanoes region. These areas receive a lot of rains that raise soil moisture triggering mass movements of soils and rocks along steep slopes. The figure below presents the results of the integrated susceptibility analysis.

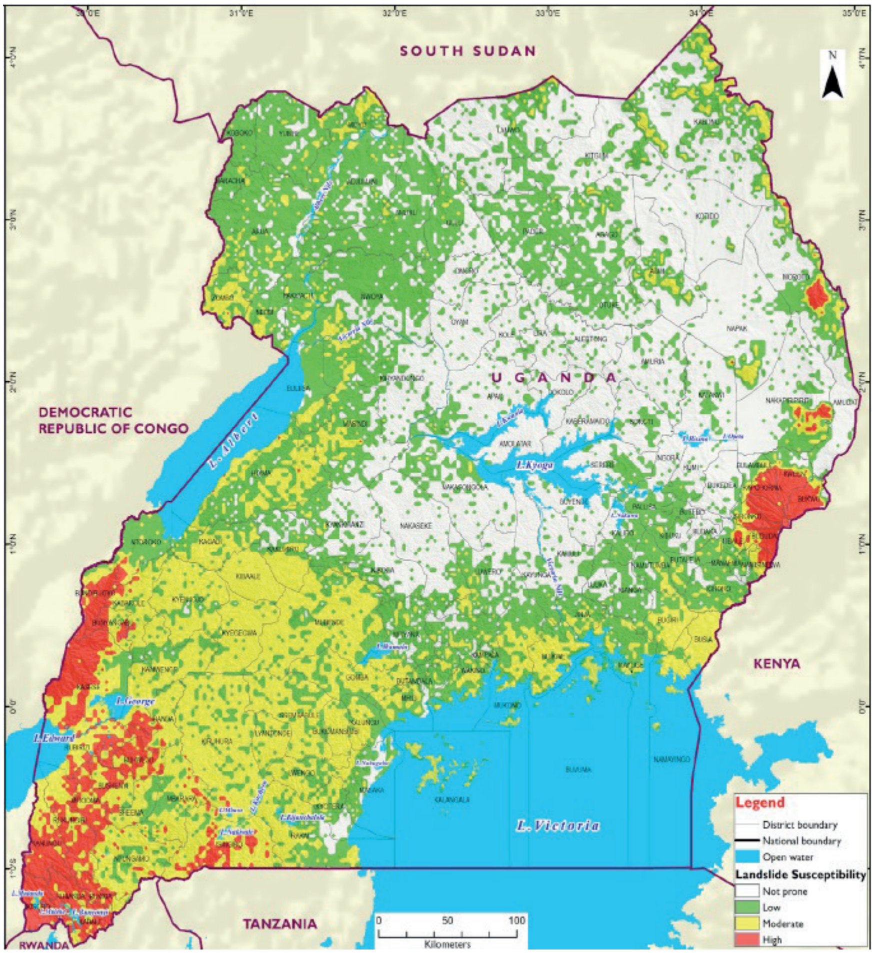

Figure 7 Integrated landslide hazard zonation. Source: Atlas, p. 42

The assessment indicated that a small area (5,793 km² or 2.83% of the territory) of the country is highly susceptible to landslides (red area in the map below). In the Western region and around Lake Victoria, there is a vast area moderately susceptible to landslides (yellow area in the map below). The Eastern and Western regions have the highest number of districts susceptible to landslides, 32 and 31 districts, respectively. The most prone districts include Kapchorwa, Bukwo, Bududa, Kasese, Sironko, Rubanda, Bulamabuli, Kween, Kasese, Bundibugyo and Kisoro.

As highlighted above, there is very strong model agreement that mean annual precipitation, runoff, precipitation during extreme storm events, and precipitation intensity will increase in Uganda, particularly in months that already receive substantial rainfall (e.g., April and October). Most climate models project that the months outside summer (June-August) could also experience precipitation increases[43]. If forecasts are correct, precipitation increases will have a direct impact over landslides. Nevertheless, even in areas where average precipitation might decrease, landslide events could occur because of higher rainfall peaks, loss of land cover, construction of transport infrastructure, housing and other aspects related to population growth.

3.3.1 Characterization of landslide

The next table provides a synthesis of the most relevant features of landslide as climate hazard in Uganda.

Table 20: Characterization of landslides

HAZARD: Landslide	
Frequency	There are reports of landslides occurring every year mainly in the wet seasons. The registration of events is limited, which leads to the conclusion that the frequency of landslides might be underestimated. Considering forecasts of increased rainfall intensities for the future, together with changes in land use, landslide episodes could become more frequent.
Duration	The sudden soil movement lasts from few seconds to minutes. But some landslides remain active (i.e., in slow movement or in risk of sudden movement) for years.
Intensity	Depending on steepness and composition of debris, landslides are considered shallow or deep. According to Jacobs et al. (2016), shallow slides in the Rwenzori region are most found in higher altitudes while deep slides are most found in lower altitudes. This feature is related to the presence of shallower soils in higher altitudes, with the bedrock lying near the surface. Although information on this topic is not abundant, this data might be used as a proxy for other parts of the country.
Geographical extent	Landslides are very localized hazards, concentrated in those areas close to mountains or hills. Mount Elgon and the Rwenzori region are the most prone areas. Some examples of districts affected by landslides are: Kapchorwa, Bukwo, Bududa, Kasese, Sironko, Rubanda, Bulamabuli, Kween, Kasese, Bundibugyo and Kisoro.
Time of year	The incidence of landslides coincides with the wet seasons because rainfall is the main triggering factor. March to May and August to November are the most common times of the year. If triggered by earthquakes, time of year might change.

3.3.2 Scoring landslide

As for drought and flooding, two different scorings were proposed for landslide. The first focused on the geographical extent, while second included frequency and intensity. The following tables were employed for the scoring of landslide, according to these characteristics, for present day and expected future. Each table also shows the results of the assessment, which was conducted through simple voting system.

Table 21: Classifying and scoring landslide for present day and expected future geographical extent

Class	**GEOGRAPHICAL EXTENT**		**Score**	**No. votes**
	Present day frequency	**Expected future frequency**		
High	Affects a large area	Expected to continue to affect a large area or an even larger area	3	6
Medium	Affects a small area	Expected to affect a larger area	2	2

[43] WB, (2021) op. cit., p. 18.

Low	Not a problem	Not expected to increase	1	0

Table 22: Classifying and scoring landslide according to frequency and intensity, for present day and expected future

Class	FREQUENCY AND INTENSITY		Score	No. votes
	Present day frequency and intensity	Expected future frequency and Intensity		
High	High frequency, high intensity	High frequency, high intensity	3	3
Medium	High frequency, low intensity	High frequency, low intensity or high frequency, intensity expected to increase	2	6
Medium	Low frequency, high intensity	Low frequency, high intensity or expected to occur more frequently, high intensity	2	0
Low	Low frequency, low intensity	Low frequency, low intensity or not expected to occur in the future	1	0

3.4 Land Degradation

Land degradation is the reduction or loss of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland, or range, pasture, forest or woodlands resulting from natural processes, land uses or other human activities and habitation patterns such as land contamination, soil erosion and the destruction of the vegetation cover[44]. An indicator of the intensity of land degradation is erosion, which is measured in average mass of soil loss per hectare: up to 1 t.ha loss per year is considered a sustainable rate, while more than 10 t.ha loss per year is considered high risk. Erosion rates vary depending on natural factors (rainfall, slope, land cover) and human activities such as land use practices. The focus of this Section is the analysis of land erosion and degradation, despite the impacts related to riverbank erosion in Uganda.

Nearly half of Uganda is affected by severe land degradation characterized by soil erosion and nutrient depletion from unsustainable land use[45] and erosion risk affects 80% of the territory[46]. The worst affected areas include the highland areas in the Southwest, Kabale and Kisoro (85%-90% affected), but also badly affected (75% - 80%) include Mbale, Rakai and Kotido cattle grazing districts. Some dryland districts (Moroto and Nakasongola, and Kakuuto county in Rakai) are said to be facing desertification[47]. Out of 112 districts in Uganda, 66 districts were found to have unsustainable estimated soil loss rates while 6 districts are in the high-risk category Bududa, Kasese, Bundibugyo, Bulambuli, Sironko and Kotido[48].

According to Olson and Berry (2003), in addition to the loss of land productivity, the siltation of lakes and rivers associated with erosion is leading to problems of eutrophication and reductions of fish populations. This problem is severe where former wetlands adjacent to lakes and rivers have been converted to cropping. Severely affected areas include Manafa, Kafu, Nyamwamba and the Nile River. Lake Victoria is also

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[44] Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, United Nations, New York, 1997.

[45] Government of Uganda (2012), National Environment and Social Assessment Stocktaking Report of the Water Sector, Water Management and Development Project (WMDP): Final Report. Ministry of Water and Environment.

[46] Karamage et. al. (2016) Soil Erosion Risk Assessment in Uganda. Forests 7(52).

[47] Olson J. and Berry L. (2003) Land degradation in Uganda: Its extent and impact. Available at: https://rmportal.net/library/content/frame/land-degradation-case-studies-05-uganda/at_download/file

[48] Karamage et. al. (2016), op. cit.

experiencing heavy sedimentation along its shores. Thus, land degradation affects water sources as well[49]. The two most fragile ecosystems in the country are the highlands and the drylands, but other regions experience various degrees of land degradation processes as well.

Table 23: Characteristics of areas affected by land degradation

	Highland Areas	Dryland Areas
Characteristics	25% of the territory; 40% of the population; found in the SW, E, W and N regions	43% of the territory; Cattle corridor ranges from the NE, through the Centre of the country and further to the SW; uncertain rainfall regime and sparse vegetation
Degradation	Loss of land productivity and erosion	Loss of land productivity and erosion
Causes	High population density; intensely cropped hillsides; steepness	De-vegetation and compaction; bush burning; overgrazing; rainfall regime; strong winds
Affected districts	Kabale, Kisoro, Bundibugyo, Mbale and Kapchorwa.	Kumi, Karamoja, Soroti, Kotido, Katakwi, Mbarara, Rakai and North Luwero

Source: adapted from Olson and Berry (2003)

Land degradation in general and soil erosion in particular affect directly the water resources. In a study carried out in representative districts of Ugandan cattle corridor where water crisis is rampant (Mbarara, Ntungamo, Katakwi, and Kasese), Rwakakamba (2009) associated water resources depletion to land degradation. Non functionality of water gravity flow systems, boreholes, water pumping systems, protected water springs, shallow wells was in part associated to erosion processes and land degradation. In total, 16 rivers, 26 wetlands, 7 forests, 4 lakes, and 2 highlands were visited in the 4 districts. In the 4 analysed districts, 11% of the wetlands, 5% of the forests, and 4% of the rivers and streams have been completely depleted. Moreover, 89% of the wetlands and 94% of the rivers and streams have been encroached upon, while only 10% of the lakes and 5% of the forests have remained intact. Reasons for encroachment ranged from a need for farmland for crop cultivation to overgrazing, poor farming methods (e.g. bush-burning), and economic activities such as brick-making along wetlands[50]. In 1994, wetland coverage on the surface area of Uganda was 15.6%. However, over time this gradually reduced and is currently at 8.9%. This is attributed to expansion in Agriculture, industry and urbanization.[51]

3.4.1 Characterization of land degradation

The next table provides a synthesis of the most relevant features of land degradation as climate hazard in Uganda.

Table 24: Characterization of land degradation

HAZARD: Land degradation	
Frequency	Constant, aggravated during heavy rainfalls and windstorms
Duration	Constant, aggravated during heavy rainfalls and windstorms
Intensity	Erosion is measured in terms of loss of soil mass per hectare (>1 t.ha is considered unsustainable and

[49] GoU (2012), op. cit.

[50] Rwakakamba T. M. (2009) How Effective are Uganda's Environmental Policies? A Case Study of Water resources in 4 Districts, With Recommendations on How to Do Better. Mountain Research and Development Vol. 29, No. 2.

[51] W&E Sector Report (2020), op. cit.

	>10 t.ha is considered high risk). Districts with mean annual soil loss rates of >10 t·ha−1·y−1: Bududa (46.3 t·ha−1·y−1), Kasese (37.5 t·ha−1·y−1), Bundibugyo (28.9 t·ha−1·y−1), Bulambuli (20.9 t·ha−1·y−1), Sironko (14.6 t·ha−1·y−1) and Kotido (12.5 t·ha−1·y−1).
Geographical extent	The two most fragile ecosystems in the country are the highlands and the drylands, but other regions experience various degrees of land degradation processes as well. Particularly affected districts include: Kabale, Kisoro, Bundibugyo, Mbale, Kapchorwa, Kumi, Karamoja, Soroti, Kotido, Katakwi, Mbarara, Rakai and North Luwero.
Time of year	Constant, aggravated during heavy rainfalls and windstorms

3.4.2 Scoring land degradation

For degradation, two scoring procedures were proposed. The first focused on the geographical extent and the second on intensity, considering that frequency tends to be constant. The following tables were employed for the scoring of degradation, for present day and expected future. For each scoring, tables also show number of votes for high – medium – low options.

Table 25: Classifying and scoring land degradation for present day and expected future geographical extent

Class	GEOGRAPHICAL EXTENT		Score	No. votes
	Present day frequency	Expected future frequency		
High	Affects a large area	Expected to continue to affect a large area or an even larger area	3	6
Medium	Affects a small area	Expected to affect a larger area	2	2
Low	Not a problem	Not expected to increase	1	0

Table 26: Classifying and scoring degradation according to frequency and intensity, for present day and expected future

Class	FREQUENCY AND INTENSITY		Score	No. votes
	Present day frequency and intensity	Expected future frequency and Intensity		
High	High frequency, high intensity	High frequency, high intensity	3	3
Medium	High frequency, low intensity	High frequency, low intensity or high frequency, intensity expected to increase	2	3
Medium	Low frequency, high intensity	Low frequency, high intensity or expected to occur more frequently, high intensity	2	2
Low	Low frequency, low intensity	Low frequency, low intensity or not expected to occur in the future	1	0

3.5 Water Pollution

Water resources pollution occurs when harmful substances – often chemicals or microorganisms – contaminate a stream, river, lake, aquifer, or other water body. It is a common issue in virtually every country, but some are better equipped and manage to cope with the problem properly, while others have to endure systematic health and environmental setbacks. Regardless of water pollution causes, that vary greatly and depend on several socioeconomic and technological aspects, it has direct implications for the WASH sector. Water pollution leads on the one hand to increasing water treatment costs, given the complexity of the removal from certain contaminants. On the other hand, when it does not work properly, the WASH sector might also be responsible for pollution, for instance when latrines are poorly constructed, when sludge is inadequately managed or when wastewater is released without any treatment in water bodies.

In Uganda, water pollution is a growing concern, especially due to crops and livestock production, urban discharges and poor sanitation conditions associated with population growth and density. Organic matter and nutrients are the major water pollutants[52]. Excess of nitrogen and phosphorus due to organic contamination in water bodies is the main cause for the proliferation of harmful algae. Although fertilizer usage in Uganda is in the present among the lowest in Africa – and therefore has low contamination potential[53] – pesticides are widely accessible and consumed[54]. Thus, this type of contamination might also be a problem, but will not be discussed in this document due to information availability. Water quality is also directly affected by climate hazards, such as landslides and flooding, and also by droughts because of higher concentration of contaminants. Future trends of expansion of cultivated land, population growth and increased hazards incidence might impact the condition of water sources in the coming decades.

Normally, water resources quality in measured also in terms of bacteriological, physical, and chemical parameters (temperature, pH, total nitrogen and phosphorus, chemical and biochemical oxygen demand, among others). According to GoU (2014), pollution related to sanitation systems was considered to be one of the most important factors affecting water quality, together with livestock contamination. Thus, the focus of this document is the analysis of bacteriological quality of water, despite the relevance of other forms of contamination such as harmful algae, due to information availability. Even though biochemical oxygen demand is more used parameter for this type of pollution, the presence of E. coli is also a valid und useful indicator, because it provides an idea of the WASH situation as well.

Broadly, open water sources are more vulnerable to pollution than groundwater sources. Soil characteristics have an important influence on the isolation level of groundwater, thus on its exposure to contaminants from the surface. Applying this rationale to the WASH sector, groundwater tends to be a more reliable source in terms of quality. Using bacteriological indicators as parameter, water safety by technology type suggests that piped water systems are the safest, followed by deep boreholes, shallow wells, the least safe source being protected springs. Drawing from field analysis conducted in rural areas and small towns, the Water and Environment Sector Performance (2020) reports that more than 90% of piped systems, 81% of boreholes, 55% of shallow wells and only 37% of protected springs had safe water for drinking based on compliance to bacteriological safety or E. coli. According to the regulation authority, the average is similar in urban settings (91% of water quality compliance), but three regional umbrellas had the worst results: Karamoja Umbrella of Water and Sanitation, Midwest Umbrella of Water and Sanitation and Central Umbrella of Water and Sanitation (79%, 86% and 87% water quality compliance, respectively). This means that service providers are performing relatively well in terms of safe water delivery.

Nevertheless, some urban areas endure lower levels of service and water access. In the Kampala region, a total of 179 water samples were collected from protected springs in twenty-eight parishes from the five divisions of Kampala (Central, Kawempe, Makindye, Nakawa and Rubaga) and two municipalities of Entebbe and Makindye Sebagabo in Wakiso district. The results are coherent with the previously assertion that protected springs are very vulnerable to water pollution. Compliance to E. coli presence was 25% in average. The worst division was Kawempe (10% compliance), where several taps dried out and forced users to resort to alternative, unsafe water sources. Additionally, it is important to insist that a good percentage of informal settlements in Kampala and small business establishments use protected springs for domestic water supply, suggesting that the socially most vulnerable population is even more exposed to water quality deficiencies.

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[52] Government of Uganda (2014) Water Resources Development and Management Strategy and Action Plan. Available at: https://www.mwe.go.ug/sites/default/files/library/UNWMZ%20Strategy%20&%20Action%20Plan.pdf.

[53] GoU (2014), op. cit.

[54] https://globalpressjournal.com/africa/uganda/amid-booming-market-pesticides-uganda-seeks-better-regulation/

In a study aiming at assessing bacteriological quality of water sources in two rural areas of Uganda (Bugoye in Kasese district and Rugando in Mbarara district), Apecu et al. (2019) found similar results. In total, 200 water samples were collected from 69 different water sources and 29% of them met the National Standards and World Health Organization (WHO) Guidelines for drinking water. 60% of the boreholes, 44% of gravitational flow taps and 14% of roof rainwater met the required standards. Of the open water sources, 75% of the rivers, 50% of open channels and 43% of unprotected dug wells plus 25% of protected springs and 9% of gravitational flow schemes had most probable number counts >100 Escherichia coli/100 mL of water. Most of the water sources in the study areas were not fit for human consumption without prior treatment. According to the authors, the two sub-counties reflect a typical picture of such settings in Uganda, where most communities rely on the use of water from open sources without treatment for both drinking and domestic use.

Table 27: Microbiological quality of water sources in Bugoye and Rugando

	WHO water quality risk categories			
Water source/types	**Safe <1 MPN/100 mL**	**Intermediate 1–10 MPN/100 mL**	**High risk 11–100 MPN/100 mL**	**Unsafe >100 MPN/100 mL**
Gravitational flow tap ($n = 34$; 49%)	15 (44%)	8 (24%)	8 (24%)	3 (9%)
Protected spring ($n = 4$; 6%)	–	3 (75%)	–	1 (25%)
Rain water ($n = 7$; 10%)	1 (14%)	2 (29%)	1 (14%)	3 (43%)
River water ($n = 8$; 12%)	–	1 (13%)	1 (13%)	6 (75%)
Borehole water ($n = 5$; 7%)	3 (60%)	1 (20%)	1 (20%)	–
Unprotected dug well ($n = 5$; 7%)	1	1	2	1
Channel water ($n = 6$; 9%)	–	–	3 (50%)	3 (50%)
Total = 69 (100%)	20 (29%)	16 (23%)	16 (23%)	17 (25%)

Source: Apecu et al. (2019)

3.5.1 Characterization of water pollution

The next table provides a synthesis of the most relevant features of water pollution as climate hazard in Uganda.

Table 28: Characterization of water pollution

HAZARD: Water pollution	
Frequency	Constant, aggravated in emergency situations
Duration	Constant, aggravated in emergency situations
Intensity	Varies according to the water source (open water sources tend to be more contaminated than groundwater and piped water systems)
Geographical extent	In urban areas with piped systems, water quality is improved, and contamination tends to be less frequent and less intense, although water treatment plants are exposed to the presence of sand in water sources. In rural settings, peripheral urban areas, and informal settlements, where population relies on open sources, bacteriological contamination is higher.
Time of year	Contamination is probably more intense in the dry seasons, because of increased concentrations of contaminants, but no precise information on this topic was available. If contamination through pesticides is an issue, there is certainly a seasonality related to the use of chemicals in crops that must be mapped and understood, but no information was available on this topic.

3.5.2 Scoring of water pollution

As for degradation, two scoring procedures were proposed for water pollution. The first focused on the geographical extent and the second on intensity, considering that frequency tends to be constant. The following tables were employed for the scoring of water pollution, for present day and expected future. The number of votes for high – medium – low options of each scoring is also presented.

Table 29: Classifying and scoring water pollution for present day and expected future geographical extent

Class	GEOGRAPHICAL EXTENT		Score	No. votes
	Present day frequency	Expected future frequency		
High	Affects a large area	Expected to continue to affect a large area or an even larger area	3	5
Medium	Affects a small area	Expected to affect a larger area	2	4
Low	Not a problem	Not expected to increase	1	0

Table 30: Classifying and scoring water pollution according to frequency and intensity, for present day and expected future

Class	FREQUENCY AND INTENSITY		Score	No. votes
	Present day frequency and intensity	Expected future frequency and Intensity		
High	High frequency, high intensity	High frequency, high intensity	3	6
Medium	High frequency, low intensity	High frequency, low intensity or high frequency, intensity expected to increase	2	1
Medium	Low frequency, high intensity	Low frequency, high intensity or expected to occur more frequently, high intensity	2	2
Low	Low frequency, low intensity	Low frequency, low intensity or not expected to occur in the future	1	0

3.6 Water Overexploitation

Overexploitation occurs if a water resource is used and extracted at a rate that exceeds its recharge capacity. The overall consequence of this phenomenon is less availability of water for all users, leading to potential conflicts and with direct impacts on the WASH sector. Despite this, Uganda is reputedly well endowed in water resources. Open water and swamps constitute 41,743.2 km^2 of total area, with about 16% of total land area of wetlands and open water, plus the annual water supply of 66 km^3 in form of rain and inflows. As well as for other analysed hazards, the rainfall patterns determine the water resources regime of the country. Forecasts of increased rainfall for the future could have a positive impact in the water availability, but due to the uncertainty of the intra-annual modelling results this assertion must be taken carefully. The figure below displays the main river basins and respective water management zones.

Figure 8 Water management zones. Source: Atlas, p. 19.

The surface water landscape in the country is marked by the presence of lakes, such as Lake Victoria (29,000 km² in Uganda), Lake Albert (2,800 km² in Uganda) and Lake Kyoga (2,600 km²). Major rivers include the Nile, Ruizi, Katonga, Kafu, Mpologoma and Aswa, all within the upper part of the White Nile. Wetlands cover 29,000 km² and perform a number of hydrological and environmental functions, such as mitigating the effects of both floods and droughts, providing fish resources and support cropping and grazing along their margins.[55]. Ground water is a relevant source as well. It supplies 75% of all sources of drinking water in Africa and 61% in Uganda, accessed from springs and boreholes around especially Lake Victoria and the South-west. Out of the total water withdrawal, domestic water supply accounted for about 51%, agriculture 41% and industry 8%. The use of ground water for consumption has the advantages of lower treatment costs and easier operation than those of surface-based systems, due to the higher probability of better water quality.

The most common forms of water exploitation are protected springs, deep boreholes, and shallow wells (90% of the people served). These are also sources through which natives access water as individuals or licensed independent water providers. Compared to other countries, the share of the agricultural sector is small, mainly because irrigation is less used than rain-fed crops. The irrigated surface is below potential, as well as the energy production and the usage for consumption, considering that part of the population lacks access to water services. Climate change will have significant impacts on water availability. Despite the forecasts of increased rainfalls in the future, negative variations in groundwater and surface water availability could be experienced, due to population growth, changes in land use, conversion of wetlands and forests into pasture, among other factors. The situation of water availability in the country is increasingly under stress.

[55] Nsbuga et al. (2014), op. cit.

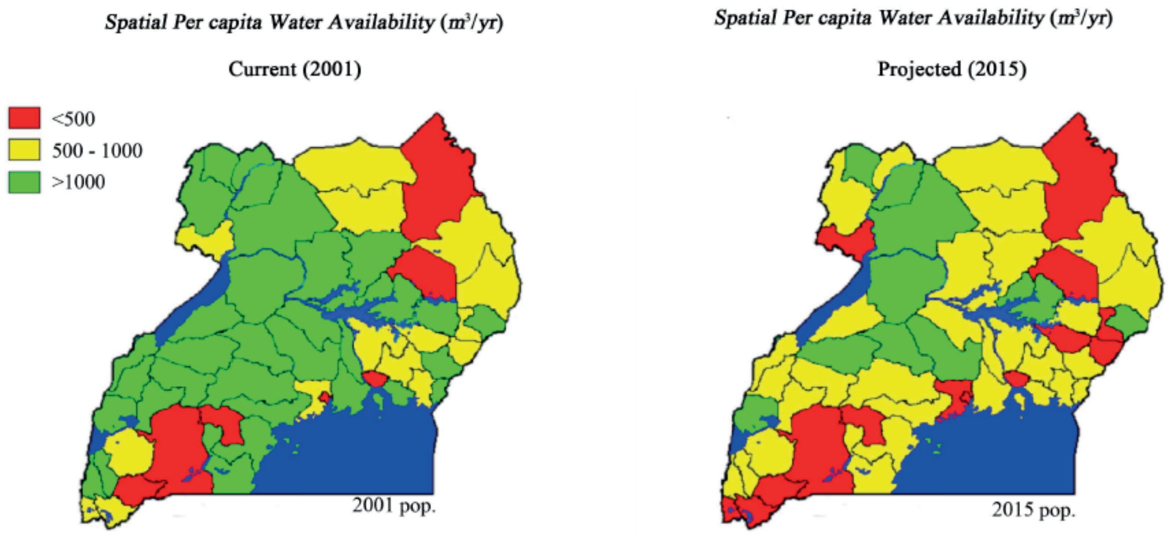


Figure 9 Spatial per capita water availability (2001 and 2015). Source: Nsbuga et al. (2014), op. cit.

In 2001, the areas of absolute water scarcity (less than 500 m^3/person/year) were concentrated in the North-east and the South-west and a significant part of the country could rely on more than 1000 m^3/person/year. By 2015, projections indicated a clear deterioration of the situation, with increasing areas of absolute scarcity and of stress (between 500 and 1000 m^3/person/year). These areas of water stress and water scarcity could thus increase even more in the future. In the Albert Nile catchment basin for instance, projections indicate that water demand will not be covered by offer during the dry season, unless storage technologies are in place[56]. This situation could be aggravated by lacking sanitation infrastructure and inadequate service provision.

3.6.1 Characterization of water overexploitation

The next table provides a synthesis of the most relevant features of water overexploitation as climate hazard in Uganda.

Table 31: Characterization of water overexploitation

HAZARD: Water overexploitation	
Frequency	Constant, aggravated in the dry seasons
Duration	Constant
Intensity	More intense in the dry seasons. Even considering the forecasts of increased rainfalls in the future, water stress could become more acute due to population growth and land degradation. Other climate related hazards could impact too.
Geographical extent	North-east and south-west are the regions that already experience water stress and scarcity. These areas might expand towards the east and the center of the country.
Time of year	Constant, aggravated in the dry seasons

3.6.2 Scoring water overexploitation

As for degradation and water pollution, two scoring procedures were proposed for water overexploitation. The first focused on the geographical extent and the second on intensity, considering that frequency tends to be constant. The following tables were employed for the scoring of water overexploitation, for present day and expected future. For each scoring, tables also show number of votes for high – medium – low options.

[56] GoU (2014), op. cit.

Table 32: Classifying and scoring water overexploitation for present day and expected future geographical extent

Class	GEOGRAPHICAL EXTENT		Score	No. votes
	Present day frequency	Expected future frequency		
High	Affects a large area	Expected to continue to affect a large area or an even larger area	3	5
Medium	Affects a small area	Expected to affect a larger area	2	3
Low	Not a problem	Not expected to increase	1	

Table 33: Classifying and scoring water overexploitation according to frequency and intensity, for present day and expected future

Class	FREQUENCY AND INTENSITY		Score	No. votes
	Present day frequency and intensity	Expected future frequency and Intensity		
High	High frequency, high intensity	High frequency, high intensity	3	6
Medium	High frequency, low intensity	High frequency, low intensity or high frequency, intensity expected to increase	2	1
Medium	Low frequency, high intensity	Low frequency, high intensity or expected to occur more frequently, high intensity	2	1
Low	Low frequency, low intensity	Low frequency, low intensity or not expected to occur in the future	1	

3.7 Other hazards

3.7.1 Earthquake

Earthquakes are defined as the seismic waves provoked by the sudden release of energy in the Earth's crust. At the surface, they manifest themselves by shaking and sometimes displacement of the ground. They have generally natural causes, such as rupture of geological faults, tectonic movements, volcanic activities. Man activities might also influence the occurrence of earthquakes, such as mining activities, nuclear bombing, among others. They can last for few minutes and their intensity is measured on the Richter scale, which is used by the Atlas to establish a classification considering occurrence and potential damage:

- Weak: magnitude 4.5 or lower (few feel vibration, similar to the passing of a truck);
- Light: magnitude 4.5-4.8 (many feel vibration, walls make cracking sound, windows disturbed);
- Moderate: magnitude 4.8-5.4 (windows broken, objects overturned);
- Strong: magnitude 5.4-6.1 (felt by all, fear strikes, slight damage);
- Very strong: magnitude 6.1-6.5 (considerable damage in poorly built structures);
- Severe: magnitude 6.5 or more (walls fall down, considerable damage and partial collapse of buildings)

Uganda lies on the most two active epicentres for seismic activity in East Africa, i.e., the Western Rift Valley and the Lake Victoria basin. Stronger events are concentrated on the Western region, especially in the Rwenzori area and around Lake Albert, along the border to DRC. The further one moves away from the Western Rift Valley of Uganda, the less of the severity of the earthquake activity. For longer return periods, the potentially affected area is larger. In the 500-year return period, more than 20% of the Western, Northern and Central regions experience high-intensity earthquake of categories very strong and severe. The most prone districts to high-intensity earthquake of these categories include Arua, Buhweju, Bundibugyo, Bunyangabu, Bushenyi, Ibanda, Kabarole, Kagadi, Kamwenge, Koboko, Kyenjojo, Maracha, Moyo, Nebbi, Ntoroko, Pakwach, Rubirizi, Yumbe and Zombo. The figure below displays the seismic hazard zonation for a 500-year return period.

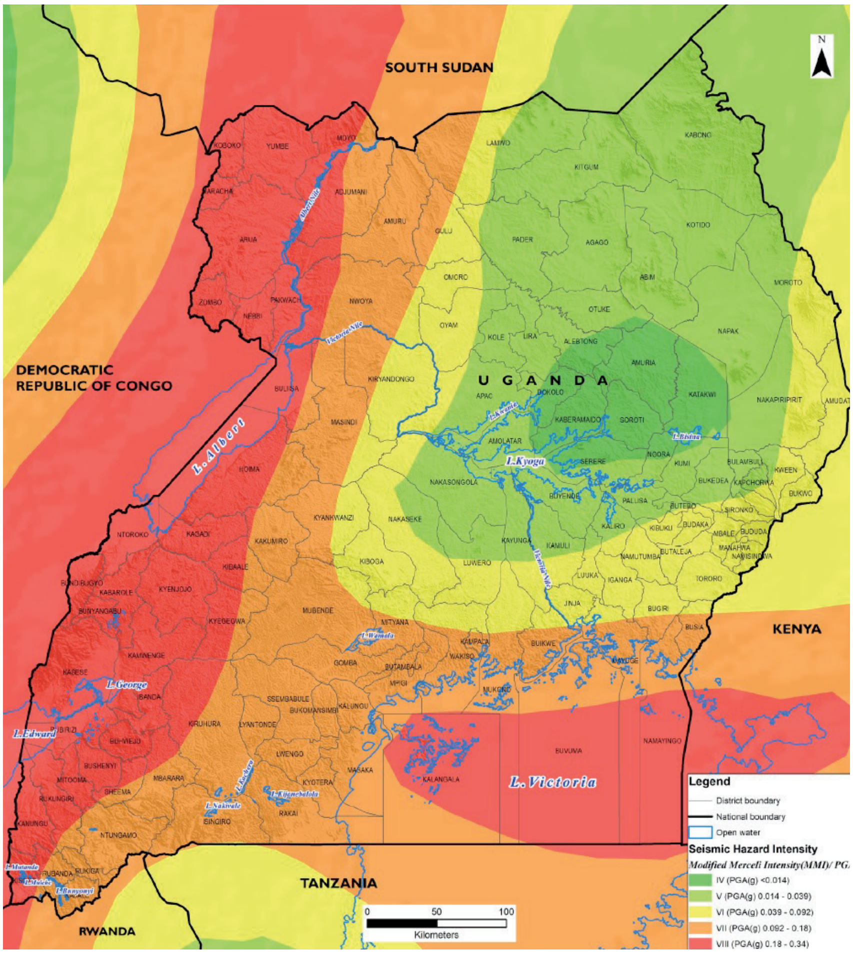


Figure 10 Seismic hazard zonation for a 500-year return period. Source: Atlas, p. 59

Earthquakes of higher magnitudes can have a devastating effect on infrastructure in general and particularly on WASH infrastructure. Damages are estimated in USD 22 million per year. The 2018 earthquake destroyed more than 10 thousand houses.

3.7.2 Windstorm

Wind is the perceptible movement of air caused by differences of pressure. Its intensity is measured in speed: moderate (20-22m/s); high (22-28m/s) and very high (>28m/s). Windstorm is a strong wind that can cause damage and both its intensity and geographical incidence change in the different seasons (Intensity being higher in average in March, April, May, and October). The biophysical features such as mountains, valleys, large water bodies and areas that experience high temperatures (causing low atmospheric pressures) highly influence the wind intensity and direction. 75,100 km² (31%) are prone to very high windstorms (28m/s or more). Windstorms can last for few minutes or even hours (80% less than 3h)[57].

The Western (42%) and Central (23%) regions experience the heaviest windstorms with about (42%) and central (23%) of the area exposed respectively. The Northern and Eastern regions follow with about (29%) and (24%) of the area exposed to heaviest windstorm, respectively. The Eastern and Western regions have the highest number of districts affected by windstorms, i.e., 32 and 31 districts, respectively. The most prone

[57] According to http://www.inpe.br/webelat/homepage/menu/infor/tempestades/tipos.php

districts to very high (gale force windstorms) include Amudat, Budaka, Bududa, Bukedea, Bukwo, Bulambuli, Butebo, Hoima, Isingiro, Kabale, Kapchorwa, Kasese, Kibuku, Kiruhura, Kumi, Kween, Manafwa, Mbale, Mbarara, Nakapiripirit, Namisindwa, Ntungamo, Pallisa, Rukiga, Sheema and Sironko all having 100% of their respective total district area exposed. The figure below presents an integrated zonation map for windstorms in Uganda.

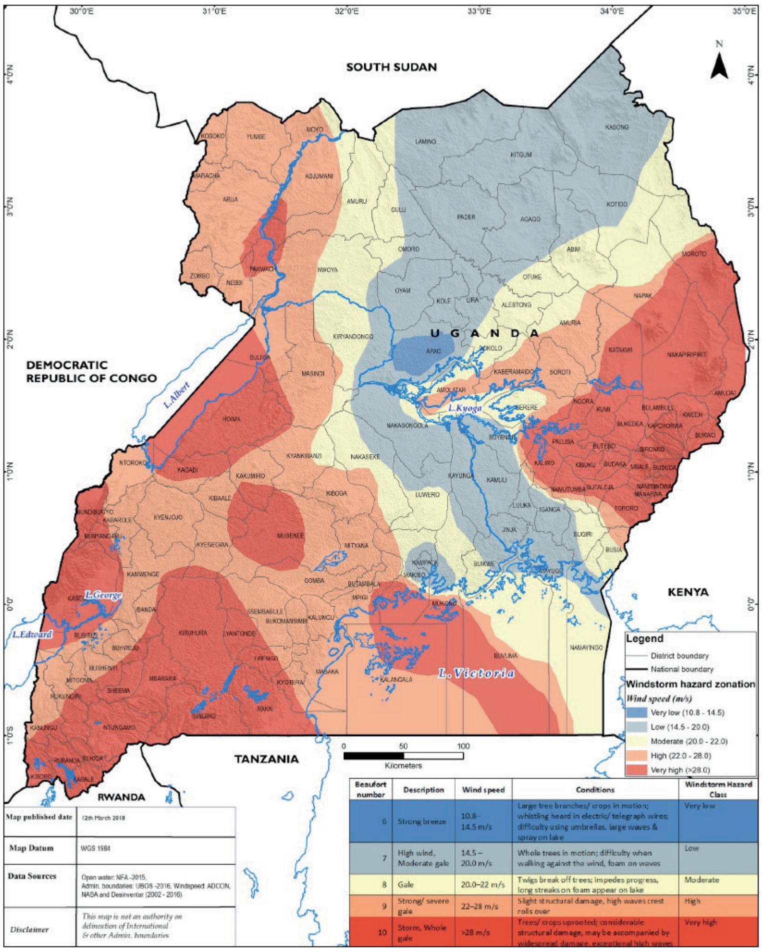


Figure 11 Integrated windstorms zonation map. Source: Atlas, p. 54

3.7.3 Hailstorm

Hail is a form of solid precipitation that consists of balls or irregular lumps of ice measuring between 5 mm and 15 cm in diameter. Although hailstorms had the least multi-sector impact[58], depending on intensity, they generally destroy crops and can cause damage in infrastructure in general and temporary damage in WASH infrastructure (water points, latrines, etc.). The Atlas considers its intensity in terms of frequency of incidence (days / year):

- Very high: 3-4 days a year
- High: 2-3 days a year
- Moderate: 1-2 days a year
- Low: <1 day a year

Broadly, hailstorms occur at the beginning of the rainy seasons and last only a few minutes. Incidences are higher in areas close to the large water bodies (lakes and rivers). In the short-wet season, hotspots for hail incidences include the Lake Victoria crescent, mid-western and south-western region, while in the long-wet season, the hotspot regions include Central, mid-western, Eastern and south-western regions. The short-wet season (March, April and May) experiences the highest number of hail days (more than five days). 75,300 km²

[58] ASDR, 2020, p. 14

of the territory are susceptible to hailstorms of moderate and high intensity. In terms of the hail intensity of more than one to three hail days per year, the central and western regions are more susceptible than the eastern and northern regions. However, with a total number of 34 hailstorm susceptible districts, the Eastern region has the biggest hailstorm prone area, followed by the Western region with 31 districts prone to hailstorms. The districts that are highly susceptible to hailstorms include Budaka, Bukomansimbi, Butaleja, Isingiro, Kalungu, Kyotera, Lwengo, Lyantonde, Manafwa, Masaka, Mbale, Namisindwa, Rakai and Tororo.

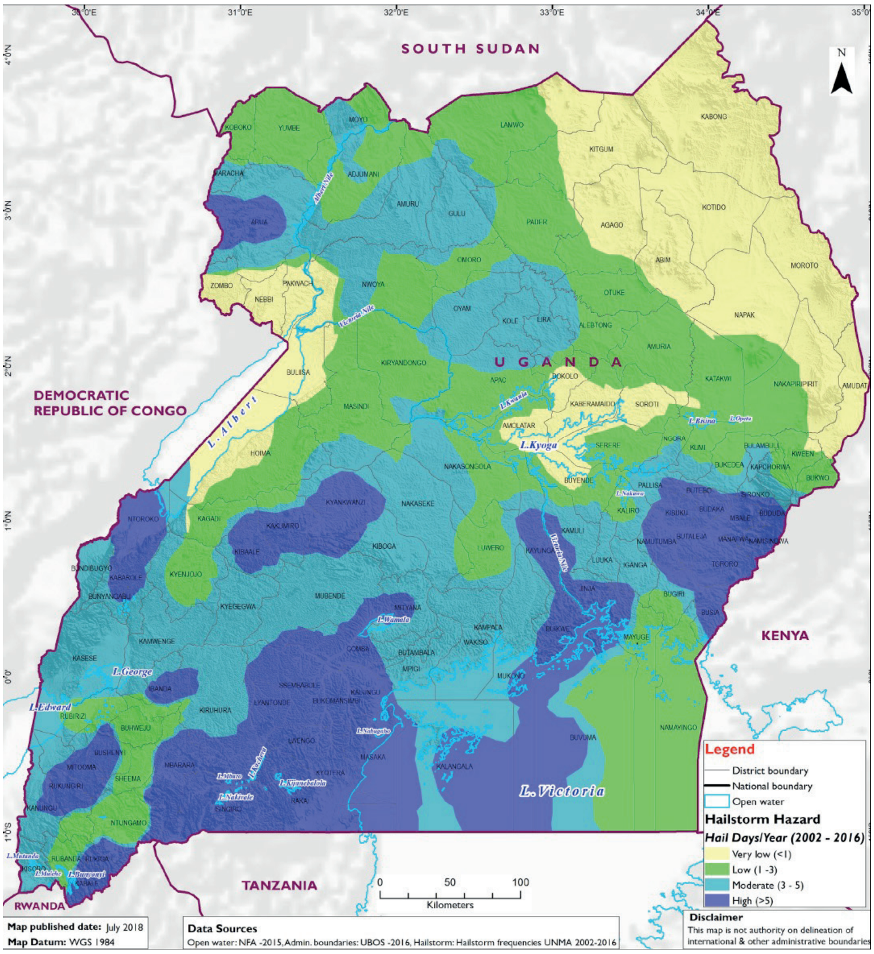


Figure 12 Integrated hailstorm zonation map. Source: Atlas, p. 50

3.7.4 Lightning

Uganda has one of the highest rates of lightning strike deaths in the world (between 2007-2014, 586 people - 395 of whom were learners- were killed and 727 injured). Lightning happens when electrical discharges occur from a charge centre in a cloud either to the induced charge on the earth, to the charge centres of the same or of another cloud. Accordingly, lightning may be categorized into two types: i) ground flash discharge between a cloud and the earth; and ii) cloud flash discharge within a cloud or between clouds, Uganda suffers approximately 70 lightning strikes per kilometre per year. One single strike lasts from fractions of seconds to few seconds, and lightning storms may last for several minutes. According to the Atlas (2020), both frequency and severity of lightning incidences have increased, resulting in significant loss of life and property.

Since Uganda is not equipped with a lightning flash counter network or a lightning detection system, the thunder-heard day is the most reliable parameter which can be used in lightning-related studies. Thunder day is defined as a calendar day during which thunder is heard at a given location, which is the measure for lightning in the Atlas. The lightning hazard zonation was generated with reference to flashes per square kilometre per year and classified as Very low, Low, Moderate, High, and Very high, with respect to their severity:

- Very high: >75 strikes / km²

- High: 50-75 strikes / km²
- Moderate: 10-50 strikes / km²
- Low: <10 strikes / km²
- Very low: -

Seasonality has an influence over lightning incidence, which is associated to the wet seasons. Events can nevertheless be experienced in the dry seasons due to unusual surges in moist air masses. Uganda experiences the highest lightning strikes in April and October. At the regional level, the Central, Northern and Eastern regions are the most susceptible regions to lightning hazard with more than 50 strikes per year. The Eastern region has the highest number of districts affected by lightning strikes followed by the Northern region with 29 districts and Western region with 24 districts.

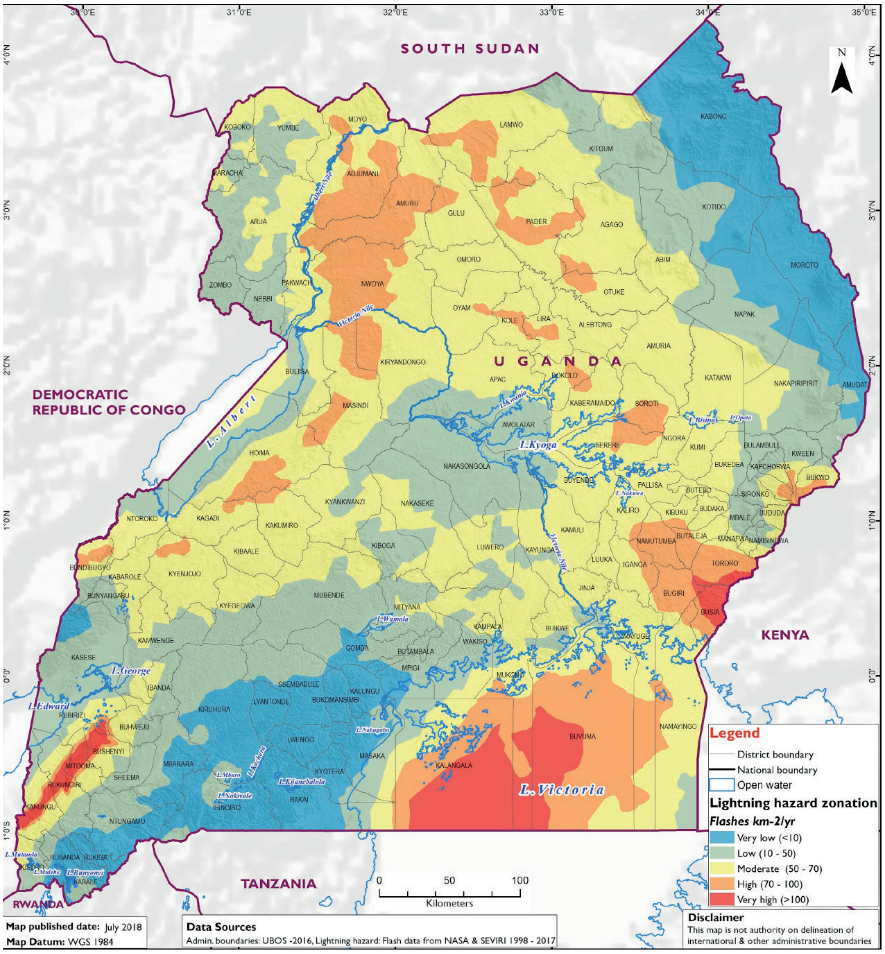


Figure 13 Integrated lightning zonation map. Source: Atlas, p. 47

4. EXPOSURE

This Section describes the identified hazards to exposure. Exposure can be defined as "people, property, systems, or other elements in places or settings that could be adversely affected by hazards and that are thereby subject to potential losses"[59].

Therefore, to determine what the exposure for a particular hazard might be, the focus of the analysis is on exposed people (if so, any specific groups such as children), critical infrastructure, water sources, any other types of assets in the area. It will be based on those areas that were previously identified as being particularly affected by each hazard.

4.1. Drought

4.1.1 Characterization of exposure to drought

To start with the analysis, the map below identifies the percentage of each district's population that is exposed to drought events of moderate to high intensities: red for very high, orange for high and yellow for moderate percentage of exposure (respectively 80-100%, 60-80% and 40-60%). It is shown that the most drought prone regions to droughts of moderate to severe intensities include Northern, Eastern and Western regions. The most drought prone districts are in the Karamoja subregion and include Kaabong, Moroto, Kotido, Napak, Amudat, Nakapiripirit, and Kitgum.

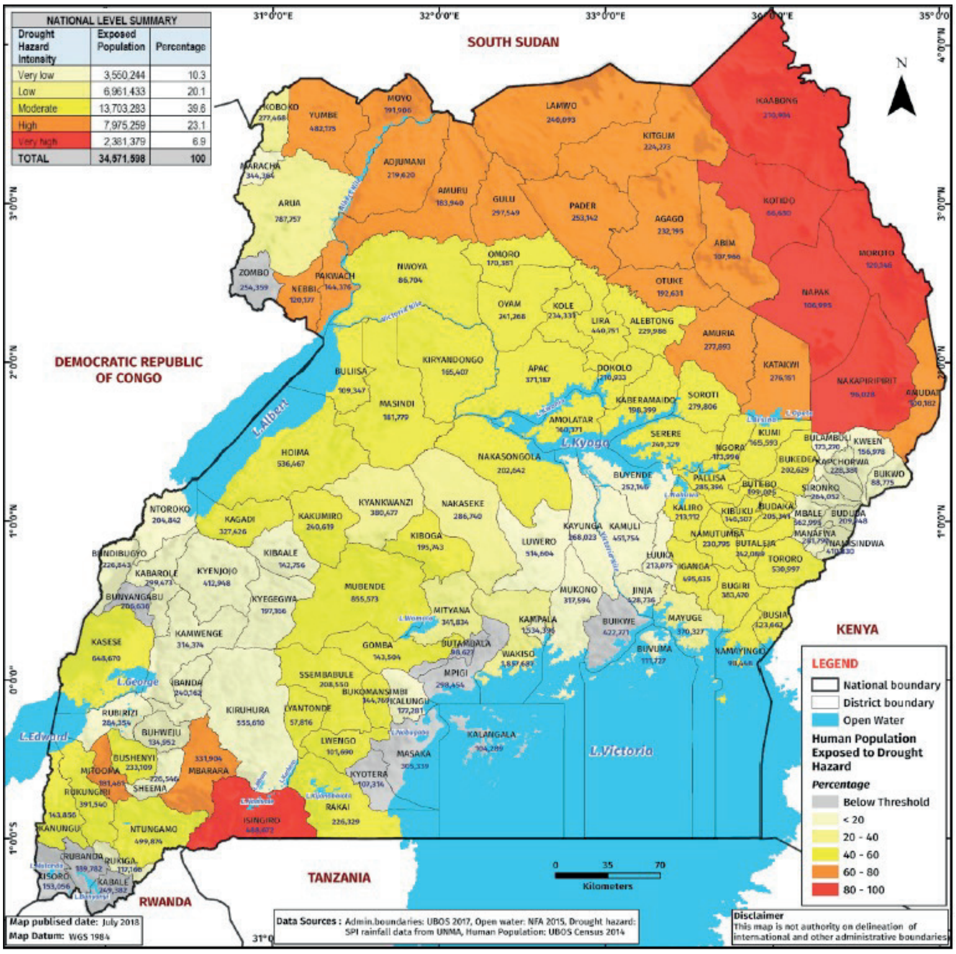


Figure 15 Percentage of population exposed to drought events. Source: Atlas (2020) op. cit.

A more detailed exposure assessment is presented in the table below.

[59] GWP and UNICEF (2017), op. cit.

Table 39: Exposure analysis for drought

Exposure to DROUGHT	Exposure description
Any particular group of people (if so specify)	According to the Atlas, 80% of adults, 52% of the population, 64% of women, 63% of men, 16,5% of children live in drought exposed areas. The population most exposed to drought lives in arid and semi-arid areas of North-eastern Uganda. Drought events affect especially the population that uses protected springs, shallow wells and harvested rainwater for consumption and hygiene, respectively 21,4%, 23,9% and 0,4% of the population[60]. Some 9,1% of the population is served by public taps, which are also exposed. Drought events might affect differently women and girls that fetch water from rivers, ponds, wells, water points etc.
Critical (WASH related) infrastructure	Water networks might be affected during drought periods. As the drought event fades and water flows again through the networks, pressure might cause ruptures in specific points of the network. Water harvesting infrastructure could be also damaged by long sun exposure. Considering most of Ugandan households use pit latrines, which is a dry technology, sanitation infrastructure is limitedly affected by drought events.
Water sources (if so, are these primary water sources)	Water abstraction points are affected by droughts. There are 5,312 water sources that are non-functional in the country, almost 20% of them because of low yield. Water availability is highly sensitive to drought events. The direct impact of seasonal droughts over groundwater is less pronounced than that over surface water because of the differences in recharge conditions for both types of sources. Most of the Ugandan population utilizes groundwater for consumption. Almost 60% of protected springs and 50% of shallow wells are located in areas of very low and low drought intensity, while 35% of protected springs and 42% of shallow wells are located in areas of moderate drought intensity. 5% of protected springs and 7% of shallow wells are located in areas of high and very high intensity (most of them in the Karamoja region and further parts of the North). Particularly exposed districts are Moroto, Kaabong, Kotido, Napak, Amudat and Nakapiripirit (Atlas, p.100).

4.1.2 Scoring exposure to droughts

The list of proposed indicators to score the drought exposure is presented in the table below, based on the analysis given above. The table provides the classification of exposure for all indicators, also linking them to the relevant exposure and vulnerability components. The table also presents the scoring for each indicator after the voting[61].

Table 40: Indicators for drought exposure and their classification

Exposure / Component	Exposure (summary narrative)	High	Medium	Low	Score
Population	Women: women and girls that fetch water from rivers, ponds, wells, water points, etc. are particularly exposed to this hazard	> 5% of women affected	0.5 – 5% of women affected	< 0.5% of women affected	**2,75**
Human		**10**	**3**	**0**	
Population	Children: girls in charge of fetching water from rivers, ponds, wells, water points, etc. are particularly exposed to this hazard	> 5% of children affected	0.5 – 5% of children affected	< 0.5% of children affected	**2,50**
Human		**8**	**4**	**1**	
Population	Due to damage to infrastructure, specific population groups are	> 5% of population	0.5 – 5% of population	< 0.5% of population	**2,33**

[60] GoU, Water Supply Atlas. Available at http://wsdb.mwe.go.ug/index.php/reports/national.

[61] All exposure indicators were individually assessed by Climate Task Force members through an online survey. For each indicator, values for high – medium – low classification indicate the number of members that score that option. Overall score is computed as previously described in Section "2. Methodology".

	diverted to lower levels of water and sanitation service (e.g., open defecation)	affected	affected	affected	
Social		**7**	**4**	**2**	
Population	Farmers' livelihoods are particularly affected in drought periods, with severe income losses	> 25% of income losses	10 – 25% of income losses	< 10% of income losses	**3,00**
Financial		**13**	**0**	**0**	
Critical infrastructure	Water supply systems might be affected by droughts, particularly damaging the distribution system	> 20% of critical infrastructure affected	5 – 20% of critical infrastructure affected	< 5% of critical infrastructure affected	**2,00**
Physical		**3**	**7**	**2**	
Water sources	Shallow wells	> 20% of shallow wells affected	5 – 20% of shallow wells affected	< 5% of shallow wells affected	**2,92**
Environmental		**12**	**1**	**0**	
Water sources	Protected springs	> 20% of protected springs affected	5 – 20% of protected springs affected	< 5% of protected springs affected	**2,58**
Environmental		**8**	**4**	**1**	
Water and sanitation services	Due to damage to infrastructure and lower level of services delivered to population, routine revenue collection might not cover O&M costs	> 25% of revenue losses by service providers	10 – 25% of revenue losses by service providers	< 10% of revenue losses by service providers	**2,58**
Financial		**8**	**5**	**0**	

4.2 Flooding

4.2.1 Characterization of exposure to flooding

The analysis of exposure and its scoring will focus on those areas that were previously identified as being prone to flooding events. Flood prone areas in central, eastern and northern Uganda are generally located alongside rivers and major water bodies, seasonal and permanent wetlands, and low-lying areas (e.g. Lake Kyoga). The Central region is more prone to lower depths floods, while the East and the North are prone to higher intensity floods. According to the Atlas, the districts prone to floods of more than 2.0m depth include: Pallisa, Bulambuli, Butaleja, Kibuku, Ntoroko, Ngora, Katakwi and Bukedea. The Teso and Bugisu areas are more likely to suffer from destructive floods them the other regions of the country. Due to the topography, the Rwenzori and Mt. Elgon areas are also susceptible to floods of higher intensity.

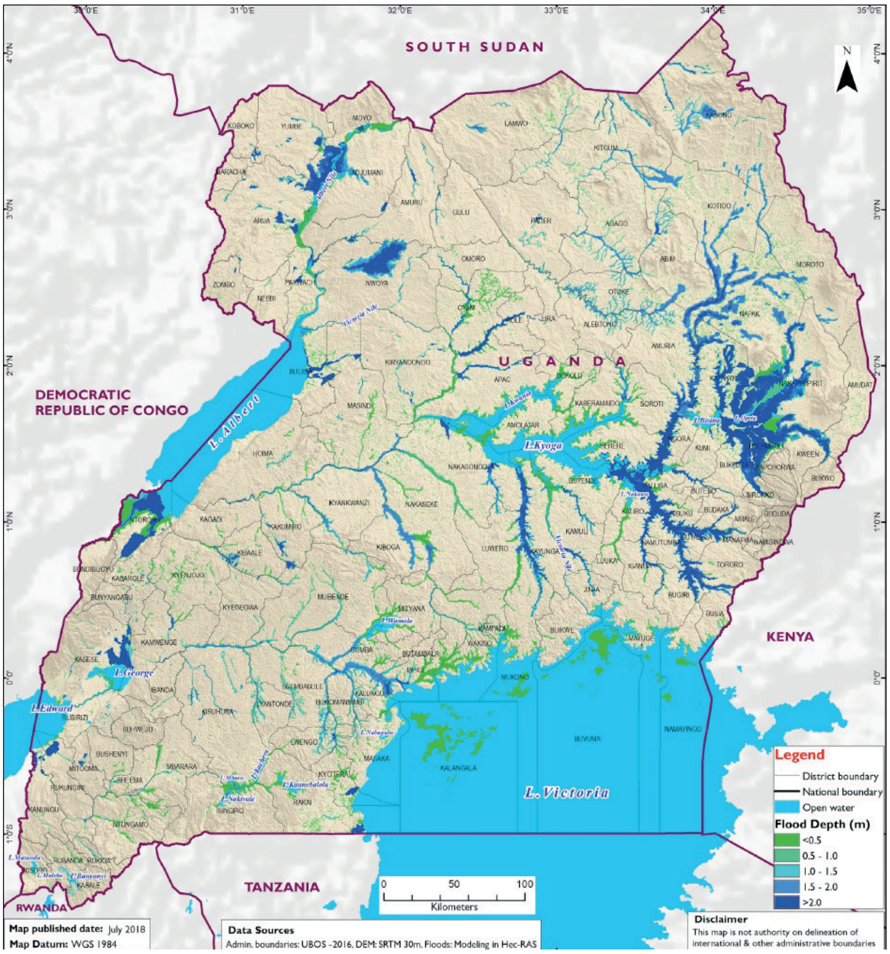


Figure 16 Flood prone areas for 50 years return period. Source: Atlas. (2020), op. cit.

The exposure assessment of the flooding hazard is presented in the table below.

Table 41: Exposure analysis for flooding

Exposure to FLOODING	Exposure description
Any particular group of people (if so specify)	Considering the Atlas criteria, 34.4% of adults, 33.5% of children and a total of 26.3% of the population are exposed to floods of 1m depth or more. Nevertheless, this criterion must be taken carefully because even floods of less than 0.5m might have a strong impact in the WASH sector. Dwellers close to water bodies are the most exposed. Over 80% of the population in the districts of Katakwi, Otuke, Kitgum, Nwoya, Sembabule and Kalungu are exposed to floods of 1m depth or more. 21% of primary schools, 35% of secondary schools and around 1/3 of health facilities are exposed to floods of 1m or more.
Critical (WASH related) infrastructure	Water treatment plants, water points, shallow wells, boreholes, networks, latrines, sewers, and treatment plants in the flood prone areas are very exposed to flooding hazards, regardless of their magnitude. The frequent use of pit latrines (more than 80% of Ugandans use a pit latrine of some sort)[62], increases the possibility of contamination. Once infrastructure is submerged by floodwaters, it becomes inactive and maybe permanently damaged, compromising WASH services for the affected population. WASH facilities at exposed schools and health centres (including exposition of less than 1m) are at risk of temporary of even permanent damage, worsening the WASH situation of affected children and sick or wounded people.

[62] Tsimpo and Wood (2018) Access to sanitation: Quantitative analysis. Water and Sanitation in Uganda, World Bank.

Water sources (if so, are these primary water sources)	Almost 40% of protected springs are exposed to floods of moderate to high intensity. The districts whose protected springs are most exposed to floods are Otuke (32%), Nakapiripirit (25%) and Ngora (20%). Exposure of protected springs to less than 1m depth flood could compromise water quality as well.

4.2.2 Scoring exposure to flooding

The list of proposed indicators to score the degradation exposure is presented in the table below:

Table 42: Indicators for flooding exposure and their classification

Exposure / Component	Exposure (summary narrative)	High	Medium	Low	Score
Population Human	People living in flooding prone areas incur in several health risks	> 5% of population affected	0.5 – 5% of population affected	< 0.5% of population affected	**2,92**
		12	**1**	**0**	
Population Human	Children and other vulnerable groups are particularly exposed to this hazard, particularly if WASH facilities in schools are affected by flooding	> 5% of children affected	0.5 – 5% of children affected	< 0.5% of children affected	**2,23**
		6	**4**	**3**	
Population Social	Dwellers close to water bodies are the most exposed to flooding	> 5% of dwellers affected	0.5 – 5% of dwellers affected	< 0.5% of dwellers affected	**2,85**
		11	**2**	**0**	
Population Financial	Urban inhabitants are particularly affected to flash flooding	> 25% of income losses	10 – 25% of income losses	< 10% of income losses	**2,31**
		6	**5**	**2**	
Population Social	Due to damage to infrastructure, specific population groups are diverted to lower levels of water and sanitation service (e.g., unsafe sources, open defecation)	> 5% of population affected	0.5 – 5% of population affected	< 0.5% of population affected	**2,62**
		8	**5**	**0**	
Critical infrastructure Physical	Water supply systems might be affected by flooding, particularly damaging the distribution system	> 20% of critical infrastructure affected	5 – 20% of critical infrastructure affected	< 5% of critical infrastructure affected	**2,23**
		6	**5**	**3**	
Critical infrastructure Physical	Pit latrines are particularly affected by flooding	> 20% of pit latrines affected	5 – 20% of pit latrines affected	< 5% of pit latrines affected	**2,69**
		10	**2**	**1**	
Critical infrastructure Physical	WASH facilities at exposed health centers are particularly sensitive to flooding	> 15% of WASH infrastructure in HCF affected	5 – 15% of WASH infrastructure in HCF affected	< 5% of WASH infrastructure in HCF affected	**2,08**
		4	**6**	**3**	
Critical infrastructure Physical	WASH facilities at exposed schools are particularly sensitive to flooding	> 15% of WASH infrastructure at schools affected	5 – 15% of WASH infrastructure at schools affected	< 5% of WASH infrastructure at schools affected	**2,46**
		7	**5**	**1**	
Water and sanitation	Due to damage to infrastructure and lower level of services delivered to population, routine	> 25% of revenue losses by service	10 – 25% of revenue losses by service	< 10% of revenue losses by service	**2,46**

services Financial	revenue collection might not cover O&M costs	providers **6**	providers **7**	providers **0**	
Water sources Environmental	Shallow wells	> 20% of shallow wells affected **5**	5 – 20% of shallow wells affected **7**	< 5% of shallow wells affected **1**	**2,58**

4.3 Landslide

4.3.1 Characterization of exposure to landslide

The analysis of exposure and its scoring will focus on those areas that were previously identified as being prone to landslide hazards. Landslides are very localized hazards, concentrated in those areas close to mountains or hills. The most exposed regions are the East and the West. Mount Elgon, Mofumbiro and the Rwenzori region are the most prone areas. Some examples of districts affected by landslides are: Kapchorwa, Bukwo, Bududa, Kasese, Sironko, Rubanda, Bulamabuli, Kween, Kasese, Bundibugyo and Kisoro.

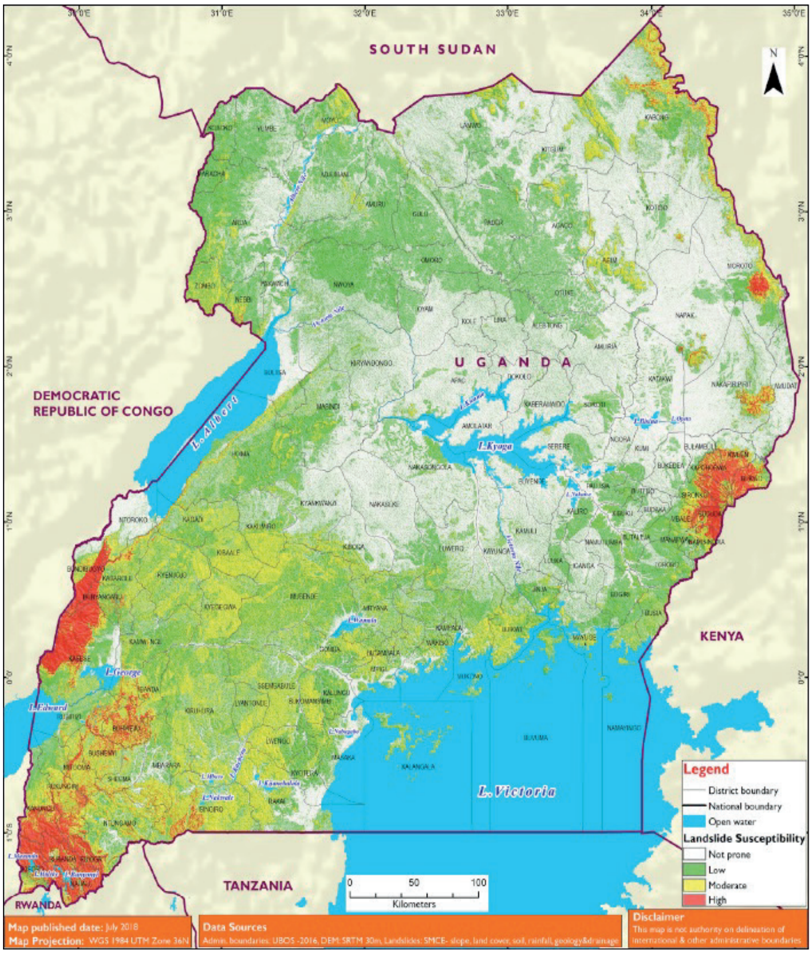


Figure 17: landslides zonation with rainfalls as triggering factor. Source: Atlas (2020) op. cit.

The exposure assessment of the landslide hazard is presented in the table below.

Table 43: Exposure analysis for landslides

Exposure to LANDSLIDES	Exposure description

Any particular group of people (if so specify)	According to the Atlas, 16,7% of the population or 5,8 million Ugandan are moderately and highly exposed to landslides. 285 thousand dwellers are exposed, and house materials have no significate influence on exposure. Exposition is more pronounced on the extreme eastern (Mt. Elgon) and western regions (Rwenzori area), and further southwest towards the Mufumbiro volcanoes. Over 80% of the population in Bulambuli, Kapchorwa, Bukwo, Kween, Kisoro and Rubanda districts are highly exposed to landslides. More than 60% of the residential buildings in Kapchorwa, Bulambuli, Kween, Bukwo and Kisoro districts are exposed to landslides.
Critical (WASH related) infrastructure	The Atlas considers that landslides sensitivity is high for all sectors that have a relation to the WASH sector (such as water and environment, health, lands, housing and urban development). Considering that almost 70% of Ugandans count on groundwater for their supply (shallow wells or deep boreholes) and that 83% use pit latrines, critical WASH infrastructure is exposed in the exposed areas. According to the Atlas (2020): 15% of shallow wells, 23% of health centers, 19% or primary schools and 18% of secondary schools are exposed to landslides of moderate to high intensities.
Water sources (if so, are these primary water sources)	Estimates count for half of all soil lost in landslides being transmitted to the stream network thus affecting the quality of the water resources[63]. Around 36% of protected springs are moderately or highly exposed to landslides, with the districts of Kapchorwa, Kween, Bulambuli and Bukwo having the highest percentages of their total protected springs exposed. In addition, 15% of all shallow wells are moderately exposed to landslides, while 43 (0,2%) are highly exposed (found in Bududa, Kapchorwa, Kasese, Rubanda, and Manafwa districts).

4.3.2 Scoring exposure to landslide

The list of proposed indicators to score the degradation exposure is presented in the table below:

Table 44: Indicators for landslide exposure and their classification

Exposure / Component	Exposure (summary narrative)	High	Medium	Low	Score
Population Human	Children in primary schools are particularly exposed to this hazard	> 5% of children affected	0.5 – 5% of children affected	< 0.5% of children affected	2,69
		9	**4**	**0**	
Population Human	Dwellers close to mountains and hills are the most exposed	> 5% of dwellers affected	0.5 – 5% of dwellers affected	< 0.5% of dwellers affected	2,77
		10	**3**	**0**	
Population Social	Due to damage to infrastructure, specific population groups are diverted to lower levels of water and sanitation service (e.g., unsafe sources, open defecation)	> 5% of population affected	0.5 – 5% of population affected	< 0.5% of population affected	2,62
		9	**3**	**1**	
Critical infrastructure Physical	Water supply systems might be affected by landslides, particularly damaging the distribution system	> 20% of critical infrastructure affected	5 – 20% of critical infrastructure affected	< 5% of critical infrastructure affected	2,23
		5	**6**	**2**	
Critical infrastructure Physical	Pit latrines are particularly affected by landslides	> 20% of pit latrines affected	5 – 20% of pit latrines affected	< 5% of pit latrines affected	2,31
		6	**5**	**2**	
Critical infrastructure	WASH facilities at exposed schools are particularly sensitive to landslides	> 15% of WASH infrastructure at schools affected	5 – 15% of WASH infrastructure at schools affected	< 5% of WASH infrastructure at schools affected	2,15

[63] WB (2011) op. cit., p. 48.

Physical		**4**	**7**	**2**	
Water and sanitation services Financial	Due to damage to infrastructure and lower level of services delivered to population, routine revenue collection might not cover O&M costs	> 25% of revenue losses by service providers	10 – 25% of revenue losses by service providers	< 10% of revenue losses by service providers	**2,38**
		8	**2**	**3**	

4.4 Land Degradation

4.4.1 Characterization of exposure to land degradation

The analysis of exposure and its scoring will focus on those areas that were previously identified as being prone to land degradation. The two most fragile ecosystems in the country are the highlands and the drylands, but other regions experience various degrees of land degradation processes as well. Particularly affected districts include: Kabale, Kisoro, Bundibugyo, Mbale, Kapchorwa, Kumi, Karamoja, Soroti, Kotido, Katakwi, Mbarara, Rakai and North Luwero.

The exposure assessment of the land degradation is presented in the table below.

Table 45: Exposure analysis for land degradation

Exposure to LAND DEGRADATION	Exposure description
Any particular group of people (if so specify)	Exposure to land degradation is higher for the population in the highlands and the drylands, but other areas are also exposed. Population living in rural areas is more exposed than those living in urban settings. Thus, the population that relies on agriculture for subsistence is particularly affected.
Critical (WASH related) infrastructure	In Mbarara, Ntungamo, Katakwi and Kasese, non-functionality of water gravity flow systems, boreholes, water pumping systems, protected water springs, shallow wells is in part associated to erosion processes and land degradation.
Water sources (if so, are these primary water sources)	Water resources are very exposed to land degradation in general and to erosion specifically. In Mbarara, Ntungamo, Katakwi and Kasese, 4% of the rivers and streams have been completely depleted. Moreover, in these districts' wetlands, rivers and streams have been encroached upon, while only 10% of the lakes and 5% of the forests have remained intact. This information might be used as a proxy for other regions.

4.4.2 Scoring exposure to land degradation

The list of proposed indicators to score the land degradation exposure is presented in the table below:

Table 46: Indicators for land degradation exposure and their classification

Exposure / Component	Exposure (summary narrative)	High	Medium	Low	Score
Population Human	The rural population is particularly exposed to this hazard	> 5% of population affected	0.5 – 5% of population affected	< 0.5% of population affected	**2,46**
		8	**3**	**2**	
Critical infrastructure	Water supply systems might be affected by degradation, particularly damaging the	> 20% of critical infrastructure affected	5 – 20% of critical infrastructure	< 5% of critical infrastructure affected	**1,92**

Physical	distribution system		affected		
		3	6	4	
Water sources Environmental	Deep boreholes	> 20% of boreholes affected	5 – 20% of boreholes affected	< 5% of boreholes affected	**2,00**
		3	**7**	**3**	
Water sources Environmental	Shallow wells	> 20% of shallow wells affected	5 – 20% of shallow wells affected	< 5% of shallow wells affected	**2,23**
		6	**4**	**3**	
Water sources Environmental	Protected springs	> 20% of protected springs affected	5 – 20% of protected springs affected	< 5% of protected springs affected	**2,23**
		5	**6**	**2**	
Water sources Environmental	Catchment basins	> 20% of catchment basins affected	5 – 20% of catchment basins affected	< 5% of catchment basins affected	**2,58**
		8	**3**	**1**	
Water sources Environmental	Erosion in recharge areas has severe consequences over water quality	> 20% of recharge areas affected	5 – 20% of shallow affected	< 5% of shallow affected	**2,58**
		8	**3**	**1**	

4.5 Water Pollution

4.5.1 Characterization of exposure to water pollution

The analysis of exposure and its scoring will focus on those areas that were previously identified as being prone to water pollution. In urban areas with piped systems, water quality is improved, and contamination tends to be less frequent and less intense, although water treatment plants are exposed to the presence of sand in water sources. In rural settings, peripheral urban areas and informal settlements, where population relies on open sources, bacteriological contamination is higher.

The exposure assessment of water pollution is presented in the table below.

Table 47: Exposure analysis for water pollution

Exposure to WATER POLLUTION	Exposure description
Any particular group of people (if so specify)	People living in rural areas and in informal settlements are more exposed to water pollution because they tend to use more open water sources for consumption. People that rely on protected springs and shallow wells are more exposed than those that use deep boreholes. Those that are connected to networks are less exposed.
Critical (WASH related) infrastructure	Water abstraction points, wells and boreholes are exposed.
Water sources (if so, are these primary water sources)	Rivers, lakes, and protected springs are very exposed to water pollution. To a lesser degree, ground water is also exposed. Exposure is higher in areas of high population density and in areas exposed to other hazards such as flooding, landslides and earthquakes.

4.5.2 Scoring exposure to water pollution

The list of proposed indicators to score the degradation exposure is presented in the table below:

Table 48: Indicators for water pollution exposure and their classification

Exposure / Component	Exposure (summary narrative)	High	Medium	Low	Score
Population	Rural population is more exposed to this hazard	> 5% of population affected	0.5 – 5% of population affected	< 0.5% of population affected	2,31
Human		**6**	**5**	**2**	
Population	People living in informal settlements are particularly affected by this hazard	> 20% of population in informal settlements affected	5 – 20% of population in informal settlements affected	< 5% of population in informal settlements affected	2,62
Human		**9**	**3**	**1**	
Water sources	Deep boreholes	> 20% of boreholes affected	5 – 20% of boreholes affected	< 5% of boreholes affected	1,62
Environmental		**3**	**2**	**8**	
Water sources	Shallow wells	> 20% of shallow wells affected	5 – 20% of shallow wells affected	< 5% of shallow wells affected	2,62
Environmental		**9**	**3**	**1**	
Water sources	Protected springs	> 20% of protected springs affected	5 – 20% of protected springs affected	< 5% of protected springs affected	2,15
Environmental		**4**	**7**	**2**	
Water sources	Water pollution affects the cost of service delivery	> 25% of increased costs	5 – 20% of increased costs	< 5% of increased costs	2,46
Environmental		**9**	**1**	**3**	

4.6 Water Overexploitation

4.6.1 Characterization of exposure to water overexploitation

The analysis of exposure and its scoring will focus on those areas that were previously identified as being prone to water overexploitation. The north-east and south-west are the regions that already experience water stress and scarcity. Although this might be more an issue of availability rather than water overexploitation, these areas tend to be more exposed to this hazard.

The exposure assessment of the water overexploitation is presented in the table below.

Table 49: Exposure analysis of water overexploitation

Exposure to WATER OVEREXPLOITATION	Exposure description
Any particular group of people (if so specify)	Particularly people that lack access to water are exposed to situations of water stress and scarcity.

Critical (WASH related) infrastructure	Over exploitation affects water supply especially the proper functioning of the network. Pumps, mortars, and other features of the networks may be damaged by fluctuating water levels.
Water sources (if so, are these primary water sources)	Surface water sources in lakes and rivers are exposed as well as groundwater.

4.6.2 Scoring exposure to water overexploitation

The list of proposed indicators to score the degradation exposure is presented in the table below:

Table 50: Indicators for water overexploitation exposure and their classification

Exposure / Component	Exposure (summary narrative)	High	Medium	Low	Score
Water sources	Deep boreholes	> 20% of boreholes affected	5 – 20% of boreholes affected	< 5% of boreholes affected	**2,08**
Environmental		**4**	**6**	**3**	
Water sources	Shallow wells	> 20% of shallow wells affected	5 – 20% of shallow wells affected	< 5% of shallow wells affected	**2,62**
Environmental		**8**	**5**	**0**	
Water sources	Protected springs	> 20% of protected springs affected	5 – 20% of protected springs affected	< 5% of protected springs affected	**2,15**
Environmental		**3**	**9**	**1**	
Water sources	Catchment basins	> 20% of catchment basins affected	5 – 20% of catchment basins affected	< 5% of catchment basins affected	**2,46**
Environmental		**8**	**3**	**2**	
Critical infrastructure	Water supply systems might be affected by water overexploitation, particularly damaging the distribution system	> 20% of infrastructure affected	5 – 20% of infrastructure affected	< 5% of infrastructure affected	**2,15**
Physical		**5**	**5**	**3**	

5. VULNERABILITY

As described in the methodology, the third step is the vulnerability assessment. Vulnerability is defined as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard[64].

In this exercise, the focus is on understanding and assessing the "underlying causes of vulnerability". Remarkably, while vulnerability is in general hazard-specific, certain factors, such as poverty, education, humand development, and the lack of social networks and social support mechanisms, will aggravate or affect vulnerability levels irrespective of the type of hazard. Vulnerability analysis considers six main components: human, social, physical, financial, political, and environmental.

The assessment has been conducted in a participatory way, through a simple voting system of the vulnerability indicators and questions proposed in the GWP and UNICEF Guidance Note, which were adapted to the Ugandan context. Results for all assessed indicators are shown in the tables below, which provide the criteria organized within the six components.

[64] GWP and UNICEF (2017), op. cit.

Table 52: Dimensions, criteria, and results of the vulnerability assessment

SOCIAL							
Factor	**Element**	**Question**	**Notes**	**High**[65]	**Medium**	**Low**	**Score**
Social networks (access to social networks such as informal social safety nets)	Access to social networks	Is there adequate access to social support networks such as informal safety nets?	Access to social network may be limited for most people in Uganda	4	3	0	**2,57**
		Do families, neighbours or communities support their members in case of need?	Access to social network may be limited for most people in Uganda	2	5	0	**2,29**
Community-wide knowledge and understanding of risks and WASH benefits	Community-based risk assessments	Are there any community-based risk assessments?	Community-based risk assessments are not conducted (or they are not available)	3	2	2	**2,14**
		How do communities perceive the impacts of climate change in their environment?	Almost 80% of Ugandans have heard of CC (Afrobarometer, 2019)	3	2	2	**2,14**
	Engagement in early warning systems	Is there sufficient engagement in early warning systems? Is there traditional (local) knowledge on EWS?		3	2	2	**2,14**
	Understanding of WASH benefits	How do the people connect their health situation with WASH services?		3	1	2	**2,17**
Norms/practice	Open defecation	What is the level of open defecation within the community?	In 2020, 5% of population in Uganda defecates in the open (6% in rural areas, and 2% in urban areas) (JMP, 2021)	2	4	1	**2,14**
	HWTS	What is the level of safe household water treatment and safe storage?		1	3	3	**1,71**
	Community awareness of protection of water sources	Is there good awareness in communities of the need to protect water sources?		3	0	4	**1,86**

[65] See Annex 3 for examples of vulnerability scoring systems

	Waste/garbage management	Is there proper waste management by the household? How is waste managed at household/community level (e.g., burning, burying, open dumping etc.)?	Most communities struggle with waste management mainly at household level so it isn't routinely done and in an ideal way.	2	2	3	**1,86**
Social cohesion	Conflict	Are there (strong) conflicts related to water access between different groups / community members?	In the past years, some conflicts have been reported in relation to access to water	0	4	2	**1,67**
	Marginalized groups	Are there marginalized groups / population in the provision of water and sanitation?		2	4	1	**2,14**
		How do marginalized groups access water?		2	3	1	**2,17**

FINANCIAL							
Factor	**Element**	**Question**	**Notes**	**High**	**Medium**	**Low**	**Score**
Routine WASH sector budget allocations, including recurrent budgets (sufficient routine investments are an obvious pre-requisite for resilience)	WASH public investment as % of GDP	How much investment is there in the WASH sector each year?	Currently, about 1.2 bn annually	3	1	2	**2,17**
	Adequacy of WASH recurrent budget	Is the WASH recurrent budget adequate?		2	2	1	**2,20**
Budget disaggregation	Budget lines	Are there clear WASH budget lines?		3		3	**2,00**
	Budget for mitigation, prevention, preparedness and response, and adaptation	Is there a separate budget for mitigation, prevention, preparedness and response, and adaptation?	Does not seem to be separate budget, but elsewhere, OPM has budget for disasters	3	2	2	**2,14**
Ability to draw on emergency funds	Contingencies	Are there any contingencies in budgets, and how quickly can they be released?	In Contracts, these are provided and accessed upon justification and approval by accounting officer	2	2	3	**1,86**

	Decentralised funding	Is there a practice of channelling spending and accounting for decentralised funding?	MWE has created regional/zonal offices. Some departments have decentralized arms of implementation	2	2	3	**1,86**
Service provider vulnerability	Cash reserves/insurance	Can service providers draw on cash reserves or insurance to rehabilitate services?	MWE supports rehabilitation and expansion, System maintenance and operation are undertaken using collections, rehabilitation	2	2	3	**1,86**
	Mitigate emergencies	Have service providers taken steps to mitigate emergency water supply? Do they have funds? Are they incentivized?	Only NWSC does this for key customers.	5	1		**2,83**

PHYSICAL							
Factor	**Element**	**Question**	**Notes**	**High**	**Medium**	**Low**	**Score**
Resilience of WASH infrastructure – e.g. designing for appropriate levels of climate variability (design and construction standards confer resilience on WASH physical infrastructure: reliability/ yield, water quality protection, infrastructure damage)	Technology	Is the available technology for WASH infrastructure resilient? For example, which latrine types are predominantly used (in urban and rural areas)? Are they resilient?	In Uganda, pumping systems and supply by gravity are common. For sanitation, water borne public toilets as pilot studies, and lined pit latrines as pilot in schools.	2	3	2	**2,00**
	Existence of sound design/construction standards	Are there any sound design/ construction standards?	DWD Design Manual and Design Guidelines 2013	3	2	2	**2,14**
	Standards observed in implementation	Are the design and construction standards observed in implementation?		1	4	2	**1,86**
	Water storage infrastructure	Is drinking water for domestic use held in tanks or other storage infrastructure? Is the storage capacity (in days) known?	Capacity is meant for a day, however in the intermediate period, some systems store for 2 to 3 days depending on consumption and availability	3	3	1	**2,29**
	Geographic conditions	Is the technology designed based on existing hazards (e.g. earthquakes, floods, etc.)		2	4	1	**2,14**

	Operation and Maintenance (O&M)	Are there appropriate measures in place for O&M?		1	4	2	**1,86**

ENVIRONMENTAL							
Factor	**Element**	**Question**	**Notes**	**High**	**Medium**	**Low**	**Score**
Environmental degradation (land use change is a major cause of vulnerability)	Role of deforestation / wetlands or catchment degradation	What is the average rate of deforestation in the country? Where is deforestation more intense?		3	4		**2,43**
		What is the rate of wetlands/catchment degradation?		5	2		**2,71**
	Soil degradation	Is there any soil degradation resulting from human activities? How extensive is this? What are some of these human activities?		3	2	1	**2,33**
	Water quality	What are the main causes for the poor quality of water sources? Are there any known dangerous spills entering water sources, or any detected leakages?		4	3		**2,57**
Resilience of water sources (poor siting and protection of WASH sources make systems vulnerable, leading to outages and reduced services)	Siting of water sources	Are water points poorly sited, e.g. outside of areas that can provide reliable and safe supply?	Communities play an important role in the definition of sites. Siting is normally based on community preferences and not based on availability		5	2	**1,71**
		Are hydrological investigations carried out to site water sources?			4	3	**1,57**
	Protection of water sources	Are water sources adequately protected? Are some better protected than others?	Water source protection framework and guidelines available: https://www.mwe.go.ug/sites/default/files/library	1	3	3	**1,71**
	Sustainability of abstractions	Are abstractions sustainable? Are groundwater resources being replenished (naturally or artificially)? Are there decrease yield due to adverse seasonal conditions?	Government regulates abstractions through permits.	1	1	4	**1,50**
Alternative water sources (the use of	Alternative water sources	Are there alternative water sources to use if necessary? Are the water supply	Each ground water-based system has alternative source, but low yields are sometimes an obstacle.		5	2	**1,71**

				High	Medium	Low	Score
alternative water sources if necessary and plans in place to use these)		systems relying on a single source?	Rainwater harvesting at household level is often an adequate alternative source of water.				
Waste disposal (poorly managed waste disposal – domestic and industrial)	Landfill sites	Are landfill sites inappropriately sited or used? Are landfill sites poorly managed?	Landfills are typically located close to larger cities	3	3	1	**2,29**
	Sewage disposal	Is sewage being disposed of safely? What about industrial waste?	Government discharge permits are in place as a regulatory tool. They are in place particularly in big towns.	4	3		**2,57**
Degradation of sub-surface and groundwater sources	Sub-surface and groundwater sources degradation	Is there any degradation of sub-surface and groundwater sources? If so, how extensive is this, how many sources are affected?		2	4	1	**2,14**

HUMAN							
Factor	**Element**	**Question**	**Notes**	**High**	**Medium**	**Low**	**Score**
Demographic characteristics (age, levels of education, health and poverty)	Human Development Index (HDI).[66]	What is the HDI? Are there other similar factors that are relevant?		2	2	2	**2,00**
	Age of population	Is there a large population of very old or young people?	In Uganda, based on the population census, 54% are below 18 years	5		1	**2,67**
Knowledge and understanding (lack of knowledge reduces efficacy of behavioural change and can lessen the demand for WASH services)	Knowledge and understanding of local hazards	How knowledgeable are people about local hazards and how to protect latrines and water supply systems?	Poor knowledge by vulnerable population and in rural areas	2	3	2	**2,00**
	Knowledge and understanding of WASH benefits	How knowledgeable are people about WASH benefits?	WASH services receive a high demand, which might be a proxy of some level of knowledge	2	4	1	**2,14**
Population growth / ubanisation (rapid population growth and urbanisation are major causes of vulnerability)	National population growth	What is the population growth rate?		6		1	**2,71**
	Urban population growth	What is the rate of urbanisation?		2	2	2	**2,00**
	Demand for water	What is the expected change in the demand for water?	Demand for water is town specific.	6		1	**2,71**

[66] Available at http://hdr.undp.org/en/data

POLITICAL (AND INSTITUTIONAL)							
Factor	**Element**	**Question**	**Notes**	**High**	**Medium**	**Low**	**Score**
WASH policies (incl. for climate), public institutions and governance (public policy and public institutions provide the necessary national guidance for dealing with vulnerabilities and risks)	Government effectiveness	Is there public policy to provide the necessary guidance for identifying and addressing vulnerabilities and risks?		2	3	2	**2,00**
	WASH and other policies	Are there appropriate WASH policies in place? Are there policies in place that specifically include climate resilience? Are these policies if available being implemented?		1	3	2	**1,83**

Based on the aggregation methodology presented in Section 2, overall values for the six components are presented in the following table:

Table 51: Aggregated scores of six vulnerability components

Social Aggregated Score: 2,08	**Financial** Aggregated Score: 2,11	**Physical** Aggregated Score: 2,05
Environmental Aggregated Score: 2,11	**Human** Aggregated Score: 2,32	**Political (and institutional)** Aggregated Score: 1,92

6. RISK PRIORITIZATION

In the last step, the individual scores for hazard, exposure and vulnerability are combined to come up with an overall score for risks. The standard risk formula is employed:

Risk = Hazard x Exposure x Vulnerability

These scores are then used to rank the risks and determine priorities. Annex 4 provides a full detailed list of all risks. In the table below, top 25 risks have been initially prioritised. Alternatively, a threshold could be defined to decide which of the risks could be taken forward to the identification and appraisal of climate options and solutions.

Table 53: List of 25 prioritized climate risks to WASH services and facilities in Uganda

Hazard	Score	Exposure		Score	Vulnerability Component	Score	Climate Risk
Flooding	2,56	Population	People living in flooding prone areas incur in several health risks	2,92	Human	2,32	**17,34**
Flooding	2,56	Population	Dwellers close to water bodies are the most exposed to flooding	2,92	Human	2,32	**17,34**
Drought	2,67	Population	Women: women and girls that fetch water from rivers, ponds, wells, water points, etc. are particularly exposed to this hazard	2,75	Human	2,32	**17,01**
Drought	2,67	Population	Farmers' livelihoods are particularly affected in drought periods, with severe income losses	3,00	Financial	2,11	**16,91**
Drought	2,67	Water sources	Shallow wells	2,92	Environmental	2,11	**16,37**
Landslide	2,54	Population	Dwellers close to mountains and hills are the most exposed	2,75	Human	2,32	**16,21**
Landslide	2,54	Population	Children in primary and secondary schools are particularly exposed to this hazard	2,67	Human	2,32	**15,72**
Water pollution	2,61	Population	People living in informal settlements are more exposed to water pollution	2,58	Human	2,32	**15,65**
Drought	2,67	Population	Children: girls in charge of fetching water from rivers, ponds, wells, water points, etc. are particularly exposed to this hazard	2,50	Human	2,32	**15,46**

Water overexploitation	2,69	Water sources	Shallow wells	2,58	Environmental	2,11	**14,62**
Drought	2,67	Water and sanitation services	Due to damage to infrastructure and lower level of services delivered to population, routine revenue collection might not cover O&M costs	2,58	Financial	2,11	**14,57**
Drought	2,67	Water sources	Protected springs	2,58	Environmental	2,11	**14,50**
Degradation	2,56	Population	Rural population is exposed to land degradation	2,42	Human	2,32	**14,37**
Water pollution	2,61	Water sources	Shallow wells	2,58	Environmental	2,11	**14,20**
Water pollution	2,61	Population	Rural population is more exposed to water pollution	2,33	Human	2,32	**14,13**
Flooding	2,56	Critical infrastructure	Pit latrines are particularly affected by flooding	2,67	Physical	2,05	**13,99**
Flooding	2,56	Population	Due to damage to infrastructure, specific population groups are diverted to lower levels of water and sanitation service (e.g., unsafe sources, open defecation)	2,58	Social	2,08	**13,75**
Degradation	2,56	Water sources	Catchment basins	2,55	Environmental	2,11	**13,73**
Degradation	2,56	Water sources	Erosion in recharge areas has severe consequences over water quality	2,55	Environmental	2,11	**13,73**
Water overexploitation	2,69	Water sources	Catchment basins	2,42	Environmental	2,11	**13,67**
Landslide	2,54	Population	Due to damage to infrastructure, specific population groups are diverted to lower levels of water and sanitation service (e.g., unsafe sources, open defecation)	2,58	Social	2,08	**13,64**
Flooding	2,56	Population	Children and other vulnerable groups are particularly exposed to this hazard, particularly if WASH facilities in schools are affected by flooding	2,25	Human	2,32	**13,37**
Water pollution	2,61	Water sources	Water pollution affects the costs of service delivery	2,42	Environmental	2,11	**13,28**
Flooding	2,56	Critical infrastructure	WASH facilities at exposed schools are particularly sensitive to flooding	2,50	Physical	2,05	**13,12**
Flooding	2,56	Water and sanitation services	Due to damage to infrastructure and lower level of services delivered to population, routine revenue collection might not cover O&M costs	2,42	Financial	2,11	**13,09**

7. DISCUSSION

This section provides a comprehensive discussion about results presented in previous sections. First, the analysis covers separately the hazards, the exposure, and the vulnerability. Second, a discussion about prioritised risks is provided.

7.1 Hazards

To start with, the following table summarizes the final scoring for all hazards.

Table 54: Aggregated results of the hazards assessment

	Geographical Extent				Frequency / Intensity				Score
	High	Medium	Low	Average	High	Medium	Low	Average	
Drought	7	2	0	**2,67**	5	4	0	**2,56**	**2,67**
Flooding	3	6	0	**2,38**	6	2	0	**2,75**	**2,56**
Landslide	6	2	0	**2,75**	3	6	0	**2,33**	**2,54**
Land degradation	6	2	0	**2,75**	3	5	0	**2,38**	**2,56**
Water pollution	5	4	0	**2,56**	6	3	0	**2,67**	**2,61**
Water overexploitation	5	3	0	**2,63**	6	2	0	**2,75**	**2,69**

Main remarks are:

All hazards scored HIGH for geographical extent, except flooding, and all hazards scored HIGH for frequency and intensity, except landslide and land degradation | Remarkably, no participant assigned a “LOW” score in any voting. Achieved results therefore indicate that stakeholders agree on the relevance of all identified hazards for the WASH sector. Except flooding, all hazards affect a large area of the country, and it is expected that the affected area will increase in the future. On the other hand, flood prone areas are limited to those areas near water bodies and to some urban settings. These results are consistent with most studies and references cited in previous Section 3.

At the same time, participants consider that all hazards will become more frequent and intense, except landslides and land degradation. However, this is only partially consistent with other findings from the literature. The latter two hazards depend directly on precipitation and land use, among other factors. Considering the trend of more concentrated rainfall patterns, frequency and intensity of landslide events and degradation (particularly soil erosion) is expected to increase in the future. Nevertheless, the fact that no hazard scored low corroborates that all of them are relevant in the present and that climate change will negatively impact their occurrence in the future.

Most relevant hazards are drought, water overexploitation and water pollution. These hazards scored HIGH for geographical extent, frequency, and intensity | Drought, water pollution, and water overexploitation are perceived as affecting a large area of the country and occurring frequently and intensely, both in the present and in the future. Being drought defined as the prolonged occurrence of lower rainfalls than average, and considering forecasts, this view is consistent with most studies and with the analysis of previous sections. On the contrary, water pollution and water overexploitation are only indirectly influenced by climate change. Although lower precipitation levels impact the quantity and quality of water sources, both hazards are mainly man-made and the length, frequency and intensity of their occurrence will depend at least in part on the ability to improve practices that have a negative incidence on the demand and management of water resources.

7.2 Exposure

The following table lists, for each hazard, top three prioritised exposure indicators.

Table 55: Three top prioritized exposure indicators per hazard

Hazard	Exposure	Exposure (summary narrative)	Score
Drought	Population	Farmers' livelihoods are particularly affected in drought periods, with severe income losses	**3,00**
	Water sources	Shallow wells	**2,92**
	Population	Women: women and girls that fetch water from rivers, ponds, wells, water points, etc. are particularly exposed to this hazard	**2,77**
Flooding	Population	People living in flooding prone areas incur in several health risks	**2,92**
	Population	Dwellers close to water bodies are the most exposed to flooding	**2,85**
	Critical infrastructure	Pit latrines are particularly affected by flooding	**2,69**
Landslide	Population	Dwellers close to mountains and hills are the most exposed	**2,77**
	Population	Children in primary and secondary schools are particularly exposed to this hazard	**2,69**
	Population	Due to damage to infrastructure, specific population groups are diverted to lower levels of water and sanitation service (e.g., unsafe sources, open defecation)	**2,62**
Land degradation	Water sources	Erosion in recharge areas has severe consequences over water quality	**2,58**
	Water sources	Catchment basins	**2,58**
	Population	Rural population is exposed to land degradation	**2,46**
Water pollution	Water sources	Shallow wells	**2,62**
	Population	People living in informal settlements are more exposed to water pollution	**2,62**
	Water sources	Water pollution affects the costs of service delivery	**2,46**
Water overexploitation	Water sources	Shallow wells	**2,62**
	Water sources	Catchment basins	**2,46**
	Water sources	Protected springs	**2,15**

Main remarks are:

Population is the most exposed element, specifically in relation to droughts, flooding, and landslide | According to the analysis, the most affected groups are women and children, that are particularly exposed to drought and landslide, and the rural population, that is especially exposed to drought and degradation. Also, those people that live in informal settlements are particularly exposed to water pollution. The location of dwellers is a key element in the exposure to flooding and landslides. Thus, people that live near water bodies or in mountainous regions are the most exposed to these hazards. The Atlas indicates for instance vulnerability to flooding reaches 40% of Ugandans. In Nakapiripirit, Katakwi, Ngora, Pallisa, Bulambuli, Butaleja, Bukedea, Kumi, Ntoroko, Kibuku vulnerability is very high, with more than 80% of the population of these districts potentially affected[67]. When events occur, the population affected by drought, flooding and landslide is directly and immediately diverted to lower service levels. They must then opt for alternative water sources, that might be either less safe or more expensive, and to practices such as open defecation, incurring in higher health risks.

Pit latrines are highly exposed to flooding. In addition, costs of water treatment might be affected by water pollution | Based on last official data from the Joint Monitoring Programme for Water Supply and Sanitation[68], roughly 35% of population use improved latrines. Other sources suggest that more than 80% of Ugandans use some type of pit latrine, either improved or unimproved[69]. In consequence, the level of exposure of basic sanitation infrastructure to hazards such as flooding in flood prone areas is very high. The combination of flooded waters with latrines has severe health and environmental consequences in the affected areas, with children and the elderly being often the first victims of waterborne diseases.

At the same time, service provision might be affected by several hazards. Results indicate as particularly relevant the exposure of water supply infrastructure to water pollution. This in turn leads to insufficient cost recovery due to higher treatment costs and users' unwillingness to pay for poor quality services. By way of example, a 1% increase in turbidity is shown to increase chemical costs for treatment by 0,25%[70].

Water sources are also very exposed, particularly in relation to land degradation, water pollution and water overexploitation | Among all water sources, shallow wells, which serve a significant proportion of the population, are exposed to drought, water pollution, and water overexploitation. While protected springs are only exposed to water overexploitation, catchment basins are highly exposed to this hazard and also to land degradation. Studies indicate that conversion of 1% of a watershed from forested to developed land is associated with an increase in turbidity by 3.9%[71], which in turn impacts service costs.

7.3 Vulnerability

The following table presents the aggregated scoring for the six vulnerability components.

Table 56: Scoring of the vulnerability components

Vulnerability component	Score
Social	2,08
Financial	2,11
Physical	2,05
Environmental	2,11
Human	2,32
Political (and institutional)	1,92

[67] Government of Uganda (2019) National Risk and Vulnerability Atlas of Uganda, p. 150.

[68] Joint Monitoring Programme, 2021

[69] Tsimbo and Wodon, 2018.

[70] Dearmont et al., 1998.

[71] Warziniack et al., 2016.

Main remarks are:

Highest levels of vulnerability relate to the human and the environment, in coherence with the high exposure of population and water sources | A significant part of Ugandans is young (based on the last population census, 54% are below 18 years). According to the Atlas, children below 5 years of age are considered highly vulnerable and children up to 17 are moderately vulnerable[72]. In addition, the population growth rate is high. These two demographic elements, combined with low levels of awareness of efficient water use, might increase and accelerate water demand. In addition, limited knowledge of the population regarding benefits from sound WASH services and poor understanding of impacts of climate risks on basic WASH infrastructure, particularly in rural areas, are factors that increase vulnerability.

At the same time, soil degradation, deforestation, low level of sanitation coverage, and poor sewage disposal lead to water pollution and poor water quality, both affecting environmental vulnerability. Contamination of water sources raises, in turn, the risk of waterborne diseases, especially for children.

Financial vulnerability is also high, in particular for service providers | According to the results, financial sustainability of service providers might be hampered in case of extreme climate events. On the one hand, routine budget allocations are not adequate and there is no distinction between budget lines for adaptation, mitigation, preparedness, and response to emergencies. On the other hand, service providers have limited conditions to mitigate emergencies, because of low access to funding, although receiving some support from the Ministry of Water and Environment.

Physical and political (and institutional) components of vulnerability seem to be less relevant in Uganda | Although physical vulnerabilities have not been clearly prioritised, poor current coverage of adequate sanitation may question, to a certain extent, this scoring. As mentioned above, pit latrines for instance, which are used by most Ugandans, are highly vulnerable to specific hazards such as flooding. Similarly, pumping systems and distribution by gravity, the most common water supply infrastructure in the country, might be affected in the event of specific hazards. In addition, storage capacity of drinking water is often insufficient, leading to less resilient services.

In contrast, political and institutional dimensions of vulnerability are considered not relevant. Achieved results show that policies and governmental institutions generally provide the necessary guidance for identifying and addressing climate risks.

7.4 Prioritised Risks

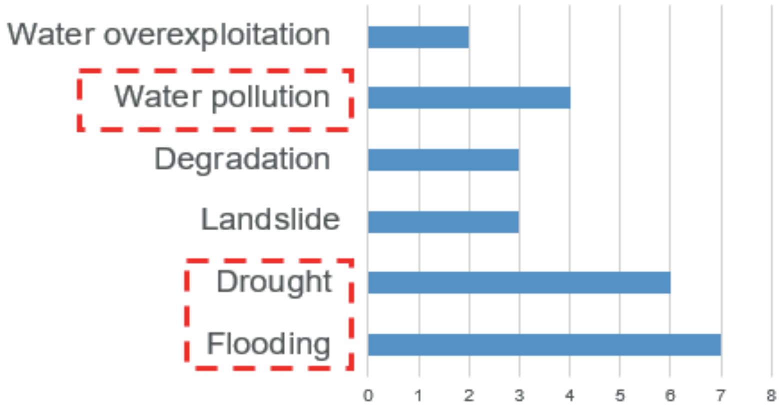
A focus on the 25 prioritised risks, shown in previous Table 53, produce complementary results. It is observed, for instance, that all hazards appear at least once in the list. However, drought and flooding seem to be more relevant both in terms of ranking and number of occurrences. The most exposed elements are population and water sources, while highest levels of vulnerability relate to the human and the environment.

7.4.1 Climate risks, aggregated by hazard

The list of the 25 prioritized climate risks aggregated by hazards (Figure 18) show that drought, flooding, and water pollution are the most relevant hazards in Uganda, with 7, 6 and 4 occurrences, respectively. Degradation and landslide come next, with 3 occurrences each, followed by water overexploitation with 2 occurrences. These results are not totally in line with those of section 7.1. In the first step of the methodology, water overexploitation was prioritized. However, when combined with exposure, associated risks appear to be less relevant. For the other hazards, the list of prioritized risks aligns well with previous analysis.

[72] Government of Uganda (2019) National Risk and Vulnerability Atlas of Uganda, p. 149.

Figure 18: hazards among 25 prioritized risks



A separate analysis by hazard shows complementary results.

Flooding impacts locally on those populations living close to water bodies and flooding prone areas, who are then affected through a diverse range of vulnerabilities, such as human, social, and financial | As mentioned in previous Section 3, flooding is a very frequent hazard, occurring every year in the wet season, and primarily affecting the districts of Pallisa, Bulambuli, Butaleja, Kibuku, Ntoroko, Ngora, Katakwi and Bukedea. The table below shows that seven flooding-related risks have been prioritised, with 2 of them scoring HIGH. It is shown, for instance, that people living in flooding prone areas and close to water bodies are the most exposed. In terms of infrastructure, flooding affects particularly pit latrines and other basic sanitation infrastructure, as well as WASH facilities at schools. On the one hand, damaged infrastructure increases the risk of specific population having to opt for lower levels of service. In addition, poor service quality might hamper revenue collection, which in turn may impact on service providers' financial sustainability. The table also shows the linkages between this hazard and human-related vulnerability, also impacting other types of vulnerability such as social, physical, and financial.

Table 57: occurrences of flooding in the top 25 prioritized risks

Hazard	Score	Exposure		Score	Vulnerability Component	Score	Climate Risk
Flooding	2,56	Population	People living in flooding prone areas incur in several health risks	2,92	Human	2,32	**17,34**
Flooding	2,56	Population	Dwellers close to water bodies are the most exposed to flooding	2,92	Human	2,32	**17,34**
Flooding	2,56	Critical infrastructure	Pit latrines are particularly affected by flooding	2,67	Physical	2,05	**13,99**
Flooding	2,56	Population	Due to damage to infrastructure, specific population groups are diverted to lower levels of water and sanitation service (e.g., unsafe sources, open defecation)	2,58	Social	2,08	**13,75**
Flooding	2,56	Population	Children and other vulnerable groups are particularly exposed to this hazard, particularly if WASH facilities in schools are affected by flooding	2,25	Human	2,32	**13,37**
Flooding	2,56	Critical infrastructure	WASH facilities at exposed schools are particularly sensitive to flooding	2,50	Physical	2,05	**13,12**
Flooding	2,56	Water and sanitation services	Due to damage to infrastructure and lower level of services delivered to population, routine revenue collection might not cover O&M costs	2,42	Financial	2,11	**13,09**

Drought affects vulnerable population groups, such as children, water sources, and WASH services, linking to a range of human, financial and environmental vulnerabilities | The 6 occurrences of drought presented in the table below suggest that this hazard is very relevant in Uganda. Among these 6 occurrences, 3 scored HIGH and relate to population and water sources. Women and children are very affected by this hazard, as well as farmers, that incur in severe income losses. Currently, intense drought events occur especially in the Karamoja region, particularly in the districts of Kaabong, Moroto, Kotido, Napak, Amudat, Nakapiripirit and Kitgum. Although in the future the geographical extent is not expected to expand, according to most forecasts, drought events will become more frequent and intense.

As a consequence of drought events, the affected groups are diverted to lower levels of service, increasing health risks. Because of damaged infrastructure and decreased quantities of water delivered to users, service providers might find it difficult to cover O&M costs, compromising service financial sustainability. Shallow wells and protected springs, that currently supply a significant portion of the population, are the most affected water sources. The table shows that human, environmental and financial components of vulnerability are prevalent.

Table 58: occurrences of drought in the top 25 prioritized risks

Hazard	Score	Exposure		Score	Vulnerability Component	Score	Climate Risk
Drought	2,67	Population	Women: women and girls that fetch water from rivers, ponds, wells, water points, etc. are particularly exposed to this hazard	2,75	Human	2,32	17,01
Drought	2,67	Population	Farmers' livelihoods are particularly affected in Drought periods, with severe income losses	3,00	Financial	2,11	16,91
Drought	2,67	Water sources	Shallow wells	2,92	Environmental	2,11	16,37
Drought	2,67	Population	Children: girls in charge of fetching water from rivers, ponds, wells, water points, etc. are particularly exposed to this hazard	2,50	Human	2,32	15,46
Drought	2,67	Water and sanitation services	Due to damage to infrastructure and lower level of services delivered to population, routine revenue collection might not cover O&M costs	2,58	Financial	2,11	14,57
Drought	2,67	Water sources	Protected springs	2,58	Environmental	2,11	14,50

Landslides impacts locally on those populations living close to mountains and hills, in particular children |Two out of 3 occurrences of landslides among the top 25 prioritized risks scored HIGH and show the relative importance of this hazard in the country, despite the fact that it is a very localized phenomenon. Landslides occur specially in the wet seasons since rainfall is most important triggering factor. Considering forecasts of increased rainfall intensities for the future, together with changes in land use, landslide episodes could become more frequent and intense, as described in Section 3. Population is the most exposed element, which relates to the presence of human and social components of vulnerability. Regarding exposure to landslides, dwellers, location is a key element; and children in primary and secondary schools are particularly affected. Similar to drought and flooding, the people affected by landslides might be induced to opt for lower levels of service, raising health concerns, especially for children.

Table 59: occurrences of landslide in the top 25 prioritized risks

Hazard	Score	Exposure		Score	Vulnerability Component	Score	Climate Risk
Landslide	2,54	Population	Dwellers close to mountains and hills are the most exposed	2,75	Human	2,32	16,21
Landslide	2,54	Population	Children in primary and secondary schools are particularly exposed to this hazard	2,67	Human	2,32	15,72
Landslide	2,54	Population	Due to damage to infrastructure, specific population groups are diverted to lower levels of water and sanitation service (e.g., unsafe sources, open defecation)	2,58	Social	2,08	13,64

Land degradation impacts directly on the rural population and the quality of water resources, showing the prevalence of human and environmental vulnerabilities | Land degradation comes 3 times among the top 25 prioritized risks. It impacts severely on catchment basins and compromises the quality of water sources. The occurrence of land degradation being inexistent in urban settings, the rural population is the one that is normally affected by this hazard, especially in the highlands and the drylands, as described in Section 3. Thus, the environmental and human components of vulnerability are present. Particularly affected districts include Kabale, Kisoro, Bundibugyo, Mbale, Kapchorwa, Kumi, Karamoja, Soroti, Kotido, Katakwi, Mbarara, Rakai and North Luwero. Being rainfall a very important cause for erosion, degradation might increase in the future due to trends of more concentrated precipitation.

Table 60: occurrences of land degradation in the top 25 prioritized risks

Hazard	Score	Exposure		Score	Vulnerability Component	Score	Climate Risk
Degradation	2,56	Population	Rural population is exposed to land degradation	2,42	Human	2,32	14,37
Degradation	2,56	Water sources	Catchment basins	2,55	Environmental	2,11	13,73
Degradation	2,56	Water sources	Erosion in recharge areas has severe consequences over water quality	2,55	Environmental	2,11	13,73

Rural population and those living in informal settlements are particularly exposed to water pollution, as well as shallow wells, which increases water treatment costs | Water pollution appears 4 times among the top 25 prioritized risks and has one of its related risks with a HIGH score. In terms of exposure, population living in rural areas and informal settlements are most severely affected. Chemicals used in agriculture together with poor wastewater treatment and sludge management are the most important sources of contamination, as discussed in previous Section 3. It affects water sources and leads to higher costs for water treatment, which in turn impacts service sustainability. This situation is more severe in the dry period, during which contaminants concentration is higher. Shallow wells, that serve more than 80% of Ugandans, are the type of water source that is most directly affected by water pollution. In consequence, human and environmental vulnerabilities are the most important.

Table 61: occurrences of water pollution in the top 25 prioritized risks

Hazard	Score	Exposure		Score	Vulnerability Component	Score	Climate Risk
Water pollution	2,61	Population	People living in informal settlements are more exposed to water pollution	2,58	Human	2,32	15,65
Water pollution	2,61	Water sources	Shallow wells	2,58	Environmental	2,11	14,20
Water pollution	2,61	Population	Rural population is more exposed to water pollution	2,33	Human	2,32	14,13
Water pollution	2,61	Water sources	Water pollution affects the costs of service delivery	2,42	Environmental	2,11	13,28

Water overexploitation impacts both shallow wells and catchment basins, thus linking with environmental vulnerability | The 2 occurrences of water overexploitation in the top 25 prioritized risks corroborate that water sources are the most affected elements by this hazard, which relates to the environmental component of vulnerability. Shallow wells appear again as a very sensitive type of water source. During the dry seasons, overexploitation is more intense because of decreased water availability. Some areas in the north-east and the south-west currently experience water stress and scarcity. Even considering forecasts of increased rainfalls in the future, water stress is expected to become more acute - due to population growth, land degradation, and other climate related hazards - and to geographically expand towards new areas in the east and the centre of the country, as described in Section 3.

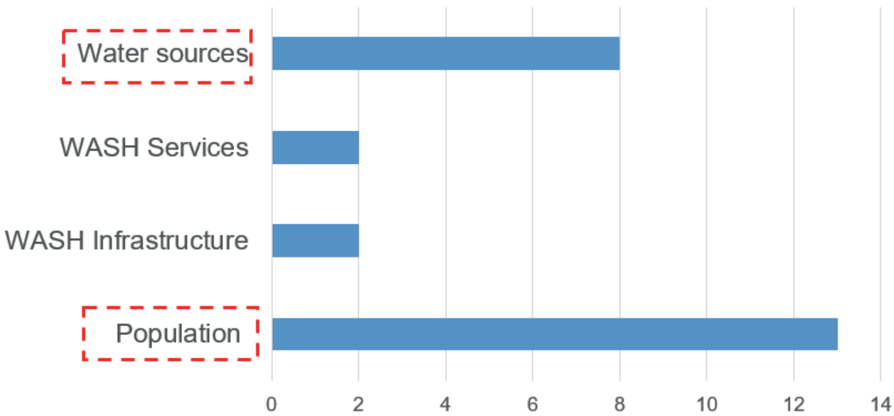
Table 62: occurrences of water overexploitation in the top 25 prioritized risks

Hazard	Score	Exposure		Score	Vulnerability Component	Score	Climate Risk
Water overexploitation	2,69	Water sources	Shallow wells	2,58	Environmental	2,11	14,62
Water overexploitation	2,69	Water sources	Catchment basins	2,42	Environmental	2,11	13,67

7.4.2 Climate risks, aggregated by exposure

Much in the same way as in previous section, the list of 25 prioritized risks can be aggregated by exposure. Figure 19 indicates that population and water sources are the most exposed elements, with 13 and 8 occurrences, respectively. These results are in line with the exposure analysis conducted in section 4, that highlight the high exposure of certain groups of the population and water sources. WASH services and infrastructure present 2 occurrences each, as shown in the figure below.

Figure 19: types of exposure among 25 prioritized risks



Several population groups are particularly exposed to more than one hazard, such as children, women, and farmers | Remarkably, eight out of top ten prioritized risks relate to population exposure, with seven of those scoring HIGH. The most exposed groups are children, women, farmers, and people living in informal settlements, being affected by several hazards simultaneously. Children for instance are exposed to drought and landslides, but poor WASH infrastructure at schools might exacerbate their exposure to other hazards. Considering that dwellers location is a significant element in terms of vulnerability to flooding and landslides, people that live close to water bodies and in mountainous regions are more vulnerable to these hazards. On the other hand, farmers that rely on rainwater for their subsistence are very vulnerable to drought and landslides and incur in income losses when these hazards occur. More concentrated rainfall patterns in the future might increase their vulnerability.

Water sources exposure analysis shows that shallow wells are highly affected by several hazards | Shallow wells are the most exposed type of water source, according to the scoring results, especially to drought, water pollution and water overexploitation, while deep boreholes are the less exposed. Exposure of catchment basins to degradation and water overexploitation is also important, which compromises water availability and quality. Contaminated water sources might lead to higher treatment costs. Higher temperatures, more concentrated rainfall patterns, deforestation, changes in land use, population growth and urbanization that tend to occur in the future might exacerbate the exposure of water sources to all hazards, with direct impacts over the WASH sector.

Exposure of WASH infrastructure mainly refers to pit latrines and to WASH facilities in schools during flooding events | As indicated previously, pit latrines are very exposed to flooding. The widespread use of this sanitation solution raises exposure concerns, especially considering forecasts of more concentrated rainfalls in the future, which will make flood events more frequent and intense. WASH facilities at schools are also affected in flood prone areas, with increased health risks for children.

Exposure of WASH services relates to the impacts of hazards over cost recovery, indicating an expressive financial vulnerability of service providers | The occurrence of hazards such as flooding and drought might impact the financial sustainability of service provision, since due to higher costs and lower levels of service delivered to the population providers might find it difficult to raise enough funds to operate and maintain infrastructure. As the analysis conducted in section 3 suggests, more frequent and intense drought and flooding events in the future will worsen this situation.

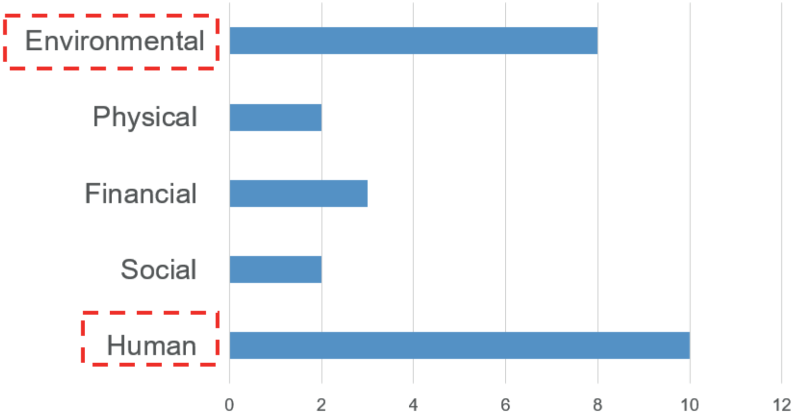
Table 63: exposure among the top 10 prioritized risks

Hazard	Score	Exposure		Score	Vulnerability Component	Score	Climate Risk
Flooding	2,56	Population	People living in flooding prone areas incur in several health risks	2,92	Human	2,32	17,34
Flooding	2,56	Population	Dwellers close to water bodies are the most exposed to flooding	2,92	Human	2,32	17,34
Drought	2,67	Population	Women: women and girls that fetch water from rivers, ponds, wells, water points, etc. are particularly exposed to this hazard	2,75	Human	2,32	17,01
Drought	2,67	Population	Farmers' livelihoods are particularly affected in Drought periods, with severe income losses	3,00	Financial	2,11	16,91
Drought	2,67	Water sources	Shallow wells	2,92	Environmental	2,11	16,37
Landslide	2,54	Population	Dwellers close to mountains and hills are the most exposed	2,75	Human	2,32	16,21
Landslide	2,54	Population	Children in primary and secondary schools are particularly exposed to this hazard	2,67	Human	2,32	15,72
Water pollution	2,61	Population	People living in informal settlements are more exposed to water pollution	2,58	Human	2,32	15,65
Drought	2,67	Population	Children: girls in charge of fetching water from rivers, ponds, wells, water points, etc. are particularly exposed to this hazard	2,50	Human	2,32	15,46
Water overexploitation	2,69	Water sources	Shallow wells	2,58	Environmental	2,11	14,62

7.4.3 Climate risks, aggregated by vulnerability

Last but not least, the analysis shows that the human and the environmental components show highest levels of vulnerability. This is coherent with the exposure analysis, that shows that population and water sources are the most exposed elements, and with previous results from sections 7.3. Other less affected components are the financial, the social and the physical. The political and institutional component is absent.

Figure 20: types of vulnerability among 25 prioritized risks



Population living close to water bodies or in mountainous areas are vulnerable to flooding and landslides, respectively. Other population groups vulnerable to climate hazards include children, women, farmers, and those in informal settlements | As mentioned above, dwellers' location is the most relevant factor determining vulnerability to flooding and landslides, since these are very localized hazards. On the other hand, specific population groups show simultaneous vulnerability to various hazards. Children, for instance, are considered the most vulnerable segment of population by the Atlas[73]. Farmers are also very vulnerable to several hazards, such as drought and landslides, and endure most directly the consequences of events occurrence. People that live in informal settlements have no safe access to water and must often use polluted sources, incurring in higher health risks. Climate change will directly impact water sources, infrastructures, and other assets, increasing the vulnerability of these groups.

Social vulnerability refers especially to the consequences of lower service levels being delivered to the population | The social component of vulnerability relates to the immediate consequence of several hazards over the affected population. In case hazards occur, the affected groups are diverted to lower levels of service (e.g., open defecation, unsafe or more expensive water sources), incurring in higher health risks, especially children, that are the most vulnerable. Climate change might impact the conditions for service delivery and related service levels, increasing social vulnerability.

Water resources, both quantity and quality, show high environmental vulnerability | The analysis allows a classification of water sources vulnerability to several hazards. Shallow wells are the most vulnerable type of water source, followed by protected springs and deep boreholes, which seem to be the most resilient. Shallow wells serve around 24% and protected springs serve around 22% of the population[74]. Both types of sources are vulnerable to drought, while shallow wells are also vulnerable to water pollution and overexploitation. As indicated in the previous sections, there is direct correlation between deforestation, erosion, and decreased quality of water sources, that in turn impact WASH services. Considering the expected consequences of climate change, the situation is expected to worsen in the future.

Financial vulnerability relates to famer's income losses and to operation and maintenance costs, which might not be covered by service providers in the occurrence of hazards | Famer's income losses deriving from hazards such as drought and degradation might severely affect their livelihoods. On the other hand, willingness to pay for water services might be hampered if service levels decrease in the event of hazards (e.g., poor water quality). Tariffs might then not cover operation and maintenance costs. In such situations, service providers will probably face higher costs to deliver services to the population and lower revenue collection, seriously jeopardizing financial sustainability of service provision. More intense flood and drought events in the future will increase financial vulnerability of both farmers and service providers.

Pit latrines and WASH facilities in schools are particularly vulnerable in flooding events | As indicated above, pit latrines are very exposed to flooding, making these sanitation solutions very vulnerable. WASH facilities at schools in the flood prone areas are also very vulnerable, increasing the risk that children suffer from

[73] Government of Uganda (2019) National Risk and Vulnerability Atlas of Uganda, p. 149.
[74] According to http://wsdb.mwe.go.ug/index.php/reports/national

waterborne diseases. Forecasts of more frequent and intense flooding for the future might increase the vulnerability of both pit latrines and WASH facilities at schools.

8. CONCLUSIONS AND RECOMMENDATIONS

Climate change is already affecting WASH services and facilities in several ways in Uganda, hindering the accomplishment of targets 1 and 2 of SDG 6 and the realization of the human rights to water and sanitation. Nevertheless, Uganda's commitment to the Paris agreement has led to the establishment of a set of strategies to understand, evaluate and deal with the risks that arise from climate change. The draft version of the country's NDC has prioritized the water sector and has given special attention to water and sanitation. Assessing the prevalent hazards and the risks related to the impacts of climate change over the WASH sector is an essential component of the mitigation and adaptation policies, programs and activities that need to be further designed and implemented.

Against this background, this study presents the results of a climate risk and vulnerability assessment for the WASH sector, based on the combined analysis of most relevant climate hazards, the associated level exposure, and different forms of vulnerability. The work has been mainly conducted through a desk review, in which data from official documents, scientific papers, reports from international organizations, among other sources, have been mobilized. The desk review has been complemented with workshops and counted on crucial inputs from a range of WASH and climate experts. The most important results are summarized in the table below.

Table 65: summarized results of the climate risk assessment of the WASH sector in Uganda

HAZARDS	EXPOSURE
DROUGHT	Women and children, in charge of searching for alternative sources and for fetching water, are exposed to work and school absenteeism, respectively, and to all kinds of risks (attacks, violence, etc.) when water access is not on premises Farmers who rely on rain-fed crops for subsistence might incur in income losses, severely impacting their livelihoods Water supply systems, particularly distribution lines and pumping stations, might be damaged due to fluctuating water levels Protected springs and shallow wells, serving around 22% and 24% of the population, respectively Exposure is more pronounced in the arid and semi-arid areas of Northeastern Uganda
FLOODING	People living near water bodies and in flood prone areas is expected to increase due to more concentrated rainfalls in the future. In urban areas, inhabitants are particularly affected by flash flooding Children are exposed if WASH facilities at schools are not climate resilient, which might lead to school absenteeism and health issues Water distribution systems, particularly pumping systems, and distribution by gravity Pit latrines (improved and unimproved), particularly in rural and periurban areas (80% of population use this sanitation solution) Protected springs and shallow wells, serving around 22% and 24% of the population, respectively Exposure is more pronounced in Central and Eastern Uganda
LANDSLIDE	People living near hills and mountainous areas, especially in Mt. Elgon and Rwenzori regions Children are affected (school absenteeism and health issues) if WASH facilities at schools are not climate resilient. This situation is expected to worsen in the future
LAND DEGRADATION	Rural population living in the highlands and the drylands, with income, nutrition and health impacts and negative spillover effects on people's WASH access.
WATER OVEREXPLOITATION	Shallow wells' exposure to overexploitation might lead to depletion and compromise water access to 1 out of 4 Ugandans

<table>
<tr><th>WATER POLLUTION</th><th colspan="2">Shallow wells, serving 1 out of 4 Ugandans</th></tr>
<tr><td colspan="3">VULNERABILITY</td></tr>
<tr><td>HUMAN
Most vulnerable groups include women, children, farmers, people that live near mountains and water bodies and in informal settlements
Population age (54% are below 18 years) and growth (around 3% per year) are relevant demographic features that increase vulnerability
Limited knowledge of climate hazards and impacts, particularly by vulnerable population and in rural areas</td><td>SOCIAL
Population affected by climate related hazards is diverted to lower service levels or to unimproved facilities. 5% of population in Uganda defecates in the open, most of them in rural areas
Limited waste management, mainly at household level, increases health impacts during flood events, particularly in urban areas
Conflicts have been reported in relation to access to water</td><td>FINANCIAL
Income losses by farmers provoked by hazards affect their livelihoods and their access to WASH
Insufficient cost recovery due to poor revenue collection and increased operation costs (e.g., treatment costs) during and after hazards hamper financial sustainability of service providers</td></tr>
<tr><td colspan="2">ENVIRONMENTAL
High vulnerability of shallow wells and moderate vulnerability of protected springs. Deep boreholes seem more resilient to shocks and extreme events
Erosion, caused by poor land management, impacts water availability and quality
Poor water quality increases the incidence of waterborne diseases and leads to higher treatment costs
Inadequate waste disposal and poorly managed landfills (those located close to larger cities) lead to water pollution in those areas</td><td>PHYSICAL
Pit latrines' high vulnerability to hazards such as flooding raises serious health and environmental concerns
Pumping systems and supply by gravity, which are the most common infrastructure in Uganda, are vulnerable to several hazards</td></tr>
</table>

In summary, the list of prioritized risks that resulted from the analysis shows that drought, flooding, and water pollution are the hazards that affect the Ugandan WASH sector the most, both in the present and in the future. In addition, landslides, degradation, and water overexploitation are especially relevant in rural areas. Although these hazards tend in general to become more intense in the coming years, some of them can be minimized or even reversed if some adaptation and mitigation practices are in place. For instance, erosion has currently high rates in several parts of the country, but sustainable land management could have a positive impact and increase soil resilience, despite the consequences of more concentrated rainfalls that are expected for the future. The quality of water sources might as well benefit from more adapted agricultural practices and increased wastewater treatment. Water scarcity and stress is already a reality in several regions and water demand tends to rise due to population growth, but overexploitation can be countered through the implementation of integrated water resources management principles and tools together with sound regulation and allocation policies.

Among prioritized risks, the analysis indicates that specific population groups are very exposed to more than one hazard and are thus the most vulnerable. It is the case of women and children, that are especially affected for instance by drought. They are often in charge of searching for alternative sources and for fetching water. In performing this task, they not only miss school or work, but they expose themselves to all kinds of risks (e.g., attacks, gender-based violence, etc.). Promoting the delivery of water on premises will significantly reduce these risks. The rural population is also vulnerable to several hazards, such as landslides, degradation, and water overexploitation. Since most of Ugandan farmers rely on rain-fed crops for subsistence, changes in precipitation and water availability will impact their livelihood, with possible income losses. New approaches to agriculture and land management will be necessary. Finally, people that live in informal settlements are very exposed to water pollution because their water is typically accessed through unimproved sources. Often, the immediate impact of a hazard is that affected population is diverted to lower service levels and incur in severe health risks. Therefore, special attention should be given to these most exposed and vulnerable groups.

Regarding WASH infrastructure and services, two aspects need to be considered. The first concerns especially pit latrines, which are used by more than 80% of the population. If forecasts of more concentrated rainfalls leading to more frequent and intense flooding events in the future are correct, resilience of these sanitation solutions must be improved in order to better cope with climate risks. The second aspect relates to service provision. Service providers are financially exposed in the occurrence of hazards due to a combination of poor revenue collection and increased costs of service provision. Although the Ugandan national government makes resources for rehabilitation available, service providers' capacities should be strengthened to better face emergencies and react timely and properly.

Regarding water sources, the analysis shows that shallow wells are particularly exposed to hazards such as drought, water pollution, and landslides. The analysis indicates that shallow wells are the most vulnerable water of source, followed by protected springs and deep boreholes, that better endure longer dry periods and contamination coming from the surface. Considering that shallow wells serve nearly one out of four Ugandans, special measures should be implemented to ensure the protection of these sources, so that the sanitary conditions in the affected areas are improved.

The prioritized risks that are the essence of the study's findings constitute the base for the next phase of the work, which consists of proposing climate resilient solutions for the identified concerns. It is recommended that in such process the following aspects are taken into consideration:

- Design and implementation of adapted strategies for the most vulnerable groups of the population: women, children, farmers, among other groups are affected differently by hazards and climate resilient WASH solutions should consider such differences and address the respective challenges.

- Focus on the financial sustainability of service providers: if cost recovery through tariffs is hindered by the occurrence of hazards, emergency response should include timely and adequate support by other actors, so that the effects of hazards over infrastructure are dealt with and service provision is normalized as soon as possible. Assess current levels of cost recovery and identify the extent to which hazards will impact those costs in the future might be needed. In parallel, a vulnerability index including the issue of affordability could be developed to support policy design and prioritization.

- Increase resilience of WASH infrastructure: considering the high vulnerability of pit latrines and widespread use of this type of facility, it is crucial for adaptation to a scenario of more concentrated rainfalls and increased flooding occurrence that they are improved so that the impacts of hazards are minimized. At the same time, alternatives should be evaluated also in terms of mitigation. Facilities at schools and health care centers in the priority areas should be also assessed in detail, so that tailor-made solutions are proposed. On the other hand, redundancy of water sources (i.e. availability of more than one source per system or community, so that if one fails the other can be used instead) should be encouraged, especially in the areas affected by drought.

- Further implementation of IWRM principles and tools: the current situation of water sources could benefit from more integrated management approaches, so that the mutual effects of water allocation and land management at basin level are considered in decision-making processes, with better outcomes in terms of tackling water overexploitation and pollution issues. It is also recommended to use a catchment basin approach for prioritization and implementation of WASH climate resilient solutions, assessing their impact not only in terms of public health but also in relation to the quality of water resources.

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ANNEXES

Annex 1: List of Climate Task Force members

Annex 2: Full list of risks organized by hazard