Integrating flood and drought management and early warning for climate change adaptation in the Volta basin

Feasibility study of the application of the IUCN Red List of Ecosystems

July 2021

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List of acronyms

CBD	United Nations Convention on Biological Diversity
CCA	Climate change adaptation
CERFE	*Centro di Ricerca e Documentazione Febbraio '74*
DRM	Disaster risk management
DRR	Disaster risk reduction
EWS	Early warning system
GBF	Global biodiversity framework
GEF	Global Environment Facility
GLDAS	Global Land Data Assimilation System
GPCC	Global Precipitation Climatology Centre
GESDICS	Goddard Earth Sciences Data and Information Services Center
Ha	Hectares
IUCN	International Union for Conservation of Nature
NbS	Nature-based Solutions
OECD	Organisation for Economic Co-operation and Development
RLE	Red List of Ecosystems
SDG	Sustainable Development Goal
SFDRR	Sendai Framework for Disaster Risk Reduction
SAP	Strategic Action Programme
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VBA	Volta Basin Authority
WMO	World Meteorological Organisation

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Summary

The international community is increasingly realizing that climate change is an issue that affects all areas of public policy and decision-making processes. It can no longer be seen as a problem limited to the environment, rather as a critical challenge in the field of development, widespread across all regions and sectors. Globalization and environmental change are significant drivers in the changing nature, frequency and intensity of natural hazards thus exacerbating the consequences of disasters.

In an effort of improving the countries' capacity to systematically and sustainably preserve, restore and manage nature and its resources in the Volta river basin, this report showcases the relevance of conducting ecosystem risk assessments. These are key to provide the most sensitive and direct measure of ecosystem conservation status, hence informing suitable and tailored conservation actions that respond to local, regional and basin-wide challenges.

The Volta Basin contains a rich and diverse set of globally significant ecosystems, including ten Ramsar sites. The distribution of these ecosystems varies widely across the basin and are of outstanding value to communities resilience and economies that are facing multiple interconnected threats. The current threats are very diverse, however as reflected in this report, climate change, bush fires, land degradation and pollution are the most significant threats.

In order to reverse the impacts of these threats, actions such as conservation, restoration and sustainable management of Volta Basin's ecosystems are fundamental, in addition to implementing the relevant environmental recommendations called for in the Paris Agreement, Convention on Biological Diversity and other key policy frameworks. To have the greatest impact in reversing the degradation of and minimising threats to ecosystems, it is essential to not just understand the status of the Volta ecosystems, but also the drivers of degradation. Identifying the types of threats and quantifying the level of risk of ecosystem collapse through tools such as the IUCN Red List of Ecosystems (RLE), can better inform drought and flood management actions and policies, as well as promote the value of ecosystems.

The IUCN RLE provides a standardized and globally recognised framework to assess the risk of collapse of an ecosystem, identifying the extent to which ecosystems are threatened or endangered. The risk categories, based on those used by the IUCN Red List of Species (RLTS), help to, systematically, assess and understand natural and manmade risks faced by an ecosystem. RLE assessments across all continents have been used to guide conservation practitioners and governments to prioritize environmental actions and policies. Furthermore, through the process of executing an RLE assessment, proponents can benefit from the added value of increased stakeholder engagement and sharing of data and expertise.

This preliminary analysis is complementary and based on previous experiences and projects carried out in the last decades in the basin in order to 1) carry out a first screening to evaluate the suitability of the existing data, as required for a solid and scientific foundations for a basin-wide integrated ecosystem management, and 2) to emphasize the role that ecosystems play with regards to disaster risk management and climate change.

Due to the unprecedented COVID-19 global virus pandemic, a survey approach combined with virtual meetings was deployed across the six countries (Ghana, Benin, Togo, Mali, Burkina Faso, and Côte d'Ivoire) of the Volta Basin o gain an overview of the feasibility of RLE assessments. This was determined based on data access, quality and availability as well as sufficient stakeholder engagement.

Unfortunately, the analysis shows a plethora of policies and frameworks. Although 40% of respondents mentioned that they have access to various sources of information most of the sources indicated offer superfluous information to carry out a detailed scientific evaluation. The most pressing next stage should be a more in-depth follow-up to access accurate and validated data.

Seventy percent (70%) of the respondents indicated they have heard about the RLE framework while only 10% are familiar with it. These results highlighted the real need for information and resource sharing. This only further supports the importance of conducting RLE assessments and in the course of executing an RLE assessment, novel stakeholders would be engaged and data shared through technical workshops. It appears that an awareness raising – training plan is the most suitable action for experts to be able to quantify known threats thereby enabling the elaboration of ecosystems conceptual models, which is a key first step for conducting informed RLE assessments.

It is worth noting that the level of detail of this preliminary analysis could have been greater if face-to-face meetings were allowed. In this case the IUCN team would have 1) conducted informative sessions by convening multiple sectoral stakeholders, 2) set up working groups for sharing data and knowledge to jointly respond to the survey and, 3) follow-up via virtual meetings adapted to the context of each country. By assessing the state of their ecosystems, using a scientifically robust and globally recognised tool such as RLE, the six countries would lead the way in evidence-based conservation prioritizing and mainstreaming informed environmental policies. It should be stressed that despite the numerous projects and interventions, bibliographic resources related to the basin and the existence of the Observatory of water resources and associated environments there is no common multidisciplinary database nor basin-wide baseline ecosystem risk assessment.

Similarly, and despite the heterogeneity and ecological relevance of the basin there is no recognition of their ecosystems beyond the area of ecosystem services. The role they can play in elaborating and establishing disaster risk management as well as climate change plans and strategies is not broadly underlined. This analysis showcases the relevance of such an approach for identifying ecosystem health status, thus informing the design of interventions that respond to local, regional and basin-wide environment challenges.

As climate change increases the likelihood of unexpected weather patterns and natural disasters, policy makers and communities need tools and methods to adapt to increased drought, floods and other climate-induced hazards. An important adaptation strategy is also for countries to be equipped with reliable environmental data and information in order to be able to undertake the necessary assessments, i.e. water resources and invasive species, as they are an important basis for decision-makers. This analysis aims to trigger a step-forward for reinforcing and fostering collaboration across non-traditional partners and sectors in order to jointly tackle such a pressing global challenge.

Chapter 1: Introduction

The World Meteorological Organization (WMO), a specialized agency of the United Nations, the Volta Basin Authority (VBA) and the Global Water Partnership - West Africa (GWP-WA) are implementing the project "Integrating Flood and Drought Management and Early Warning for Climate Change Adaptation in the Volta Basin (VFDM)" financed by the Adaptation Fund. The project activities, started in June 2019, and will proceed until mid-2023. Besides the National Services and Agencies in charge of Meteorology, Hydrology, Water Resources Management, Civil Protection and the Environment, the implementation of the VFDM Project also involves the WMO partners, such as the CIMA Research Foundation, the International Union for Conservation of Nature (IUCN) and CERFE.

Climate change and variability, coupled with widespread ecosystem decline, poses tremendous risks that call for not only cost-effective solutions, but also accessible and locally applicable solutions. The sustainable management of ecosystems and ecosystem services is therefore more often considered as an effective approach to implement priorities actions towards disaster risk reduction (DRR) and climate change adaptation (CCA).

IUCN, through the environmental component of the VDFM project, proposes ways to incorporate ecosystem benefits and ecosystem-based approaches into DRR and CCA actions, including early warning systems, with emphasis on long-term planning and the prevention and preparation of risks. The analysis and integration of ecosystems and the services they provide to communities are part of the basis for capacity building in terms of flood and drought forecasting, warning and management as well as adaptation to climate change in the Volta basin.

The environmental component of the project consists, among others, of evaluating and integrating environmental data and indicators into the flood and drought early warning system (EWS) for effective strengthening of resilience and responses to climate change and disasters in the Volta Basin subregion

This feasibility study supplements and is built upon previous reports elaborated and projects carried out by a wide range of organisations in the last two decades that are present in the area. Similarly, this preliminary analysis also brings[1] specific environmental inputs collected by CERFE (C*entro di Ricerca e Documentazione Febbraio '74),* partnering in this project, during their community consultations The approach adopted is based upon a scientific literature review to provide insight into the existing bibliography on ecosystems and related matters; and a series of surveys that were designed to better understand 1) stakeholders' perceptions and relationships with ecosystems and environment as well as 2) their knowledge on existing environment related information.

[1] Due to COVID-19 all actions within the framework of this project have been delayed, particularly those that required field visits and consultation with local communities / stakeholders;

1.1 Unique value, services and threats

The ecosystems of the basin are varied and conditioned by the climatic diversity of the basin, distributed as follows: semi-deciduous dense forests, dry dense forests and clear forests, savannas, steppes, riparian forests, grasslands and mangroves. Aquatic ecosystems in the Volta Basin include rivers, ponds, lagoons and lakes[2].

These ecosystems provide multiple relevant ecosystem services that are crucial for local communities which rely directly on the natural capital provided by their ecosystems in various forms such as energy, nutrition, clean water and ecotourism. They are also critical to the global community for their global environmental benefits. In fact, healthy ecosystems provide essential and indispensable services such as food, medication, purification of water and air, climate regulation, as well as social and recreational services. In order to strike a better balance between human and environmental wellbeing, a robust scientific knowledge baseline for the different ecosystem types is needed, especially given the finite resources of this planet.

Yet, the six countries (Ghana, Benin, Togo, Mali, Burkina Faso and Côte d'Ivoire) of the Volta basin often overlook when assessing ecosystem services, fauna and flora diversity as well as designing biodiversity strategies when assessing ecosystem services. General knowledge on ecosystem conservation status, and especially on how to map and assess them, is lacking. At the global level, many countries have significant data gaps on biodiversity knowledge, along with difficulties in sharing and disseminating information widely among stakeholders. This is also evident in the Volta basin which can hinder and undermine the decision and policymaking processes for the elaboration of conservation as well as natural resources use and management strategies and plans.

Knowledge and data availability, and in some cases the lack of baseline information, is a major constraint to undertaking full ecosystem risk assessments; thus, slowing down progress in policy to preserve, protect and restore biodiversity. It is therefore critical to invest in research, innovation and knowledge sharing for compiling and generating reliable data and information.

This is particularly relevant in order to contribute towards the achievement of well-established global conventions and policy frameworks such as the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention to Combat Desertification (UNCCD), the Sendai Framework for Disaster Risk Reduction (SFDRR) and/or the forthcoming post-2020 Global Biodiversity Framework of the Convention on Biological Diversity (CBD). To this end, in environmental terms, countries will require a comprehensive and robust monitoring and compilation of data, of a different nature, to better determine the timelines and criteria for the protection, restoration and sustainable use of their ecosystems.

The Volta basin countries are prone to a greater negative impact on their biodiversity, due to both natural and human driven factors; including invasive alien species, climate change, pollution and/or unsustainable use of natural resources. In all the six countries, a standardised framework underpinned by strong scientific principles appears as the most appropriate means

[2] UNEP-GEF Volta Project, 2013. Volta Basin Transboundary Diagnostic Analysis. UNEP/GEF/Volta/RR 4/2013.

for conserving and protecting the unique biodiversity across geographical and temporal scales.

1.2 Need for assessments of ecosystem status

It is necessary to reinforce the understanding of the Volta ecosystems, and how best they can be preserved in a changing conservation, development and climate scenario. The adoption of robust and updatable ecosystem health baselines will catalyse the uptake of the Post-2020 Global Biodiversity Framework (GBF)[3]. A clear understanding of the functioning and dynamics of ecosystems is critical to design and implement actions that contribute the most towards the achievement of the goals and targets which will constitute the abovementioned framework. But beyond the conservation arena, ecosystems play an important role in the Sendai Framework[4].

The Volta Strategic Action Programme (SAP), is one of the outcomes of the UNEP-GEF-Volta project[5] aimed to solve cross-border problems in the Volta Catchment Area and its downstream coastal area, highlights the importance of healthy ecosystems to achieve the following environmental quality objectives:

1. Water use is optimised among the main users (domestic use, agriculture, in the ecosystems and for hydropower) that receive adequate and sustainable supplies;
2. The coast is stabilised between Ada and Keta by 2025;
3. The proliferation of invasive species is controlled, particularly in the five priority areas of biodiversity;
4. Sedimentation in five priority areas is reduced by 20% by 2025;
5. Critical ecosystem functions are conserved, restored and managed for sustainable use in at least five selected areas;
6. Water is available in good quality to meet the needs of ecosystems in 4 priority areas of the Volta river basin;
7. The legal and institutional framework for governance is strengthened in the Volta Basin.

A key concern that guided the formulation of these objectives was whether they should be defined prior to the action required or whether the action needs to be defined first and the objectives derived from it. A total of 33 actions were established and organised into four components:

- Component A: Ensuring water availability
- Component B: Maintaining and restoring ecosystem functions
- Component C: Ensuring good water quality
- Component D: Strengthening governance and improving the quality of information on water resources

[3] Zero draft of the Post-2020 GBF, more information here;

[4] Z. Sebesvari, J. Woelki, Y. Walz, K. Sudmeier-Rieux, S. Sandholz, S. Tol, V. Ruíz García, K. Blackwood, F.G. Renaud,2019. Opportunities for considering green infrastructure and ecosystems in the Sendai Framework Monitor,Progress in Disaster Science,Volume 2, 2019, https://doi.org/10.1016/j.pdisas.2019.100021;

[5] Projet PNUE-FEM-Volta, 2014. Programme d'Action Stratégique du Bassin de la Volta, PNUE/FEM/Volta/RR. 1/2014 - http://abv.int/wp-content/uploads/2018/04/PROGRAMME-DACTION-STRATEGIQUE-ABV-1.pdf.

For actions that refer to ecosystem conditions and functionalities, there is no common assessment that can determine the baseline and post-intervention state of ecosystems across geographies. Also, there is no standardised protocol on how critical ecosystem functions are defined and identified thus allowing comparison of results. This analysis brings to light the accessibility and availability of existing data and results, in order to enable the implementation of a common protocol for the six riverine countries using the standardised RLE global protocol. It identifies and analyses the data and information gaps precluding a full-fledged ecosystem risk assessment considering its spatial and functional conditions.

The lack of understanding of the potential, complexity and benefits of ecosystems together with a limited access to meaningful information about the range of biodiversity values and the cost of its loss amplify the relatively slow progress. When applied at the appropriate scale, RLE provides value as a reporting mechanism to inform governments and the global community on progress towards achieving international and national targets - i.e. sustainable development goals (SDGs) - but also as a framework to guide local to national conservation, restoration and sustainable management policy/legislation/regulation beyond the conservation domain[6], including disaster risk management.

While more effective protection of biodiversity in the basin will depend on a range of factors, particularly accessible information, available funding mechanisms and the assessment of ecosystems and their services are essential for the further biodiversity mainstreaming into sectoral policies, strategies, plans and practices.

1.3 The IUCN Red List of Ecosystems

Until recently, no equivalent standard existed at the ecosystem level[7]. Assessing the conservation status of ecosystems is crucial to understand their functional and spatial conditions, and eventually their capacity for maintaining and providing ecosystem services (ES) vital to society. In 2014, IUCN adopted the RLE Categories and Criteria[8] at a global level as a scientifically robust and consistent framework for monitoring the conservation status of ecosystems between regions and over time to plan appropriate conservation actions, applicable at local, national, regional and global levels. The RLE, underpinned by strong scientific-foundations, evaluates the level of degradation and identifies the level of risk of ecosystem collapse thus informing better ecosystem management solutions and help identifying areas that need fast and effective actions.

Assessments using the RLE protocol estimate the risk of collapse of ecosystems according to a set of threats previously identified. The categorisation and description of threatening processes and stresses together with informative conceptual models enable the conducting of uniform and comparable assessments for any ecosystem type, at local, national, regional or global scales.

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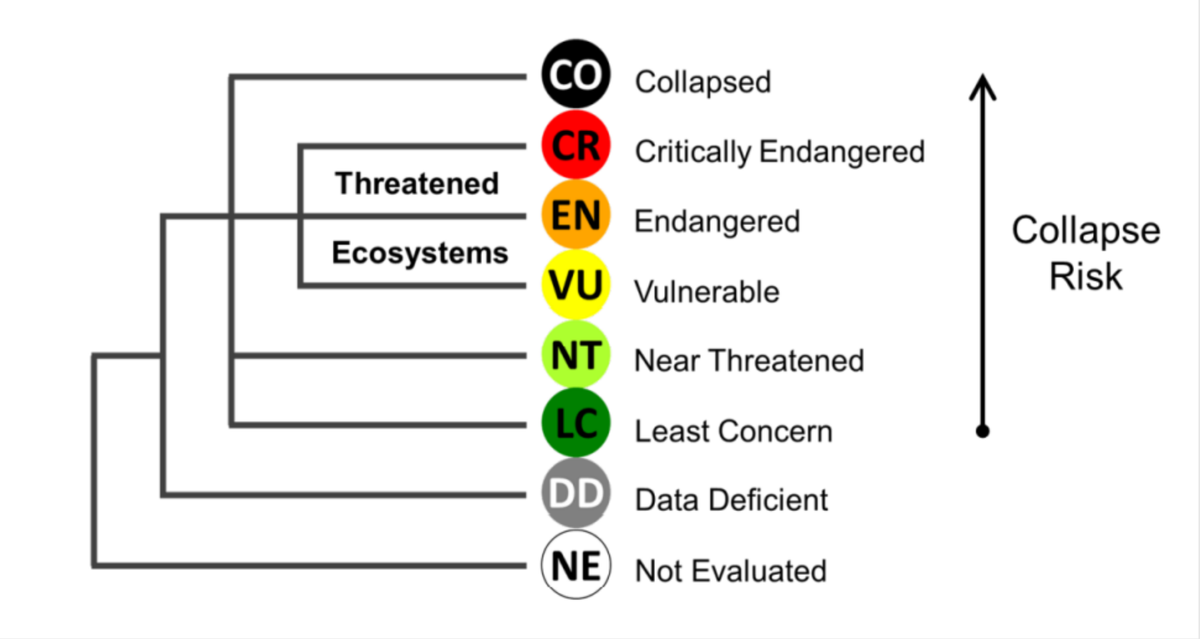
[6]Rowland JA, Bland LM, Keith DA, et al., 2019. Ecosystem indices to support global biodiversity conservation. Conservation Letters. 2019; e12680. https://doi.org/10.1111/conl.12680.
[7] Keith D.A., Rodríguez J.P., Rodríguez-Clark K.M., Nicholson E., Aapala K., et al., 2013. Scientific Foundations for an IUCN Red List of Ecosystems. PLoS ONE 8(5): e62111. doi:10.1371/journal.pone.0062111;
[8] For more information, visit the IUCN Red List of Ecosystems website, https://iucnrle.org/.

A key component of any RLE assessment, a conceptual model assists in understanding the ecosystem dynamics and informing the selection of the key variables for assessing change in abiotic and biotic function. Collapse is understood to mean "the transformation of identity, a loss of defining features, and a replacement by a different ecosystem type"[9]. There are five criteria for assessing the risk of ecosystem collapse, each with its own data and knowledge requirements:

A) Reduction in geographic distribution
B) Restricted geographic distribution
C) Environmental degradation
D) Disruption of biotic processes or interactions
E) Quantitative analysis that estimates the probability of ecosystem collapse.

The evaluation of these criteria allows the assignation of one of the eight possible categories of risk of loss of characteristic native biota (Box 1): Critically Endangered (CR), Endangered (EN), and Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Not Evaluated (NE) and Collapse (CO). The first six categories (CO, CR, EN, VU, NT and LC) are ordered in decreasing risk of collapse. The categories Data Deficient and Not Evaluated do not indicate a level of risk:



Box 1. Possible categories of risk for the IUCN Red List of Ecosystems. Collapse is defined as when all occurrences of an ecosystem have moved outside the natural range of spatial and temporal variability in composition, structure and function. Critically Endangered (CR), Endangered (EN), and Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD), Not Evaluated (NE) and Collapse (CO).

[9] Bland L.M., Keith D.A., Miller R.M., Murray N.J. and Rodríguez J.P. (eds.), 2016. Guidelines for the application of IUCN Red List of Ecosystems Categories and Criteria, Version 1.0. Gland, Switzerland: IUCN. ix + 94pp.

- Collapsed (CO): An ecosystem is Collapsed when it is virtually certain that its defining biotic or abiotic features are lost from all occurrences, and the characteristic native biota are no longer sustained. Collapse may occur when most of the diagnostic components of the characteristic native biota are lost from the system, or when functional components (biota that perform key roles in ecosystem organisation) are greatly reduced in abundance and lose the ability to recruit.

- Critically Endangered (CR): An ecosystem is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered. It is therefore considered to be at an extremely high risk of collapse.

- Endangered (EN): An ecosystem is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered. It is therefore considered to be at a very high risk of collapse.

- Vulnerable (VU): An ecosystem is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable. It is therefore considered to be at a high risk of collapse.

- Near Threatened (NT): An ecosystem is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

- Least Concern (LC): An ecosystem is Least Concern when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widely distributed and relatively undegraded ecosystems are included in this category.

- Data Deficient (DD): An ecosystem is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of collapse based on decline in distribution, disruption of ecological function or degradation of the physical environment. Data Deficient is not a category of threat, and does not imply any level of collapse risk. Listing of ecosystems in this category indicates that their situation has been reviewed, but that more information is required to determine their risk status.

- Not Evaluated (NE): An ecosystem is Not Evaluated when it is has not yet been evaluated against the criteria.

Collapse is the endpoint of ecosystem decline, and occurs when all occurrences of an ecosystem have moved outside the natural range of spatial and temporal variability in composition, structure and/or function. This natural range of variation must be explicitly defined in the description of each ecosystem type. Collapse is thus a transformation of identity, a loss of defining features and a replacement by another and essentially different ecosystem type[10].

Additionally, the RLE protocol can contribute to informing effective ecosystem management to address threats and drivers of change while providing a scientific-based pathway for understanding the variation of ecosystem health status over time. Repeated RLE assessments can be a potential means to monitor the effectiveness and progress of conservation and restoration actions (Box 2).

Box 2. Mechanisms of ecosystem collapse, and symptoms of collapse risk (Keith, 2013). A robust application of the RLE Categories and Criteria requires a synthesis of the diverse causes, mechanisms and pathways of ecosystem decline within the generic risk assessment framework, as well as calculations based on quantitative estimates of variables. The use of the RLE methodology leads to the identification of the variables implicated in ecosystem's collapse processes and their variation across time.

[10] Rodríguez J.P., Keith D.A., Rodríguez-Clark K.M., et al., 2015. A practical guide to the application of the IUCN Red List of Ecosystems criteria. *Philos Trans R Soc Lond B Biol Sci*. 2015;370(1662):20140003. doi:10.1098/rstb.2014.0003.

Chapter 2: Approach adopted

Due to the diversity and heterogeneity of the basin, this study aims to take the first steps towards conducting a basin-wide risk assessment of Volta ecosystems. This feasibility study maps ongoing actions and potential entry to carry out such risk assessment.

The initial approach that was planned included a whole process with field visits, consultations and face-to-face meetings to collect data, understanding stakeholder's perception on environmental matters and simultaneously raise awareness of the importance of biodiversity for disaster risk reduction (DRR) and climate change adaptation (CCA) actions.

Due to the unprecedented COVID-19 global pandemic, and the restrictions it has brought with it, we were forced to develop a contingency plan to develop this document based on a virtual approach. The elaboration of this document has been a challenging task not only because of the change in the approach - i.e. complexity of creating a dialogue and reinforcing existing connections - but also due to the on-ground conditions. Nevertheless, the development of this document allowed the identification of opportunities and entry points for future improved uptake of ecosystems in flood and drought actions from local to basin levels.

The elaboration of a step-by-step work plan has been key to conducting this preliminary study that relies on 1) peer-to-peer support and 2) the integration and interpretation of compiled data. Over 60 people has therefore contributed to this analysis, primarily from governmental entities, figure 1.

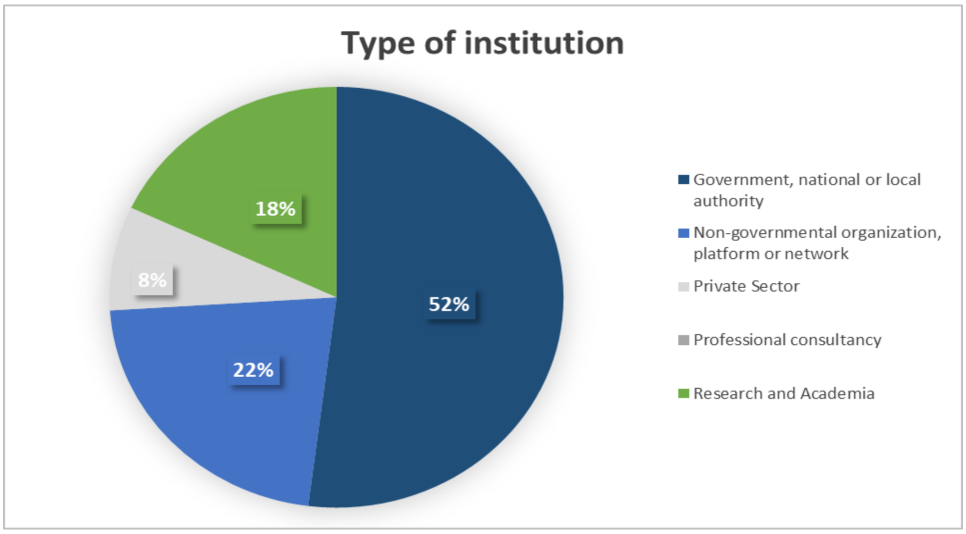


Figure 1. Source of responses received through the survey. The percentage per category was as follows: government, national or local authority (52%) / non-governmental organization, platform or network (22%) / private sector (8%) / professional consultancy (0%) / research and academia (18%).

The details of the different procedural steps are as follows (Box 3):

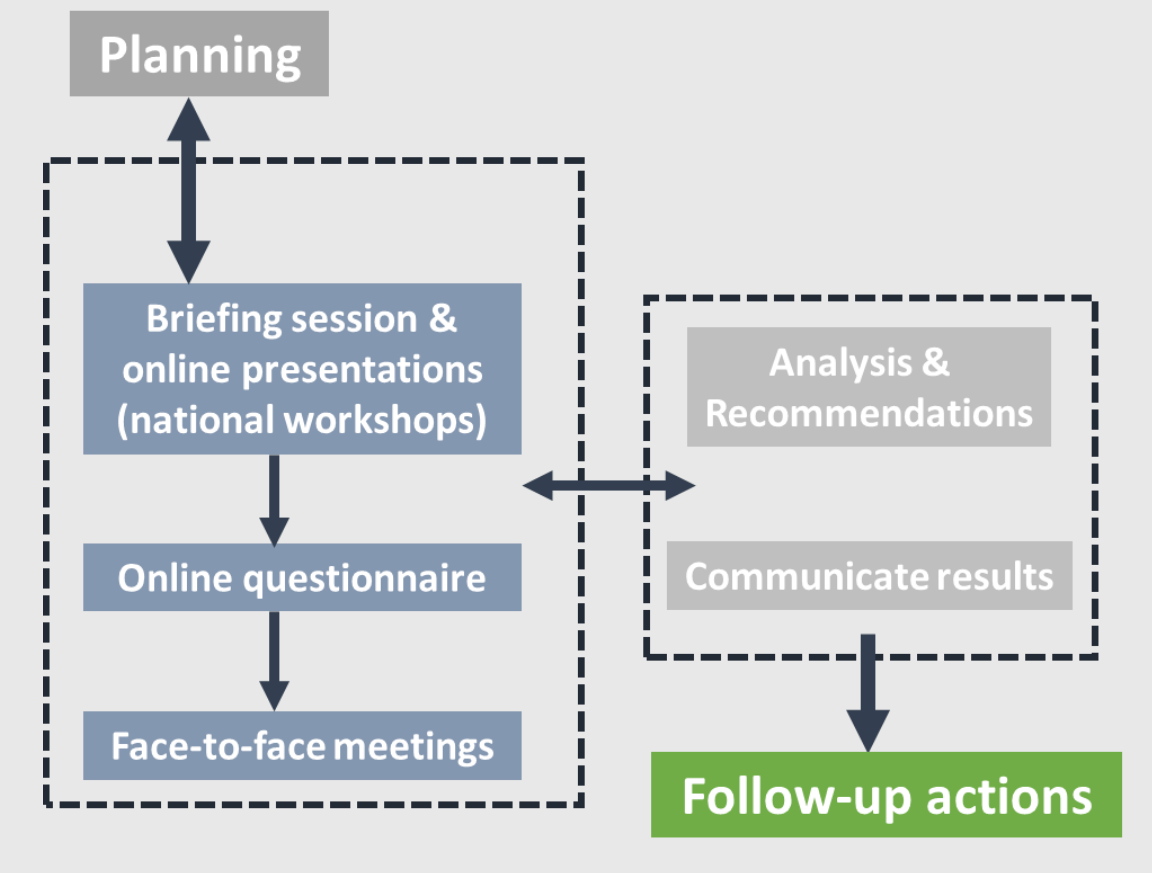
1. **Organisation of a group briefing session**: aiming to provide an overview on the role and activities to be carried out by IUCN in this project, including this report, as well as to respond to questions / concerns from the GWP, VBA and WMO, thus to ensure their engagement and to facilitate the data compilation process;

2. **Elaboration of the "environment component" questionnaire:** to compile information on data availability, major threats and existing policy instruments;

3. **Organisation of virtual explanatory sessions:** to provide tailored information and respond to the requests and concerns. IUCN also participated in all the national meetings organised by GWP, VBA and WMO;

4. **Dissemination of the questionnaire**: the national focal points shared it amongst a wide network of stakeholders and followed up for information from the stakeholders. To encourage participation and ease the data compilation process, the questionnaire was translated into French and English;

5. **Data and information analysis:** to identify and analyse overall trends, ecosystem threats and limitations as practical inputs for elaborating recommendations and guidance for foreseeable opportunities for conducting ecosystem risk assessments.



Box 3. Simplified step-by-step approach adopted to conduct this feasibility assessment. The initial approach that was planned included a whole process with field visits, consultations and face-to-face meetings. These meetings have been possible thanks to the national focal points appointed by the Volta Basin Authority (VBA).

The questionnaire was the core element for understanding the current status and extent of the existing knowledge and data resources related to ecosystems. It was designed with simple to complex questions for drawing respondents into a situation through perception and interest. A simplified version of the questionnaire was elaborated as per request by the IUCN Ghana Office to ease the time of stakeholders who felt the survey was very time-consuming. This simplified version was also translated into French and English (Annexes 1 –2).

The role of the junior assistants has been key to collecting the information since they were able to have in-person meetings as an alternative to the field visits. In Burkina and Ghana, where IUCN has country offices, the dissemination of the questionnaire was done by IUCN colleagues.

IUCN team also prepared a series of questions to be included in the questionnaire developed by CERFE within the context of the "field study on the multidimensional factors of vulnerability and risks in the areas of the Volta river basin exposed to various hydro-meteorological hazards (floods and droughts)". CERFE questionnaire included other queries that already had an environmental connotation, so IUCN's suggestions came as an additionality. This activity is still in the pilot phase for the local risk mapping, so at this stage, no information could have been processed.

The knowledge and perception of local communities in terms of the environment combined with the information collected would have been very relevant to reinforce the importance of the inclusion of environmental indicators in early warning systems

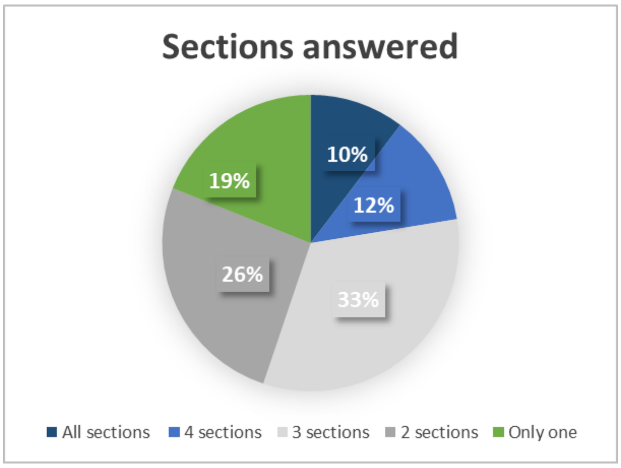
1	*What types of ecosystem do we find in your area? Example: Forests, savannahs, riparian forests, grasslands, sacred forests, wetlands, etc.*
2	*What services/benefits do you get from these ecosystems? Explain how if possible. Example: flood protection, food, water, wood, spiritual, etc.*
3	*What are major ecosystem threats?*
4	*What are the main observed changes in climate over the past 10-30 years? Example: strong wind, extreme heat, extreme cold, too much rains, wildfire, livestock disease, irrigation problem.*
5	*What is your perception of the impact of climate change on people? Example: employment, conflict, food security, health, poverty.*
6	*Have any adaptation measure been put in place? Example: flood protection. Yes / No If yes, which ones?*

Chapter 3: Overview of questionnaire results

The results and recommendations derived from the study are based on the responses of the online questionnaire which provided all interested stakeholders with the opportunity to engage on a voluntary basis. Over a period of two months, 58 surveys were collected. The questionnaires circulated are available in annexes 1(English) and 2 (French).

The questionnaire was divided in 5 major sections: 1) threats identification, 2) sources of spatial data/information, 3) sources of environmental data/information, 4) existing policy instruments and, 5) consideration of environmental aspects in disaster risk management. Only 10.3% of the respondents answered the five sections while the core of the majority of respondents (32.8%) provided information for at least 3 sections. Figure 2 shows that 19% only responded to a single section.

Across all countries, data is available to some extent on ecosystem distribution, features (abiotic and biotic), processes and threats to varying extents. The type of data (spatial, field, bibliographic and expert knowledge) differs greatly in accessibility and coverage between different survey responses for the same country. This suggests that overall, there is a real need for information and resources sharing.



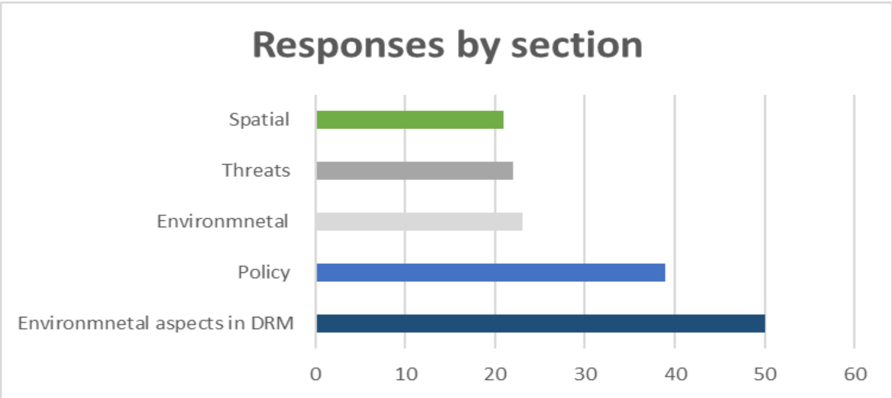


Figure 2. Distribution of respondents per the questionnaire sections (%). Regarding the sections answered only 10.3% answered all the sections and provided information. The majority of the respondents only answered 2 or 3 sections while 19% only answered one. The most responded question was n°12 with regards to environmental aspects section (What do you think are the key environmental issues to be considered in disaster risk management?) with 86% of coverage.

This could be achieved either through collaboration across sectors towards a common goal within the framework of the Volta Basin Authority Strategic Action Plan – i.e. conducting a basin-wide ecosystem risk assessment - or through a centralized database or repository of information.

3.1. Distribution of ecosystems

Despite the fact that the question was phrased quite broadly, see below, only 21 respondents answered the question related to the availability of data for mapping ecosystem distribution.

Where past spatial data is available, (36% of responses), very few of the references provided are relevant for the purpose of this VDFM project. Also, either information provided focuses on areas out of the geographical scope of the project or the information is in a format that cannot be extrapolated into a manageable GIS format.

A separate repository of information has been created for complementing the resources gathered via the questionnaire. As a key follow-up step, it would be convenient to circulate the repository amongst a wider group of stakeholders across the six countries to enrich its content.

3.2 Ecosystems threats and processes

In comparison to spatial data availability, respondents have a slightly greater access to it.

- Question 9. Please list below any existing reference and link (data type, ecosystem type, repository, national center, experts, etc.) regarding ecosystems threats - coastal erosion, pollution, deforestation, etc.- (digital maps, satellite images, etc.). Please list the maximum possible number of references.

A total of 39.6% of respondents provided at least one source of information regarding this matter. The majority of them shared their country biodiversity profiles as well as information on various species's population and dynamics – i.e. macro and microinvertebrates. The low transfer and knowledge sharing level might be one of the limiting factors. Another limiting factor is the low diversity of respondents, see figure 1. Half of the respondents work at the government level and they don't necessarily work on environmental related matters. In this case, the engagement of academia and research stakeholders is critical to explore which information is available via thesis, grey literature and scientific publications.

This is one area of concern that lacks field data for ecosystem processes and it could be addressed by 1) setting up a basin-wide repository and/or 2) conducting a basin-wide ecosystem risk assessment. This second option entails the gathering of experts as the baseline for compiling all the required information to conduct such assessment, see section 4.2.

3.3 Environmental aspects and disaster risk management (DRM)

Participants were asked which key environmental issues should be considered in disaster risk management. Disasters are thus defined by the impacts of these hazards on a society. Disasters are mainly social constructs: they are largely determined by how a society manages its environment, the conditions of vulnerability that are present, its capacity to face adversity and the resources available for recovery. So, while natural hazards cannot be prevented most of the times, the ability for these to result in disasters can on the other hand be prevented or at least mitigated through effective disaster risk reduction (DRR) strategies (Box 4).

The increasing incidence and severity of disasters such as hurricanes, floods and landslides are leaving more people vulnerable each year, particularly the poor and marginalized. Climate change is increasing the frequency and intensity of these climate-related hazards, leading to a higher number of deaths and injuries as well as increased property and economic losses. Human vulnerability to natural hazards is further exacerbated by ongoing environmental degradation, high population densities in exposed areas, increased frequency of extreme weather events and lacking or ineffective government policies.

Environmental degradation reduces the capacity of these ecosystems to provide important services to communities like food, firewood, medicines and protection from natural hazards. It also greatly reduces a landscape's ability to sequester carbon - a crucial element in climate change mitigation.

On the other hand, healthy ecosystems have important roles to play in reducing the risks of disasters through multiple ways. Healthy ecosystems such as wetlands, forests and coastal

Human well-being depends on ecosystems that provide multiple livelihood benefits. They also increase the resilience of vulnerable people to withstand, cope with and recover from disasters resulting from hazard events such as droughts, floods and others.

Ecosystems can provide cost-effective natural buffers against natural events and the impacts of climate change.

Healthy and diverse ecosystems are more resilient to extreme weather events.

Ecosystem degradation reduces the ability of natural ecosystems to sequester carbon, increasing the incidence and impact of climate change and climate related disasters.

Human conflicts can cause devastation to communities similar to the effects of natural hazards and are often caused by competition over scarce natural resources. These conflicts cause further environmental degradation. Environmental management is therefore essential to both decrease risk of conflict and allow post-conflict recovery.

Box 4. Five reasons why ecosystems are central to disaster risk reduction. Healthy ecosystems have important roles to play in reducing the risks of disasters through multiple ways. Healthy can not only reduce vulnerability to hazards by supporting livelihoods but also act as physical barriers that reduce the impact of hazard events. Ecosystem restoration and sustainable management of natural resources can therefore play a critical role in people's ability to prevent, cope with and recover from disasters (IUCN, 2020).

areas, including mangroves and sand dunes can not only reduce vulnerability to hazards by supporting livelihoods but also act as physical barriers that reduce the impact of hazard events[11].

These two sections had the most response rate (86.2%). After analysing the responses, it was observed that, there is a tendency from the participants to list threats as key environmental issues to be considered in disaster risk management. Specific threats and factors were identified, however, some respondents also included factors that go beyond and relate to the coordination and management of the basin such as:

- Need for a standardised and coordinated strategy for data collection
- Development of an integrated early warning system
- Participatory communication
- Developing resilient attitudes in exposed people
- Accurate hazard, vulnerability and risk mapping
- Document each disaster episode

The majority of the responses indicated threats and environmental factors that can be translated into environmental indicators to be included in the basin-wide early warning system (EWS) that is being developed – under the framework of this project – but also as indicators to conduct a basin-wide risk assessment. In this way, the results of such assessment could also be integrated into the EWS and updated every 5-7 years, (see figure 3).

The threats and factors compiled across the responded surveys are in line with the VBA SAP as reflected in the UNEP-GEF Volta Transboundary Diagnostic Analysis (TDA)[12] which identified three clusters of priority transboundary issues and problems as follows:

1. Changes in water quantity and seasonality flows;
2. Degradation of ecosystems, leading to i) loss of soil and vegetative cover, ii) increased sedimentation in the river courses, iii) coastal erosion downstream and, iv) aquatic invasive species;
3. Water quality deterioration (from agricultural, industrial and domestic/municipal effluents).

These issues and challenges contribute to related problems of desertification that exacerbate climate change impacts (flooding and droughts), and devastate livelihoods especially of the rural communities. In addition, there are crosscutting issues such as limited availability of reliable and useable climate information and generally weak institutional capacity. Information

[11] The Role of Ecosystems in Disaster Risk Reduction (2013). UNU-Press Editor: Fabrice G. Renaud, Karen Sudmeier-Rieux, Marisol Estrella - ISBN: 978-92-808-1221-3;
[12] UNEP-GEF Volta Project, 2013. Volta Basin Transboundary Diagnostic Analysis. UNEP/GEF/Volta/RR 4/2013. volta-basin-tda-english (iwlearn.org).

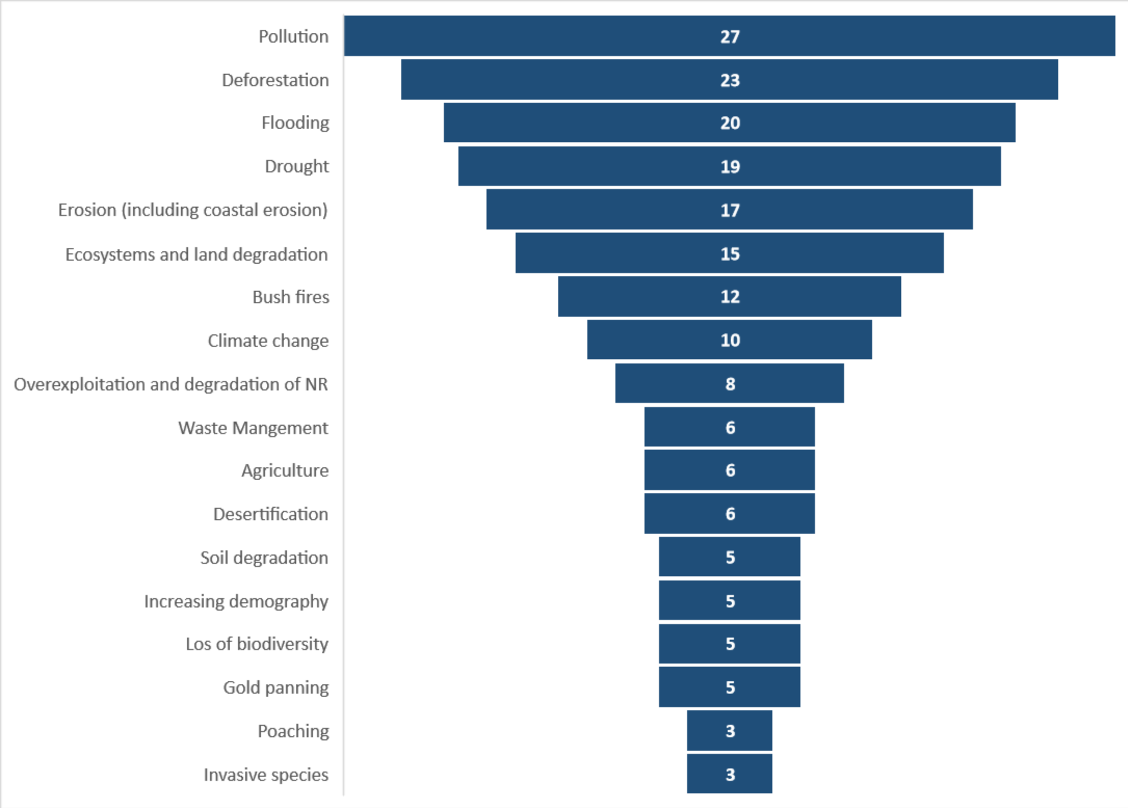


Figure 3. Major threats identified by the respondents and environmental factors to be considered in disaster risk management.

is key in planning for adaptation to climate change. Building climate resilience requires multi-level actions across multiple sectors, particularly water resources, land use/forest, and agriculture.

Ecosystems provide essential services and also play an important role in disaster risk and climate adaptation and mitigation. Conservation and restoration of ecosystems can contribute to addressing the above transboundary challenges. An integrated basin-wide ecosystem risk assessment could be a baseline starting point to address the gaps in data and information. For this purpose, one of the questions within the survey was to understand the level of familiarity with the IUCN Red List of Ecosystems. A total of 71% of the respondents have already heard about it, figure 4.

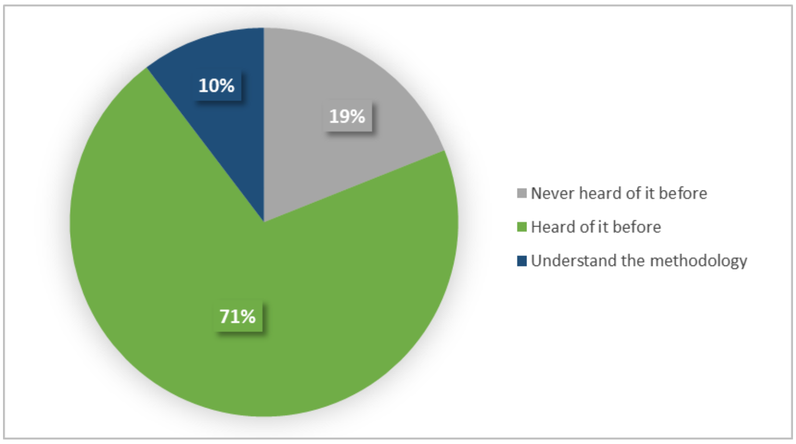


Figure 4. Level of familiarity with the IUCN Red List of Ecosystems.

Finally, the survey included an additional question to get respondents' views on how the environment can be better promoted as a key component of disaster risk management for flood and drought. Raising awareness amongst stakeholders and across sectors (89.6%) together with the facilitation of exchange of good practices and improvements in disaster management policy and operations through mutual learning and expert review (82.7%) were deemed the most relevant key actions to be considered for a greater uptake of the environment by respondents, (figure 5).

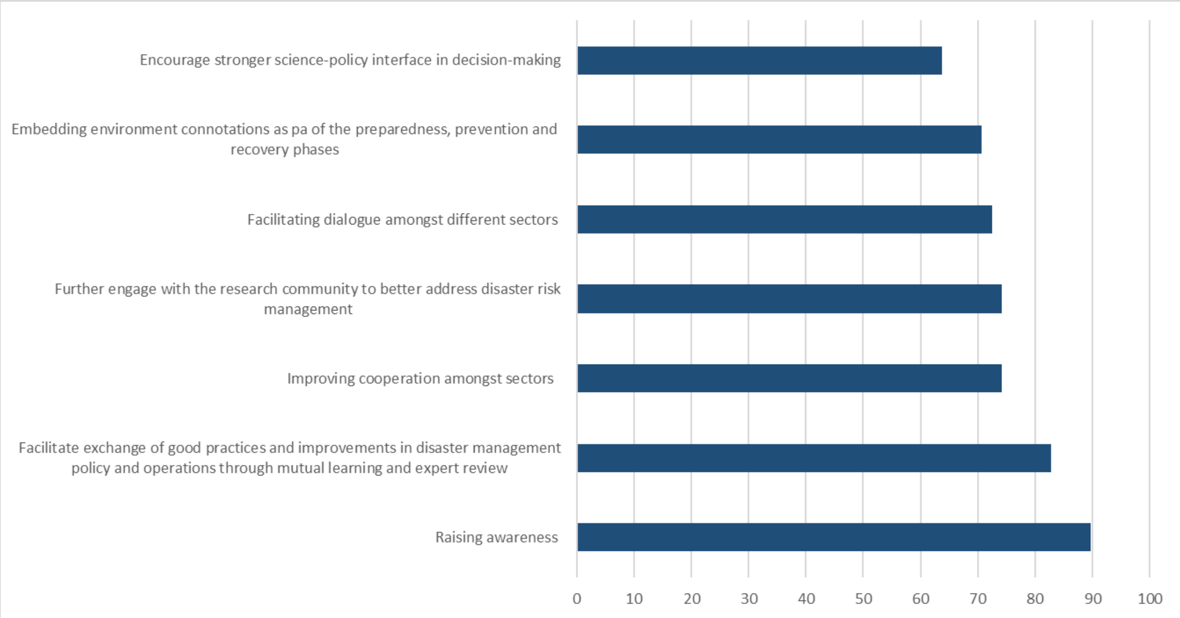


Figure 5. How can we better promote the environment as a key component of disaster risk management for flood and drought?

Besides the proposed options, other recommendations were suggested by the respondents, all of which are aligned with the objectives of the VDFM project:

1. Improve political will towards policy and decision-makers;
2. Organize stakeholders around the management of the sub-basin's resources;
3. Mobilise financial resources for the implementation of the development and management plan for the basin and sub-basins resources;
4. Initiate and encourage the inter-communal approach to the management of the basin and sub-basins;
5. Carry out studies on the knowledge of the water resources of the sub-basins and proceed to the realization of infrastructures for the development and management of the resources;
6. Ensure that affected communities are the main actors in disaster risk management;
7. Involve beneficiaries at all stages of the project.

Based on the results of this survey, a set of additional environmental indicators to those already included in the CIMA questionnaire - which has also been shared with the national focal points - can be considered and be integrated into the basin-wide early warning system (EWS) that is currently under development. Similarly, the following sources could bring additional value towards setting a scientifically robust EWS:

- Global Precipitation Climatology Centre (GPCC)[13], product, which provides quality controlled monthly gridded data sets of global land-surface precipitation;
- Global Land Data Assimilation System (GLDAS)[14], data, which simulates various fields of land surface states and fluxes was obtained from the Goddard Earth Sciences Data and Information Services Center (GESDICS)[15],
- MODIS global terrestrial evapotranspiration project[16], available for download at the Earth Observing System of NASA's website[17]. The MODIS-derived ET estimates indicated a relatively lower magnitude of uncertainties over the Volta basin.[18]

3.4 Limitations, opportunities and recommendations

As mentioned in the summary section of this document, the major challenge has been how to cope with the impacts of COVID-19 in our working plan. The data compilation was supposed to be done via face-to-face interviews, e-mails and field visits, however, the established travel restrictions for the past 8 months didn't allow us to pursue this initial plan.

Slow communication has been the subsequent challenge that hindered the compilation process. Even though IUCN has been presenting and attending several virtual events, a strong and trustful dialogue can mainly be successful by in person meetings. This has been highlighted in some of the survey received; this implied that some respondents were not very comfortable sharing the information.

Also, unavailability of data was a major challenge since most of the stakeholders indicated that links to data sources such as maps were not available.

While more effective protection of biodiversity in the basin will depend on a range of factors, particularly available funding mechanisms, the economic valuation of biodiversity and ecosystem services can provide arguments for the integration of biodiversity aspects into other policy domains. By informing policy-making, the IUCN Red List of Ecosystems holds potential for contributing to smarter and more sustainable management of biodiversity.

Such ecosystem risk assessment can demonstrate how improved ecosystem management can reduce risks, enhance resilience, and promote adaptation, and allows conservationists,

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[13]Schneider, U., Becker, A., Finger, P., Meyer-Christoffer, A., Ziese, M., Rudolf, B., 2014. GPCC's new land surface precipitation climatology based on quality-controlled in situ data and its role in quantifying the global water cycle. Theoret. Appl. Climatol. 115 (1–2), 15–40. http://dx.doi.org/10.1007/s00704-013-0860-x;

[14] Rodell, M., Houser, P.R., Jambor, U., Gottschalck, J., Mitchell, K., Meng, K., Arsenault, C.J., Cosgrove, B., Radakovich, J., Bosilovich, M., Entin, J.K., Walker, J.P., Lohmann, D., Toll, D., 2004. The global land data assimilation system. Bull. Am. Meteorol. Soc. 85 (3), 381–394. http://dx.doi.org/10.1175/BAMS-85-3-381.R;

[15]GESDICS - http://grace.jpl.nasa.gov/data/gldas/.

[16] Mu, Q., Zhao, M., Running, S.W., 2011. Improvements to a MODIS global terrestrial evapotranspiration algorithm. Remote Sens. Environ. 115 (8), 1781–1800. http://dx.doi.org/10.1016/j.rse.2011.02.019;

[17] NASA website - http://www.ntsg.umt.edu/project/mod16;

[18] Andam-Akorful, S.A., Ferreira, V.G., Awange, J.L., Forootan, E., He, X.F., 2015. Multi-model and multi-sensor estimations of evapotranspiration over the Volta Basin, West Africa. Int. J. Climatol. 35 (10), 3132–3145. http://dx.doi.org/10.1002/joc.4198.

private sector and policy-makers to make informed land/water use management decisions based on robust information about risks to ecosystems.

It can help prioritize investments in nature-based solutions[19] for restoration, conservation and sustainable management thus highlighting the economic costs of reduced ecosystem services and potential economic benefits of improved ecosystem management; assess in designing future projects.

A general recommendation is the need 1) to strengthen national data collection and monitoring systems as well as capacities in ecosystem data/environmental assessment; and 2) to increase awareness of the role of ecosystems data in improving the functioning and delivery of EWS.

Limitation	**Description**	**Recommendation**
Response rate	In some cases, there was a poor response rate to questionnaire. Local stakeholders may have received more information about the project and its activities.	Use focal points and networks to push for more participation. Prioritise face to face interviews to gather information/data. One reason for the low response to the electronic survey is the unknown level of understanding of the topic/themes of the survey making it difficult for the potential respondents facing difficulty to understand to abandon filling in the questionnaire. The face-to-face survey helps improving respondents understanding before they can provide answers.
	It is worth noting that the level of detail of this preliminary analysis could have been greater if face-to-face meetings were allowed.	Collect additional information during the regional workshop that will take place early next year. A communication will be sent to all the participants beforehand so they can anticipate the compilation of data and also to spread the request to a wider audience.
Buy in	There was a lack of buy in from certain stakeholder groups, as previous ecosystem assessments have not had an impact	Knowledge building and case studies supplied on how ecosystem assessments can be used to make a real impact on the ground.

[19] IUCN (2020). Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of NbS. First edition. Gland, Switzerland: IUCN.

	on policy, legislation or action on the ground.	
Variation in knowledge at scale	The variation in interests in knowledge confounded data analysis. This made comparison between countries and identifying global trends difficult to do with any degree of certainty.	Structure future surveys to account for this difference to allow data segmentation.
Level of understanding	Misunderstanding certain questions meant some data might have been missed.	Provide a platform to answer questions about the survey and additional guidance in future surveys.
	Questions should have been formulated using a less technical language thus being more explicit.	If the current situation remains in 2021, regular online meetings have to be considered to fulfil the needs of local actors and timely achieve our deliverables.
		Organise informative sessions with regards to the different tools and approaches promoted and used, such as the Red List of Ecosystems, Nature-based Solutions

IUCN and its strategic partners in Central and West Africa have carried out the following activities a reflection that led to the identification of a large-scale project entitled "***Regional Partnership on Water and Environment in Central and West Africa"*** (PREE, as per its French acronym)". The aim of this project is to contribute towards achieving the following main challenges (i) integrated management of water resources and associated ecosystems in West Africa and in the basins of Lake Chad and the Fouta Djalon Massif, (ii) the management of conflicts related to water and associated ecosystems, (iii) climate change and (iv) strengthening the capacities of sub-regional integration institutions and transboundary basin organisations in West and Central Africa.

The Project will be implemented in the Volta, Chad, Senegal, Mono, Lake Chad and the Fouta Djalon Massi and essentially aims to strengthen the resilience of the natural ecosystems and local communities in these river and lake basins. The VDFM project could benefit by reinforcing the linkages with the PREE since it will have a component dedicated to the IUCN Red List of Ecosystems and the establishment of a regional Hub made by ecosystem experts.

This activity doesn't target the Volta basin, however, experts from some of the riparian countries will be involved. This will be an opportunity for continuing the compilation of the environmental data and for VDFM stakeholders to better understand the mechanism behind the Red List of Ecosystem methodology and its contributions in terms of national policies for conservation, development and climate among others (i.e. National Biodiversity Strategic Action Plans, NBSAPS; National Action Plans, NAPs).

Within the Volta basin, IUCN is currently implementing a project in the Mono Volta landscape (Songor Lagoon and Anlo-Keta Lagoons in Ghana, Roy Mouth in Benin and Mono Delta Biosphere Reserve in Benin and Togo). The title of the project is "***Management of mangroves forest from Senegal to Benin"*** for a period of 3 years (2019-2022). The project is funded by the European Union.

The goal is to achieve integrated protection of the diversity and fragile ecosystems of mangroves in West Africa and strengthen resilience to climate change. Opportunities available through this project are that, small grants are available to support experts/NGOs within the landscape to undertake activities that would measure the value of ecosystem services in the Mono Volta (Volta basin inclusive), promote the implementation of natural resource development models for added value –livelihoods; and support the strengthening of monitoring, control and law enforcement capacities, among others.

Opportunity
Key partners were already interested in the process and willing to take future steps to further mainstreaming environment into disaster risk management actions.
The datasets that are available through this network will enrich the early warning system to be developed and could later inform or catalyse basin-wide or national assessments.
National working groups have been already established so they can take this preliminary compilation of information forward. It can be updated any time over the project lifecycle as a live document.
This preliminary compilation can attract other experts, particularly from the academia and research sector, to incorporate more information/data.
As the project and its activities progress, more information can be integrated not only scientific information but also local and traditional knowledge. It is very important to reflect as well the perception from local communities.
Ecosystem risk assessment (or integrating ecosystem risk assessment in EWS) will accelerate the operationalisation of the coordination of policy sectors, hence will catalyse and increase investment towards nature-based solutions (NbS).

Climate change is projected to intensify the hydrological cycle and increase the occurrence and frequency of flood events. Early warning systems (EWS) are key elements of climate change adaptation and disaster risk reduction, and aim to avoid or reduce the damages caused by hazards. To be effective, early warning systems need to actively involve the people and communities at risk from a range of hazards, facilitate public education and awareness of risks, disseminate messages and warnings efficiently and ensure that there is a constant state of preparedness and that early action is enabled. The significance of an effective early warning system lies in the recognition of its benefits by local people.

Chapter 4: A basin-wide early warning system

Early warning systems (EWS) have the potential to play a central role in climate change adaptation and disaster risk reduction through avoiding or reducing the severity of damages caused by hazards. People and communities who are at risk of one or several hazards, need to be actively involved in the early warning systems through public educations. Sufficient information and training must be provided for local people to obtain awareness about risks, messaging systems, how to react and what instructions to follow when a potential risk is identified. The effectiveness of an early warning system is dependent on the local people practical commitment and preparedness.

The flood early-warning systems are built around the principle that floods only occur in high potential risk areas and when precipitation exceeds the threshold. The warning systems are designed around hydrological and geomorphological concepts within river basins. Developing a flood early-warning system can provide enough time for alerts to be transmitted via different methods such as message boards, SMS, web pages, or within traditional warning signals such as speakers and gongs. Furthermore, it provides a response time for local authorities and residents to take appropriate crisis management actions.

Future projections for the Volta Basin show that the basin is likely to experience longer and drier periods of drought, with shorter monsoon seasons with more intense rainfalls. These predictions call for the implementation of climate change adaption measures, otherwise, food security and farmers' livelihood will be at risk, and the number of people settled in the high-risk flood-prone zones will increase. In the last 20 years, floods have affected approximately two million people who live along the stretch of the Volta, where 68% of the population is working in the agricultural sector.[20]

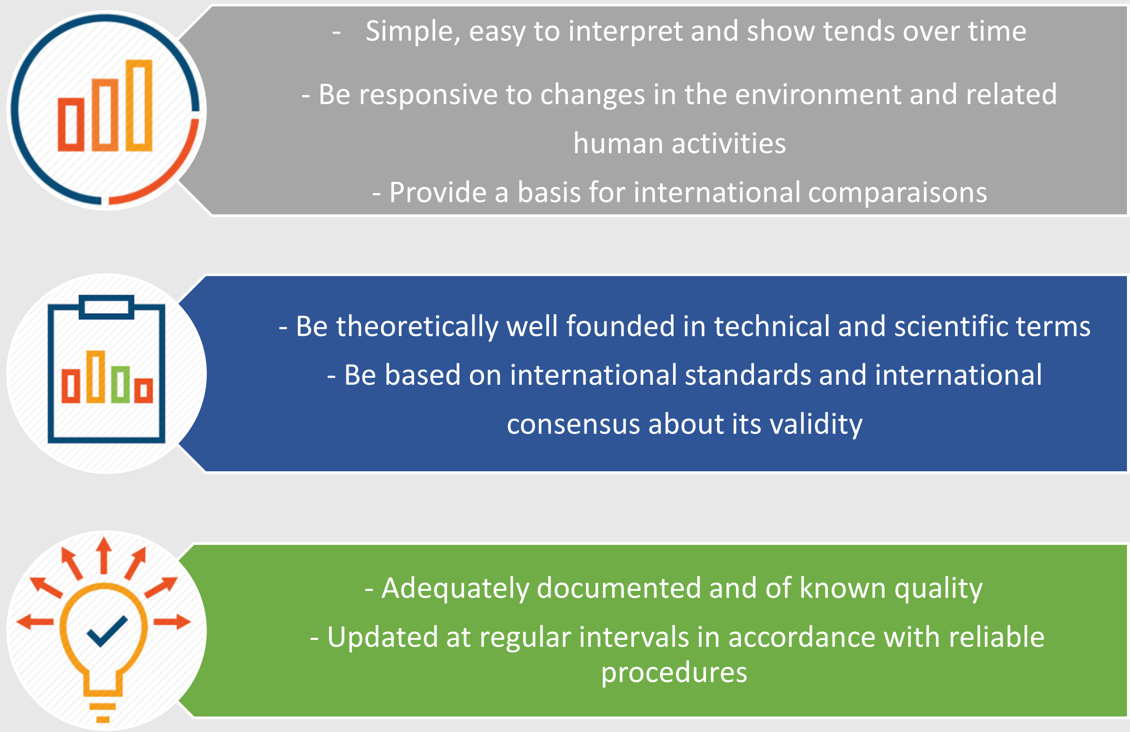
There are several environmental indicators and factors that are associated with flood risks in river basins, parameters such as water level, soil moisture, maximum precipitation, surface and soil characteristics, the cumulative value of surface topography, the weathered shell of the surface, landslides and the average slope of tributaries are listed as the main factors associated with the basin's vulnerability to floods.

4.1 Defining environmental indicators

According to the OECD an indicator is "a parameter or a value derived from parameters giving information on a phenomenon".[21] The objective of the indicator is therefore to describe or give indications on the state of a or a geographical area, of greater than the scope of the phenomenon, the environment or the information directly related to the value of a parameter.

Its major quality is its ability to report concisely on phenomena such as complex. An indicator therefore always presents a model of reality, not reality itself (Box 5). Within the framework of

[20] Integrated approach to Flood and Drought Management in the Volta Basin, https://public.wmo.int/en/resources/bulletin/integrated-approach-flood-and-drought-management-volta-basin;
[21] OECD, 2003. Environmental indicators: development, measurement and use. http://www.oecd.org/environment/indicators-modelling-outlooks/24993546.pdf.



Box 5. Criteria for selecting environmental indicator. As indicators are used for various purposes, it is necessary to define general criteria for selecting indicators and validating their choice. Three basic criteria are used in OECD work: policy relevance and utility for users, analytical soundness, and measurability (OECD,2003). Content adapted from OECD, 2003.

this project, data availability and accessibility play an important role since the definition of environmental indicators to be integrated into the EWS depends on them.

The definition of such indicators has to be linked not only with national / regional existing mechanism but also to policies and regulatory frameworks. This will allow the periodic update of the indicators and adherence to well established international mechanisms. By doing so, it would be then possible to compare the trends across the six Volta riparian countries thus enabling a holistic and basin-wide drought/flood management approach.

The lack of responses and low quality of the majority of responses are the two major challenges for defining these indicators. However, a broader list of environmental indicators is available here below; this list could be updated and indicators integrated into the EWS during the project life cycle according to the availability of information:

- ***Biodiversity***: Land cover (%, rate or Ha), Deforestation (%, rate or Ha), Land conversion (% or Ha), Threatened species (number or %), Protected areas (by type of ecosystems - % or Ha), Key ecosystems (Ha);

- Resources and soil: Forest resources use (rate or intensity), Forest area management and protection (% or Ha), fish catches (number), biological index (number of fishes), food production, soil productivity, soil loss, burned surfaces (% or Ha), bushfires (number).

The environmental indicators have to have the capacity of giving an overview of key environmental issues and related trends of the six countries – again allowing the comparisons.

These indicators have to be simple, understood by decision makers and communicated to the general public; therefore, they provide comparable information that is useful to respond to common policy goals and to which countries can add to suit their circumstances.

- Water level

The majority of early flood warning systems use data collected from sensors or float switches installed at strategic locations (local water basins such as rivers and lakes or flood defence barriers such as dikes and dams) to identify a potential flood event. The sensors and float switch sensors measure water level to determine whether it is in a safe or high-risk zone. When heavy precipitation in the upper catchment leads to a rise in water level beyond a certain threshold, an electric pulse is generated when detecting the presence of water. The warning system analyses the collected real-time data compared to the pre-determined values and is able to identify different levels of risk.[22]

- Rainfall threshold approach for flash flood risk management

Flash flood guidance (FFG) is the depth of rain over a certain duration on a certain basin that is necessary for causing minor flooding at the outlet of the basin. This value is computed by hydrological models and is compared to real-time-measured or forecasted rainfall of the same period on the same basin. If the real-time of predicted rainfall depth is greater than the FFG value of the basin, then flooding is likely. The FFG concept is used for developing of watches and warning systems requires a present or forthcoming flash flood-inducing rainfall accumulation.[23]

- Soil Moisture and hydrodynamic parameters

Analysing the current and initial soil moisture status of certain locations within a catchment is a critical step to anticipate the locations of the river system which may be hit by the flood, as well as estimating the peak discharge, flow volume and flood duration. Such information could provide enough time for planning the flood management measures and lead to an anticipatory rather than responsive manner.[24]

Other parameters such as the volumetric water content at saturation (which is reached when all soil pores are filled with water), the field capacity (which is the amount of water remaining in the soil after excess water has drained and the downward movement rate has decreased), the saturated hydraulic conductivity (which describes how easily water can move through saturated soil) and the soil matric potential at saturation (which is the potential energy of water

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[22] Flood disaster indicator of water level monitoring system, https://search.proquest.com/docview/2201006292?pq-origsite=gscholar&fromopenview=true.

[23] Norbiato D., 2008. Flash flood warning based on rainfall thresholds and soil moisture conditions: An assessment for gauged and ungauged basins, Volume 362, Issues 3–4, 5 December 2008, Pages 274-290. https://doi.org/10.1016/j.jhydrol.2008.08.023;

[24] Chifflard P., Kranl J., zur Strassen G., Zepp H., 2018. The significance of soil moisture in forecasting characteristics of flood events. A statistical analysis in two nested catchments, Journal of Hydrology and Hydromechanics 66(1):1-11. https://doi.org/10.1515/johh-2017-0037.

in saturated soil. It characterizes the suction energy) employed in the modelling and analysing basin flooding vulnerability.[25]

- Land degradation

Land use change can lead to land degradation, vegetation loss, changes in soil characteristic, soil erosion and reduce the soil water holding capacity. The joint impact of extreme rainfall and land degradation can increase the risk of flood. Land degradations can cause an extension of the drainage network and contribute to a further discharge increase.[26]

- Topology

The topology of the rivers and floodplains of a region can be a contributing factor to flood vulnerability and cause flooding to occur rapidly and spread significantly through the catchment, especially when a flood defence is overtopped. Topology and slope constrain can lead to certain areas being susceptible to flooding.[27]

4.2 Flood Vulnerability Index

Vulnerability studies aim to identify fitting actions for reducing vulnerability before possible damage occurs. Flood Vulnerability Index (FVI) is a powerful tool that can assist policy and decision makers to prioritise actions and investments. Flood vulnerability studies and early warning systems identify parameters and provides indices which are designed to produce pragmatic information for strategic and target areas.

The flood vulnerability of a catchment is dependent on the meteorological, hydrogeological, and socio-economic conditions of the area. There are four key components that form the FVI concept:

- Meteorological Component (MC), such as precipitation, measures the quantity of water that enters the catchment
- Hydrogeological Component (HC), such as catchment's rainfall threshold and flood speed, measures how difficult it is for the incoming water to pass through and exist the catchment
- Socio-Economic Component (SC), such as population and assets within the flood zone, measures the vulnerability of an area to flood in terms of population and economic development
- Countermeasure Component (CC), such as flood control structural and non-structural measures, assess the resilience and/or resistance of an area to flood

Flood vulnerability studies allow decision makers and users to identify and analyse the main factors responsible for the vulnerability of catchment which could guide the decision makers

[25] Edouard S., Vicendon B., Ducroq V., 2018. Ensemble-based flash-flood modelling: Taking into account hydrodynamic parameters and initial soil moisture uncertainties, Volume 560, May 2018, Pages 480-494. https://doi.org/10.1016/j.jhydrol.2017.04.048.

[26] Mahe G., Paturel J-E., Servat E., Conway D., Dezetter A., 2005. The impact of land use change on soil water holding capacity and river flow modelling in the Nakambe River, Burkina-Faso. Volume 300, Issues 1–4, 10 January 2005, Pages 33-43. https://doi.org/10.1016/j.jhydrol.2004.04.028.

[27] Pasquier U., He Y., Hooton S., Goulden M., Hiscok K.M., 2019. An integrated 1D–2D hydraulic modelling approach to assess the sensitivity of a coastal region to compound flooding hazard under climate change, Natural Hazards volume 98, pages915–937(2019). https://doi.org/10.1007/s11069-018-3462-1.

towards taking appropriate measures to achieve flood preparedness and reduce vulnerability in different spatial levels.[28]

4.3. Drought indicators

The choice of indicators/indices is based on the specific characteristics of droughts most closely associated with the impacts of concern to the stakeholders. Drought indicators are proliferating, but with little consideration of which are most meaningful for describing drought impacts. A number of recent reviews compare different drought indicators, but none assess which indicators are actually used in the many operational drought monitoring and early warning efforts,

Drought indicators are variables or parameters used to describe drought conditions. Examples include precipitation, temperature, streamflow, groundwater and reservoir levels, and soil moisture. Drought indices are typically computed numerical representations of drought severity, assessed using climatic or hydrometeorological inputs including the indicators listed above. They aim to measure the qualitative state of droughts on the landscape for a given time period. Indices are technically indicators as well.

The Handbook of Drought Indicators and Indices[29] - is part of the 'Integrated Drought Management Tools and Guidelines Series', compiled by the Integrated Drought Management Programme (IDMP) in partnership between WMO and GWP - is based on available literature and draws findings from relevant works wherever possible. The handbook addresses the needs of practitioners and policymakers.

This document provides an extensive and detailed list of indicators that can enrich the Volta-Alarm EWS and can be used as well as indicators for assessing the status of ecosystems in the Volta Basin.

[28] Connor R.F., Hiroki K., 2005. Development of a method for assessing flood vulnerability, Water Science & Technology (2005) 51 (5): 61–67. https://doi.org/10.2166/wst.2005.0109;

[29] World Meteorological Organization (WMO) and Global Water Partnership (GWP), 2016: Handbook of Drought Indicators and Indices (M. Svoboda and B.A. Fuchs). Integrated Drought Management Programme (IDMP), Integrated Drought Management Tools and Guidelines Series 2. Geneva.

Chapter 5: Ecosystem risk assessment in Volta Basin

5.1 Planning a basin-wide assessment

The importance of recognizing and interpreting which threats and stressors impacted, and/or are impacting, or may impact the status of the ecosystem is critical to developing a conceptual model that highlights key environmental processes and the transitions between healthy and collapsed states to be assessed. This will ultimately enable critical risk-informed decisions that align with the strategic biodiversity, disaster risk reduction, climate change goals and objectives; therefore, making a transformative shift from a singular focus on protection to a strategic territory-wide-and-adaptive ecosystem management plan(s).

The IUCN RLE provides a mechanism for integrating data and knowledge to document trends in the extent and condition of ecosystems with clear implications in the provision of ecosystem goods and services for human well-being. The results of a basin-wide assessment can inform decision and policy-making processes and help prioritize investments towards sustainable and long-term ecosystem management, protection and restoration plans. Considering the limitations and opportunities derived from this preliminary evaluation, IUCN proposes to co-design a roadmap as the step forward towards a standardised and scientifically robust ecosystem risk assessment maximizing the available resources and processes in place, (figure 6).

5.2 Organisation and steps forward

As illustrated in figure 6, a Red List of Ecosystem assessment has to include three major phases to be able to conduct and produce a scientific robust evaluation. This section gives an overview of the actions to be considered. It's worth highlighting that such processes can bring together relevant actors that can help in growing the environmental compilation of information and thus reinforcing the content and indicators of the basin-wide EWS.

Scoping

The first step before going into the assessment phase is to organize an RLE training to build the capacities and set a common understating for all the experts identified previously. For example, if the selected ecosystems are seagrasses and mangroves, if possible it would be worth considering local experts on both ecosystems and if need be, bringing external experts. Why it is important to emphasize the fact of engaging local actors, simply because these experts and actors have a strong understanding of the local conditions and their knowledge/capacities can be critical for the integration of the assessment results at the policy level.

A key step is the compilation of information and documentation. This can be a cumbersome and time-consuming process. All assessments must be accompanied by documentation and supporting information, undergo peer review, and be made freely available when completed.

Assessment

During the assessment stage, the experts assemble data on status and trends in quantity and quality of the ecosystem types within the country/basin and deliver this information.

This second step requires strong coordination amongst experts and if need be, especially if it is the first-time experts go through this process, interaction/follow-up with IUCN experts. To highlight that IUCN's aim is to develop capacities and create RLE champions worldwide building on the skills and competencies of ecosystem and other related experts worldwide. This will ultimately allow the largest possible number and coverage of ecosystem assessed.

Relevant maps in their account or provide full bibliographic references, and justify why the selected dataset is appropriate for assessing distributional change. In some cases, for example, there may be several sources of data available and it may be uncertain which is the most appropriate. In such cases, the sensitivity of ecosystem status to data uncertainty has to be documented and properly justified.

Output

The assessment has to be drafted, peer reviewed and validated before being published. This means that the expert group has to meet together with the IUCN experts to validate the result and evaluate the process followed. This is an important exercise particularly when undertaking the first assessment; it is very useful to use the lessons learned to then establish a protocol to be adopted for further assessments.

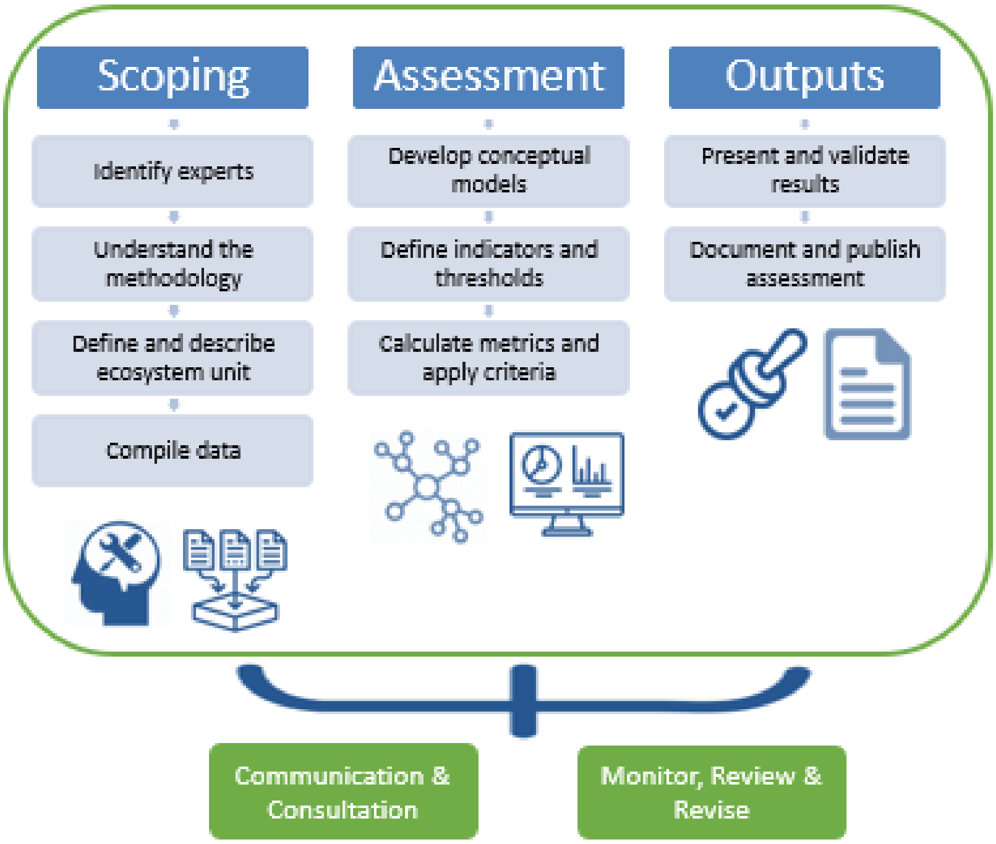

Figure 6. Roadmap with next steps to conduct a basin-wide ecosystem risk assessment.

5.3 Policy mainstreaming

As mentioned in section one, the IUCN RLE offers a range of possibilities for its integration at the policy level beyond the conservation sector. However, so far, no protocol has been developed as a step-by-step guidance for ensuring its appropriate adoption and further integration; this is being done on country basis according to national/local needs and objectives. This sub-section provides an overview and examples of how the IUCN RLE has been embedded and pioneered in some countries across different regions.

The process of mainstreaming and operationalising the RLE in public policy varies from country to country so there is no common established framework or pattern to be adopted. The identification of ecosystem at risks and major threats makes it possible for the implementation of targeted and appropriate measures to the territorial context.

Spatial information enables policy, management and restoration responses to be targeted at particular purposes. By adopting such a framework, countries will be able to also inform and report against global policy frameworks – CBD and its post-2020 targets and/or the UN 2030 Sustainable Agenda and its SDGs; particularly 6 (sustainable water management) goal 14 (life below water) and 15 (life on land). Here below are listed some of the applications of the building on experiences from several countries[30]:

i. **Legislation:** incorporation of the IUCN RLE into environmental laws and regulations, e.g. in sub-national / national environment protection acts and environmental management plans for regulatory protection and reporting for threatened ecosystems.

ii. **Conservation planning and protected area expansion:** ecosystem types can be compared, ranked and prioritized within conservation planning. This is what is being done for the UN Decade of Restoration in combination with the IUCN Global Ecosystem Typology and also to inform designation of new protected areas by identifying under-protected threatened ecosystems

iii. **Environmental authorization and offsets:** When endangered ecosystems are identified this directly triggers a full impact environmental assessment. National offset policy also uses these ecosystems to assess which impacts cannot be offset and sets higher minimum offset ratios.

iv. **Monitoring and reporting:** as mentioned the IUCN RLE can be used for **n**ational reporting frameworks, including NBSAPs, for developing national mapping programmes on important ecosystem types.

v. **Voluntary ecosystem management:** provide recommendations for other sectors like agriculture or fisheries. Sectors that have a direct impact on the creation of jobs and delivery of other ecosystem services. In some countries like Norway, the RLE information has been used to inform eco-certification schemes for timber.

vi. **Expert networks – long-lasting networks**

[30] Alaniz A., Pérez-Quezada J., Galleguillos M., Vásquez A., Keith D., 2019. Operationalizing the IUCN Red List of Ecosystems in public policy. Conservation Letters. 12. 10.1111/conl.12665.

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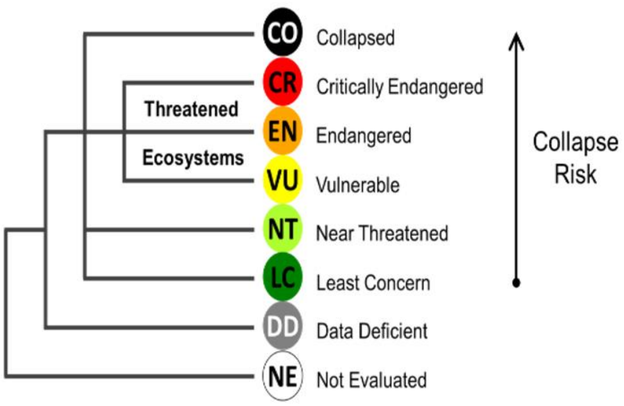
Annexes

Annex 1 – Survey English version

IUCN Ecosystem risk assessment Feasibility Survey

Here more context about The IUCN Red List of Ecosystems (RLE) Categories and Criteria and the importance of addressing disaster risk and climate adaptation from a socio-ecological angle. The IUCN RLE is a global standard for how we assess the conservation status of ecosystems, applicable at local, national, regional, and global levels. The Red List of Ecosystems evaluates whether ecosystems have reached the final stage of degradation (a state of Collapse), whether they are threatened at Critically Endangered, Endangered, or Vulnerable levels, or if they are not currently facing a significant risk of collapse (Least Concern).



It is based on five criteria for performing evidence-based, scientific assessments of the risk of ecosystem collapse. In this survey, participants are asked for the availability and accessibility of data required for these five criteria, to assess the feasibility, priorities and opportunities for a wide RLE assessment in the Volta basin. For more information on RLE see here: https://iucnrle.org

The survey takes approximately an hour and is a simple way for collaborators to assess what information, partners and data they already have on the ground that could easily feed into the ecosystem risk assessment. It will provide a springboard for partners to identify opportunities, access resources and funding, forge new partnerships and increase global knowledge of ecosystems and the threats they currently face.

The information provided is crucial to further environment-related research, policy and governance in the future. The more detailed and informative the answers are the more robust and valuable the outcome will be. Thus, we kindly ask that you take the time to fill in the questionnaire with as much information as you have access, allowing us to get a better picture of the current situation at the national and basin scales.

1. Email address
2. Your name
3. Name of your institution and Country
4. You are replying as:
   - As an individual in your personal capacity
   - In your professional capacity on behalf of an organisation

5. Type of Institution:
   - Government Regional or local authority (public or mixed)
   - International or national public authority
   - Non-governmental organization, platform or network
   - Private Sector
   - Professional consultancy
   - Research and Academia
   - Other (please specify):

6. The International Union for the Conservation of Nature (IUCN) is committed to respecting your privacy in accordance with Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data. I declare:

   - I hereby authorize the treatment of my personal data (country and type of institution) under the "Integrating Flood and Drought Management and Early Warning for Climate Change Adaptation in the Volta Basin" project, for reporting purposes;
   - The data collected will be used for reporting purposes under the "Integrating Flood and Drought Management and Early Warning for Climate Change Adaptation in the Volta Basin" Project and access will be granted to the project coordination team;
   - The data collected will be stored until the end of the lifetime of the project (March 2023).

7. How familiar are you with the Red List of Ecosystems?

   - Never heard of it before
   - Heard of it before
   - Understand the methodology

8. Please list below any existing reference and link (data type, ecosystem type, repository, national center, experts, etc.) regarding ecosystems spatial distribution (digital maps, satellite images, etc.). Please list the maximum possible number of references:

   Example: Mangrove distribution in Western region – map - link

   1. …..
   2. ……
   3. ……

9. Please list below any existing reference and link (data type, ecosystem type, repository, national center, experts, etc.) regarding ecosystems threats - coastal erosion, pollution, deforestation, etc.- (digital maps, satellite images, etc.). Please list the maximum possible number of references:

   Example: Mangrove deforestation – scientific publication - link (Causes and Consequences of Mangrove Deforestation in the Volta Estuary, Ghana: Some Recommendations for Ecosystem Rehabilitation)

   1. …..
   2. ……
   3. ……

10. Please list below any existing Environmental indicators and thresholds and link (data type, ecosystem type, repository, national center, experts, etc.) r Please list the maximum possible number of references:

    Example:
    - *Ghost crabs population – scientific paper - link (The ecological effects of beach sand mining in Ghana using ghost crabs (Ocypode species) as biological indicators)*

    - *Water quality – official UN brief - link (Ghana's Statistics Office)*

    1. …..
    2. ……
    3. ……

11. Please indicate below any existing policy / regulatory mechanisms / instruments for environment protection / ecological assessments or related legislation.

12. What do you think are the key environmental issues to be considered in disaster risk management?

13. How can we better promote environment as a key component of disaster risk management for flood and drought? Please highlight in yellow a maximum of 3 responses:

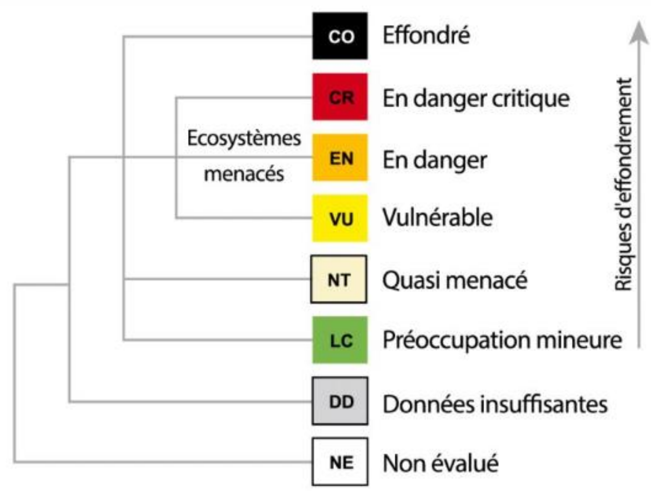
    - Raising awareness
    - Embedding environment connotations as pa of the preparedness, prevention and recovery phases
    - Facilitating dialogue amongst different sectors
    - Improving cooperation amongst sectors
    - Further engage with the research community to better address disaster risk management
    - Encourage stronger science-policy interface in decision-making
    - Facilitate exchange of good practices and improvements in disaster management policy and operations through mutual learning and expert review

Annex 2 – Survey French version

UICN - Etude de faisabilité pour l'évaluation des risques des écosystèmes

Voici plus de contexte sur les catégories et les critères de la Liste rouge des écosystèmes (RLE, par son acronyme en anglais) de l'UICN et sur l'importance d'aborder les risques de catastrophes et l'adaptation au climat sous un angle socio-écologique. La RLE est une norme mondiale pour l'évaluation de l'état de conservation des écosystèmes, applicable aux niveaux local, national, régional et global. Cette méthodologie évalue si les écosystèmes ont atteint le stade final de dégradation - état d'effondrement, s'ils sont menacés ou s'ils ne sont pas actuellement confrontés à un risque important d'effondrement.

Il repose sur cinq critères permettant de réaliser des évaluations scientifiques fondées sur des preuves du risque d'effondrement des écosystèmes. Dans cette enquête, les participants sont invités à indiquer la disponibilité et l'accessibilité des données requises pour ces cinq critères, afin d'évaluer la faisabilité, les priorités et les possibilités d'une large évaluation des risques d'effondrement des écosystèmes dans le bassin de la Volta. Pour plus d'informations sur le site web : https://iucnrle.org.



L'enquête dure environ une heure et constitue un moyen simple pour les collaborateurs d'évaluer les informations, les partenaires et les données dont ils disposent déjà sur le terrain et qui pourraient facilement alimenter l'évaluation des risques écosystémiques. Elle servira de tremplin aux partenaires pour identifier les opportunités, accéder aux ressources et aux financements, forger de nouveaux partenariats et accroître la connaissance globale des écosystèmes et des menaces auxquelles ils sont actuellement confrontés.

Les informations fournies sont essentielles pour faire progresser la recherche, la politique et la gouvernance en matière d'environnement à l'avenir. Plus les réponses sont détaillées et instructives, plus les résultats seront solides et précieux. Nous vous demandons donc de bien vouloir prendre le temps de remplir le questionnaire avec autant d'informations que vous avez accès, ce qui nous permettra d'avoir une meilleure idée de la situation actuelle à l'échelle nationale et à celle du bassin.

1. Adresse électronique:
2. Prénom, Nom(s) de Famille :
3. Nom de vote institution, pays :
4. Vous répondez comme :
    - En tant qu'individu à titre personnel :
    - En votre qualité professionnelle au nom d'une organisation

5. Type d'institution:
    - Gouvernement / Autorité régionale ou locale (publique ou mixte)
    - Autorité publique internationale ou nationale
    - Organisation non gouvernementale, plateforme ou réseau :
    - Secteur privé
    - Société de conseil
    - Institut de recherche / Université
    - Autre (specifier svp):

6. L'Union Internationale pour la Conservation de la Nature (UICN) s'engage à respecter votre privacité conformément au règlement (UE) 2016/679 du Parlement Européen et du Conseil du 27 avril 2016 relatif à la protection des personnes physiques à l'égard du traitement des données à caractère personnel et à la libre circulation de ces données. Je déclare :

   - J'autorise par la présente le traitement de mes données personnelles (pays et type d'institution) dans le cadre du projet "Intégrer la gestion des inondations et des sécheresses et l'alerte précoce pour l'adaptation au changement climatique dans le bassin de la Volta", à des fins de reportage ;
   - Les données collectées seront utilisées à des fins de compte rendu dans le cadre du projet "Intégrer la gestion des inondations et des sécheresses et l'alerte précoce pour l'adaptation au changement climatique dans le bassin de la Volta" et l'accès sera accordé à l'équipe de coordination du projet ;
   - Les données collectées seront conservées jusqu'à la fin de la durée de vie du projet (mars 2023).

7. Connaissez-vous la Liste Rouge des Ecosystèmes ?
   - Jamais entendu parler
   - J'en ai déjà entendu parler :
   - Je comprends la démarche

8. Veuillez indiquer ci-dessous toute référence et tout lien existant (type de données, type d'écosystème, dépôt, centre national, experts, etc.) concernant la distribution des écosystèmes (cartes numériques, images satellites, etc.). Veuillez indiquer le plus grand nombre possible de références :

   Exemple: Distribution des mangroves dans la région occidentale in Western région – carte - lien

   1. …..
   2. …..

9. Veuillez indiquer ci-dessous toute référence et tout lien existant (type de données, type d'écosystème, dépôt, centre national, experts, etc.) concernant les menaces pesant sur les écosystèmes - érosion côtière, pollution, déforestation, etc. (publication, rapport, cartes, etc.). Veuillez indiquer le plus grand nombre possible de références :

   Exemple : Déforestation des mangroves – publication scientifique - lien (Les maladies liées à l'eau dans le bassin de la Volta : état de lieux et perspectives)

   1. ……
   2. ……

10. Veuillez indiquer ci-dessous tous les indicateurs et seuils environnementaux existants (type de données, type d'écosystème, dépôt, centre national, experts, etc.). Veuillez indiquer le plus grand nombre possible de références :

    Exemples:
    - *Population des poissons – publication scientifique - lien (Les poissons des bassins d'eau douce des bassins côtiers du Togo)*
    - *Qualité de l'eau – document officiel de l'OMM - lien WHYCOS*

    1. ……
    2. ……

11. Veuillez indiquer ci-dessous tout politique, mécanisme réglementaire, instrument de protection de l'environnement, évaluation écologique ou législation connexe existants.

12. Quels sont, selon vous, les principaux problèmes environnementaux à prendre en compte dans la gestion des risques de catastrophe ?

13. Comment mieux promouvoir l'environnement en tant qu'élément clé dans la gestion des risques de catastrophes pour les inondations et les sécheresses :
    - Sensibilisation:
    - Intégrer des connotations environnementales en tant que phases de préparation, de prévention et de récupération :
    - Faciliter le dialogue entre les différents secteurs impliqués :
    - Améliorer la coopération et coordination entre secteurs :
    - S'engager davantage avec la communauté des chercheurs pour mieux gérer les risques de catastrophes :
    - Encourager une interface science-politique plus forte dans la prise de décision :
    - Faciliter l'échange de bonnes pratiques et l'amélioration de la politique et des opérations de gestion des catastrophes par l'apprentissage mutuel et l'examen par des experts :