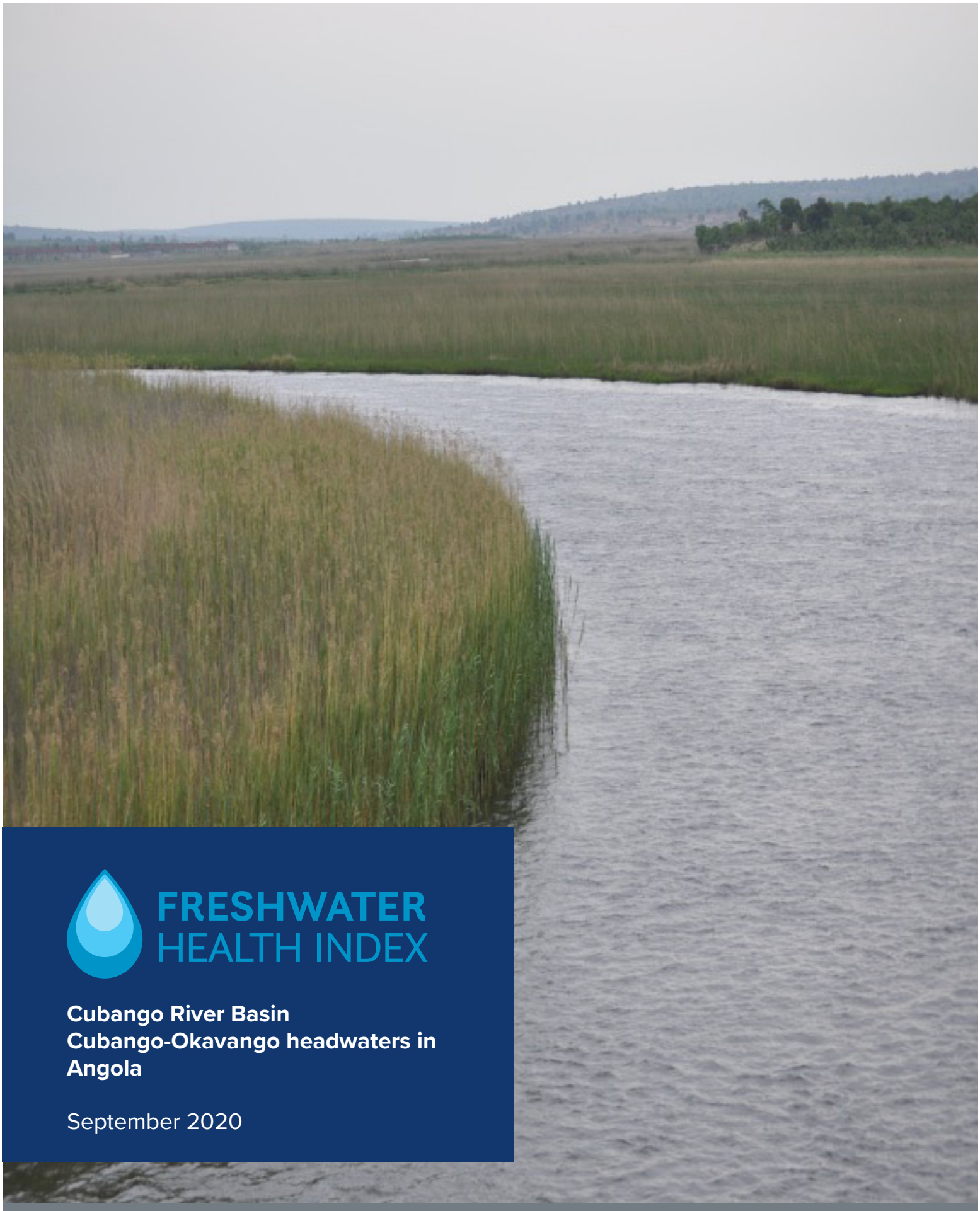

FRESHWATER HEALTH INDEX

Cubango River Basin
Cubango-Okavango headwaters in Angola

September 2020

Okavango headwaters© CI/Derek Vollmer

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Led by:

CONSERVATION INTERNATIONAL

Institutional partners:

OKACOM
Comissão Permanente das Águas da Bacia Hidrográfica do Rio Okavango

GABHIC

NATIONAL GEOGRAPHIC

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CUBANGO RIVER BASIN, ANGOLA

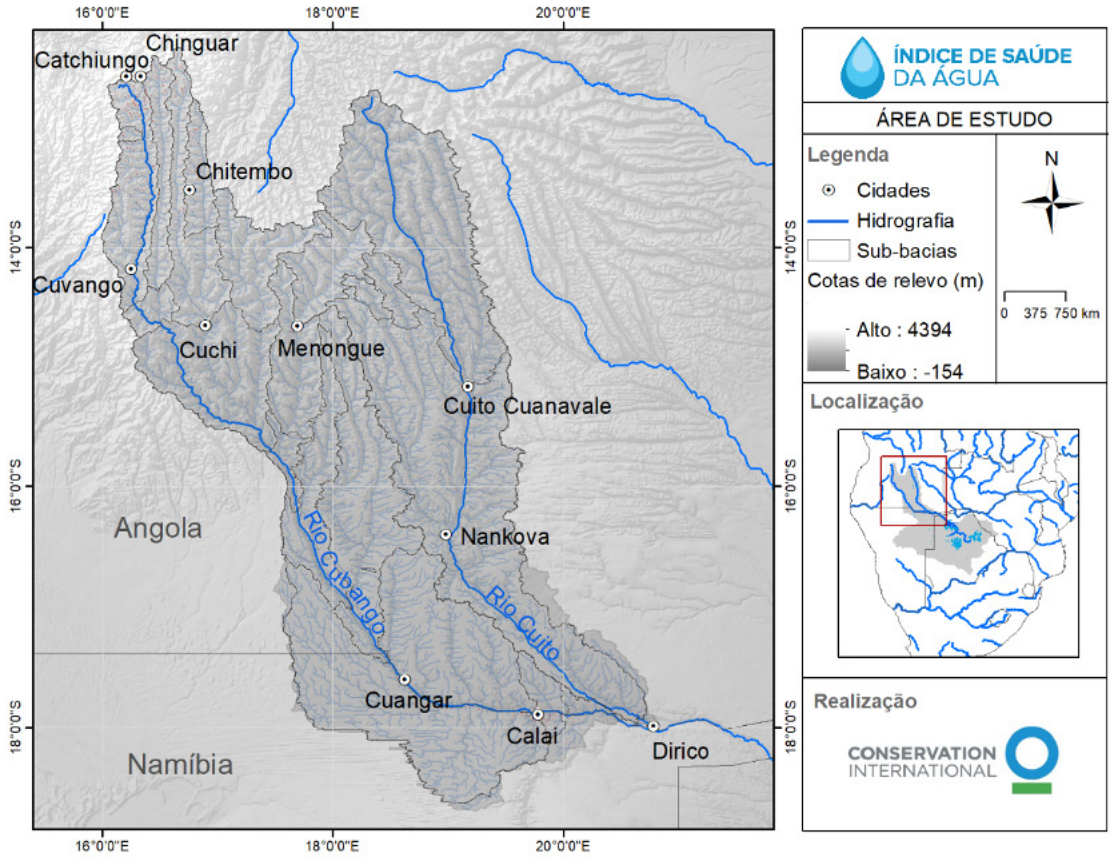

Figure 1. Map of the assessment area

EXECUTIVE SUMMARY

CUBANGO RIVER BASIN

TThe Cubango River Basin (hereafter referred to as the Cubango Basin) is of great importance for the maintenance of global biodiversity, because it is the headwaters of the Okavango River Delta and represents 95% of the average annual flow of the Cubango-Okavango basin. The Delta is characterized by untouched wetlands that are home to some of the world's most endangered large mammals. In addition to its ecological relevance, the Cubango Basin is economically important to Angola, given its potential for agricultural production (GABHIC, 2014). Considering the growing demands for water to advance the economic use of the natural resources of the Cubango Basin (e.g., irrigation for agricultural areas, population expansion and hydroelectric use) and also to improve the quality of life of its inhabitants through improvements in water distribution infrastructure and basic sanitation, the Freshwater Health Index (FHI) was applied in the Cubango Basin to evaluate its general health in three components: Ecosystem Vitality, Ecosystem Services and Governance and Stakeholders. This evaluation included the organization of stakeholder meetings to not only obtain data necessary for the calculation of FHI and validate results, but also to understand how the FHI can contribute to decision-making on the use of available water resources and land, allowing managers to understand synergies between the biophysical system, provision of benefits and the water governance system.

The FHI can be used as an instrument for monitoring and measuring the achievement of public policy goals adopted at the level of the Cubango River Basin, and may also assist in their formulation or application. The FHI's usefulness stems from its ability to communicate aspects of development, thus contributing to the pursuit of sustainability.

The sustainability of water resource management is based on the joint consideration of various dimensions: social, environmental, economic, cultural and political, the latter being critical to ensure the proper involvement and development of institutions and the legal and regulatory framework. Integrating these dimensions of sustainability must be done throughout the water resource management process, from the very beginning in planning but also in the systematic assessment of the resources and through to assessing management impacts. Thus, the FHI can play a major role in sharing knowledge about the state of the Cubango Basin, and evaluating the basin's governance, as well as supporting the establishment of a participatory system of governance and decision support on priority areas of intervention.

It is also expected that the FHI can contribute to the generation of specific results of OKACOM's Strategic Action Programme determined in the Basin Development and Management Framework (BDMF) and Thematic Areas. More specifically, the FHI has high potential to be the tool that provides the 'State of the Basin' (expected result of BDMF number 9) and improve the knowledge and awareness of stakeholders about the Cubango-Okavango River Basin (expected result of BDMF number 8).

KEY RESULTS

- The Ecosystem Vitality component obtained the highest overall score (92). This score suggests that aquatic ecosystems are in a state of low disturbance and high conservation. None of the indicators evaluated (Water Quantity and Quality, Basin Condition and Biodiversity) presented a score lower than 80, which corroborates the high score of this component. This very low level of degradation means that the provision of the expected benefits is generally ensured for the short and medium term. Considering the individual scores for each sub-indicator, the Water Quality Index obtained the lowest score (82) and, therefore, this would be the variable that could require special attention from basin managers in the future.
- The Ecosystem Services component scored 73. This score indicates that, although the expected benefits of the Cubango Basin are being provided satisfactorily, in general, there is already an indication that supply for some services is being compromised. The priorities pointed out by the FHI are for the following services: Regulation of Diseases (56), Conservation of Cultural Heritage (50) and Recreation (60). In addition to knowing these priorities, basin managers should take into account that provisioning services were considered the most relevant for the stakeholders consulted, as they received a high overall weight (nearly half of the total for all three Ecosystem Service Indicators). In other words, the integrated and sustainable management of the Basin depends not only on making decisions to ensure the adequate supply of services, but also on considering and balancing stakeholders' collective interests.
- The Governance and Stakeholders component is the most worrisome from the point of view of integrated and sustainable management of water resources, because it received a very low score (35) compared to the other two components. Therefore, advances in water governance need to be a priority for managers, especially considering the growing demands for water and the potential effects of climate change on the amount of water available. In addition, the result highlights the need for in-depth analysis to understand the factors that led to poor performance. With the exception of the Water-Related Conflict (67) sub-indicator, all other sub-indicators exhibited low scores, which implies that all aspects of governance require attention. The lowest scores were for Technical Capacity (22), Distribution of Benefits of Ecosystem Services (24), Financial Capacity (25) and Monitoring Mechanisms (26), suggesting that these areas should be priorities for further investigation and investment.

The results of the baseline evaluation of the FHI appear to be in line with the reality on the ground for the Cubango Basin. The highest score of Ecosystem Vitality in relation to the Ecosystem Services component is an interesting result, as the environment usually shows signs of degradation in its biophysical factors before exhibiting a reduction in the provision of services. The pattern observed for the Cubango Basin demonstrates the limits of the system in providing services naturally, given that this basin is underdeveloped--that is, interventions and infrastructure that are generally implemented to maximize human benefits (e.g., dam construction, irrigation works) are still uncommon. As noted, the main services requiring attention relate to Regulation of Diseases, Conservation of Cultural Heritage and Recreation. It is also important to highlight that management priorities should be aligned with the common interests of stakeholders. In the case of the Cubango Basin, the most collectively important ecosystem service is water supply for the different sectors of the economy (in this case, domestic and agricultural use). Thus, integrated management of the Basin should balance the provision

of the most relevant services for stakeholders and areas that need attention from managers (those with lower scores). Finally, the low score obtained for the Governance and Stakeholders component indicates that water resource managers may not yet be prepared to manage the basin in a holistic and integrated manner to ensure the sustainable and equitable distribution of its benefits.

CONCLUSIONS & NEXT STEPS

The results of the FHI can support decision-making in prioritizing the implementation of activities defined in the *Strategy and Program of Measures and Actions of the General Plan for Integrated Use of Water Resources* (PGUIRH) of the Cubango River Basin, a support tool for planning and management at basin level. The PGUIRH presents the main development scenarios, considering the needs and use by different sectors, and the availability of existing water resources based on projected development in the basin through 2030.

The FHI can now be used to help evaluate specific actions and measures identified by the Cubango PGUIRH. These actions are grouped in 6 major areas of intervention, namely: water quality, water quantity, risk management and enhancement of the public water domain, monitoring, research and deepening of knowledge, communication, and the institutional and regulatory framework. The FHI is well-aligned with these areas and offers an added value in monitoring and setting priorities for the implementation of the Cubango Plan.

In the event that water health in the three components: (Ecosystem Vitality, Ecosystem Services, and Governance and Stakeholders) continues to be monitored over time, it is essential that stakeholders are trained to conduct these assessments so the FHI can be reevaluated approximately every three years. The present application of FHI in the Cubango Basin should also be integrated into the forthcoming application of the FHI for the Okavango Delta region to provide a comprehensive overview of the health of the entire Cubango-Okavango Basin.

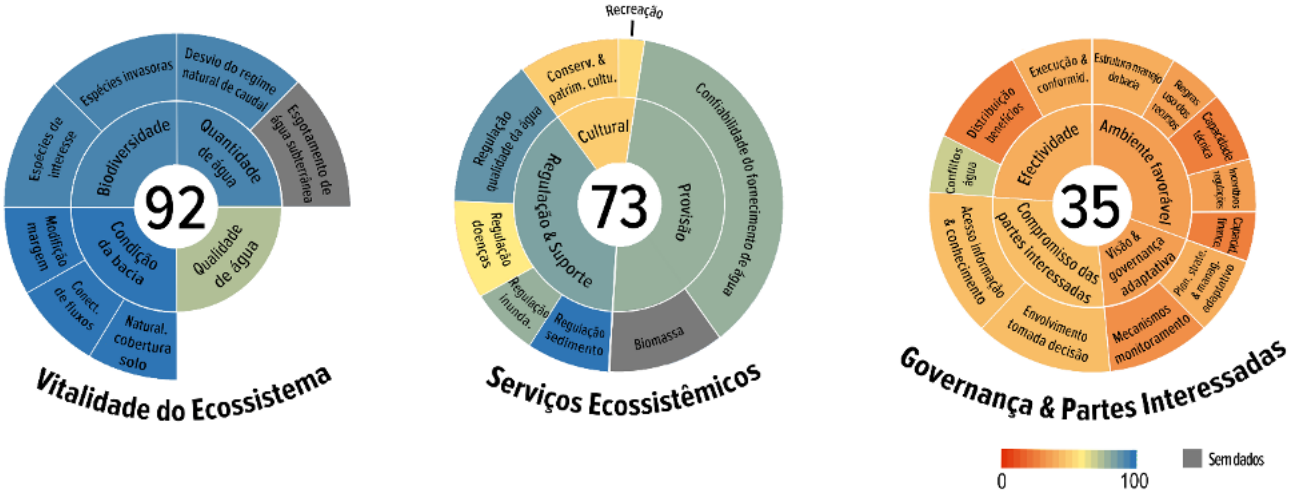

Figure 2. Baseline of the Freshwater Health Index for the Cubango River Basin

1. INTRODUCTION

The Cubango River Basin covers an approximate area of 165,000 km2 within Angola and part or all of 14 municipalities. The municipalities of Calai, Nancova, and Cuchi, are fully situated in the basin, while the municipalities of Tchicala-Tcholoanga, Chinguar, Chitembo, Kuvango, Cuito Cuanavale, Mavinga, Cuangar, Calai, Dirico are partially located with in the basin boundaries. The main tributary of the Cubango River is the Cuito River; both originate in the Central Plateau in Angola. The Cubango River and its tributaries are located in the western part of the study area (Figure 1) and its headwaters are characterized by granite outcrops with rocky substrates, rapids and some waterfalls. The Cuito River and its main tributary, the Cuanavale River, are located in the eastern part of the study area and have wide valleys, with watercourses that wind through the deep sands of the Kalahari and are characterized by extensive moist wetland, peatland and ox-bow lakes. The high precipitation and lack of drainage in the rainy season generate soggy soils that prevent the development of forest but sustain the wetlands of the pastures with humid soils and dwarf shrubs (Revermann et al. 2013). These areas act as "sponges" that slowly release water into the Okavango system. In its upper stretches, the surrounding hills are dominated by various forms of miombo forest. The Cubango River forms the border between Namibia (where it is referred to as the Kavango) and Angola before flowing through the panhandle and flowing into the Okavango River delta in Botswana - the world's only freshwater delta. All biodiversity in the Okavango rRver delta depends on seasonal floods originating in the headwaters of the Cubango River Basin in Angola.

Although the panoramic view of the Cubango Basin still shows a largely untouched and naturally functioning ecosystem, the intensification of human activities in the basin is beginning to put pressure on its ecology. There is, for example, a growing concern about rapid deforestation, uncontrolled burning and disorderly development, which can irreparably alter the amount and quality of the water flowing into the drainage network, as well as other biophysical factors in the Basin. As a result of this and other degradation, there may be affects to the provision of benefits obtained by people not only in the Angolan portion of the basin, but also in Namibia and Botswana.

As a transboundary basin, the Cubango Basin has the support of the Permanent Okavango River Basin Water Commission (OKACOM) to coordinate water governance issues in the region. OKACOM was established by an agreement between the Governments of the Republic of Angola, the Republic of Botswana and the Republic of Namibia in 1994 and serves as a technical consultant to the three States on matters of common interest related to the conservation, development and use of water resources in the Okavango River Basin, including the Cubango Basin.

Socioeconomically, there is a substantial disparity between the upstream rural communities in the Cubango Basin, and the downstream areas of industrial agriculture in Namibia and ecological tourism in Botswana. Therefore, in addition to maximizing the benefits of the Cubango Basin, there is a push to manage pressures from any upstream development, which would bring economic growth for Angola, but could seriously threaten the downstream water supply. To help stakeholders in the Cubango Basin assess conditions and improve planning for the future, the FHI has been applied in the Cubango Basin to measure health in three dimensions: Ecosystem Vitality, Ecosystem Services and Governance and Stakeholders.

POLERS PLYING THE WATERS OF THE OKAVANGO DELTA © CI/ DEREK VOLLMER

As the degree of socio-economic development of the Cuito River sub-basin is much lower than that of the rest of the basin, the FHI assessment considered the data separately for these two regions. Specific results highlight summary scores for both the Cubango sub-basin and the Cuito sub-basin, as well as areas within each. But it is important to highlight that the final summary result for each sub-indicator, indicator and FHI component is the average value obtained from these two sub-basins.

2. ECOSYSTEM VITALITY: INDICATOR AND SUB-INDICATOR RESULTS

The Ecosystem Vitality component of The Freshwater Health Index measures the integrity and functioning of ecosystems (streams, rivers, wetlands and forests) within the Basin. Healthy ecosystems are essential to provide clean water, fish, flood protection and a variety of other benefits that people depend on. The four main indicators within the Ecosystem Vitality component measure: water quantity, water quality, basin condition and biodiversity. The data for evaluation of this component in the Cubango Basin come mainly from official government sources and databases, technical reports and analyses from partner organizations and are presented at the sub-Basin level (when possible), to show how the scores of the sub-indicators vary spatially.

Combining the four main indicators, **the Cubango Basin receives a score of 92 for Ecosystem Vitality**. This suggests excellent ecosystem health, though it is worth noting that some indicators have better scores than others (Table 1). It is important to highlight that, unlike the other two components of the FHI, the Ecosystem Vitality component indicators and sub-indicators are not weighted by stakeholders before they are aggregated, because they represent characteristics inherent to the environment or ecosystem, whereas other indicators are more readily influenced by management preferences.

HIPPOS SWIMMING. © ROD MAST

2.1 Water Quantity

The Water Quantity indicator measures the amount and flow of water within the Basin, including surface and groundwater. Aquatic ecosystems depend on seasonal water patterns in the Basin, and in many places, people also rely on seasonal fluctuations in the amount of water. The pattern of these natural fluctuations can be altered by the construction of dams to regulate periods of flooding and droughts. That is, generally, the natural condition is sacrificed to meet human needs. However, these *trade-offs* can also have negative consequences for aquatic biodiversity and for human communities that rely on a natural flow pattern, such as for fishing. The Water Quantity Indicator is measured through two sub-indicators: Deviation of Natural Flow and Groundwater Storage Depletion. T**he Cubango Basin obtained a score of 94 for the Water Quantity indicator**, but this score considers only one sub-indicator (Deviation from Natural Flow) because necessary groundwater data were not available.

2.1.1 Deviation from Natural Flow

The Deviation of Natural Flow measures the degree to which the flow pattern has been altered by land use changes. The presence of reservoirs, agricultural activities, deforestation and urbanization can affect the regime and volume of surface flows, which in turn influences the general functioning of rivers and streams and, consequently, the ecosystem services provided. For example, changes in flow pattern are often necessary to meet water demand and smooth out the natural seasonal variability of the flow rate to reduce flood damage or ensure adequate water supply. **The Deviation of Natural Flow received a score of 94 for the Cubango Basin**, which means that the flow rates during the development period of the region (from 1960 onwards) did not change substantially when compared the flow rates of the pre-development period (before 1960). This very high score reflects the low development/ change of land use and, mainly, the absence of large engineering works in the Basin, such as hydroelectric plants. It is important to point out that the score for this indicator was calculated only as a function of flow data from a single monitoring station, Mukwe in Namibia, which, because it is located downstream of the confluence between the Cubango and Cuito rivers, represents the aggregate effect of development for the entire study area. Therefore, this result does not allow us to understand whether the flow pattern has changed on a smaller scale, for example, in specific sub-basins. The result for smaller scales would be ideal for the management of water resources since integrated management of water resources is generally more effective if it takes into account knowledge of conditions at local scales.

2.1.2 Groundwater Storage Depletion

Groundwater Storage Depletion measures changes in the availability of water stored in underground aquifers. Underground water resources represent a significant portion of the water resources available for human use and, usually, their reserves are much higher than surface water availability. Increasingly, groundwater extraction is assuming importance to meet the demands of rural, urban and industrial communities in the Cubango Basin, although knowledge about the number of wells and their volumetric capacities is lacking. In general, the data and level of knowledge about the basic characteristics of groundwater in the basin is quite limited. At the moment, there is no approved plan for groundwater monitoring, but The Cubango PGUIRH has identified gaps in this area and it is expected to begin a process of monitoring groundwater in the basin in the short-term. On the other hand, OKACOM is currently carrying out an assessment of the groundwater potential at the level of the entire Cubango-Okavango Basin. Therefore, this sub-indicator was not calculated due to the absence of monitoring data on groundwater extraction. But as monitoring improves, the data will be used to calculate this sub-indicator in subsequent FHI assessments and thus provide a more complete picture of the status of water quantity in the basin.

2.2 Water Quality

Water Quality refers specifically to the physiochemical characteristics (e.g., concentrations of substances) required to maintain aquatic biodiversity in the most natural state possible. Pollution by sewage disposal, for example, can directly damage aquatic life and alter the ecological balance by triggering the proliferation of harmful algae. This indicator consists only of a sub-indicator, the Water Quality Index, that comprises multiple quality parameters in line with recent efforts to intercept and remediate pollution from these sources.

2.2.1 Water Quality Index

The Water Quality Index measures how much physiochemical characteristics, for example, concentrations of water quality parameters, differ from thresholds necessary to maintain aquatic biodiversity. **The Water Quality Index in the Cubango Basin received an aggregate score of 73, indicating reasonably good health.** Separately, the Cubango sub-basin scored 70 and the Cuito sub-basin 87, that is, the water quality of the former is under greater negative influence of human activities than the latter. In the case of Cubango sub-basin, the most problematic stations (with a score lower than 70) were: Rio Cacuchi (51), Cuandlei (64), Menongue-Rio Cuebe (57), and Capico (58). The results for these four stations reflect a deviation from the acceptable limit for concentrations, mainly, of total dissolved solids, oxygen saturation, chemical oxygen demand, iron concentration, and fecal coliforms. The low score for the Menongue station may be associated with pollution from the city of Menongue (OKACOM, 2011; GABHIC, 2014)). Similarly, the score for the Cacuchi River station probably reflects pollution from the city of Chitembo.

The score obtained for the Capico station integrates the quality of the drainage network upstream (almost half of the Cubango sub-basin area, where most monitoring stations are located), and possibly reflects the aggregation of low quality water from all of the upstream areas, rather than substantial additional pollution. As this subindicator included only quality data from 2009 and 2012,

it is necessary to consider the inclusion of more recent data so that the final result correctly reflects the current state of water quality in the Cubango Basin. For example, the most recent data (2018 and 2019) under the OKACOM/UNDP/GEF Project to support the implementation of the Strategic Action Plan should be used to evaluate whether conditions have changed. In general, it is noted that the water quality of the basin could be better evaluated if there is the expansion of the monitoring network so that it is possible to provide a status for the entire Cubango basin area, considering that monitoring is presently concentrated in the upper half of the Basin area, as illustrated in Figure 3.

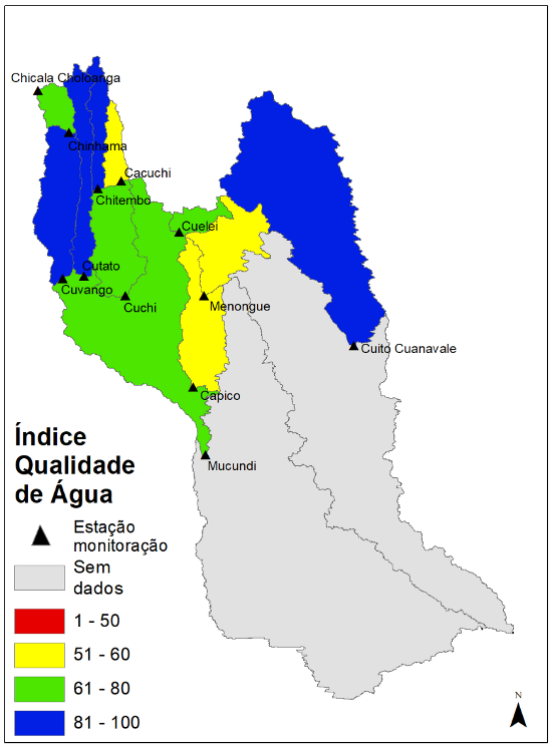

Figure 3. Results of the Water Quality Index

2.3 **Basin Condition**

The Basin Condition measures the extent of physical modifications, both of land cover (e.g. forests converted to agriculture) and of streams and rivers (e.g. the construction of dams or the expansion of canals), which can affect the flow and quality of water, as well as habitat for aquatic life. The Basin Condition is measured through three sub-indicators: Bank Modification, Flow Connectivity and Land Cover Naturalness. **When these three subindicators were combined, the Cubango Basin scored 99.** The almost perfect score indicates that the condition of the drainage network can be considered very little changed from its natural state.

2.3.1 **Bank Modification**

The Bank Modification sub-indicator assesses the lateral connectivity of flows responsible for the exchange of material between rivers and floodplains. Lateral connectivity determines how surface water flows reach rivers and streams, and also how materials (e.g., nutrients and sediments) are exchanged between terrestrial and aquatic systems. Changes in this pattern, whether by channeling

or flooding through dams, affect the establishment of native riparian vegetation and wildlife (including spawning fish and waterbirds), the biogeochemistry of streams, as well as the extent of floodplains. **The Bank Modification received a score of 99, indicating almost no changes in the banks of rivers and streams being observed in the Cubango Basin**. This score is consistent with the low degree of land use change of the Basin; inspection of high-definition satellite images confirmed that the degree of bank modification can still be considered low, as there are few instances of human-made channels. In general, it is noted that the changes in banks occurred mainly in the Cubango sub-basin where the conversion of natural vegetation has been concentrated (Figure 4). The main regions with bank modifications were the areas associated with the city of Menongue and the part of the Cubango River that borders Namibia. Both areas have a high concentration of agricultural activity, including large irrigated regions in the case of Namibia, which usually alters the natural morphology of channels.

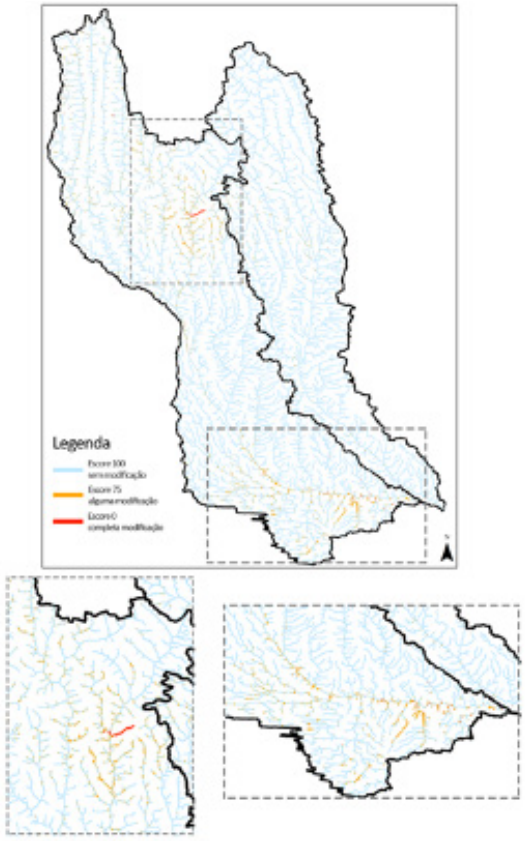

Figure 4. Bank Modification in the Cubango Basin

2.3.2 **Flow Connectivity**

Flow Connectivity measures drainage network fragmentation, and is particularly important for the movement of aquatic life, such as fish, but also affects the natural flow of materials. The connectivity of flows can be altered by natural obstructions, such as waterfalls, or artificial obstructions such as engineering structures (dams and weirs). Reduced connectivity can negatively impact fish migration and reproduction and can prevent sediments and other nutrients from naturally flowing downstream. In this case, the Delta of the Okavango River depends closely on

this natural pattern of material flow. **The Cubango Basin received a score of 99 for this sub-indicator, indicating a high connectivity of flows.** Specifically, the Cubango sub-basin received a score of 99 and the Cuito sub-basin a score of 100. This slight difference occurred because only the Cubango sub-basin currently has dams. However, because these dams are not located in main channels and are near the top of the drainage network, they did not significantly interfere with the overall connectivity of the Cubango Basin drainage network, which explains the high resulting value.

2.3.3 **Land Cover Naturalness**

The Land Cover Naturalness (LCN) measures how much the basin's land cover has been modified by human activities. Forests and wetlands regulate the flow and quality of water, but when degraded or converted into pastures, agricultural areas or urban areas, the ecosystem loses its ability to regulate the water cycle. **The Cubango Basin received a score of 99, indicating that the natural vegetative cover has been minimally modified so far.** The Cubango sub-basin presented slightly more degraded areas (LCN = 98) in relation to the Cuito sub-basin with LCN = 100. The location of the most significant changes can be seen in Figure 5. It is important to highlight that this sub-indicator is one of the most important drivers of change in other in Ecosystem Vitality sub-indicators (Groundwater Depletion, Water Quality Index, Bank Modification and Species of Interest).

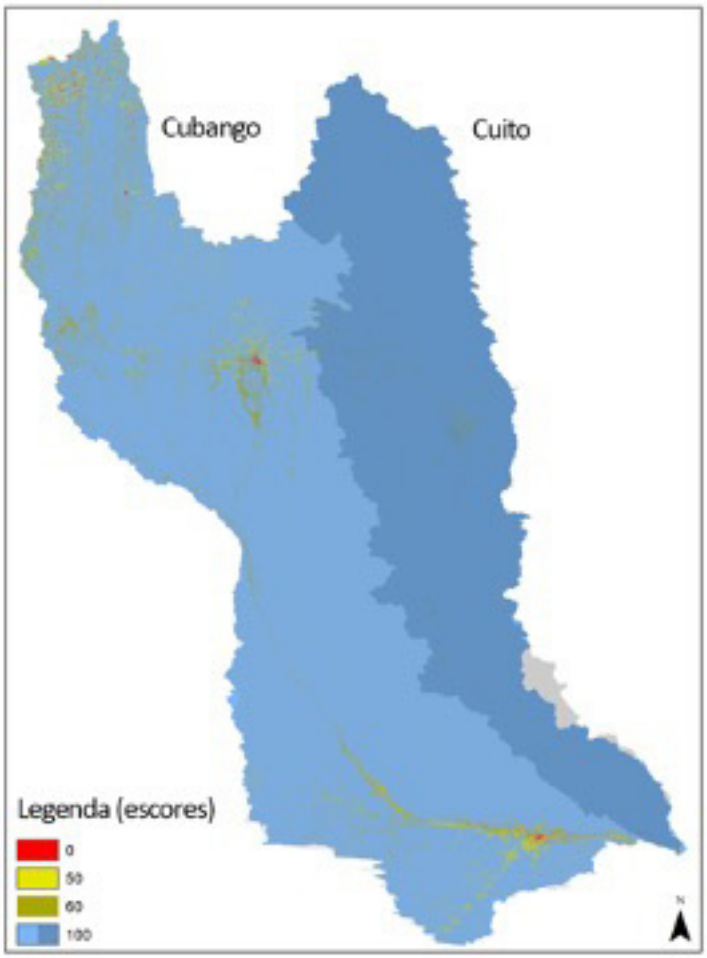

Figure 5. Land cover naturalness in the Cubango Basin.

2.4 **Biodiversity**

Biodiversity refers to the status and trends of populations of animal and plant species that live directly in or near watercourses. Data on reductions in native species or increases in invasive species are used as indicators of ecosystem degradation. In addition, aquatic and riparian biodiversity are often positively associated with fishing and cultural services such as recreation. The Biodiversity indicator is divided into two sub-indicators: Species of Interest, which focuses on endangered, threatened or vulnerable species, and Invasive Species. **When the two sub-indicators are combined, the Cubango Basin has a Biodiversity score of 92, suggesting excellent health**, as few species of interest are threatened and few invasive species are present. The scores of the sub-indicators represent, however, only the proportion of threatened and invasive species in relation to the total, and data on species populations over time are necessary to improve the evaluation of the trends of biodiversity.

2.4.1 **Species of Interest**

Species of Interest measures how much native aquatic and riparian species are threatened. The decrease in species diversity is a warning sign of the deterioration of the ecosystem and may also correspond to declines in benefits for people, such as fishing. **Species of Interest received a score of 94, indicating good health for the biodiversity of the Cubango Basin**. That is, there are few species that are threatened in relation to the total number of evaluated species. Considering the most problematic classes (critically endangered and endangered), with the exception of one plant species, all species whose populations are drastically decreasing are birds. The Cuito River sub-basin received a score of 96, did not contain any species classified as critically endangered and is home to only two threatened species (*Genlisea angolensis* and *Balearica regulorum* – "the gray crowned crane").

The Cubango River sub-basin received a slightly lower score of 93; in addition to the same two threatened species found for the Cuito River sub-basin, another species of bird is threatened in the Cubango sub-basin (*Neophron percnopterus* – "Egyptian vulture") and two more species of birds are listed as critically endangered status (*Gyps africanus* – "white-backed vulture" and *Necrosyrtes monachus* – "hooded vulture"). All of these species live near freshwater systems, and with the exception of the critically endangered birds, their main habitat is flooded areas and wetlands. In general, populations of these species are decreasing mainly because of the degradation of natural habitats, mining, pesticide use in agricultural areas and pharmaceuticals in livestock.

Figure 6. Egyptian Vulture (left), White-backed Vulture (center) and Hooded vulture (right). Photos Wikipedia

2.4.2 **Invasive & Nuisance Species**

The Invasive Species sub-indicator specifically measures the presence of exotic species introduced into the ecosystem, both intentionally and accidentally, that are able to compete or that impose some kind of threat on native species. Increasing numbers and populations of exotic species can put pressure on native species, degrade ecosystems and negatively impact the economy and human health. **The Cubango Basin received a score of 90 for this sub-indicator, indicating good health in relation to the presence of invasive species.** This value is based on the presence of Nile Tilapia (*Oreochromis niloticus*), which was recently identified in the upper part of the Cubango River Basin. Its presence is most likely be due to the existence of aquaculture in the region, something that should continue to be monitored.

3. ECOSYSTEM SERVICES: INDICATOR AND SUB-INDICATOR RESULTS

The Ecosystem Services component measures water-related benefits, including, for example, the supply of drinking water, hydroelectric power and flood protection. These benefits, often delivered in place of or as a complement to infrastructure, are a way to connect people to the natural ecosystems on which they depend. Ecosystem Services are commonly classified according to how people experience them, and this is reflected in the three main indicators: Provisioning (goods/services extracted from the ecosystem), Regulation and Support ("background" processes that occur in ecosystems, in other words, the functioning of ecosystems) and Cultural (experiences that people obtain from ecosystems).

Combining the three main indicators of Ecosystem Services, the Cubango Basin received a total score of 73. This suggests that the Basin is currently meeting people's welfare needs, although there is variation among the specific specific services, meaning some services require further attention. This is also a partially complete score, since data were missing for the calculation of an important sub-indicator for the region (Biomass for Consumption). It is also important to note the final score for this indicator weights each sub-indicator and indicator differently, i.e., according to the relative importance given by stakeholders to each of the indicators and sub-indicators. Weighting revealed a preference for Provision Services (45%) in relation to Regulatory and Support services (32%) and Cultural (23%). For ecosystem service sub-indicators associated with Provision and Regulation and Support, scores are calculated based on spatial, temporal and magnitude factors explained in Appendix 1.

3.1 **Provisioning**

Provisioning services refer to the physical benefits, mainly water and fish, that people get from aquatic ecosystems. These benefits provided by aquatic ecosystems are essential elements for economic development and are essential for food security and water supply security. The Provisioning Services indicator has two sub-indicators: Water Supply Reliability and Biomass for Consumption. **The Provisioning Services indicator obtained a score of 77**, but is based solely on the result obtained for the Water Supply Reliability sub-indicator, since the data to estimate biomass for consumption were not available. Stakeholders assigned a higher weight (60%) for the Water Supply Reliability sub-indicator compared to the Biomass sub-indicator (40%), which indicates the higher importance they place on a secure water supply to meet various needs.

3.1.1 **Water Supply Reliability**

Water Supply Reliability measures the basin's current capacity to meet water demand from various sectors throughout the Basin area. It takes into account seasonal

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variability, minimum amounts of water for ecological maintenance, known as environmental flows, as well as the distribution of water access infrastructure. A decrease in supply reliability corresponds to increased water insecurity, ecological degradation, or unsustainable water consumption. **The Cubango Basin received a score of 77, indicating satisfactory water security.** It is important to highlight that this score accounts for two aspects: *the capacity of the Basin to meet the demand for water, and the degree of access to water*. Domestic and agricultural water consumption was considered because they are the main sectors that use water according to the Basin Plan (GABHIC, 2014). Currently, the Basin has sufficient water availability to meet all demand. In fact, approximately only 1% of the total volume of available water is being used (Figure 7). This results in a reliability of 100 when only water supply and aggregate demand are considered. However, as the infrastructure for access to water is not yet equally distributed in the Basin, the overall score for this indicator drops from 100 to 77.

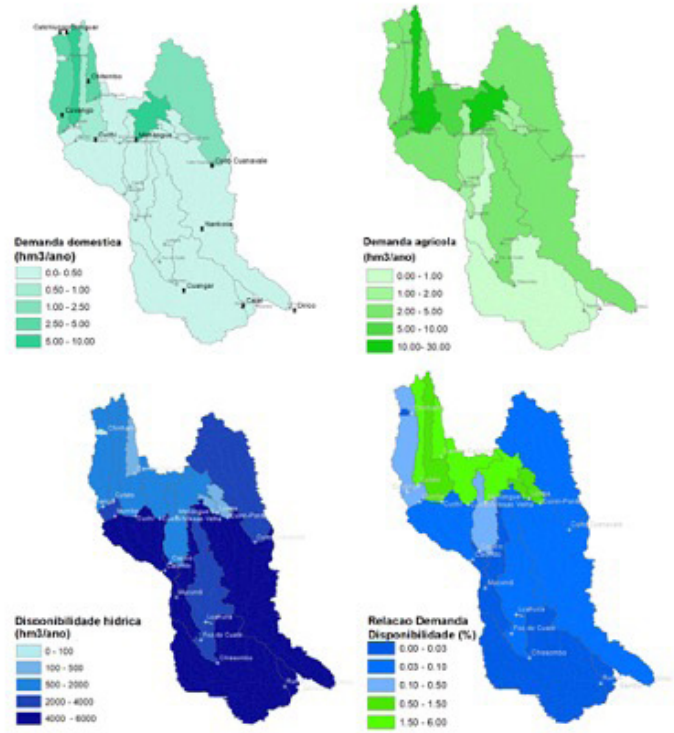

Figure 7. Water Demand and Availability Ratio for Different Sub-Basins

3.1.2 **Biomass for Consumption**

Biomass for Consumption evaluates the amount of biomass (aquatic biota) that is used or acquired for consumption. Currently, there is no data available on the consumption of fish harvested in the Cubango Basin. Fishing activity occurs throughout the basin, but at present there is no evidence that populations highly dependent on this resource are suffering from reductions in its availability.

3.2 **Regulation & Support**

Regulation and Support services refer to natural processes that (1) maintain the availability of water and fish (e.g. keeping water clean and flowing) and (2) provide protection against flooding and other hazards. Water resource management decisions often ignore the regulatory processes provided by the ecosystem, even replacing these "free" regulation services with built infrastructure, which can be costly. The Regulation and Support indicator comprises four sub-indicators: Sediment Regulation, Water Quality Regulation, Flood Regulation and Disease Regulation. **The Cubango Basin has a score of 81 for this service group.** This score was weighted according to the relative importance given to the different services by stakeholders. Stakeholders placed greater weight (38%) on the Water Quality Regulation service, followed by the Disease Regulation service (24%). Sediment Regulation (21%) and flood regulation (17%) were weighted as less important.

3.2.1 **Sediment Regulation**

Sediment Regulation measures the ecosystem's ability to regulate the flow of sediment from terrestrial systems to streams and depositing it in floodplains or downstream outlets. Excessive sediment, for example, from exacerbated erosion, can compromise the capacity of reservoirs to store water, or it can degrade water quality, while a lack of sediment distributed downstream generally deprives aquatic life and agricultural land of critical nutrients. **Regulation of Sediment in the Cubango Basin received a score of 99.** As this indicator was calculated taking into account potential erosion rates in the different sub-basins, the score obtained indicates that soil erosion is still very low in general, which, in turn, supports a natural flow of sediments into rivers and streams. However, it is worth noting that there are areas where exacerbated erosion is already a problem such as the north of the Cubango Basin (GABHIC, 2014), since it is an area more susceptible to erosion naturally (GABHIC, 2012a) and where the loss of natural land cover exacerbates erosion.

Figure 8. Exposed soil after removal of natural vegetation in the region. Photo credit: Sam D. Cruz

3.2.2 **Water Quality Regulation**

Water Quality Regulation refers to the ability of the ecosystem to regulate the concentrations of different water quality parameters in terms of potability for human consumption and other uses. Ecosystems, of course, “filter” many pollutants from water, but this capacity can be easily overcome by the volume of pollutants released by different human activities. **This sub-indicator obtained a score of 88, indicating a good ability to regulate water quality for human activities.** This result confirms that the Cubango Basin still has a very low urban population, and other human activities that can pollute rivers and streams, such as industry and agriculture, are still incipient in the region. Although waste released into rivers near the city of Menongue and other cities reduces water quality for the maintenance of aquatic biodiversity of the Cubango River (as indicated by the water quality indicator score of 73 in the Ecosystem Vitality component), the impact is less when applying standards for human use.

3.2.3 **Disease Regulation**

Disease Regulation measures the exposure of the population to water-associated diseases. Freshwater ecosystems play an important role in the transmission and containment of pathogens and vectors associated with various common diseases such as dengue, malaria and yellow fever. These diseases are one of the main causes of hospitalizations worldwide, and their risk to people increases with human changes in freshwater ecosystems (e.g., dam construction, pollution, riparian forest degradation). **The score for Disease Regulation for the Cubango Basin was 56.**

This result took into account the most problematic water-related diseases in the region according to official technical reports, i.e., malaria and oncoercosis (river blindness). Scores for each of these two diseases were calculated separately. For malaria the score was 95 and based on mortality observed in 2015. This score took into account the fact that the Cubango basin is located in an area where malaria is endemic. On the other hand, the score for Oncoercosis was low (33), which suggests that the management of water resources in the region should also prioritize the reduction of this disease burden, considering that its occurrence may be related to the conditions of access to water in the region, especially in rural areas. For example, the absence of piped water leads many families to have to use rivers and streams near their homes to meet basic needs, exposing them to the risk of contracting river blindness from flies living around the streams. It is worth noting that this result requires further review, since recent data on the prevalence of river blindness were not readily available for all communes within the Cubango Basin (Table 2).

Table 2. Prevalence of river blindness

Prevalência de cegueira dos olhos em porcentagem da população								
	Chinguar/ Cachipa	Chitembo/ Cachinque	Cunene/ Cuvelai	Kuvango/ Yissonga	Calai/ Sofe	Dirico/ Tuni	Cachiungo/ MissaoDoNdondi	C Cholohanga/ Samboto
2003	15.4	4		7.7	40.0	23.0	10.0	20.0
2015	16.0	0.6		0.0		0.0	3.1	0.0

OKAVANGO DELTA © JAOCHIM HUBER/ FLICKR CREATIVE COMMONS

3.2.4 **Flood Regulation**

Flood Regulation measures the ecosystem's ability to reduce surface runoff volume by decreasing downstream peak flows and/or absorbing flood waters. The common practices of soil "waterproofing" during the urbanization process reduces water infiltration and increases floods in rainy periods, which in turn leads to the need to implement measures to control the excess water. **The Flood Regulation obtained a score of 77, indicating the Cubango basin's ability to control flood effects is still relatively health.** In the case of the study region, whose coverage is still mostly natural, this result reflects that, in the Cubango Basin, the dynamics of the flow rates of these rivers and their main tributaries still follows a natural, seasonal pattern, that is, there is a predominance of natural floods which can affect human populations and agricultural activities that are located in the natural floodplains. As expected, the greatest deviations from the objective (of having up to 10% of the affected population experiencing a flood event) were observed for the region comprising part of the municipality of Menongue, due to its higher population density as observed in Figure 9.

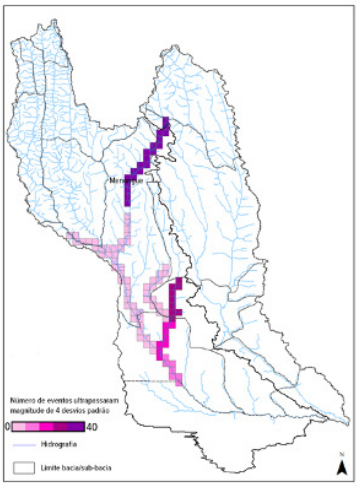

Figure 9. Number of floods with magnitude greater than 4 standard deviations observed in the Cubango basin during the study period (1 October 2018 – 30 April 2019)

3.3 **Cultural**

Cultural Services refer to the non-material benefits people experience from aquatic ecosystems, such as their scenic beauty, recreational and cultural opportunities, or spiritual practices. These cultural services are linked to the benefits of physical, emotional and mental health, as well as to opportunities for economic development, such as ecotourism. Freshwater ecosystems, in particular, are often associated with the cultural identity of a society. Stakeholders attributed a lower weight to this indicator (23%), which suggests that it currently has less importance in relation to Provision and Regulation and Support services. The Cultural indicator comprises two sub-indicators that represent experiences and values associated with freshwater ecosystems: Conservation of Cultural Heritage and Recreation. **The Cultural Service indicator overall obtained a score of 53.** The stakeholders of the Cubango Basin gave much greater importance (68%) to the sub-indicator Conservation of Cultural Heritage than to the Recreation Service sub-indicator (32%).

Figure 10. Example of using water bodies for cultural activities. Photo credit: CI/Derek Vollmer

3.3.1 **Conservation of Cultural Heritage**

Conservation of Cultural Heritage measures the degree to which freshwater ecosystems are preserved for their cultural importance, including biological and spiritual importance. These areas may relate to or reflect a society's cultural, religious and scientific values. **This sub-indicator received a score of 50, the lowest of all Ecosystem Services indicators.** This relatively low value directly reflects the low number of protected areas (official and potential) within the Cubango river sub-basin, where only 6138 km2 are protected (or almost 6% of the total area), which results in an almost negligible length of the drainage network being protected and a final score of 25. In the case of the Cuito River sub-basin, 81% of its area can be considered potentially protected when considering KAZA, the Okavango Wilderness Project (OWP) area and flooded areas. This results in a score of 97 for the Cuito sub-basin. Figure 11 shows this pattern. It should be noted, however, that there is a need to include areas related to traditional communities (e.g. Bantu and non-Bantu ethnic groups) and regions relevant to religious practices, which may confer some additional protection on the natural landscape. However, spatial data on these practices were not available.

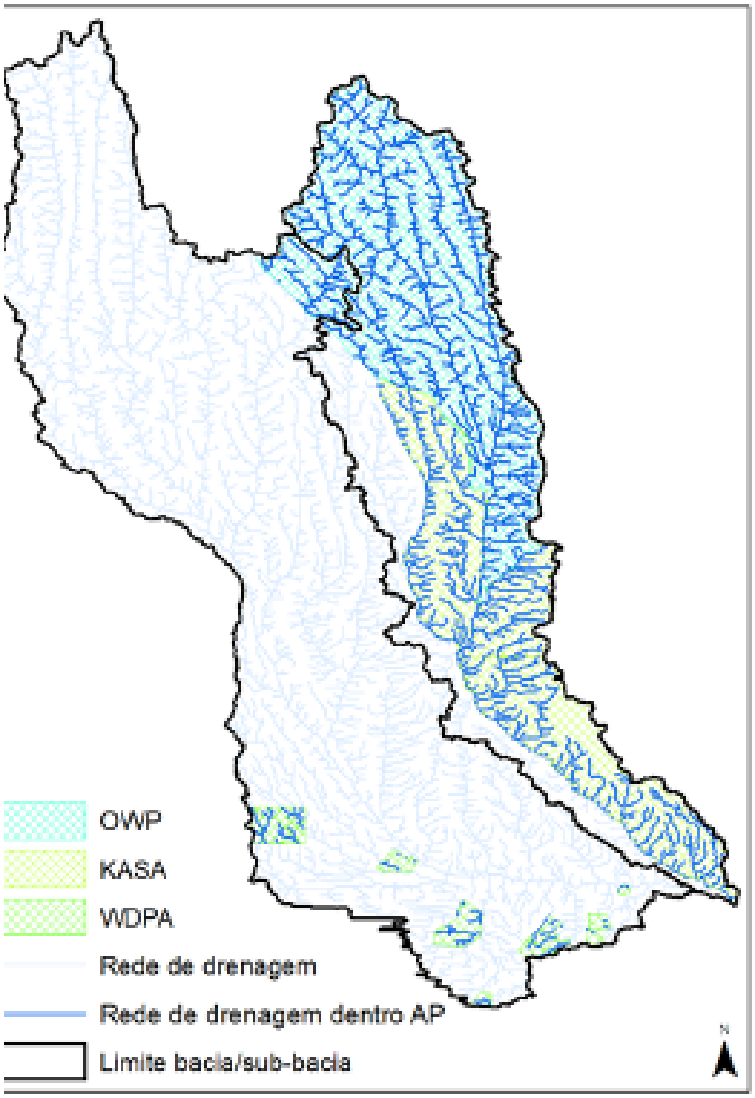

Figure 11. Conservation of Cultural Heritage in the Cubango Basin (OWP: Okavango Wilderness project; WDPA: worldwide database on areas of protection; AP: Protected Area)

3.3.2 **Recreation**

The Recreation sub-indicator refers to water-related recreational activities such as fishing, hiking, boating or enjoying waterfront landscapes. These recreational activities provide important benefits for physical, emotional and mental health, but can also offer opportunities for economic development, especially if they attract tourism from people outside the basin. **The Recreation sub-indicator obtained a score of 60, indicating a moderate provision of recreation opportunities in the basin.** Due to the absence of specific data for the calculation of the actual demand for this service, this sub-indicator was calculated as potential depending on the degree of naturalness within a buffer area of the drainage network, presence of protected areas, and distance from waterfalls, rapids and other unique water features (Figure 12). The score of 60 suggests that there

is significant room to increase the attractiveness of recreation and tourism activities in the basin, especially due to its high degree of preservation. The realization of this potential depends in part on the increase of protected areas and infrastructure to access these areas.

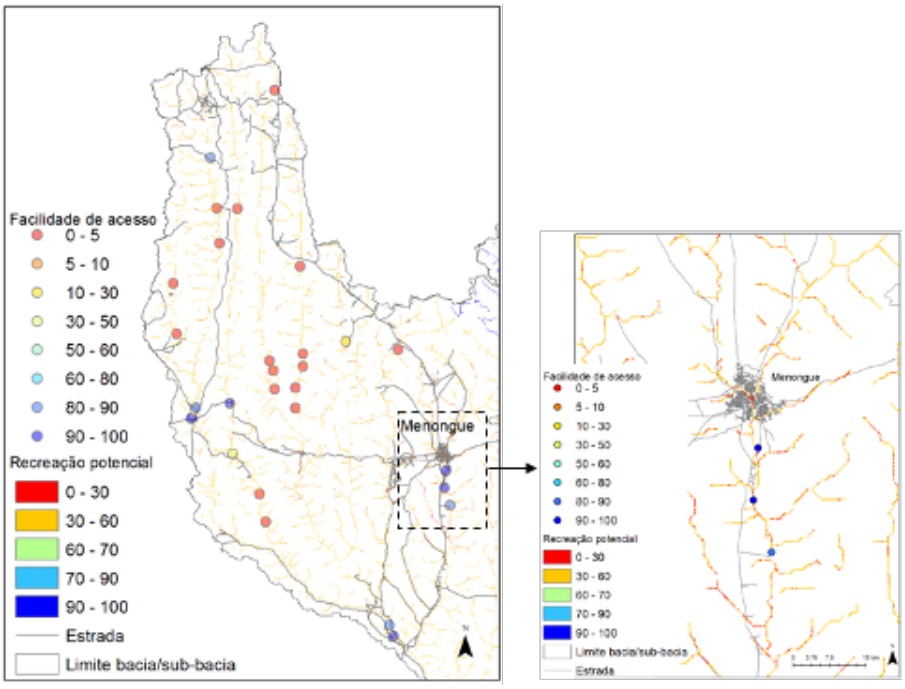

Figure 12. Results for the recreation sub-indicator for part of the basin where most of the waterfalls and rapids (circles) mapped in the Cubango Basin Plan are located. The buffer area of the drainage network is colored according to the final potential recreation score for each stream reach within the basin. The colors of the circles represent the scores for the attractiveness component (i.e., the nearer the waterfalls and rapids are to roads, the greater their attractiveness).

4. GOVERNANCE & STAKEHOLDERS: INDICATOR AND SUB-INDICATOR RESULTS

The Governance and Stakeholders component assesses the structures and processes by which people make decisions related to water resources. In contrast to the indicators of the components of Ecosystem Vitality and Ecosystem Services, where data are routinely collected and measurement methods are widely known, governance measurement is an emerging area without standardized approaches. Topics are also more subjective, which means that people's perception is a valid source of information. To gather this information, a survey was conducted with a group of stakeholders whose work relates to the management of the Cubango River Basin. These stakeholders mainly represented government officials, researchers and the civilian community with knowledge of governance issues in the Cubango Basin.

Combining the results of the survey, the Cubango Basin obtained a score of 35 for the Governance and Stakeholders component. This is the lowest score among the three performance components of the Basin evaluated by the FHI, which is not surprising, considering that improving water governance is a global challenge. Improving this score should be a priority for decision makers in the Cubango Basin, particularly considering the expected increases in water demand and climate variability. The detailed assessments below provide information on where these improvements could be made. It is also important to note that the indicators and sub-indicators of this component were weighted by stakeholders, which revealed a preference for the Enabling Environment indicator (weight of 34%), followed by the Stakeholder Engagement indicator (weight 27%).

Figure 13. Group photo of participants of the first stakeholder meeting conducted in Luanda, Angola in March 2020. Photo credit: CI

4.1 Enabling Environment

The Enabling Environment refers to the policies, regulations, market mechanisms and social norms that exist to help govern and manage water resources. Together, these attributes determine which rights and assets are protected within a river basin, as well as their management in the face of conflicts. **Combining the five sub-indicators below, the Cubango Basin had a score of 31 for Enabling Environment**. This result suggests the need for significant improvements, which may involve national, regional and local actors. Among the five sub-indicators within the Enabling Environment indicator, stakeholders attributed the highest weight to the Sub-indicator Water Resources Management (27%). The second highest value was attributed to the Technical Capacity sub-indicator (22%). Relatively similar values were given to the three remaining sub-indicators: Rules for Resource Use (19%), Incentives and Regulations (17%) and Financial Capacity (15%).

4.1.1 Water Resource Management

The Water Resources Management sub-indicator assesses the degree to which institutions are responsible for performing functions such as coordination within

the Basin, planning and development of infrastructure, mobilization of financial resources and protection of ecosystems. Water Resources Management is a complex set of tasks, usually involving various public agencies and other stakeholders. Fragile coordination between these groups can lead to inefficient, unfair or ineffective results. **The Cubango Basin received a score of 39 for Water Resources Management.** This sub-indicator scored higher than the other four sub-indicators in its group and was also recognized as the most important by stakeholders (weight of 27%). Among the evaluated functions, 'Policies and actions to promote the development and management of water resources are coordinated with cross-border countries' was the best evaluated function. The lowest-rated function, according to the survey, was 'Ecosystem conservation priorities are developed and actions implemented'.

4.1.2 Rights to Resource Use

The Rights to Resource Use measures the clarity of rights to water and water-related resources. Clear and enforceable rules, whether formal or informal (e.g. community rights), are important for the efficient use of water resources and their equitable distribution throughout the Basin. **The Cubango Basin received a score of 34 for this sub-indicator, indicating that stakeholders consider the rules for the use of different types of water resources and water allocation unclear, although it was the second highest score among the sub-indicators of Enabling Environment.** Among the rules evaluated, the lowest score was for 'Quality and clarity for wastewater treatment and water pollution'.

4.1.3 Incentives & Regulations

Incentives and Regulations refer to the availability of different management tools, such as impact assessments or financial incentives, which can be applied to promote human activity with a minimal negative impact on water and related environmental resources. In principle, a greater diversity of management tools means more flexibility to design solutions while producing efficient responses. **The Cubango Basin received a score of 34 for Incentives and Regulations.** Stakeholders realize, in this case, that socio-environmental impact studies, financial incentives, market schemes, fee programs and territorial zoning policies are only recently being introduced in the basin. Among the incentives and regulations evaluated, stakeholders indicated 'Existence of honorary recognition programs' as the least used tool at present.

4.1.4 Technical Capacity

Technical capacity refers to the adequacy of the workforce, in terms of number, skill level and training opportunities, to fulfill technical functions related to the management of water resources and, not necessarily, to the level of available technology. Even with sufficient financial capacity, the scarcity of technical skills, such as environmental engineering, can hinder the efficient and sustainable development of water resources. **The Technical Capacity of the Cubango Basin received a score of 22, the lowest score among the sub-indicators within Enabling Environment and also the lowest among all sub-indicators of the Governance and Stakeholders component overall.** Stakeholders indicated that, among the four aspects of technical capacity analyzed (number of personnel, specialized personnel, training opportunities and professional certifications), the lowest quality is the level of staff specialization.

Figure 14. Participants at the first meeting of stakeholders answering the Governance poll. Photo credit: CI/ Bruno Coutinho

4.1.5 **Financial Capacity**

Financial Capacity measures the extent to which the necessary investments are made to support the development and protection of water resources. Water infrastructure such as dams and treatment plants have high costs, while economic instruments such as water prices or pollution rates can be applied to consumers or users (including individuals and corporations) to help offset these high costs and fund additional measures. Public investment may be necessary to ensure adequate funding for safeguards, ecosystem protection and remediation. **The Financial Capacity of the Cubango Basin obtained a score of 25, which is the second lowest score among the five sub-indicators of Enabling Environment.** In general, the low score for this sub-indicator suggests that stakeholders believe that it is difficult to procure financial resources to make improvements in the Basin. Specifically, stakeholders indicated that the 'Level of investment in wastewater handling and treatment' is the aspect with the lowest degree of investment among the aspects evaluated (including investments in: water supply, service delivery systems, wastewater handling and treatment, conservation and rehabilitation of the ecosystem, and application monitoring).

4.2 **Stakeholder Engagement**

The Stakeholder Engagement indicator refers to all forms in which actors interact with each other within the Basin and the degree of transparency and accountability that characterizes these interactions. While stakeholder engagement takes place in different ways around the world, it is generally regarded as a key principle of good water governance, ensuring that the full range of concerns is considered before important decisions are made, to avoid possible conflicts and ensure equitable distribution of benefits. The Stakeholder Commitment indicator is divided into two sub-indicators: Information Access and Engagement in Decision-Making Processes.

Commitment of the Cubango Basin Stakeholders received a score of 42, the highest among the indicators in the Governance and Stakeholders component, but still low enough to be an area of concern. Stakeholders attributed relatively similar weights to the two sub-indicators within this indicator group: Information and Knowledge with a value of 54% and Engagement in Decision Making Processes with a value of 46%.

Figure 15. Group discussions during the first stakeholder meeting conducted in Luanda, Angola in March 2020. Photos credit: Olerato Ramodimo

4.2.1 Information Access

Information Access ensures the availability and accessibility of data on water quantity and quality, resource management and development. Even in cases where data is routinely collected, if they are not available to those interested in research or analysis, decisions may be considered less transparent. Access to data also helps communities hold decision-makers accountable (for example, to determine whether a particular policy or project is delivering the expected results). **Information Access for the Cubango Basin received an overall score of 43.** This indicates that stakeholders are not satisfied with the level and availability of information about the Basin. In general, stakeholders indicated that they are similarly dissatisfied with the four aspects analyzed (access, quality, transparency of information, and use of information in decision-making).

4.2.2 Engagement in Decision-Making Process

Involvement in Decision-Making Processes measures the extent of stakeholder participation in some aspects of decision-making processes and the degree to which they have a voice in the policy and planning cycle. While there are different levels of "adequate" commitment, greater participation is generally associated with better transfer of more specific and equitable information, plans and policies, transparency and accountability, and conflict reduction. **Engagement in Decision-Making Processes received a score of 42, indicating that the actors are dissatisfied with the degree of participation of different stakeholders in the decision-making processes of the Cubango Basin.** This score was similar to that obtained for the other Stakeholder Engagement sub-indicator. According to the stakeholders surveyed, among the four processes analyzed, the process in which stakeholders believe they have the least ability to participate is the provision of comments before the main decisions are made.

4.3 **Effectiveness**

Effectiveness refers to the results of water-related policies and investment decisions. In other words, it is meant to measure if the governance system is achieving what it was intended to do. Around the world, there is often a gap between policy and practice, between what is expected based on a complex decision and what actually happens. Thus, the effectiveness sub-indicators try to assess whether decisions are having the intended effects. **The Cubango Basin obtained a score of 36, suggesting a disconnect between policy and practice.** Among the three Effectiveness sub-indicators, stakeholders attached greater importance to the Distribution of Benefits from Ecosystem Services (40%). Less importance was given to the Enforcement and Compliance sub-indicator (26%), followed by the Water-Related Conflict indicator (24%).

4.3.1 **Enforcement & Compliance**

Enforcement and Compliance measures the degree to which laws are respected and agreements are executed. The "compliance gap" may reflect insufficient regulatory capacity or lack of accountability, which weakens the effectiveness of laws and policies. **The Cubango Basin received a score of 38 for Enforcement and Compliance, that is, the stakeholders surveyed show significant concern about the effectiveness of laws and policies.** Among the execution of five types of guidelines analyzed (for water collection, for groundwater collection, for flow, for water quality and for land use), stakeholders attributed a similar degree of deficiency to all five.

4.3.2 **Distribution of Benefits**

Distribution of Benefits refers to the impacts of decisions on the management of water resources, with special attention to the different segments of society: rural, urban, migrants without local work registration, and those employed in resource-dependent sectors, such as fishers. Water-related ecosystem services are by their nature unequally distributed in a basin, so measures (such as the development of reservoirs and water distribution networks) often must be taken to ensure that resources are allocated equally. **The Cubango Basin obtained a score of 24 for this sub-indicator, the second lowest score among all sub-indicators within the Governance and Stakeholders component.** This low score held across all of the different groups being compared. The minority groups evaluated were economically vulnerable populations, indigenous people, women and girls, resource-dependent communities and riparian countries (a measure of transboundary benefit sharing).

4.3.3 **Water-Related Conflict**

Water-Related Conflict reflects tensions between the parties when there is competition for scarce resources such as water. Tension results in legal battles or can prevent the resolution of conflicts and therefore can delay or weaken decisions within the basin. The FHI is restricted to the evaluation of disputes over water allocation, access, pollution, diversion and infrastructure development. **In the Cubango basin, Water-Related Conflict received a score of 67, which was the highest score among all sub-indicators within the Governance and Stakeholders component.** That is, stakeholders currently view the presence of water-related conflict as the least worrisome theme from the point of view of water governance. In other words, more efficient resolution of water-related conflicts is not a major priority needing immediate improvement. Among the five

types of conflicts analyzed (overlapping jurisdictions, allocation of water rights, conflicts of access to water, positioning of infrastructure, and conflicts over water quality and other negative downstream impacts), the most frequent, according to stakeholders, are those related to overlapping jurisdictions.

4.4 Vision & Adaptive Governance

Vision & Adaptive Governance measures the ability to gather and interpret information and then use this information to establish policies, develop plans for the Basin, and adapt to changing circumstances. Effective management of water resources requires flexible and integrated forms of governance to address often changing conditions and uncertainty associated with climate change and other emerging challenges. Therefore, Strategic Planning and Adaptive Management is an important aspect and is one of the sub-indicators here, along with Monitoring and Mechanisms, which allow updating and adapting management actions as circumstances change. T**he Cubango Basin received an overall score of 32 for Vision and Adaptive Governance, the second lowest score among the indicators of the Governance and Stakeholders component.** Stakeholders attributed similar values to the two sub-indicators: 52% for Monitoring Mechanisms and 48% for Strategic Planning and Adaptive Management.

4.4.1 Monitoring Mechanisms

Monitoring Mechanisms refer to the quality and use of physical, chemical and biological monitoring of water resources in the Basin to guide planning policies and processes. Ideally, decisions on water resource management are based on robust data and information, but this requires collecting this information (which entails costs) and use of that information by decision-makers. **The Cubango Basin obtained a score of 26 for this sub-indicator, a score that was the lower of the two sub-indicators of this last grouping and the fourth lowest score among all sub-indicators of the Governance and Stakeholders component.** In other words, increasing the monitoring network is an area considered of high priority by stakeholders to make significant advances in the governance of water resources in the Basin. All four variables analyzed (quantity, quality, biological, and access to monitoring) were given low scores.

Figure 16. Actors participating in the first meeting of stakeholders conducted in Luanda, Angola in March 2020. Photo credit: CI

4.4.2 **Strategic Planning & Adaptive Management**

Strategic Planning and Adaptive Management is about the extent to which strategic planning (i.e., the accounting of land and water use and infrastructure development) takes place within the Basin. Having comprehensive plans, with well-defined objectives and long-term resource development priorities, can help establish a vision to sustainably meet water needs. More importantly, perhaps, they need to be adjusted as circumstances change, when new information is made available, or when unforeseen events occur. **The Cubango Basin Strategic Planning and Adaptive Management sub-indicator received a score of 39.** The scope of the four evaluated processes (shared vision, existence and use of strategic planning mechanisms at national and cross-border level, and existence and use of an adaptive management structure) were all given similar scores.

5. CONCLUSION

Scores for the three components of the FHI reveal that the Cubango Basinis is not showing signs of stress in its biophysical component (Ecosystem Vitality 92), which is providing ecosystem services relatively well (Ecosystem Services 73). On the other hand, the current water governance system in the Basin is unsatisfactory (Governance and Stakeholders 35). It can be inferred, therefore, that the current level of supply of ecosystem services is sustainable, but this sustainability can be short-term and limited if the governance system is not able to manage the current and future degradation pressures on the biophysical system.

The Ecosystem Vitality still shows no clear signs of compromise. However, the FHI already points out that special attention should be given to water quality, because this indicator received the lowest score among the other characteristics analyzed. The most worrying region when it comes to water quality is the one downstream of the city of Menongue, with a direct influence from urban pollution. Both indicators Water Quantity and Drainage Basin Condition showed very high scores, indicating that the conversion of natural to anthropic areas and engineering works has had still very little impact on the natural flow regime of the system. However, it is worth noting that there are still no large infrastructure systems (e.g., dams) installed in the Basin and the occupation of the territory has been somewhat slowed in recent decades due to the civil war in the country. The maintenance of the natural flow regime has a positive effect not only on local populations, immediately close to bodies of water, but also on economic activities that lie downstream in Namibia and Botswana. The fact that the Biodiversity indicator is also in good condition is a reflection that the physical system as a whole is still balanced.

The moderately high score for Ecosystem Services was a reflection of the scores of the Regulation & Support and Cultural indicators. More specifically, three problematic sub-indicators were found: Disease Regulation, Conservation of Cultural Heritage and Recreation. In the case of Disease Regulation, which included two water-related diseases (malaria and river blindness), the low score was determined exclusively by the score obtained for river blindness. The low score may be linked to the low level of distribution of piped water, especially in rural populations, which leads to the need to use rivers and streams directly to perform hygiene activities more frequently, increasing exposure to the disease. The moderate-low score for Conservation of Cultural Heritage suggests that the protection of rivers and streams needs to be expanded by increasing protection/ conservation areas especially in the Cubango River sub-basin. Finally, it was observed that there is an opportunity to expand the opportunities for recreation, owing to the

vast amount of relatively pristine waterways in the basin. The realization of this potential depends in part on the increase of protected areas and infrastructure access to these areas.

The low score for the Governance and Stakeholders component highlights underdeveloped management systems, which can hinder the ability to influence and respond to economic development and its likely consequences—environmental degradation. The lowest scores were for Technical Capacity (22), Distribution of Benefits from Ecosystem Services (24), Financial Capacity (25) and Monitoring Mechanisms (26). The absence of Technical and Financial Capacities was expected, especially in light of Angola's current level of economic development. This pattern is not unique and has generally been observed in all developing countries where FHI has already been applied. A compromised Benefit Distribution and a low level of Monitoring Mechanisms may also be associated with the overall level of underdevelopment in the region. Unsatisfactory Financial Capacity, however, is worrisome due to the low level of water distribution and sanitation infrastructure, which may further exacerbate inequitable distribution of services within the basin.

The results of the FHI can support decision-making in prioritizing the implementation of activities defined in the Strategy and Program of Measures and Actions of the General Plan for Integrated Use of Water Resources (PGUIRH) of the Cubango River Basin, a support tool for planning and management at basin level. The PGUIRH presents the main development scenarios, considering the needs and use by different sectors, and the availability of existing water resources based on projected development in the Basin through 2030.

The FHI can now be used to help evaluate specific actions and measures identified by the Cubango PGUIRH. These actions are grouped in 6 major areas of intervention, namely: water quality, water quantity, risk management and enhancement of the public water domain, monitoring, research and deepening of knowledge, communication, and the institutional and regulatory framework. The FHI is well-aligned with these areas and thus offers an added value in monitoring and setting priorities for the implementation of the Cubango Plan.

It is also expected that the FHI can contribute to the generation of specific results of OKACOM's Strategic Action Programme determined in the Basin Development and Management Framework (BDMF) and Thematic Areas. More specifically, the FHI has high potential to be the tool that provides the 'State of the Basin' (expected result of BDMF number 9) and improve the knowledge and awareness of stakeholders about the Cubango-Okavango River Basin (expected result of BDMF number 8).


FRESHWATER
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