

Preliminary Reflections on Water Vulnerability Stemming from Anthropogenic Activities and Climate Change in the Forested Province of Tshopo, Democratic Republic of Congo

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Abstract

In Tshopo, a forested province in the north-eastern part of the DRC (Democratic Republic of Congo), the regulation of water availability and quality is crucial for sustaining livelihoods and protecting communities from natural hazards. These ecosystem services are crucial for reducing water vulnerability and providing sufficient water for domestic use in places where the government's capacity to manage water resources is insufficient. However, the forests of Tshopo are threatened by climate change and various anthropogenic activities. Its rural landscape is dominated by forests that are undergoing several transformations, exposing water bodies to contamination. Hence, water is one of the key resources vulnerable to climate change in the Tshopo Province. As few studies have focused on the understanding of water availability at the sub-national level in the DRC, in this work, we aim to review the current water situation and its relation to climate change and forest degradation in the Tshopo province. Our analysis shows the necessity to develop well-defined strategic plans that consider contextual specificities and to find a trade-off between forest and water management strategies to respond to water-vulnerability risks in the region.

Keywords: water vulnerability, climate-change adaptation, forested Tshopo province, anthropogenic activity

1. Introduction

In Tshopo, a province in the central part of the Democratic Republic of Congo (DRC), almost 87% of the region is covered by humid dense tropical forests (Johannes and Sophia 2021, de Wasseige *et al.* 2015). A substantial part of this province consists of protected areas, logging concessions with a vocation to be managed sustainably, reserves, and natural communitarian forests, with or without forest ownership (Drachoussoff *et al.* 1991, UICN 2010, Katembo 2011, Iyongo *et al.* 2013). The presence of an immense forest landscape generally represents a major asset for the regulation and renewal of water resources (Partow 2011).

Unfortunately, the pressure on these forests is likely to be amplified by climate change and human activities, including mining, artisanal logging, slash-and-burn agriculture, fuelwood production, and oil palm exploitation (Denis *et al.* 2020, Likoko *et al.* 2019, Flouriot 2008). Furthermore, many people from surrounding areas who experience sustained violence and insecurity are migrating to Tshopo, leading to significant additional pressure on forest and water ecosystems (Bogaert *et al.* 2017). Only 40% of the entire Tshopo province has water services, and access to safe drinking water is insufficient in almost all territories (almost less than 5%). In addition, a climate-change-predictive model for the Congo Basin shows that water vulnerability is likely to exacerbate in the future (Likoko *et al.* 2019). Moreover, the potential benefits of tropical forests in improving water availability are not straightforward—the presence of forests is not always synonymous with water availability at the watershed level (Mapulanga and Naito 2019). Indeed, targeted studies must be conducted to elucidate the link between forest resources and water vulnerability in the context of Tshopo province. Nevertheless, forests provide many other ecosystem services (Bogaert *et al.* 2017) and should not be protected only for the benefit of water-resource regulation. A trade-off between the different aspects of the ecosystem services delivered by forests must be considered. Therefore, it is essential to develop strategic plans for sustainably managing forest ecosystems with explicit attention to water resources. In this study, we aimed to review the current water situation and its relation to climate change and forest degradation in the Tshopo Province. To this end, this study provides preliminary insights into the gaps in knowledge regarding the links between water and forest resources in Tshopo. These insights will help policymakers develop and adopt appropriate strategies and sustainable forest and water management plans.

2. Administrative context of Tshopo province

The Tshopo province is located at 24°29'E–0°49'N. It comprises seven territories (Isangi, Opala, Banalia, Bafwasende, Ubundu, Basoko, and Yahuma), six communes in the city of Kisangani (Kabondo, Kisangani, Lubunga, Makiso, Mangobo, and Tshopo), seven cities (Kisangani, Isangi, Yangambi, Lokutu, Basoko, Yahuma, and Ubundu), 58 sectors/chieftaincies, and 2,597 villages (South Pole 2020).

The province extends over an area of 200,559km², including Kisangani, which is its chief town, and is limited to the southeast by Ituri, to the northwest by Mongala, to the north by Bas Uélé, to the southeast by Maniema, to the east by North Kivu, and to the southwest and southeast by Sankuru (South Pole 2020).

According to the classification of Köppen and Geiger (1928), Tshopo province is subject to an Af-type climate. The data received at the Yangambi meteorological station indicated an average annual rainfall of 1845 ± 719 mm (2000-2017). It rains all year round with two maxima, one in October (major rainy season) and the other in April-May (minor rainy season). The average annual relative humidity varies between 77.5% and 85.2% (Djiofack 2018).

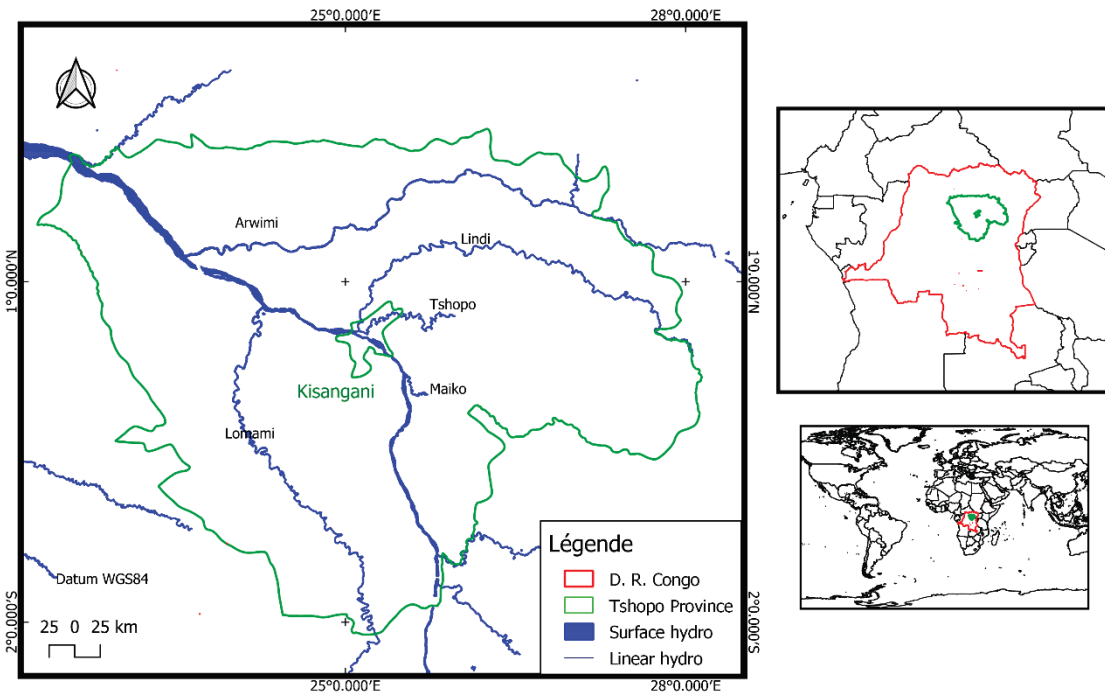


Figure 1. Location of Tshopo, a forested province in the D.R. Congo (drawn by the authors with QGIS software)

3. Vulnerability to climate change and anthropogenic activities

Forest and water vulnerability related to climate change and anthropogenic activities in the context of the Tshopo province can be summarized using the diagram in Figure 2, as previously discussed by Chishugi *et al.* (2021). They showed that reduction of precipitation and increasing temperatures coupled with a range of destructive human activities can cause a transition of forest cover into other types of land cover, which will likely negatively influence the quality and quantity of water at the watershed level. Communities are highly vulnerable to the resulting impacts on water resources, as they have a limited capacity to mitigate negative impacts or adapt to a changing environment (PNUD 2019).

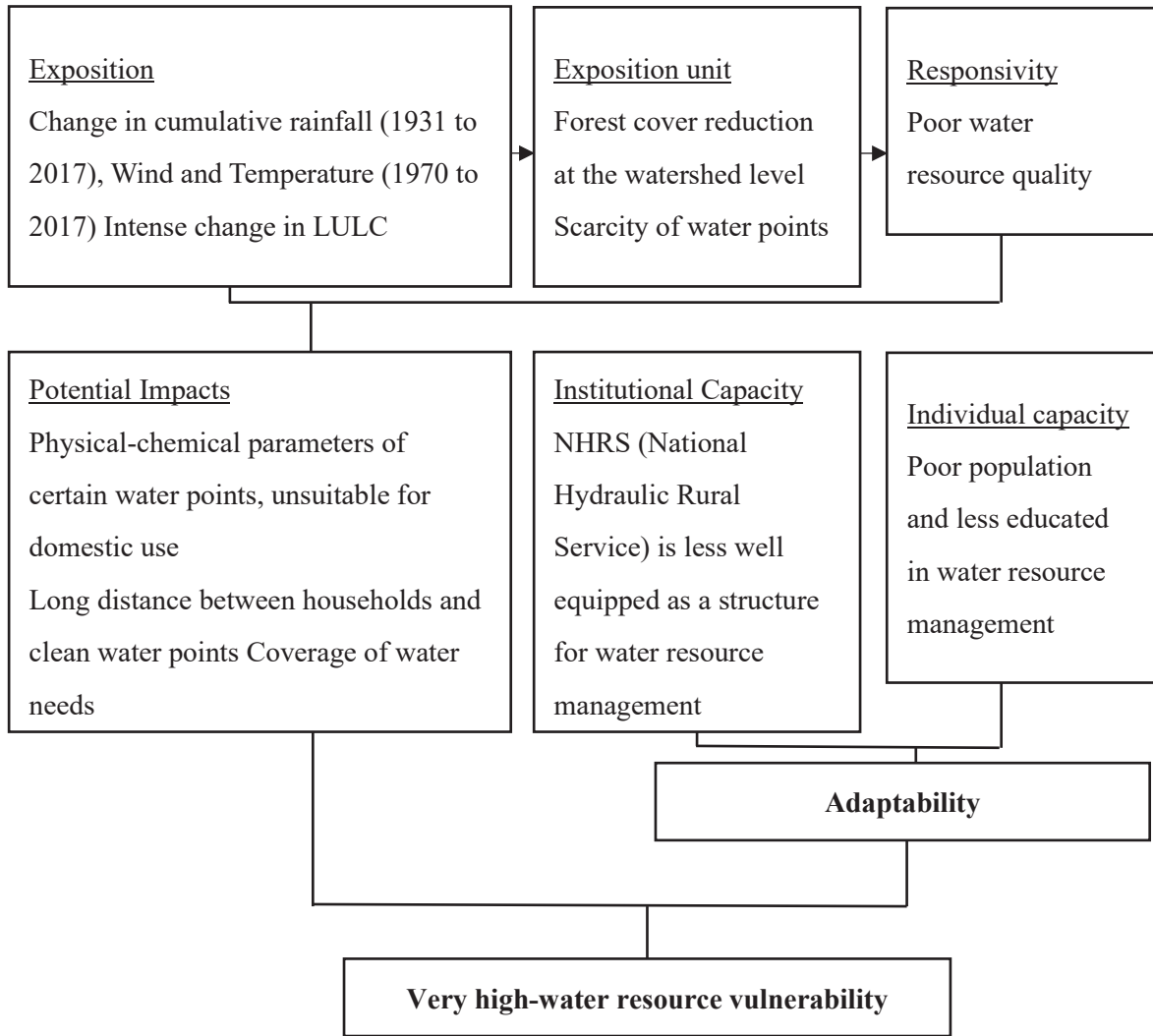


Figure 2. Chain of impact for vulnerability to water resources in Yangambi (Chishugi *et al.* 2021)

4. Water nexus Forest protection and conservation strategies

Pristine forests are known to protect water resource quality and quantity in many watershed landscapes worldwide (Uemaa *et al.* 2005, Carvalho-Santos 2014, Zhu *et al.* 2015, Brummett *et al.* 2008). By increasing water infiltration while decreasing soil erosion, the groundwater is recharged, thus supplying springs with a lot of quality water that is less contaminated than surface water. However, forests do not necessarily improve water quality and quantity (Mapulanga and Naito 2019). The processes of water regulation in forests are complex. In some regions, forest land cover is responsible for decreasing the surface water quantity in streams and springs by enhancing soil infiltrability, and some uncontrollable sources of contamination can reduce water quality (Maréchal 2011).

Furthermore, a trade-off must be found between ecosystem services related to water regulation and other ecosystem services delivered by forests that are beneficial to communities and the environment. We need to better understand the different processes occurring in forests and their different uses in local contexts when attempting to promote water nexus forest protection and conservation strategies.

In the case of Tshopo Province, the links between forest protection, conservation, and water availability are not well-defined. By assessing the state of forest and water, the possible synergies between the two resources, and the level of the other roles of the forest, we can develop better forest management strategies that simultaneously promote water resource protection and conservation.

4.1. State of forest ecosystem in the Tshopo

In Tshopo, the forest ecosystems total gross area is estimated at 87% of its area (South Pole 2020). It is primarily composed of dense and humid equatorial forests (Bogaert 2017). However, in the Ubundu, Opala, Isangi, Yahuma and Basoko Territories, forests are predominantly swampy or periodically flooded (MINAGRI 2010).

The main protected areas are the Yangambi Biosphere Reserve, which has an area of 6,297km² (Drachoussoff *et al.* 1991) and contains an important species diversity, the Yoko Forest Reserve with an area of 6,975ha, and the Masako Forest Reserve, which has an area of 2,105ha (Iyongo *et al.* 2013). The Maiko National Park and Lomami National Park have a large part located in the Tshopo province, covering an area of 1,083,000ha and approximately 888,000ha, respectively (UICN 2010, Katembo 2011). Tshopo is on the list of provinces in the DRC with the largest area of forest concessions (142,957,661ha) and second on the list with the largest number of loggers permits (14 permits) after Mai-Ndombe. The forest code of 2002 protects the forest massifs exploited for economic income to be managed sustainably (ATIBT 2019).

The other parts of the forest belong to local communities. However, nowadays, through the forest code of 2002¹, the government gives the opportunity to the local community to obtain a permit for their forest, so that they may manage them sustainably and be protected by law. This law offers local communities the possibility of obtaining free and perpetual Local Community Forest Concession (LCCF), which covers all or parts of the protected forests among those regularly owned by custom. Many of them are in process, and others already have the required documents (Trefon 2010).

4.2. State of water in the Tshopo

The forests in Tshopo are part of the watershed of the Congo River, including tributaries such as Tshopo, Lomami, Lobilo, Ituri, Lindi, and many other secondary streams (CICOS 2015). The Congo River divides Tshopo Province into two approximately equal parts.

Owing to the situation of the Congo River on the equator and the high rainfall patterns throughout the year, the river has a large hydrological potential. For example, a hydroelectric plant is located on the

¹ Loi Portant Principes Fondamentaux Relatifs à La Protection de l'Environnement. 2011. République Démocratique du Congo. <<https://www.leganet.cd/Legislation/Droit%20administratif/Environnement/JOS.16.07.2011.pdf>, Accessed on 21 February 2023>

Tshopo River. In addition, owing to the low population density in the DRC, the potential water availability per capita was very high. Approximately 15,000–70,000m³ per person per year in all countries (WHO 2017). The rivers in Tshopo supply drinking water to almost the entire city of Kisangani and to the principal villages of the provinces. However, the rate of access to safe drinking water and sanitation is paradoxically very low in the province, especially in principal villages (Table 1). This is the case in most other provinces in the DRC (Brummett *et al.* 2008). Despite its large hydrological reserves, only 29% of its rural population and 79% of its urban population have effective access to safe water to meet various basic needs, including those related to domestic use (IMF 2015).

Finally, apart from rivers and rainforests, few other water-related ecosystems are present in Tshopo. Preliminary cartography of wetlands carried out by the Congo peatland project, led by the FAO and other partners, shows that wetland coverage in Tshopo province is very low. Wetlands are generally located in the western part of the country, apart from small-scale marshes (Bambuta and Freeman 2021).

Table 1. Water supply rate in the principal towns of the Tshopo province (DRC)

Town	Total population covered	Total population	% Population served
Kisangani	590,698	1,293,221	46%
Ubundu	2,121	42,773	5%
Opala	695	31,922	2%
Tshopo	593,514	1,367,916	43%
RDC	14,095,564	35,034,196	40%

Source: GIZ and Ministère des Ressources Hydrauliques et Electricité (RDC) 2020

Table 2. Water supply rate in the territories of the Tshopo province (DRC)

Territories	Population	Number of households	Households accessing water	Drinking water access rate
Bafwasende	363,505	77,341	1,589	2.05%
Banalia	3,462,414	73,663	1,832	2.49%
Basoko	331,642	70,562	400	0.57%
Isangi	652,034	138,731	1,250	0.90%
Opala	203,881	43,379	900	2.07%
Ubundu	233,133	49,603	2,922	5.89%
Yahuma	233,128	49,603	450	0.91%

Source: GIZ and Ministère des Ressources Hydrauliques et Electricité (RDC) 2020

4.3. Possible synergies and trade-offs between forest and water resources

Finding synergies between forests and water resources will be a more integrated and sustainable way to manage them. NGOs, such as TropenBos DRC and its partners, are leading projects related to water and forest resource protection and conservation. The objective is to find better ways to exploit forests sustainably and implement sustainable agricultural practices while promoting the forests' capacity to regulate, provide, and sustain water resources in terms of quality and quantity. Furthermore, other projects related to oil bloc exploitation in wetland zones are developing, while others attempt to map wetlands (peatlands) to help manage them sustainably.

However, the protection and conservation of forests for water in the Tshopo province will only be possible if synergies between different (conflicting) users are well documented and analysed. For example, while only one oil bloc is envisaged in Tshopo province, the latest one was adopted without considering the socio and ecological specificities of the region, which led to unsustainable management and catastrophic consequences (Partow 2011).

Despite possible synergies that can be developed between water and forest management, it is important to note that forests also provide other ecosystem services beyond water. For example, timber extraction, Produits Forestiers Non Ligneux (PFNL), land for agriculture, hunting, wood energy, and cultural activities (Brummett *et al.* 2008). Therefore, finding trade-offs between different usages is essential. Conservation strategies play a key role in determining these trade-offs.

4.4. Conservation strategies

Deforestation and the degradation of forest and water ecosystems are often the result of mismanagement and inadequate policies that are not adapted to the local context (Verburg *et al.* 2004). For example, an estimated 84% of forest disturbance area in the region is caused by small-scale, non-mechanized forest clearing for agriculture. Unfortunately, these drivers are sometimes neglected by strategic resource management plans when conceived at a large-scale level (Tyukavina *et al.* 2018). The major concern is that most strategic resource management plans in the DRC have been conceived on a large scale using top-down or downstream approaches, thus holding the risk of underestimating local specificities. There is an urgent need to develop management plans at local scales to protect and conserve forest and water resources, such as in Tshopo province.

To meet this need, strategic documents have been developed at various levels. The objective was to promote sustainable forest ecosystem management, which would not have negative impacts on water resources in the current context, to improve the livelihood of the population. Illustrative cases include the Sustainable Development Goals (SDG 6 and SDG 15), Agenda 2063 of the African Union, the global Bonn challenge goal of bringing 350 million hectares of worldwide deforested land into restoration, the AFR100 (the African Forest Landscape Restoration Initiative), the national action program for

adaptation to climate change, and sustainable forest management plans, *etc.* (Guizol *et al.* 2022).

a) Government responses

Indeed, the DRC government recognizes the key environmental challenges facing the country when it comes to considering multiple policies, strategic documents², and all the environmental framework laws that deal with the issue of water resources and forest ecosystem protection. For example, the water law promulgated in 2015³ gave more power to local communities, such as those living in forest landscapes, so that they may be involved in the management of resources with more decision power. In addition to this, there is also the 2002 Forest Code Act, already cited above, through which the logging of timber and collection other forest resources are conducted in a sustainable way, considering the rights of the local population and the preservation of some vital ecosystems such as river banks and all water bodies within the forest massif. The reduced impact logging standards inspired by the DRC's 2002 forestry code prohibit logging on riverbanks in swampy areas covered by dense forests and hydromorphic soils. Article 48 of this code prohibits all deforestation within 50 m on either side of watercourses and within a radius of 100 m around their sources. There are also many other legal arsenals initiated at national or international levels, such as the Law on Fundamental Principles of Environmental Protection (2011)⁴, the Congo Basin Blue Fund⁵ for Climate Transition and Sustainable Economic Growth in Central and East Africa, and the National Action Program for Adaptation to Climate Change⁶ (NAPA), whose goal is to identify long-term climate risks and guide management initiatives in the country. This legal arsenal contributes to the regulation of forest and water resources by considering ecological aspects, the need for development, and the reality of climate change (Guizol *et al.* 2022).

At the local scale, in the Tshopo province, there is, for example, the PIREDD program, initiated by the DRC government as a part of the UN's international REDD+ goals, which include stabilizing forest cover in the country by recognizing the role of climate change causing rainfall irregularities, heat waves, floods, erosion, *etc.* (South Pole 2020).

b) Implementation of national plans

Unfortunately, the strategic documents developed to address these issues are not always well implemented, and sometimes not even clear or adapted to the local context of the DRC's sub-zones. In addition, the lack of clear responsibilities at the institutional level and the need to mobilize more funds for these plans constitute a major challenge. The Nationally Determined Expected Contribution (2017),

² CSC RDC. Cadre Stratégique Commun République Démocratique Du Congo 2022-2026. ; 2021

³ République Démocratique du Congo. Loi n° 15/026 du 31 décembre 2015 relative à l'eau. 2015. <<https://leganet.cd/Legislation/JO/2016/JOS.13.01.2016.pdf>, Accessed on 21 February 2023>.

⁴ République Démocratique du Congo. Portant Principes Fondamentaux Relatifs à La Protection de l'Environnement. 2011.

⁵ Commission Climat du Bassin du Congo. Le Fonds Bleu du Bassin du Congo. 2021. <<https://www.cbcc-bbcc.org/>, Accessed on 21 February 2023>.

⁶ République Démocratique du Congo. Programme d'Action National d'Adaptation Aux Changements Climatiques 2010.

submitted to the United Nations Framework Convention on Climate Change, outlines the DRC's main priority actions related to climate change for the period 2021-2030. In this document, the government expresses major concerns about the lack of real capacity to address adaptation issues in the DRC on a large scale. Similarly, the absence of a real policy of cross-sectoral intervention in the context of fighting conflicts of interest between different sectors (mining, agriculture, water, and forestry) does not facilitate the implementation of actions in the field of climate change within a federating framework of mitigation and adaptation programs.

5. Socio-ecological system and community resilience

In Tshopo, almost all rivers are directly protected by the forest cover of the region. However, in some watersheds, destructive activities such as logging, slash-and-burn agriculture, cutting wood for energy, and heavy erosion occur frequently (Chishugi *et al.* 2021). These activities increase pollution, which directly threatens forest ecosystems and water bodies. In addition, immigration into the province, mainly from the surrounding provinces, especially North Kivu (Yira), Haut-Uelé, and Ituri, constitutes a significant pressure on local forests (PNUD 2019).

The observed degradation of forests will increase the negative impacts of climate change mitigation. The population is poor and highly dependent on natural resources for their livelihoods and is therefore particularly vulnerable to the effects of climate change and water ecosystem-related issues (Sonwa *et al.* 2020). The fact that they are not well informed and lack the capacity to lobby to defend their rights decreases the socio-ecological resilience of the ecosystems and their inhabitants to deal with changes in the environment and climate.

It is therefore essential to explore how communities can maximize their well-being on the one hand without compromising the resilience of the forests and their resources. This was the main challenge in the context of Tshopo.

6. Lack of data availability and access

Deforestation can be driven by a range of factors (*e.g.*, need for firewood, need for construction wood, population growth, *etc.*), and can also lead to a range of impacts (*e.g.*, erosion, loss of soil fertility, reduced water infiltration, *etc.*). Unfortunately, the drivers and impacts are likely to be underestimated if they are not studied at an appropriate scale (Tyukavina *et al.* 2018). In addition, there is a lack of comprehensive data on the quality, quantity, and sustainability of natural resources such as water in relation to human activities and environmental change in the Tshopo province. Although the policy documents reveal an awareness of these challenges and concerns about their potential negative impacts and the need for responses, the country has difficulty accessing scientific data to support policy

development. These challenges make local and sub-regional actions to conserve and protect water resources and ecosystems highly relevant. Therefore, local research at the small-scale level is needed in this area (Tyukavina *et al.* 2018). For the entire province, data on water quantity, quality, and biological characteristics are missing. There is no sufficient temporal series data on rivers and spring flows that could help reveal the pattern of this resource with regard to other resources such as forests. In addition, meteorological stations are insufficient for analysing water patterns in relation to climate. Even the mapping of different water points is weak because it considers only the principal water bodies. Studies dealing with water needs or the relationship of the latter with the other elements of the ecosystem), are difficult to perform in this region.

7. Conclusions

Appropriate strategic plans for sustainably managing forest ecosystems with explicit consideration of water resources are urgently needed. However, currently, there is a lack of reliable data and scientific studies at the local scale to support the development of such plans. More insights and evaluation tools are needed to understand how anthropogenic activities and climate change increase water vulnerability in Tshopo province. Well-defined political approaches need to be conceived and applied through the inspiration of peer-reviewed scientific studies that consider the specificities and context of the Tshopo region.

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