REVIEW ARTICLE

Developing indicators for wetlands conservat on using DPSIR framework: A systematic review in Ethiopia

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Wetlands are responsible for providing provisioning, regulatory, supporting, and cultural services. Due to many challenges, wetlands have become severely degraded. The understanding of wetlands and their values is inadequate. There is no evidence indicating the development of indicators for wetlands conservation. This study's purpose was to emphasize the importance of integrating the DPSIR framework with some developed environmental indicators for wetlands conservation. A total of 135 papers were collected using web-based search engines. The DPSIR framework analysis of Ethiopian wetlands degradation is being carried out using scientific knowledge and documented literature. In Ethiopia, besides of high cost of intervention on degraded wetlands, the issue has gotten less attention; no quick and one-off solution to alleviate these problems, there is little or lack of research, community awareness, knowledge of planners and resource managers and policy gaps. The local community's involvement in wetlands conservation is limited. To develop some important and applicable indicators based on the collected data, the application of the DPSIR model was quite essential. Based on professional experience and literature review, some steps were used for developing some relevant indicators for sustainable wetlands conservation. Some applicable components of the conceptual framework were used as DPSIR indicators. The conceptual framework was designed to enable an understanding of the causal relationships between driving forces and socioeconomic impacts. Baseline information from the developed DPSIR indicators can be utilized to guide management actions in implementing short or long-term responses to conservation measures.

Key Words: *Conservation; DPSIR; Indicators; Wetlands*

INTRODUCTION

Wetlands account for 890 million hectares (6%) of the global land surface. However, an estimated 50% of the world's wetlands have been lost in the last 50 years [1]. Ethiopia's landmass is made up of 2% of wetlands [2]. The country has two main freshwater resources: Surface water and groundwater. Surface water is composed of lakes, rivers, and wetlands. Gebresilassie et al., reported that Ethiopia has more than 58 wetlands that are composed of various landscapes, such as grasslands, grazing land, ground forest, woodland, and swamps (Figure 1). Ethiopia has a vast variety of wetlands, with the only exceptions being coastal and marine-related and wide swamp forest complexes [3-5].

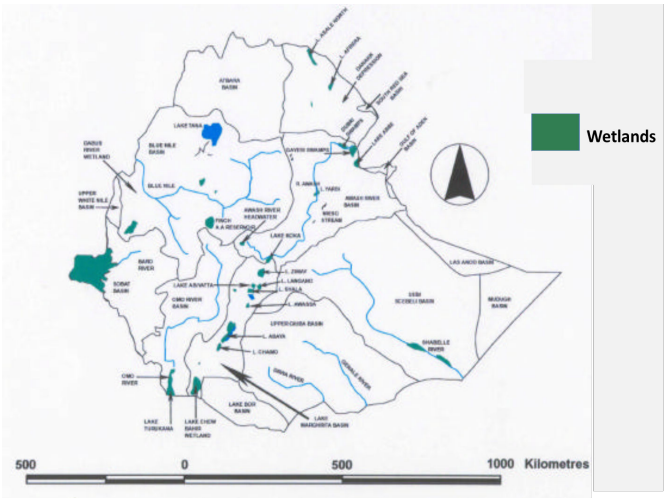

Figure 1) *Geographical distribution of Ethiopian wetlands*

The supply of wetlands resources, which provide provisioning, regulating, supporting, and cultural ecosystem services, is crucial for riparian communities [6-8]. For example, wetlands provide or serve as a food source, water source, income source (eco-tourism), crop production, fish livestock, plant medication, fuel wood source; regulating services such as water purification, water storage and supply, sediment accretion, coastal flood control, pollutants retentions (microclimate regulation; carbon sequestration); supporting services like biogeochemical cycling, soil formation, pollination, shelter and care for diverse flora and fauna such as fungi, bacteria, phytoplankton, macrophytes, weed bed fauna, zooplankton, amphibians, reptiles and waterfowl and important for biodiversity and wildlife conservation [9-12]. Wetlands products are utilized as sources of cultural resources, spiritual services, house construction, educational and research services [13].

However, Ethiopian wetlands are facing many challenges and become heavily degraded due to wide driving forces or socioeconomic activities held on or nearby their catchments and driving factors include anthropogenic and natural forces [14]. In Ethiopia, the management of wetlands was compromised by the general public and decision-makers [15]. Different approaches can be used to model environmental problems and socio-economic factors. The Driver-Pressure-State-Impact-Response (DPSIR) framework is the most commonly used model as a tool for integrating socioeconomic activities that could affect the wetlands ecosystem by identifying all driving factors (Figure 2). The DPSIR framework has a limited application in developing countries. The DPSIR framework has the potential to be utilized effectively as a systematic tool for decision and policymakers in wetlands conservation. More efforts are being made to address the degradation of wetlands in Ethiopia. Developing indicators for wetlands conservation using the DPSIR framework is not suggested by any evidence. This study is the first to develop DPSIR indicators for wetlands conservation in Ethiopia. Therefore, the aim of this review was; to highlight the importance of integrating the DPSIR framework with environmental indicators for wetlands conservation and to identify the current gaps in scientific investigations and provide suggestions for further studies

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that will promote a detail understanding of wetlands conservation through the application of DPSIR indicators.

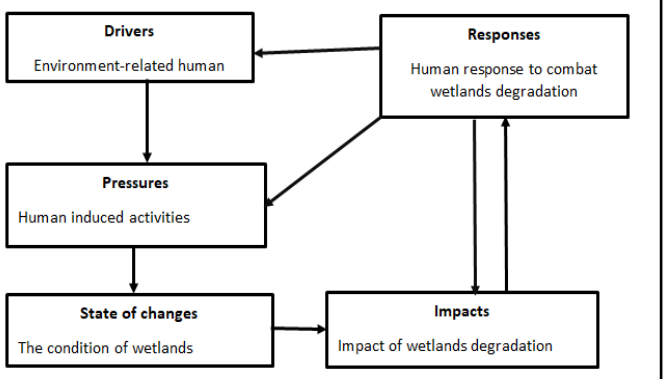

Figure 2) *A self-creation of DPSIR framework of wetlands degradation*

LITERATURE REVIEW

The study has been conducted between May 12-August 16, 2022. Google Scholar, PubMed and SCOPUS were mainly used for web searching of peer-reviewed articles. Totally, 135 papers were collected (Figure 3). To collected data, important keywords mainly "Wetlands", "Wetlands in Ethiopia", "Wetlands degradation" and "Wetlands ecosystem service" were used in the search engines databases. The focus of this study was published papers. The study period of peer-reviewed articles was left open-ended to permit for an applicable amount of literatures to be included. Throughout the review, all searches and the review may have a limitation according to the following considerations; published literatures may be omitted due to a lack of a linkage with the keywords, all used literatures were only in the English versions, some papers may not available due to closed or limited access to articles, others were not catalogued in these electronic databases and lastly online available MSc and PhD thesis works were not included.

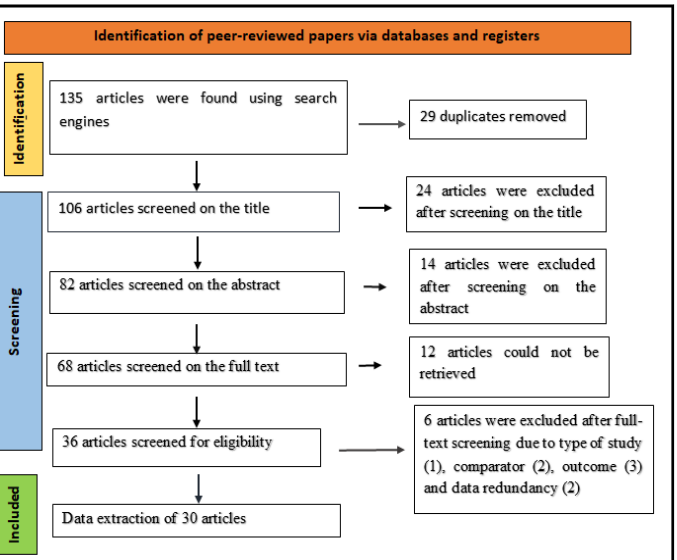

Figure 3) *A personal creation of the flowchart representing the methodology of the review*

RESULTS AND DISCUSSION

Depending on the scientific knowledge and documented literatures, the Driver-Pressure-State-Impact-Response (DPSIR) framework analysis of Ethiopian wetlands degradation is analyzed. Drivers are hydrological and socioeconomic forces such as climate change, population growth, economic growth and government initiative (policy changes) [16,17]. This could be the reason for high cost of intervention on degraded wetlands, no quick and one-off solution to alleviate problems, little or lack of research, community awareness, knowledge of planners and resource managers and why Ethiopia has yet to ratify and implement the Ramsar convention. Pressures entertain human activities which directly contribute to wetlands degradation include deforestation or improper agricultural practices and expansions, urbanization, industrialization, recurrent drought, over extrapolation of wetland water, increase fish harvesting, lack of knowledge and awareness and weak policies on wetlands [18,19]. This may be due to the absence of a stand-alone national wetlands policy or strategy and the existing policies and laws have not adequately addressed the wetlands issue, and even some laws are contradicting the wise use of wetlands.

State changes of wetlands are existing environmental conditions affected by driving forces and may include wetlands size reduction, reduced water quality, habitat modification, reduced biodiversity richness, reduced fish livestock, biological invasions (invasive alien species), eutrophication and siltation or sedimentation [20]. This would happen due to improper intervention of the driving forces. The possible impacts of wetland degradation are direct and indirect effects of wetlands degradation and comprise loss of biodiversity, lack of food and food insecurity or malnutrition, climatic disturbance, low precipitation pattern and effect on the health of organisms (humans and animals). Absence of adequate protocols for assessment, monitoring and inventory of wetlands, sufficient formal institutional setup and legal framework and lacks of specialized experts in wetlands assessment and management may aggravate wetlands degradation. Finally, response to wetlands fragmentation includes human mitigation measures to overcome wetlands degradation and conserve wetlands are preferable to be applied to driving forces to alleviate pressures, state and impact. Ways used to reverse existing wetlands degradation which may include intervening in Driver-Pressure-Impact-State change factors as well as implementing sustainable resource management and conservation practice, technical support, funding, training and awareness creation or adequate knowledge on the status and functioning of wetlands, sufficient information database on wetlands, national inventories and National directory of wetlands, political conviction, prioritization and management plan for wetlands, continuous monitoring plan for wetlands and upstream-downstream users relation, carrying out Environmental Impact Assessment (EIA) for developmental activities and strengthening and building partnership with stakeholders.

Following reviewing of literatures, to develop some important and applicable environmental indicators, DPSIR model was applied. The first outcome of DPSIR model and developed indicators was a conceptual framework of the DPSIR components and interaction between each identified component of the model (Figure 4 and Table 1). The conceptual framework was done in a way which enables an understanding of the causal-relationships between driving forces and socioeconomic impacts. Then, the preliminary list of environmental indicators for sustainable management and conservation of wetlands were identified. This was done based on professional experience and literature review and first, some steps were used for developing relevant indicators such as, identifying all the proxies which state a specific management challenge or wetlands degradation, sorting these identified proxies into DPSIR framework categories, establishing a linkage between the different components of DPSIR in terms of a conceptual model, assigning an indicator for each category of the developed conceptual model. Then, each component of the conceptual framework, not all, was taken as environmental indicator. Generally speaking, the overall effectiveness of the DPSIR framework can be maximized and should be integrated with a set of developed indicators for each category of DPSIR framework. However, further studies are necessary to build a concrete base of applicable and wise indicators for wetlands conservation.

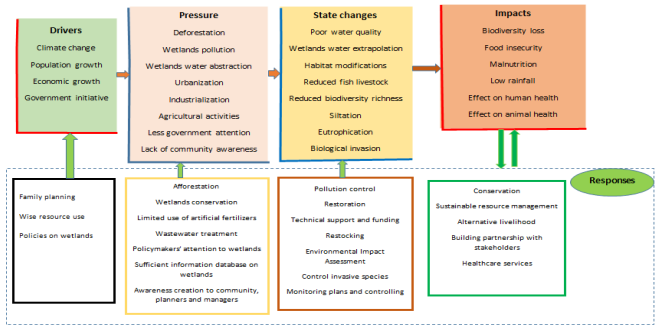

Figure 4) *The conceptual DPSIR framework components developed for wetlands conservation*

TABLE 1

DPSIR framework components and developed indicators for wetlands conservation

DPSIR framework	DPSIR component	Developed DPSIR indicator
Driver	Climate change	Climate change report (IPCC)
	Population growth	The fertility rate of the population (Central statistics agency reports)
	Economic growth	GDP reports
	Government initiative	Standalone policies and conventions on wetlands (Ramsar convention ratification and development of wetlands policy)
Pressure	Deforestation	Area of cleared area
	Improper agricultural practices and expansions	Soil quality (decreased soil fertility)
	Urbanization	Number of people in urban areas
	Industrialization	Number of industries in the catchments of wetlands
	Absence of appropriate policy	Absence of policies on wetlands
	Natural disaster (recurrent drought)	Shortage of water
	Wetlands water abstraction	The water content of wetlands
	Increase fish harvesting	Food shortage
	Overgrazing	Number of animals near the wetland areas
	Lack of knowledge and awareness of wetlands	Lack of wetlands common ownership
State	Wetlands size reduction	Reduced catchment size
	Poor water quality	Deviation from standard guideline values
	Habitat modification	Species distribution
	Reduced biodiversity richness	Richness indexes
	Reduced fish livestock	Overfishing
	Biological invasions (invasive alien species)	Presence of invasive species
	Eutrophication	Presence of algal bloom
	Siltation	Sedimentation
Impact	Loss of biodiversity	Extinction of organisms
	Food insecurity or malnutrition	Shortage of food surplus
	Climatic disturbance	Climate change reports (CO_2 and CH_4 build up in the atmosphere)
	Effect on the hydrological cycle and rainfall pattern	Low annual rainfall
	Effect on the health of organisms (humans and animals)	Human and animal illness and death

Response	Family planning	Low fertility rate
	Wise resource use	Sustainable use of resources
	Policies on wetlands	Establishment of national inventories, a national directory of wetlands and established political convictions (signatories of conventions)
	Afforestation	Tree covered area (catchment)
	Wetlands conservation	Number of protected areas
	Limited use of artificial fertilizers	Use of natural fertilizer
	Wastewater treatment	Low level of pollutants
	Policymakers' attention to wetlands	Signing convention of wetlands (Ramsar convention) and prioritization and management plan for wetlands
	Awareness creation to community and planners and managers	Number of awareness-raising materials distributed, number of awareness creation seminars and workshops, establishment of wetland clubs or groups and number of sessions for environmental education
	Pollution control	Application of pollution prevention and control measures
	Restoration	Restoration of damaged wetlands, number of projects on wetlands and number of restored damaged wetlands
	Technical support and funding	Number of workshops on wetlands and intergovernmental collaborations
	Preliminary inventory and environmental impact assessment	Number of firms around the catchment of wetlands with EIA inventory or report
	Restocking	Increase of fish population and harvesting
	Control invasive species	Physical, mechanical, biological and chemical measures taken
	Monitoring and controlling	Environmental quality and continuous monitoring plan of wetlands and upstream-downstream users relation
	Alternative livelihood	The annual number of newly generated jobs
	Building and strengthening partnerships with stakeholders	Panel discussion on wetlands issue
	Healthcare services	Health service coverage
	Sustainable resource management and conservation practice	Constant use of resources in the present and future
	Sufficient information database on wetlands	Number of damaged and healthy wetlands

CONCLUSION

Ethiopian wetlands are facing many challenges. Depending on the scientific knowledge and documented literatures, the Driver-Pressure-State-Impact-Response (DPSIR) framework analysis of Ethiopian wetlands degradation are analyzed. This review has shown studies deal with scientific information on Ethiopian wetlands status is much needed. Some steps were used for developing relevant environmental indicators based on professional experience and literature review. The application DPSIR framework can be enhanced by developing environmental indicators. The review will contribute to indicating the effectiveness of developed DPSIR framework indicators for wetlands conservation. Through the application of the DPSIR approach, this review may be important for future investigators and stakeholders, managers, planners and policymakers in Ethiopia and other parts of the world to implement either short-term or long-term plans, policies, programmers and strategies in wetlands degradation intervention and conservation. Therefore, these developed DPSIR indicators would be an input for planners and decision-makers for wetlands conservation.

AUTHOR CONTRIBUTIONS

Conceptualization: BAM.

Developing methods: BAM, SME and TSA.

Data analysis: BAM, SME, TSA.

Preparation of figures and tables: BAM. Writing: BAM, SME, TSA.

All the authors have read and agreed to the final version in the publication of the review.

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CONFLICT OF INTEREST

The authors declare that, no conflict of interest.

DATA AVAILABILITY

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

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