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WETLAND POLICY AND LEGISLATION

Reconciling East-African Wetland Conservation with Human Needs: Managing Uncertainties in Environmental Policy Design

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Abstract
Rapidly developing societies in East-Africa impose increasing pressures on wetlands due to rising food demand and degradation of upland soils. Reconciling wetland conservation with human needs for food and energy is therefore becoming an increasing contentious issue. Stakeholders and actor coalitions generate and apply a great variety of meanings, values, and interests when interacting with wetlands which are hardly predictable. Wetland policy-making is hence fraught with uncertainties which need to be managed for finding solutions to this problem. Based on experiences of a collaborative wetland research in East-Africa we developed a new wetland policy process framework which promotes social deliberation and reconciliation of plural wetland values to reduce these uncertainties. A new cognitive-driven information design (CDID) method has been developed to assist wetland policy-analysts in achieving these aims and also to overcome limitations of prescriptive decision-making. The method employs information and communication technologies to analyze, integrate and visualize complex socio-ecological wetland information for developing policy scenarios. It is applied at all stages of the wetland policy process including agenda setting, identification of plural wetland values, establishment of decision-scenarios, social deliberation during policy formulation, governmental decision-taking, policy implementation and evaluation. A three-stage implementation process is recommended.

Keywords Wetland use · Conservation · Ecosystem Services · Plural Valuation · Decision-making · Policy process theory

Introduction

Wetlands filter and purify water. They are the kidneys of our landscapes (Mitsch and Gosselink 2015). They cover a global area of 12.1 million km^2 according to the latest outlook of the Ramsar Convention on Wetlands Secretariat (RAMSAR) which was formed 50 years ago in response to widespread global destruction of wetlands (RAMSAR 2018). Some 35% of the globe's wetlands were lost between 1970 and 2015, mainly due to crop cultivation and dam construction with severe negative consequences on biodiversity, hydrology and ecosystem processes. Yet, about a billion households in Asia, Africa and the Americas depend on wetland crop cultivation to sustain their livelihoods (RAMSAR 2015).

Human pressures on wetlands will continue to rise with a growing world population and climate change. This will be particularly the case in East-Africa where populations will likely double within the coming 30 years (United Nations 2019). Hunger, poverty and malnutrition were alarming and widespread in rural East-Africa in the 1990s despite some considerable improvements until the 2000s but there has been stagnation since then while populations continued growing (von Grebmer et al. 2020, FAO 2020, FAO 2021, World Bank 2020). Wetlands are hence seen as new agricultural frontiers of Africa and wetland policy-makers need to develop ecologically sustaining livelihood-generating approaches (Wood et al. 2013, Dixon 2020). While such thinking is certainly understandable from an ethical point of view, more differentiated approaches are needed to avoid

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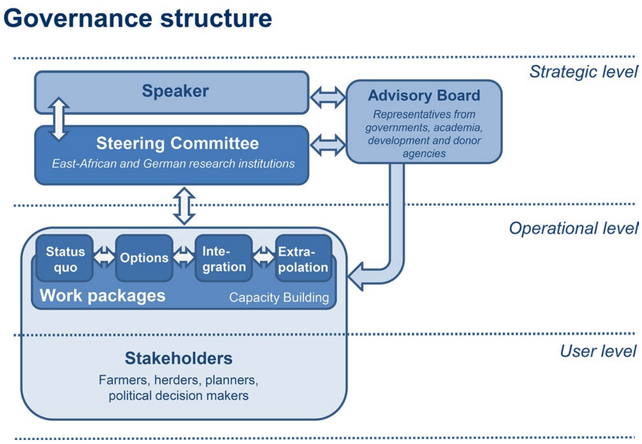

Fig. 1 Governance structure of the project "Wetlands in East-Africa: Reconciling future food production with environmental protection"

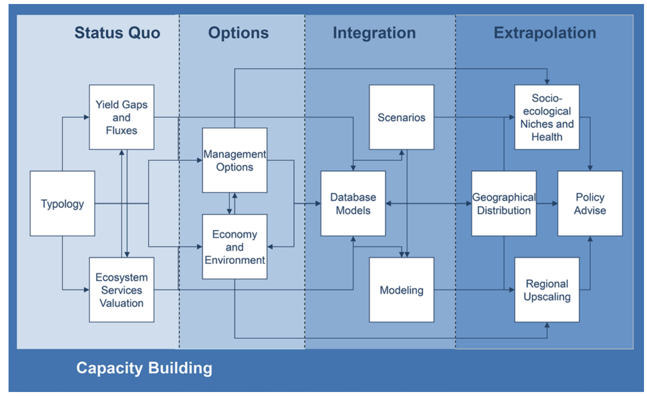

Fig. 2 Linkages between work packages

unintended deteriorations of wetlands (Mafabi 2016; Dixon et al. 2021). Several recent studies confirm that conservation measures must be undertaken to ensure that East-African wetlands remain resilient to human interventions in the future (Musasa and Marambanyika 2020; Maua et al. 2022; Munishi and Jewitt 2019). Holistic approaches are needed which do not only pay attention to food production, but also take wetland resilience into account because it is critical for people's health, food and energy demand. Failure to implement laws and appropriate management frameworks for wetlands has seriously compromised wetland biodiversity and ecosystem services across Africa (Mandishona and Knight 2022).

Within this context, this paper describes and presents critical reflections on our attempt to develop a science-based decision tool for reconciling wetland conservation with human needs by a collaborative research project. Although most scientific objectives had been reached, the research was of little relevance to practical wetland policy-making, because it was technically oriented and did not consider socio-political wetland dynamics. We provide comprehensive background information about the project and elaborate on the reasons which lead to this problem. Based on lessons learned we present a new wetland policy-framework which links technical and political framing of wetland issues and overcomes prescriptive decision support through social-deliberation and reconciliation of plural wetland values. A new method of cognitive-driven information design (CDID) was developed in this context to assist policy-analysts in comprehending large streams of information from socio-political wetland environments and designing decision-making scenarios for social deliberation during wetland policy-formulation.

Background

This work is motivated by experiences collected during a five-year collaborative research titled: "Wetlands in East Africa: Reconciling future food production with environmental protection" conducted by African and German research institutions. The initial project concept was formulated by an established network of African and German scientists working in the areas of agriculture and hydrology. East-African policy-analysts responsible for shaping national environmental and agricultural policies were engaged in conceptualizing and establishing the project to maximize impact on practical wetland agriculture. The consortium finally agreed on the governance structure shown in Fig. 1.

Research focused on reconciling wetland conservation against human needs which had been identified as an urgent issue on national environmental policy agendas in East-Africa. It was integrated across four work packages dealing with current states, functions and uses of wetlands (*Status quo*), identification of possible use scenarios (Options), assessments of future socio-ecological consequences (Integration), and policy recommendations considering wetland geographies, health issues and identification of socio-ecological niches (Extrapolation). Capacity building was considered of importance. As a result, 24 PhD and 45 Master theses were written. In addition, six stakeholder workshops, four training courses and four wetland farmer field days were organized in East-Africa. Local stakeholders were engaged in field research at the user level. Linkages between work-packages are shown in Fig. 2.

A wetland survey covering major socio-ecological wetland characteristics was conducted in areas prioritized by policy-analysts of each East-African country. Procedures were developed based on experiences collected during a previous survey (Sakané et al. 2011) and the Wet-Health concept of MacFarlane et al. (2020). Researchers and policy-analysts prioritized one wetland in each country for following detailed studies: Assessment of wetland use and protection options along a population gradient from Kampala to northern Kalungu in Uganda (Fig. 3A), sustainable intensification of agricultural production along strong altitude gradients in the northern province of Rwanda (Fig. 3B), strong contestation of wetland access and use among farmers and herders involving violent ethnically based conflicts on the semi-arid Evaso Narok in Kenya (Fig. 3C) and intensification of rice production in the Kilombero wetlands of southern Tanzania (Fig. 3D). Research activities were coordinated by a steering committee composed of principal investigators from the participating East-African and German research institutions. Research progress was reported annually to an advisory board composed of representatives from governments, academia, development and donor agencies in all countries. Wetland investigations were continuously adapted according to its annual recommendations. Therefore, local stakeholder interests were considered at both, the strategic and user levels of the collaborative research.

A system analysis approach was initially chosen for integrating findings in a quantitative model. A wide range of disciplines were engaged including agronomy, hydrology, economics, geography, soil science, meteorology, geology, ecology, human health, animal science, sociology, and anthropology. Discussions about research integration revealed that the theoretical and methodological approaches applied by the participating research groups were difficult to harmonize in an integrated computer model. Thus, the decision was taken to focus modeling on quantitative integration of household economic, hydrologic and agronomic wetland characteristics under the boundary conditions simultaneously investigated by the other disciplines.

In spite of challenges associated with establishing coherency, policy-analysts became increasingly concerned about missing linkages between the research and policy development processes. Moreover, there was no conceptual policy framework, policy options were not determined and, most importantly, comprehensive decision support for designing wetland policies was not provided. These arguments were discussed by the advisory board, which recommended shifting the focus of research integration from quantitative modeling to evidence-based decision support following a decision tree approach (Greenwell 2022). Identifying wetlands for sustainable economic intensification of crop cultivation was set as the focus (Fig. 4A). Wetland conservation was balanced against human needs based on a quantitative tradeoff analysis of ecosystem services implemented in the decision tree. Thereafter, scientists and policy-analysts selected ecosystem services to be considered in the analysis as shown in Fig. 4B.

Software design criteria were principally based on the Agile Modeling Paradigm which emphasizes the importance of frequent interaction between programmers and users in collaborative and evolutionary manners (Ambler 2002). It was also decided that data demand should be as low and informative as possible, decisions primarily based

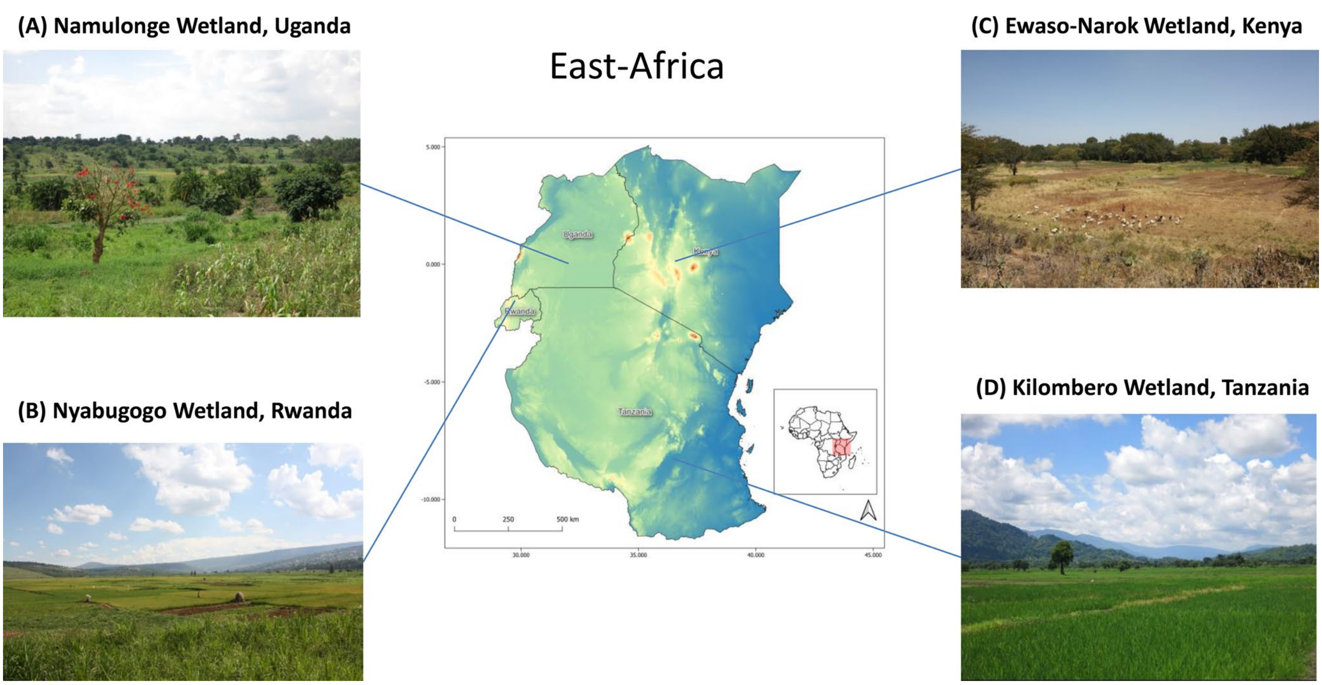

Fig. 3 Agriculturally used wetlands selected by African and German researchers in consultation with wetland policy-advisors: (A) Namulonge inland valley wetland, Uganda, (B) Nyabugogo wetland between Kabuye and Gasanze, Rwanda, (C) Ewaso-Narok highland floodplain in the Laikipia savannah of Kenya, and (D) Kilombero floodplain near Ifakara, Tanzania

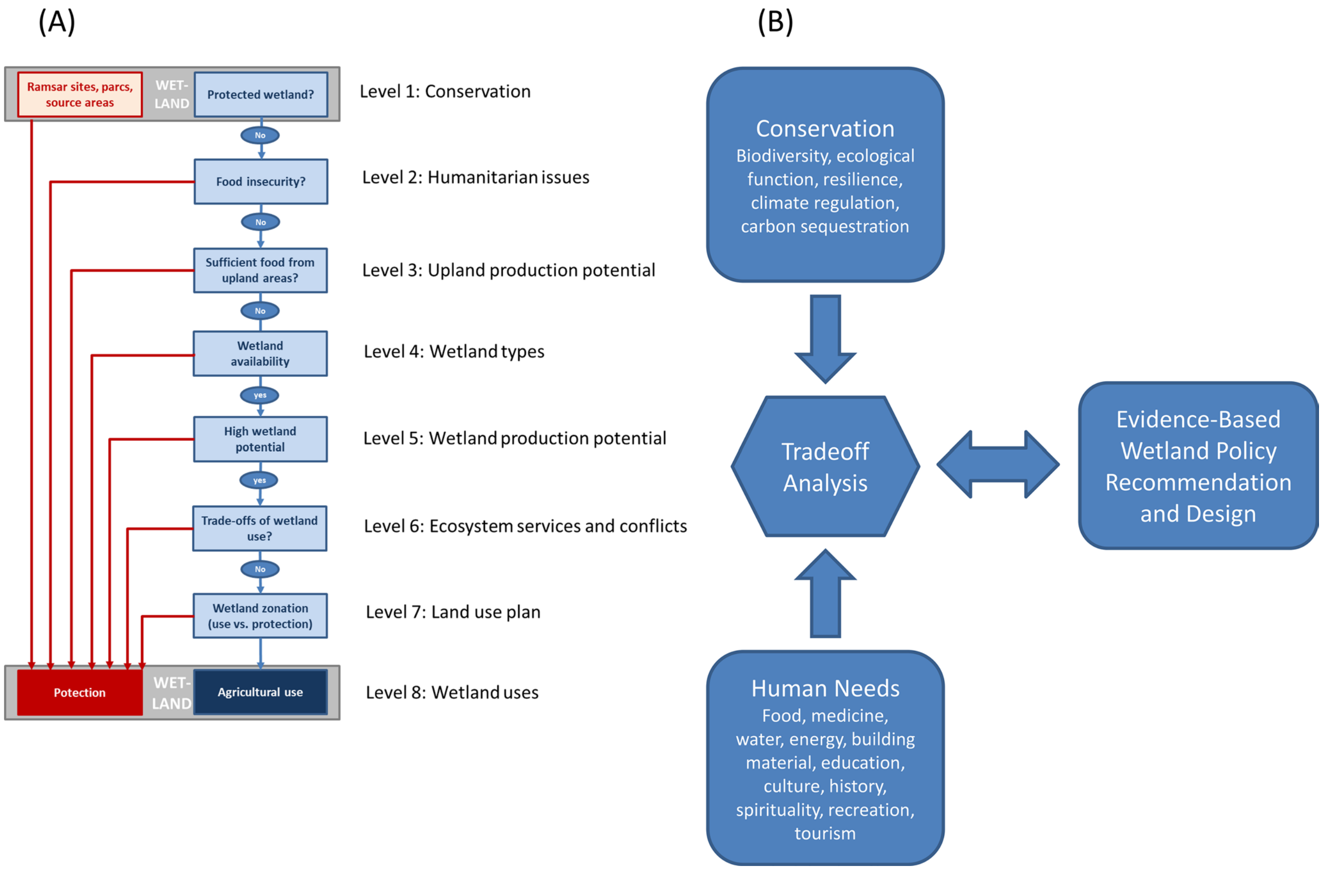

Fig. 4 (A) Original decision tree for identifying wetlands with high potentials for sustainable economic intensification of crop cultivation. (B) Ecosystem services selected for analyzing tradeoffs between wetland conservation and human needs at level 6 of the original decision tree

on real-world instead of predicted information, uncertainties quantified, and the applied software framework be modular, robust, simple, documented and open source. A spatial-temporal scenario engine and a mockup decision tree were coded in R (R Core Team 2022) for discussions with wetland policy-analysts who were senior advisors of state secretaries, ministers and president advisors. Meetings were held in all East-African countries and culminated in a three-day wetland decision-making workshop. The decision tree concept (Fig. 4A) was received with strong reservations, as wetland policy-analysts were concerned about a heavy bias towards agronomy, missing consideration of wetland ecological functions, lacking attention towards rural social issues, inflexible valuation of ecosystem services, inappropriate conceptualization of wetland zonation, and a missing implementation of RAMSAR's Wise Use guidelines (RAMSAR 2010). It also became apparent that the binary nature of the selected decision tree concept was too simple for supporting complex wetland decision-making. Although the German donor agency regarded the collaboration between wetland scientists and policy-analysts as innovative, the finally chosen decision-support approach turned out to be inadequate for practical wetland policy-making in East-Africa. In response to these concerns we developed a new wetland-policy framework. Details are provided in the following section and are based on four major lessons learned:

Lesson 1 Policy-analysts commonly apply heuristics in prioritizing evidence in the context of social framing of human-ecological conflicts (Cairney and Kwiatkowski 2017). Scientists, in contrast, typically reason analytically to investigate their socio-ecological characteristics. The joint development of wetland management principles should ideally be based on the harmonization of the underlying epistemologies, but this has been rarely done before and also appears to be impractical. Co-production of knowledge integrating facts, meanings, values, beliefs and interests through transdisciplinary exchange is a solution to this problem. Social deliberation of value-based decisions in the policy arena promotes the acceptability of wetland policy formulations. Figure 5 illustrates this thinking.

Lesson 2 Associating wetland science with socio-anthropological wetland characterization turned out to be a challenge. In addition, the inability to establish coherency by

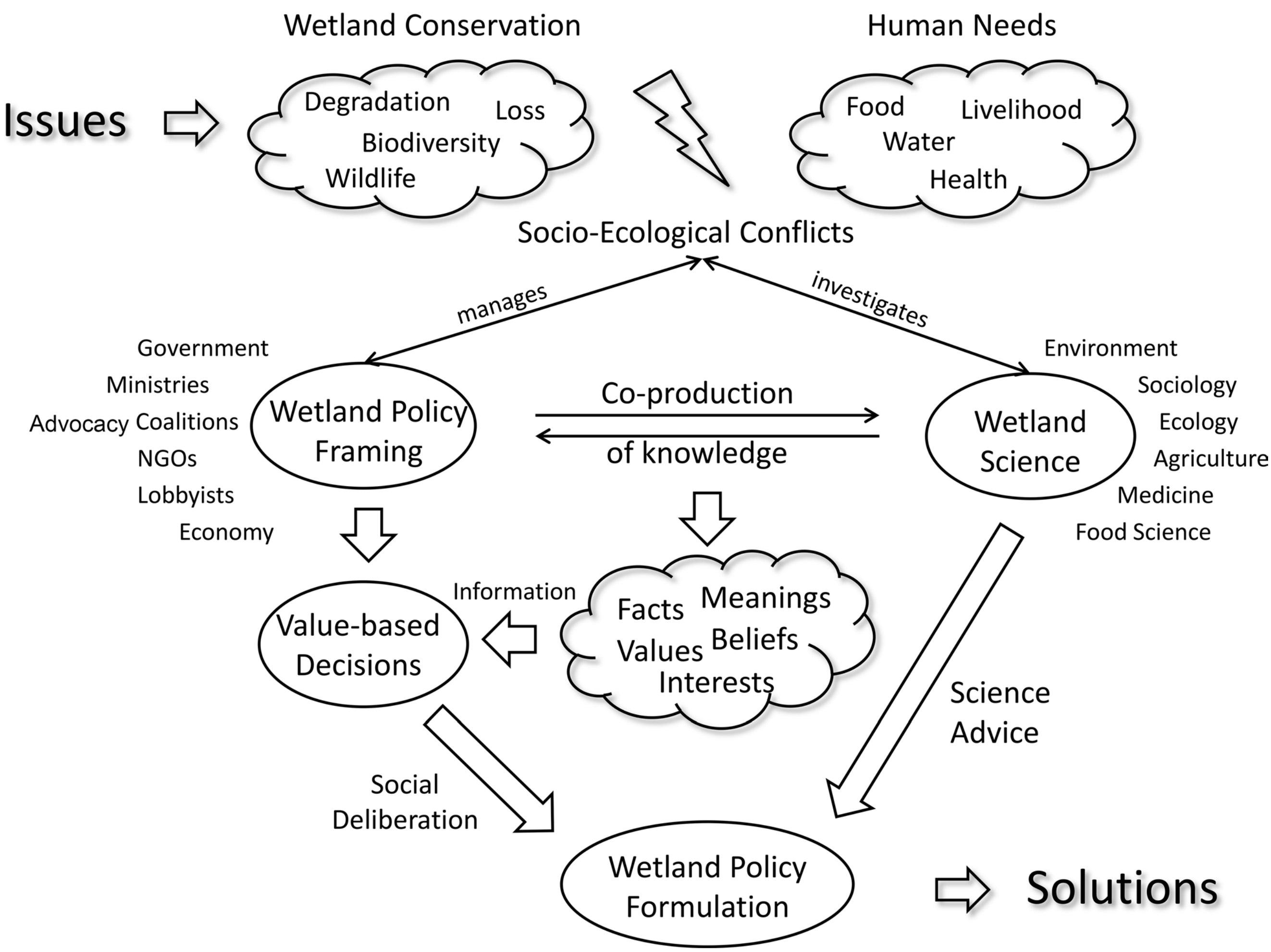

Fig. 5 Co-production of knowledge by wetland policy and science to support value and evidence-based wetland policy formulation for reconciling wetland conservation with human needs

making research results practically relevant through a quantitative economic concept of ecosystem services prevented the application of significant insights from policy studies regarding the meaning and values of environments to stakeholders and how they value them. Therefore, a more flexible approach associating qualitative and quantitative information about wetland socio-ecologies was needed, taking into account that decision-making must not necessarily be based on coherent information (Olsson 2005).

Lesson 3 Evidence-based policy-making is predominantly based on optimizing quantifiable facts. Social norms and values can also be used as 'evidence', but societies often change and evolve in unpredictable ways. People use meanings, beliefs, values and emotions in interpreting their social and natural environments and continuously alter them in response to new experiences. This 'irrationality' is just as much part of our human nature as rationality: human decision-making is driven by both. The question is not, how to exploit this capacity in search for 'evidence', but by which means it can be supported in solving complex problems of wetland policy-making. This has psychological and technical implications which are considered in the new wetland policy-framework we present in the following section. It must be also taken into account that evidence can only arise from analyzing the past or present. The future is inaccessible. Socio-ecological dynamics of East-African wetland systems are also often uncertain, erratic and non-linear. Therefore, extrapolating past characteristics into the future will always involve the risk of prediction failure. Furthermore, uncertainties also arise from the policy process, which can only be managed through socio-political deliberation. We therefore abandoned prescriptive wetland policy-support and replace it by a new cognitive driven information design (CDID) method. It (i) processes real-time information, (ii) supports human cognition in decision-making, (iii) drives reconciliation of multiple wetland values and (iv) promotes social deliberation of policy options to balance wetland conservation with human use.

Lesson 4 The decision tree (Fig. 4A) has several limitations which prevent its practical application in wetland policy-making. First, its static top-down structure and binary characters do not provide the flexibility to navigate according to changing requirements during the wetland policy development process. Secondly, scientific advice regarding wetland management is coded in software likely becoming outdated after a short period of time. Third, incorporated information originated from only one location in each country, thus preventing scaling to the national levels. Realistic nation-wide monitoring and scaling of socio-ecological wetland information require modern information technology infrastructures which are rapidly developing in East-Africa (O'Briain et al. 2020; Salam 2020). The concept of the wetland policy framework below uses these infrastructures for social deliberation of wetland policy scenarios and socio-technical monitoring of policy implementation through government institutional networks.

A Wetland Policy Framework

Wetland policy-making must consider opinions, ideas and interests of a wide range of actors and stakeholders. It must also consider the socio-ecological context and institutional cultures at all scales of policy implementation. Various theories can be applied for understanding and shaping policy processes (Weible and Sabatier 2018). The classical policy cycle model divides the policy process into five successive stages (Wu 2018; Pant et al. 2020): (i) Agenda setting politicizing societal issues, (ii) policy-formulation for developing alternative solutions, (iii) decision-taking leading to a particular course of government action, (iv) policy implementation and (v) evaluation (Fig. 6 left). Birkland (2020) cautions that this stage-by-stage model does not constitute a workable theory, because policy ideas often do not pass the agenda phase, implementation and evaluation cannot be separated, and decisions are taken at any stage of the policy-process. Nonetheless, the policy-cycle model is still regarded as a useful metaphor for understanding and describing the policy process (Cairney 2020) which is why

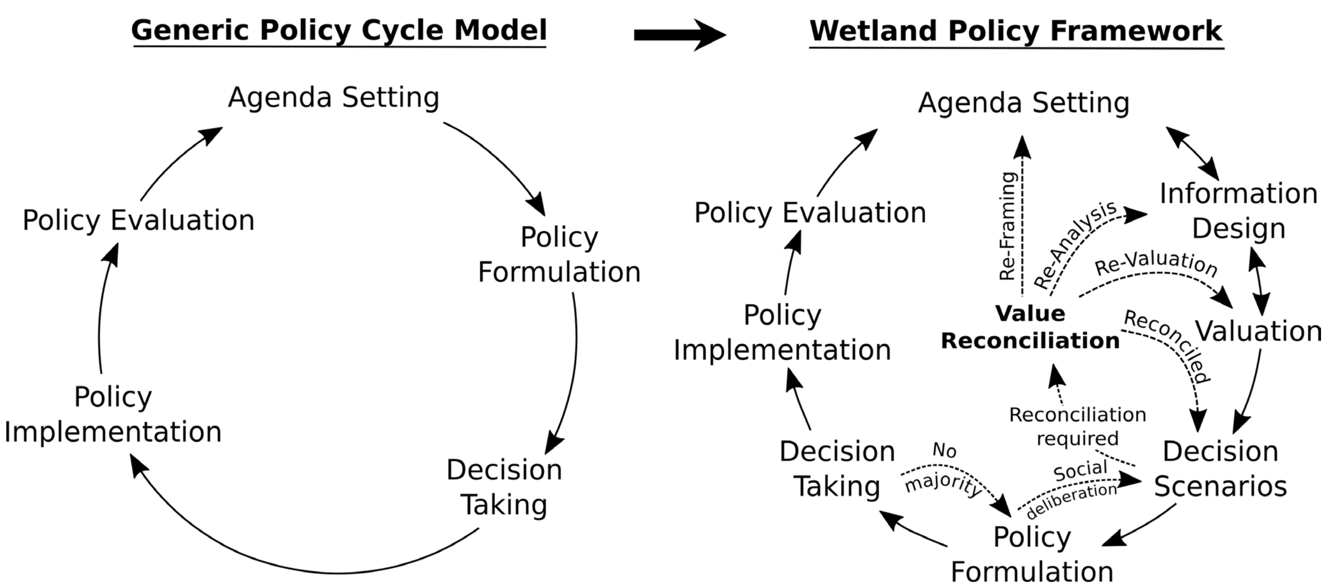

Fig. 6 A wetland policy framework (right) developed based on the classical generic policy cycle model (left - Wu et al. 2018; Pant et al. 2020). The sequence of steps in the classical model was altered to reduce uncertainties in wetland policy design through reconciliation of plural values and social deliberation of decision scenarios. Wetland meanings, facts and values are framed during (i) agenda setting. Narrative and other data analyzing methods are applied on wetland policy analyst's cognitive demands during the (ii) information design stage for identifying (iii) plural value constellations contested by different actor coalitions. Likely (iv) decision scenarios are constructed on this basis, (v) socially deliberated during policy formulation, (vi) legalized by national governments, (vii) implemented as concrete wetland policies and finally (viii) evaluated. Details are given in the following subsections, arranged according to the sequence of steps in this wetland policy framework

we have chosen it as a basis for developing the wetland policy process framework shown in Fig. 6 (right).

We initially improved the original wetland decision-support concept based on lesson 4 by transforming the decision-tree (Fig. 4A) into a flexible technical decision framework for identifying socio-ecological wetland policy options (Fig. 7). Although the framework addresses human ethical, social, cultural and economic wetland aspects, it is nevertheless termed as "technical" in the policy theory literature because it pays little attention to socio-political dynamics and institutional aspects of policy-making (Birkland 2020; Kenter 2020). Political decisions about socio-ecological futures are primarily determined through value deliberation (Kenter et al. 2016). Technical facts are important in assessing socio-ecological consequences. Integrating wetland values and facts required the harmonization of quantitative and qualitative information (lesson 2) which turned out to be theoretically and technically challenging. Moreover, how information is processed during human decision-taking and how this process could be possibly technically supported were additional questions that needed to be answered before proposing a procedure for wetland decision-making based on lesson 3. We subsequently realized that the developed decision-scenarios procedure could not be straightforwardly incorporated into the classical policy cycle (i) to avoid prescriptive policy-formulation (lessons 3 and 4), (ii) to strengthen the impact of expert analysis and (iii) to promote social deliberation of wetland policy options. We inserted three phases between the agenda setting and policy-formulation stages of the classical policy cycle model for this reason (Fig. 6): Wetland facts, meanings and values identified during the (i) agenda setting phase are integrated and visualized during a subsequent (ii) information design stage according to policy-makers' cognitive demands. Recognizing the importance of plural valuation in environmental decision-making and policy design (IPBES 2022), socio-ecological wetland characteristics are subsequently (iii) valued according to opinions of actor groups attached to particular socio-ecological wetlands types of question. Values are reconciled (see center of Fig. 6 right), (iv) political decision scenarios constructed on this basis to inform their social deliberation during the subsequent (v) wetland policy formulation phase. The remaining (vi) decision-taking, (vii) policy implementation and (viii) policy evaluation phases were structured according to the classical generic policy cycle model considering advances in recent policy process theory (Weible and Sabatier 2018). Details are discussed in the following sub-sections.

Agenda Setting

Wetland issues requiring government attention are framed during an agenda setting phase. Political framing provides information on prevailing situations, political issues, envisaged solutions and resources required for implementing policies. Framing shapes mental models of wetland environments applied in (i) deliberating future scenarios, (ii) providing cognitive shortcuts, and (iii) making identification of decision options more targeted, easier and faster (Cukier et al. 2021). Categorizing wetland issues into frames establishes coherence and also reflects prioritization of issues evolving during the policy discourses. That is why van Hulst and Yanow (2016) distinguish between frame and framing: **Technical frames** such as shown in Fig. 7 are more definitional and may result from taxonomizing socio-technological policy issues, whereas **political framing** is an interactive and socio-dynamic process influenced by actor coalitions and their power relations. Taken together, they facilitate the heuristic-analytical identification of wetland political issues during the agenda setting phase and identifying possible solutions during the decision-scenario and policy formulation phases (Fig. 6 right).

A **technical** wetland decision framework based on lesson 4 was discussed by politicians and scientists of this project on several occasions (Fig. 7). It is open for modification and flexible in technical scenario analysis. Wetland conservation is balanced against human needs by identifying vulnerable wetlands needing protection and resilient wetlands suitable for sustainable agricultural intensification. Decision analysis is initiated by identifying wetlands in conservation areas which should not be converted into food production sites to maintain their ecological and hydrological integrity [Step 1 – numbers in square brackets refer to steps in Fig. 7]. Conservation-policy and ecosystem restoration dynamics could be considered at this step. Human issues [Step 2] are still serious in some regions of East-Africa, especially hunger, poverty and malnutrition (von Grebmer et al. 2020; FAO 2021). Regions where people are particularly dependent on wetlands are selected next and options for sustainable livelihood generation such as farming, fishing, tourism, or transport assessed. Other wetlands are selected as conservation areas. The same is true for wetlands where generation of alternative livelihoods is possible [Step 3]. Livelihood alternatives considering people's perceptions, needs, and factors influencing livelihood choices must be asserted in this case (Wright et al. 2016; Wood and Halsema 2008). Wood et al. (2013) argue that wetland conservation and livelihood goals could be integrated where this is not possible. Therefore, continuous monitoring of wetland ecological states is necessary to ensure that well-meant livelihood and food security

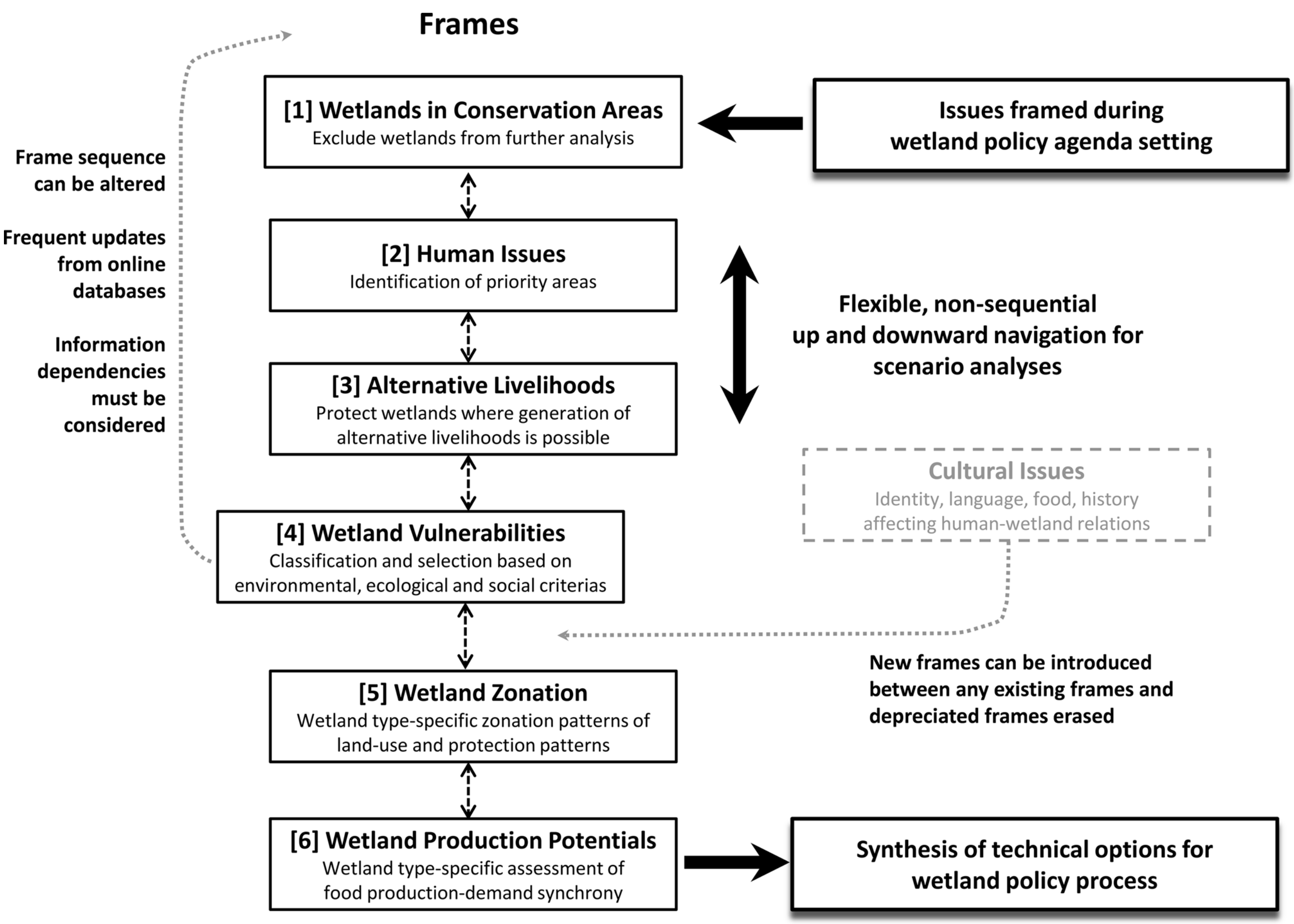

Fig. 7 Decision framework for identifying technical options for reconciling wetland conservation with human needs during the wetland policy process. Details are given in the text

generating wetland use policies do not lead to their unintended deterioration (Kotze and Wood 2021).

Classifying wetlands according to environmental, ecological and social criteria, and protecting those particularly vulnerable to human intervention is of central importance in wetland policy-making [Step 4]. Consequently, morphological, hydrological, soil and climate classifications are important, because they are major determinants of biophysical wetland characteristics. In addition, complementary spatial-temporal classification of plant-functional types provides information about biodiversity, ecological vulnerability, vegetation dynamics, and other landscape characteristics determining ecological wetland functions and their resilience to human interventions. People near wetlands have detailed knowledge about environmental characteristics their communities share and apply in generating livelihoods from wetland resources. Hence, collecting and classifying information about local relations between people and wetlands strengthens such understanding.

Protected and cultivated zones are identified in those wetland types which are particularly suitable for food production [Step 5]. There was unanimous agreement among policy analysts in our group that their landscape ecological functions must be maintained at all costs to prevent environmental deterioration. Maintaining eco-hydrological functions of used wetlands (Thorslund 2017) can be further promoted through nature-based design of cropping systems (Malézieux 2012). Production potentials of wetlands suitable for food production are determined during the final step of the technical framework [Step 6]. Fermont (2011) argues that yield concepts may take different forms, depending on whether they are established by sociologists, agronomists, or economists. Therefore, this needs to be accounted for when establishing policies for smallholder farming development in East-African wetlands. Adopting a nature-based wetland zonation design principle would further require an extension of crop species selection criteria towards hydro-ecological functionality. This could be achieved by applying information about wetland plant-functional type characteristics (Moor et al. 2017) in designing agro-ecological zonation patterns and cropping systems (Faucon et al. 2017; Langensiepen et al. 2020; Wojtkowski 2019).

Focusing on technical framing of wetland conservation versus food production conflicts without considering wider socio-political contexts was a major reason why policy-analysts of our group became skeptical about the political relevance of the taxonomic approach just explained. **Political framing** of wetland issues during the agenda setting phase would have been required to understand how technical solutions are contested among actor coalitions, why political power asynchronies emerge and which wetland governance approaches could be developed based on this information. Wetlands in our study region were all officially government-owned and either partially protected, excluded from settlements and agriculture (Kenya, Uganda, Tanzania) or land-use regulated through development plans (Rwanda). *De facto* use and land ownerships were, however, often regulated by customary rights, historic land use practices and, occasionally, through title deeds. Increasing destruction of wetlands, limited law enforcement, demographic growth and associated demands for food, fodder, fiber, livelihoods, water, energy, industrialization, housing and infrastructure constitute multi-dimensional wetland conflicts high on East-Africa's environmental policy agendas. A method supporting social deliberation and political framing of multi-dimensional wetland issues across scales of wetland governance would have been required to inform the wetland policy development process (Fig. 6 right). The motivation for developing a new wetland policy framework was to support such exchange during agenda setting and policy formulation.

Addressing local wetland issues is of particular relevance for national environmental policy-making, because they are most nuanced and varied at this level. Based on thousands of cases explored under different political circumstances and literature studies, Mortensen et al. (2022) identified four key variables explaining local policy agendas: Institutions, problems, elections and actors. For wetland policy-making this implies, that public administration institutions are responsible for (1) structuring inputs and outputs of the wetland agenda-setting process, (2) problem analysis leading to the identification of issues of high concern and (3) facilitating communication between local and national policy-environments. Advocacy coalitions among different wetland actor groups contest for priorities on the wetland agenda and elections determine political power relations affecting wetland management and legislation. Measurability of problem strengths is of high importance, social and ecological characteristics of wetlands must be integrated, and information designed to enable policy-analysts to comprehend and manage large streams of information for developing policy scenarios. The following section describes a new information design method we developed for this purpose.

Information Design

The new method we have developed is called Cognitive-Driven Information Design (CDID). We describe it in three parts in this subsection: First, we explain what we mean by information in the context of wetland policy making. We then explain why cognitive-driven processing of such information is of particular relevance in developing wetland policy decision scenarios. We propose it for overcoming the many limitations of prescriptive decision making and wetland policy design. The third part discusses how CDID can be implemented from a methodological point of view. Further details about its integration in the wetland policy process are given in the following subsections.

Information about socio-ecological wetland characteristics is composed of facts, meanings and ethical values which must be understood for developing political decision scenarios. Wetland facts are primarily expressed by numbers such as species densities, land-use allocation or seasonal water balance. Wetland actors perceive these facts in different ways and therefore assign different meanings to them. Water is (i) of fundamental ecosystem importance to a wetland ecologist, (ii) a production resource to a farmer, and (iii) an aesthetic feature to a tourist. These meanings are established, communicated, and debated through exchanges of signs (Valsiner 2016). Signs are constructed by social processes through triadic interactions between self, others and objects (Zittoun and Gillespie 2016; Peirce 1878; Chandler 2017). For a brick-maker wetland soil is (i) some material for building houses, for a farmer (ii) an important livelihood for crop production, for an environmentalist (iii) the basis of ecosystem health, and for a city dweller it is (iv) likely not important at all. These and other actors do not live in isolation, but continuously debate wetland meanings and values in different social constellations, and this often entails formation of actor coalitions based on value deliberation. Outcomes of these debates are communicated in and among actor coalitions, through government institutional information networks, as well as in the press, media and various internet outlets. Analyzing such narratives using qualitative text analysis reveals actor-related patterns of wetland facts, meanings and values (Bazeley 2018, Shanahan et al. 2018). Integrating them is not a trivial task because qualitative information (i.e. words, images) must be associated with quantitative information (i.e. numbers). Various methods can be employed for this purpose such as the concept of ecosystem services (Westman 1977; Hein 2010; Boeraeve et al. 2015; O'Neill 2017), mixed method design (Creswell 2017), or socio-ecological systems analysis (Biggs et al. 2022). These methods are employed in an attempt to establish coherence between qualitative and quantitative information, often through statistical quantification of qualitative information. This approach is problematic for three reasons: First, meanings and values become normalized hence, not contestable during social deliberation of wetland issues during the agenda setting, decision-scenarios and wetland policy formulation phases. Second, normalization hampers human decision-making about socio-ecological wetland futures because it is of little importance in unconscious thinking as further explained below. Third, the compulsion to think coherently is incompatible with the psychology of human decision-making (Olsson 2005; Evans 2008). Following Bazeley (2018), decision analysts freed from thinking about data and methods in binary terms will conduct problem-oriented searches for information, take differences in data sources into account, and apply their cognitive skills in analyzing them. CDID is based on this thinking.

Political decision-making is driven by search for possible solutions to issues identified during agenda setting (Fig. 6). Interpretation of associated policy-relevant information is augmented through linkages between deliberative and emotional coherences (Cairney and Kwiatkowski 2017; Thagard and Kroon 2010). Mental models play an important role in human decision-making. Banasiewicz (2019) terms them as neural networks-stored 'collections' which are flawed by cognitive bias when information is uncertain, i.e. bounded rationality (Gigerenzer 2021). According to one school of thought, uncertainty can be dealt with by application of cognitive heuristic search, stopping and decision rules that are adapted fast-and-frugally to the decision environment through ecological rationality (Gigerenzer and Gaissmaier 2011). Such decision-making is appealing but bears the risk of missing out important criteria which are potentially important in policy-making such as climate change (Evans 2017). Another school of thought argues that decisions evolve from slow reflective processes in conscious memory which are endorsed by fast intuitive processes in unconscious memory (Evans and Stanovich 2013). Application of both schools of thought in political decision-making is attractive, because heuristic search for policy solutions can be combined with rational approaches. It also acknowledges the role of emotions in decision-making (Cairney and Kwiatkowski 2017; Evans 2008; Groome 2021). In general, advancements in cognitive science have a high potential to improve environmental policy development from a psychological perspective which has been largely neglected so far. Computers cannot mimic the complexity of human decision-making. We should let them do what they can do best, analyze data and inform, rather than explain (Cukier and Mayer-Schoenberger 2013). Human strengths lie in cognitive processes guiding judgments and decisions (Eysenck and Keane 2010). CDID supports these processes in wetland policy-making in five ways:

1. Data science can be employed to integrate vast amounts of wetland facts, meanings, and values with their associated uncertainties incomprehensible to human minds.
2. Visualization and narration improves cognitive perception, attention and mental processing of socio-ecological wetland information.
3. Cognitive-driven information retrieval and related database design overcome human working memory limitations in wetland decision-making.
4. Statistical analyses support heuristic unconscious memory processes in search for solutions for wetland conflicts under uncertainty.
5. Value-based scenario-analysis and modeling support reflective conscious memory processes in wetland decision-making.

Wetland decision-analysts continuously exchange information with stakeholders, actor coalitions and relevant government institutions each having their own ways of interpreting wetland socio-ecologies and taking decisions. A network of distributed cognition is thereby created which facilitates social deliberation of plural wetland values during decision-making and policy formulation. Processing such information before the policy formulation phase makes wetland policy-making more flexible, informed and targeted, because all those concerned with wetland issues are considered or included in the wetland decision-making process. To our knowledge, principles of individual and distributed cognition have not been applied in wetland policy-design so far. Establishing wetland decision scenarios through CDID requires socio-ecological data collected at monthly (ecosystem information) and annual (social information) intervals at local, regional and national scales. Surprise events such as the ones we experienced in the mountainous regions of Rwanda (severe wetland flooding), Uganda (erratic stakeholder conflicts) or semi-arid North of Kenya (multidimensional violent conflicts about wetland access and use) should also be accounted for. All information is initially extrapolated into the immediate future (months, years) using descriptive, stochastic or multivariate time-series analyses, and visualized on the computer screen on cognitive demand of wetland policy-analysts. Making sense of this unrelated information requires associative thinking driven by experience and memory processes (Eysenck and Keane 2010). In the wetland policy-process, this includes, for example, associations between wetland ecosystem states (vegetation communities, nutrition concentrations, hydrology, etc.), wetland meanings for different stakeholders (livelihood, water purification, grazing ground for herders, tourism, etc.), associated values of wetlands' contributions to people (food, pest regulation, recreation, etc.) and intrinsic values (functional biodiversity, landscape ecology, etc.). Experienced wetland analysts can apply their analytical skills and intuition in analyzing this information and identify political decision scenarios. Their cognitive capacities enable them to identify complex patterns and relationships in such data and to develop an understanding of wetland socio-ecological system dynamics requiring policy intervention. Search for such solutions is supported by data analyzing, artificial intelligence and information visualization tools implemented in CDID (e.g. Lindquist 2015). It is important to emphasize that these tools are made available on cognitive demand, not prescribed. The same applies to the use of socio-ecological wetland models which can be employed in scenario analyses and guide search for long-term solutions. The advantage of coupling real-time information processing in CDID with long-term model prediction is that stored trajectories of wetland meanings and values difficult to forecast become empirically accessible retrospectively. Employing adaptive non-generic modeling concepts, this opens opportunities for parameterizing site-specific models of socio-ecological wetland systems which can be employed in the development of wetland socio-ecological futures. The general principle of CDID is however that policy decisions are based on real-time information, not models which are only used for guiding search for future solutions.

Valuing

Following our donor's grant policy, we focused the valuation of the four studied wetlands (Fig. 3) on two important issues, conservation and human needs. Human needs for food were quantified by economic household and market analyses. Human health issues comprised studies on wetland water sanitation, parasite spreading under different use and climate scenarios, human health behavior, mental health and socio-ecological effects on malaria dynamics. Wetland food production potentials were experimentally characterized through yield gap analyses. Human nutritional analyses were not carried out. Other material contributions such as fish, fodder, roof thatching material, soil mud for brick-making or availability of medicinal plants were also not assessed. Conservation criteria were established through comparative vegetation classifications conducted in wetlands with different use intensities, regeneration trials in previously agriculturally-used wetland patches and zoological assessments of arthropod diversity and densities. Alternative use options were assessed by trade-off analyzes between human needs and conservation requirements through economic valuation of ecosystem services. Scenarios for sustainable agricultural intensification were established using information from a scenario-development workshop. Models simulating hydrological catchment processes, agent-based economic household behaviors and crop growth were also applied. Apart from difficulties associated with translating this information into a wetland decision-making tool (lessons 1–4) principally basing valuation on the dichotomy between intrinsic (wetland conservation criteria) and instrumental (human needs) values has its own limitations because they are impossible to reconcile as shown in Fig. 4A. Rejecting the either/or mentality of this approach Himes and Muraca (2018) propose that something can be valued "(1) in virtue of its relation to other objects, but independently of human needs, meanings, interests or preferences …or (2) in virtue of its specific relations to people". Chan et al. (2018) define such relational values as "preferences, principles, and virtues about/based on meaning-saturated relationships." Although relational valuation solves the problem of the intrinsic/instrumental value dichotomy, the question remains however if realistic wetland decision-making can be based on assessing values of conservation and human need characteristics alone. Many aspects related to wetland sociologies, stakeholder interests, cultural, spiritual, religious and environmental psychological dimensions are not considered in such narrow approach. This is the reason why reconciling wetland conservation with human needs must be framed against other relevant issues on the wetland agenda, as has been mentioned before. This can be achieved through application of the plural valuation concept by Jacobs et al. (2020) which integrates policy-relevant values through collective, iterative deliberation of values by all actors concerned with wetland issues.

RAMSAR based its wetland valuation recommendation (Kumar et al. 2017) on a preliminary framework of IPBES (2016) which has been recently revised (IPBES 2022). This revision includes the plural valuation concept of Jacobs et al. (2020) and Life Frames of Values concept of O'Connor and Kenter (2019) in which people-nature relations are considered from four perspectives: (i) living *from* nature; (ii) living *with* nature; (iii) living *in* nature; (iv) living *as* nature. Living *from* wetlands entails food production, fishing, herding, brick-making, and generation of livelihoods for example. Living *with* wetlands means taking responsibilities for maintaining ecosystem functions, biodiversity and conservation. Living *in* wetlands relates to how aesthetics, beauty, wildlife, flora, spirituality and other features related to psychological well-being and recreation are perceived. The concept of living *as* nature addresses oneness between nature and people and was recently added to the IPBES valuation framework because it has been politically undervalued in the past. In essence, it provides opportunities for plural inclusions of utilitarian and non-utilitarian ethics which cannot be easily reconciled by present valuation approaches (Kenter and O'Connor 2022). However, operationalizing the concept in wetland valuation practice does not seem straightforward. It would be based on the assumption that people living in the vicinities of wetlands are tightly in tune with their environments which is often not the case anymore, because modernity substantially alienated them from nature. Following IPBES (2022), applying the living *as* nature concept in wetland valuation would be an advisable strategy for RAMSAR to reduce the resulting negative impacts on wetland ecosystems. This is perhaps not totally unrealistic, but requires great educational and scientific efforts and policies supporting the implementation of the learned experiences in practice. Rutter et al. (2022) for example demonstrated that awareness of wetland ecological benefits and a stronger sense of connection to wetlands resulted into a greater willingness to participate in wildlife recreation in wetlands and conservation. McInnes et al. (2020) further stress that citizen science is increasingly recognized as a valuable approach to make wetland management more robust. There are also methodological hurdles to be tackled. In their living *as* concept, Kenter and O'Connor (2022) encapsulated intrinsic values as a social concept termed as 'articulated intrinsic values', but wetlands are not only socially constructed as is particularly the case with strictly conserved wetlands. To become operational this concept must be complemented by comparative ecological studies conducted in conserved and used wetlands to understand ecological consequences of human interventions. Applying the Nature-based Solution concept has a high potential to improve socio-political framing of wetland socio-ecological issues (e.g. following Palomo et al. 2021).

Decision-Scenarios

Value integration can be seen as a decision process based on reconciling multiple value frames (Kenter and O'Connor 2022). To achieve this goal, technical information about socio-ecological values, states and trends of contested wetland types are first analyzed, visualized and alternative technical solutions explored. Stakeholder's and actor's attitudes towards wetland meanings and values are subsequently assessed using CDID's narrative analysis tools yielding information about value constellations, formation of advocacy coalitions and power relations. It will likely become apparent then that realistic solutions of the conservation versus human needs conflict must be framed against interests and values expressed by other wetland actor coalitions. Reconciling such plural values poses a 'wicked' political problem characterized by uncertainties embedded in divergent interpretations, relationships and sense-making (Head 2022). DeWulf and Biesbroek (2018) suggest a framework for analyzing such uncertainties which can be employed for making wetland policy design more effective and targeted. They distinguish between three sources determining the nature of uncertainty: Ontological uncertainty (e.g. unpredictability of wetland resilience to climate change), epistemic uncertainty (e.g. incomplete knowledge about human-wetland relations) and ambiguity (e.g. multiple wetland meanings and knowledge). They further distinguish between three objects of uncertainty: Substantive uncertainty (e.g. incomplete understanding about the nature of wetland issues), strategic uncertainty (e.g. different government actors choose to compete or collaborate) and institutional uncertainty (e.g. opaque wetland management rules in government institutions). Relating these uncertainties reveal interdependencies among uncertainties which can guide search for solutions on the wetland policy agenda. Stakeholder collaboration is necessary for this purpose (Head 2022) and government forms and practices must be considered in this context. Governments in Kenya, Uganda, Rwanda and Tanzania apply different policy approaches ranging between participation and domination (Hyden and Onyango 2021) and also vary with respect to administrative decentralization (Wanyande 2021; Singiza 2020; Reyntjens 2013). Wetland policy-design has to be streamlined towards these different government forms and also consider realities on the ground. For instance, stakeholder participation is still regarded as self-help rather than civic right, colonial traditions are still in the people's minds (Wanyande 2021), governance influenced by centralized state nostalgias (Singiza 2020), and ethnic conflicts only partially solved through devolution (Hassan 2019).

Returning to our case, it is getting clear against this backdrop why policy analysts in our group became critical about the missing relevance of technical decision-support we had provided. It had completely ignored the complexity of wetland policy design. In searching for solutions, we noted that, regardless of government form, wetland policy analysts play a fundamental role in moderating value deliberation among stakeholders which would be otherwise much more untargeted. Moderating the wetland policy-formulation process enables them to explore tensions between actors and steer debates towards reconciliation of wetland values. However, this does not imply that technical details do not matter overall in wetland policy design, because socio-political decisions about wetland futures have technical consequences. Policy solutions must hence take both, political and technical issues of wetland management with their associated uncertainties, into account. We hence see wetland policy formation not as a straightforward rational process, but as a management strategy to reduce uncertainties in wetland policy design through social deliberation of decision-scenarios based on value reconciliation (Fig. 6). CDID has been developed to achieve this aim. Introduction to wetland policy-making practice requires sufficient time and testing. It is appropriate to start simple and then add sophistication as needed (Gregory et al. 2012). CDID design requires effective communication with wetland policy-analysts to understand what is really needed (Cairney and Kwiatkowski 2017). Decision options often have to be prepared on short notice, sometimes within hours. Processing and visualizing information have to be fast, comprehensible, interactive, flexible, robust and highly automated for this purpose. Such analytical machinery must also provide room for reflection and long-term planning. Implementing and testing CDID in practical wetland policy-making will thus likely take several years and is best carried out in three consecutive phases:

Phase 1

The initial version is built on information about existing decision-making cultures and socio-technical wetland management infrastructures in wetland policy-making environments explored through policy and institutional analyses. It supports experienced wetland decision-analysts with integrated information established through known quantitative, evidence-based valuation approaches. The technical decision-framework depicted in Fig. 7 can be applied in reconciling conservation with human needs using wetland type-specific vulnerability criteria and information about current ecological states. Resilience to human influences may be quantified through spatial-temporal scenario analyses if landscape ecological information is available. Successful implementation requires framing against wetland agendas from other policy sectors.

Phase 2

Quantitative wetland ecosystem information is increasingly interpreted in socio-political contexts to identify and explore meanings stakeholders associate with wetland characteristics. This strategy is motivated by the Narrative Policy Framework (NPF) which emphasizes the importance of narrative communication and cognition in public policy (Jones et al. 2014). Narratives are typically composed of four elements, (i) a setting description, (ii) a story plot shaped by (iii) human characters and (iv) a story morale suggesting a policy solution (Jones and McBeth 2010). The purpose of narrative analysis is to capture political perceptions at micro-, meso- and macro-levels of governance and estimate their effects on the policy system (Shanahan et al. 2018). Qualitative data mining and analyzing methods are adopted in CDID to assist policy-analysts in narrative analysis. The main advantage of this approach is that wetland decision-analysts do not have to assign meanings to wetland policy issues all by themselves, but are computer-assisted in this cognitive task.

Phase 3

Full functionalities of CDID and the wetland policy process framework (Fig. 6) are established during the third phase by introducing value reconciliation to wetland decision-making. Narrative analysis has to be extended towards the identification of Life Framework of Values for this purpose (Kenter and O’Connor 2022; IPBES 2022). Wetland policy analysts can use this information then for establishing socio-ecological wetland scenarios with CDID for identifying value constellations that are feasible from wetland political points of view. The ultimate goal is to reduce uncertainties in policy design and identify decision options for developing wetland policies. If this is not possible with an existing set of values, corrective measures would involve (a) re-valuing of wetland characteristics at stake, (b) re-analysis of available information or (c) even re-framing of wetland issues (Fig. 6 right).

Once relations between chosen wetland values have been reconciled, likely decisions scenarios are formulated by wetland policy analysts and scenarios illustrated for the following policy formulation phase. CDID is used for visualizing the resulting information for different actors of the wetland policy formulation process (i.e. government institutions, public administration, stakeholders, public, etc.). The advantage of swapping the decision-making and policy-formulation phases in the classical policy cycle model becomes apparent at this point. Instead of letting decision scenarios evolve from fuzzy information exchange among different actors and advocacy coalitions during the policy-formulation process (Fig. 6 left), they are supplied with well analyzed, integrated and visualized wetland decision scenarios prepared by senior wetland policy analysts making deliberations more informed, targeted and timely efficient (Fig. 6 right). It is important to note that decision scenarios are not prescriptive, but meant as comprehensive information for open-ended discussions during the following policy-formulation phase. Narrative and visualization techniques are applied in CDID to supply involved actors with storylines and scenarios from which policy objectives can be derived.

Policy Formulation and decision-taking

Wetland policy formulation starts with conceptualizing policy solutions to wetland conflicts based on the outcomes of the valuation and decision-scenario phases. Trade-offs between legitimate public demands for action and political resources need to be addressed (Jordan and Turnpenny 2015). Based on long-term experience in Ugandan wetland policy-practice, Bakema and Mafabi (2003) recommend organizing the wetland policy formulation process as a participatory bottom-up exercise in which actors not only become responsible owners of wetland resources, but also get involved in generating ideas how to manage them. Kenter et al. (2016) stress that environmental policies become more robust and legitimate when based on social deliberation of shared meanings and values. Social construction of meanings is also one of the core principles of the Narrative Policy Framework which emphasizes the importance of individual narratives in processing information, communication and policy-making (Shanahan et al. 2017). In a study conducted in the Lukanga wetlands of Zambia, for example, Mapedza et al. (2012) compared RAMSAR's conservation narrative, state-based narratives from different sectors and narratives of local communities with each other to reveal power asymmetries across society which contributes to the improvement of wetland policy design. Wetland policy analysts can act as knowledge-brokers in these processes through stimulating discussions with comprehensive insights into problem structures gained during the preceding decision-scenario phase (Knill and Tosun 2020). In spite of their advanced experiences, policy analysts might still unconsciously introduce bias to their judgments. Yet, by exposing wetland decision options to social deliberation during policy formulation, a network of distributed cognition is created which can efficiently deal with this problem, reduce uncertainties in policy design and manage power asymmetries at the same time. How the results are processed during the policy formulation phase depends on government form and administrative structure. Application of the Social Construction of the Targeted Population Framework (Pierce et al. 2014) and Advocacy Coalition Framework (Jenkins-Smith 2018) might be considered.

The decision-taking phase (Fig. 6) is initiated by consultations between governing politicians, their wetland-policy advisors and potential beneficiaries who elaborate and chose wetland policy options identified during the preceding policy formulation phase. Wetland policy objectives should be checked, feasibilities of policy instruments elaborated, and public administration support sought. Formulations of laws, by-laws and land-use policies have been identified as important instruments in East-African wetland policy design. Challenges associated with their implementation and enforcement in reality should not be underestimated. Access to protected wetlands and fragmentation of land-tenure systems should be controlled. Economic incentives and educational measures are suitable instruments for gaining public acceptance of wetland policies. On a larger scale, international trans-boundary wetland issues must be regulated.

Policy-layers, scaling information in institutional frameworks and data sharing policies have been identified as important issues in East-African wetland policy design. While definitely important, the initial version of this wetland policy-making framework cannot support complex cross-sectoral policy-formulation and decision-taking practices. Its prime purpose is to assist wetland policy analysts in analyzing available information, structuring, interpreting, valuing, deliberating decision scenarios and preparing wetland policies for governmental decision-taking. That does not imply that its functionality cannot be extended towards cross-sectoral policy-making after its initial objectives have been reached. Nonetheless, thorough testing under practical policy-making conditions is required before further extensions can be considered.

Policy Implementation and Evaluation

Wetland policy implementation is carried out to a large extent by environmental extension officers who use their own discretion to satisfy policy objectives under practical constraints. It is important that wetland policies are clearly formulated for this purpose and related to concrete wetland socio-cultures of the regions where they are implemented. Consideration of human issues, wetland socio-ecologies, values and reflection on long-term consequences during wetland policy formulation improves acceptance of wetland polices under local conditions. Institutional support is required and sufficient financial resources committed to policy implementation.

CDID not only supports decision-making, but can also be used for tracing gaps between wetland policy intent and outcome during the implementation and evaluation phases. It is useful to set benchmark criteria during the policy-formulation phase for this purpose based on wetland policy objectives. Establishing long-term wetland ecosystem monitoring networks based on experiences collected in the Long-Term Ecological Research (Willig and Walker 2016) and FLUXNET (Delwiche 2021; Baldocchi et al. 2001) networks for example would enable wetland policy analysts to compare policy outcomes against reality and adjust decision-making accordingly. Based on a 10-year case study conducted in Zambia and Malawi, Kotze and Wood (2021) strongly recommend that long-term monitoring of ecological wetland health is necessary to ensure that well-meant livelihood and food security generating wetland use policies do not lead to unintended deteriorations of wetlands.

Other causes of gaps could be traced as well, such as changing wetland agendas, poor policy design, institutional barriers, policy resistance or weak political support. Whatever the causes are, it is difficult to find objective criteria for measuring wetland policy successes. Application of the framework shown in Fig. 7 can provide evidences to what extent the policy objective of reconciling wetland conservation with human needs is technically achievable. Political achievements can be measured by analyzing outcomes of value deliberations, changes in power dynamics, and popularity of political opinions. Wetland policy evaluation can thus be regarded as part of the policy making process. CDID is also helpful at this stage, because it can be used as an instrument for tracing changes in wetland policies.

Conclusion

Developing wetland policies for reconciling wetland conservation with human needs cannot be based on scientific-technical deliberation of socio-ecological facts alone, because they are largely determined by stakeholders, actor coalitions, power relations, wider political contexts, institutional arrangements, and government forms and practices where uncertainties, emotions and social deliberation matter. Managing this entangled matter requires a political-psychological approach which we have developed to assist wetland policy-analysts in developing policy solutions.

Wetland scientists have the choice to remain in their comfort zone or to engage in the policy arena where the futures of wetlands are determined. They are needed to ensure that political deliberations about wetland futures are informed by wetland science.

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