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Combining Expert and Stakeholder Knowledge to Define Water Management Priorities in the Mékrou River Basin

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Abstract: Participatory approaches to water management, and specifically to transboundary river management, have been widely applied over recent decades. Regarding transboundary rivers, the active involvement of key actors in policy planning is of great importance. In this context, a participatory approach has been used to identify sectors of interest and priorities related to water and development in the Mékrou transboundary River Basin involving three countries: Benin, Burkina Faso and Niger. We conducted a web-based survey to quantify expert opinion on sectors of water management policy and priorities for the Mékrou River Basin. The same set of questions was then put to a sample of local stakeholders living in this river basin. Our analysis reveals some points of convergence and some discrepancies between the opinions of experts and local stakeholders. Overall, it provides a comparative analysis of how experts and local stakeholders prioritize water policy measures, which could influence decision-making.

Keywords: participatory approaches; water; river basin; water management; web-survey; stakeholders

1. Introduction

Given the complex nature of water management problems, a flexible and transparent decision-making process is required in order to account for the diversity of knowledge and values [1]. For this reason, expert knowledge and stakeholder participation have been increasingly used in river basin modeling and, more generally, in environmental decision-making [2].

In this paper, we propose a participatory approach to elicit expert and local stakeholder opinions on sectors of interest and on policy priorities related to water management in the Mékrou River Basin, a transboundary river basin located in West Africa. Following the existing literature, we define here "experts" as those persons whose knowledge of the subject of interest (in our case water management in West Africa) has been gained through his/her life experience, education or training, while a stakeholder is a person or entity with a declared or conceivable interest or stake in a policy concern [3].

The Mékrou River Basin has some specific characteristics. First, it is a transboundary river basin shared by three countries, namely Benin, Burkina Faso and Niger. The transboundary nature of this basin raises some important political and management challenges. Second, the Mékrou River Basin is characterized by an underdeveloped water infrastructure and the presence of vulnerable communities (malnutrition, poverty, and reduced security). Third, there are specific hydro-climatic trends. The mean seasonal temperature has risen by approximately 1 °C between 1970 and 2006, while the frequency of floods and the area covered by flooding have increased in the greater region over the past 24 years, with up to 10 floods occurring during this period [4]. Fourth, there is a lack of coherent and long-term data series related to the climatic, hydrological and socioeconomic characteristics of the Mékrou River Basin. These four characteristics of the Mékrou River Basin pose a challenge to the development of an integrated water management approach. They also provide strong motivation to rely on expert and local stakeholder opinions to identify and assess water-related policies and provide recommendations for water-management priorities.

The opinions and knowledge of experts and stakeholders have often been included in participatory approaches to water management. Dong *et al.* [5] have recently reviewed the existing research on scenario development in water-resource management. Despite the wide variety of settings, scales, and geographic characteristics considered in the reviewed articles, Dong *et al.* [5] indicate that most studies follow the same general procedure in developing scenarios regarding water resources. In particular, Dong *et al.* [5] indicate that there is a general tendency to rely on expert judgment and on stakeholder involvement when "defining focal questions and main driving forces, and identifying main sources of uncertainty". The opinions and knowledge of experts and stakeholders can be elicited and combined in several ways. This is the central topic we develop and explore in this paper.

More specifically, the main goal of our work is to elicit and analyze the opinions of experts and local stakeholders regarding priorities related to water management in the Mékrou transboundary River Basin. This paper addresses the following research questions: (a) to which extent experts and local stakeholders share similar opinions on water management priorities; and (b) how decision making and project planning can be benefited by ranking water-management priorities based on expert and stakeholder opinions. In order to address these research questions, we present the results of a survey of experts and stakeholders carried out at an early development stage of an integrated water modeling approach at a river-basin scale. We conducted a web-based survey to quantify expert opinions on sectors of interest and priorities related to water and development in the Mékrou transboundary River Basin. The same questions were put to a sample of local stakeholders living in this river basin. In Section 2 of the paper, we present the case study area and the theoretical framework. In Section 3, we describe the design and the implementation of the expert and local stakeholder surveys. In Section 4, we present the empirical results and we make some policy recommendations in Section 5.

2. The Selected Area and the Theoretical Framework

2.1. The Mékrou River Basin

The Mékrou River Basin (Figure 1) is a sub-basin of the wider Niger River Basin, and covers an area of 10,635 km^2 or about 3% of the total Niger River Basin area. The transboundary Mékrou River Basin is distributed across Benin (80%), Burkina Faso (10%) and Niger (10%). It is characterized by underdeveloped infrastructures and weak socioeconomic conditions. Due to water scarcity, there are emerging risks of local and transboundary water conflicts, which may constrain the region's economic growth. However, practices of transboundary water cooperation are also emerging, which support regional integration as a driver of growth. In this context, Benin and Niger have signed a cooperation agreement for the construction of the Dyodyonga Dam on the Mékrou River. In the Mékrou River Basin, arable land is mainly used for food production and for raising cattle. Agriculture is the key

sector of the economy in the three riparian countries, and is critical for poverty alleviation and for food security. The Mékrou River Basin also includes a very important transboundary natural park, the "W Park" (Ramsar site) [6]. The W Park is known for its large mammals, including baboons, buffaloes, elephants, giraffes, hippopotamuses, leopards and lions.

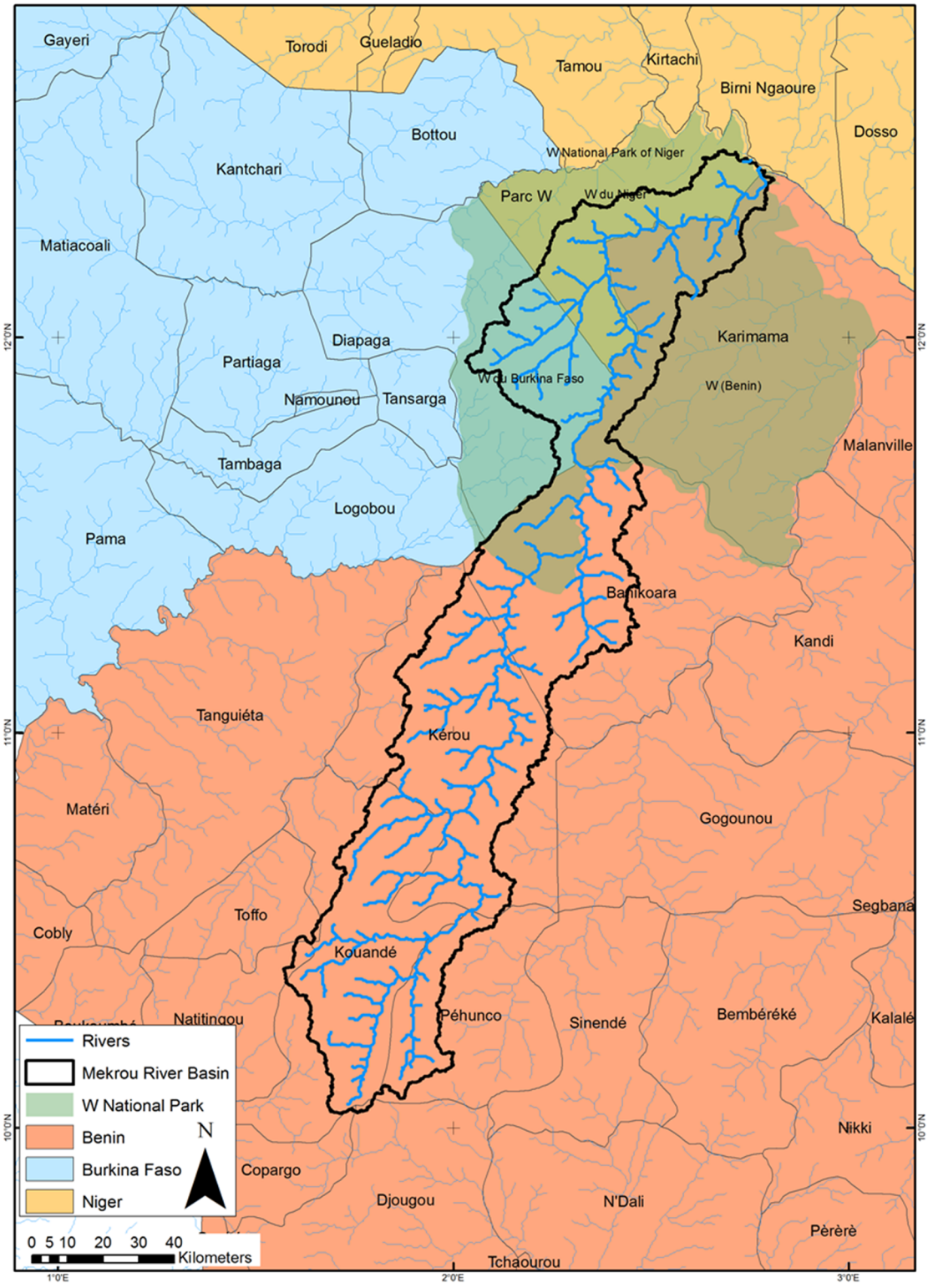

Figure 1. Location of the Mékrou River Basin.

The water resources of the Mékrou River are used in several ways, such as domestic consumption, crop irrigation, animal production, fishing and fish farming, recreation and religious practices. In the transboundary basin of the Mékrou River, the need for clean drinking water in 2014 is estimated at 3,106,242 m^3 (1,957,358 m^3 for urban areas and 1,148,884 m^3 for rural areas), serving a total population of 280,000 inhabitants. The main pressures on water resources come from production activities, which include activities related to agriculture, livestock, fisheries, forests, hunting, mining, industry and energy.

Our preliminary investigations and discussions with local authorities responsible for water management in the Mékrou River Basin revealed that the level of knowledge, both from a hydrological (water availability, water variability, and water quality) and a socioeconomic perspective (water needs, types of water use, and anthropogenic pressures), is very limited for this specific basin.

2.2. Expert and Stakeholder Opinions: The Scientific Basis

The inclusion of expert and stakeholder knowledge in decision making is crucial for water management policies, particularly with respect to transboundary river basins. Although water management has traditionally been influenced by water experts from governmental and research organizations [7], the use of the local knowledge of stakeholders has recently emerged as a complementary approach. The rationale is that experts and stakeholders may have different perspectives, values and motivations, which lead to different forms of knowledge and measures that can be used in decision-making regarding water [8].

While experts hold scientific knowledge that is based on scientific facts, models and methods [9], the knowledge of stakeholders is based on experiences related to context or location [10], and provides local insights related to their daily activities. In this context, Edelenbos [11] analyzed the co-production of knowledge by experts, bureaucrats and stakeholders in two Dutch water-management projects. He also explored the impact of the combined knowledge on the decision-making process. The combination of stakeholder and expert input to decision-making [11] provides an integrated methodological framework for co-valuing the spatial issues of water management. In another study, [12] a survey was carried out of the general population and of a group of marine experts in order to assess marine management pressures and priorities in the Azores archipelago. A comprehensive analysis by Chow [13] used both experts and stakeholders to assess the weights to be given in a multi-criteria decision-making approach for land-use planning. This was achieved through an iterative survey of local stakeholders and external experts.

Experts are often asked to advise on complex environmental issues. However, their role as policy advisers is not always clearly defined. In an effort to summarize the role of expert opinions, Spruijt [14] presents an overview of the interdisciplinary literature on the roles of scientific experts when advising policymakers on complex issues, and in particular on the factors that influence these roles. Based on a structured literature search (267 publications were reviewed in total), this study demonstrates that experts' opinions vary depending on their roles. Recently, Jones [15] used a discrete choice survey method to elicit the opinions of both experts and farmers on the relative effectiveness and practicality of mitigation measures to reduce greenhouse gas emissions from sheep production systems. This method has enabled individual mitigation measures to be ranked on a ratio scale of effectiveness (expert opinion) and practicality (farmer opinion).

It is often the case that a degree of uncertainty accompanies expert judgments, since their estimates are based on different experiences, knowledge of environmental systems, or anecdotal observations. Addressing the consistency of expert opinions, Giannetti [16] analyzed a procedure that uses different expert opinions in constructing a composite environmental index. For this, a sensitivity analysis of the environmental sustainability index was used as an example to assess the reliability of expert opinions. The study has revealed the existence of uncertainty due to disagreements in expert opinions, clearly indicating that they are insufficient to monitor and measure the actual environment.

Analyzing the different opinions of stakeholder groups regarding participatory water management planning, Baggett [17] proposed a web-based survey of four stakeholder groups (Regulators, Water Managers, Researchers, and Customers). This type of survey has been selected to provide effective and credible sources of information at reduced application costs. In another study [18] that explores stakeholder knowledge about the transformation of water governance, stakeholders' opinions were collected from the Middle Manyame sub-catchment area (Zimbabwe). This paper revealed that the majority of stakeholders in the study area did not have much knowledge on the reformed water governance institutions, an element that put pressure on policy makers to follow more participatory approaches. In the study of Lorance [19], stakeholders' knowledge was collected through questionnaires in order to identify regional management issues and solutions for several deep-water fisheries. This case study demonstrated how stakeholder involvement and the use of qualitative and quantitative data both improved management processes and fish stock assessments, when data are limited. Morgan-Davies and Waterhouse [20] relied on an adaptive joint analysis survey to assess stakeholders' preferences for policy priorities and their trade-offs for the management of the hill areas of Scotland.

3. Design, Implementation and Validity of Surveys

3.1. Design

Different methods can be used to accurately elicit expert and stakeholder opinions [21]. Among the most frequently used survey techniques are telephone interviews, in-person (face-to-face) interviews, mailed questionnaires and web-based questionnaires. According to Assefa [22], the factors that determine the data collection method to be employed include the type and depth of information needed, ease of data quantification, scale of applicability, representativeness, staff requirements, time constraints and cost constraints. How these factors were incorporated in this study is further analyzed in this section. We have used a questionnaire that aimed to identify three important issues for building a river management plan: the relevant economic sectors of interest, the policy priorities per sector, and the long-term drivers affecting water management in the Mékrou River Basin.

We have chosen to use a questionnaire approach in order to elicit expert and stakeholder opinions. Experts were selected based on their knowledge of water management issues in the Mékrou River Basin (or more generally in West Africa) gained through their life experience, education or training. To build our stakeholder sample, we considered people with a declared or conceivable interest or stake in water management in the Mékrou River Basin. Since stakeholders will be impacted by the water management policies that are expected to be proposed for the Mékrou River Basin, their visions and opinions might be different from those of experts.

The questionnaire was developed under consultation and discussion with local, mainly academic, actors from Benin and in Burkina Faso. Following this consultation, we drew up a questionnaire structured into four main sections. In the first section, we ask for some basic information on each respondent (name and institution). The second section aims to identify the main sectors of interest to be included in the analysis. Seven sectors were proposed (households, agriculture, fishing, industry, energy, environment and tourism). According to the feedback received during the consultation process, these seven sectors were indicated as being most relevant to the use and management of the Mékrou river water resources. For each sector, respondents were asked if they were relevant for the Mékrou River Basin using a 5-point Likert scale (non-relevant, eventually relevant, relevant, strongly relevant, and I don't know). The third section of the questionnaire is dedicated to identifying some water-related priorities for each sector. A set of possible priorities, which had been discussed with researchers in Benin and in Burkina Faso, is proposed for each sector. Each respondent was asked if these priorities are relevant for the sector considered, again using the same 5-point scale. In the fourth section, we propose specific long-term drivers which may impact on

water management in the Mékrou River Basin. Again, each respondent was asked to indicate how relevant these long-term drivers were for the Mékrou River Basin, using a 5-point scale.

3.2. Implementation

As discussed by Assefa [22], the data collection method is dependent on the ease of data quantification, the scale of applicability, and time and cost constraints. Taking this into account we have chosen two different ways of addressing the questionnaire to experts and local stakeholders. For the group of experts, we used a web-based survey, whereas a face-to-face survey was carried out on the sample of local stakeholders.

Based on the questionnaire described above, a web survey was designed (October 2014) by a group of environmental economists affiliated with the Joint Research Centre (JRC) of the European Commission using the EU-survey tool (an online survey-management system built for the creation and publishing of globally accessible surveys). Discussions with local partners resulted in a list of potential experts that could answer the survey. The selection of the relevant experts had to ensure a valid representation of the three countries that share the Mékrou River Basin, a multiplicity of expertise (water, development and environment) and a diversity of type of institutions (non-governmental organizations (NGOs), administrations, research centers and universities). We ended up with a list of 75 potential experts, each of whom was asked to participate in the web survey on 20 October 2014. After sending two reminders, we received answers from 41 experts, a response rate of 54.7%, which is quite high for this kind of survey, according to Nulty [23].

In a second phase (14–24 October 2014), a face-to-face survey of local stakeholders in the Mékrou River Basin was carried out, using the same questionnaire. Due to financial constraints, the survey was only applied in Benin, which represents by far the largest area and the largest population share of the Mékrou River Basin. To minimize cultural biases, all interviewers were recruited in Benin. In the eight municipalities located in the Beninese part of the Mékrou River Basin, we identified a set of 27 possible local stakeholders (representatives of municipalities, water services, local farmers' associations and local NGOs) who were then contacted by the three interviewers. The selection of the stakeholders was made in cooperation with the Water Authority (PNE) of Benin. Local institutions involved in the water sector and related sectors were selected. From each selected institution, we interviewed one official in charge of the water sector or a representative who was competent to answer questions.

All of the stakeholders contacted agreed to respond to the survey. The average time taken to answer the questionnaire was 45 min, with a maximum of approximately one hour.

3.3. Validity

The validity of a survey can be initially assessed based on its representativeness. Although we do not claim that those who responded to our surveys formally constitute a "representative" sample of all stakeholders and experts involved in issues related to water and development in the Mékrou River Basin, we demonstrate that our sample of respondents encompasses a wide variety of expertise and type of institutions.

With regard to the experts' Web-based survey, slightly more than 40% of the sample are respondents from Benin (the country with the largest area in the Mékrou River Basin), followed by Burkina Faso (30.3%) and Niger (15.7%). The remaining respondents belong to regional or international institutions (e.g., the Global Water Partnership and the World Bank) that may not be based in one of the three countries. Respondents also differ in terms of their primary field of interest/expertise. For 44%, the primary field of interest/expertise is related to water. For 22%, the primary field of interest/expertise is the environment (hydrology, meteorology, *etc.*). Lastly, agriculture is considered as the primary field of interest/expertise for 16% of respondents. Respondents also differ in terms of the type of institution for which they work. In our expert sample, 40.6% of the respondents work for a university or for a research institute, 18.8% work in

administration in one of the three countries, and the same percentage to a regional organization (such as the Global Water Partnership's Benin office). Concerning the face-to-face survey of local stakeholders, a great variety of profiles was considered: 40.7% of respondents belong to local public institutions in charge of the agricultural sector (Secteur Communal pour le Développement Agricole (SDCA)), 22.2% of respondents are representatives of municipalities, 18.5% of respondents belong to water services, and 11.1% to local NGOs. In addition, local stakeholders come from 11 different municipalities spread over the Beninese part of the Mékrou River Basin.

Another important validity criterion of the survey is that the questions must be properly understood and accepted by all respondents. We added three questions at the end of the survey in order to measure how the survey was perceived by respondents. Respondents were first asked to indicate whether they believe that the questions were useful for the Mékrou project. All experts mentioned that the web survey was useful, and this opinion was also shared by 26 of the 27 local stakeholders. Respondents were then asked whether the questions were clear enough. Respectively, 94.6% and 92.6% of experts and local stakeholders considered that the questions in the survey were clear. Finally, respondents were asked whether the questions were exhaustive. Of the sample of experts, 40.6% answered "Yes", 37.5% answered "I don't know", and 18.7% answered "No". Additionally, 70.4% of local stakeholders considered the questions to be exhaustive.

Lastly, since experts originate from the three countries whereas all stakeholders belong to Benin, the differences in opinions across the two samples could be linked to differences in nationalities. In the following section, we will explore the divergences of opinion according to the nationality of the experts.

4. Empirical Results

4.1. Expert and Stakeholder Views on the Sectors Of Interest

Our first focus was to identify the relevant economic sectors of the Mékrou River Basin. Experts and local stakeholders were asked to evaluate the relevance of the seven predefined sectors:

1. households;
2. agriculture and livestock;
3. fishing/hunting/forest residues collection;
4. industry/transport/services;
5. energy;
6. environment and biodiversity; and
7. tourism.

Each respondent was asked to assess the pertinence of each sector on a 5-level scale ("not relevant", "possibly relevant", "relevant", "strongly relevant" and "I don't know"). The exact wording of this question was "Given the objectives of Mékrou project (developing tools and planning approaches to enable decision makers to address the complex challenges of managing water in the Mékrou transboundary basin) and your knowledge of local issues, can you tell us how much it is relevant or not to consider each of the seven following sectors of interest in the basin of the Mékrou?". Most of the sectors (households, agriculture, industry, fishing, energy and tourism) are traditional economic sectors, which can be found in any national accounting system, and are the most important for the water use of the Mékrou River Basin, as indicated by local institutions during the consultation process. We also added a sector called "Environment and biodiversity" since our discussions with local partners showed that environmental protection was an important issue in the Mékrou River Basin, specifically linked to economic growth and to water resource management.

In Figure 2, we compare the opinions of experts and local stakeholders for each proposed sector. To formally compare the distributions across experts and the local stakeholder samples, Fisher's exact tests were carried out.

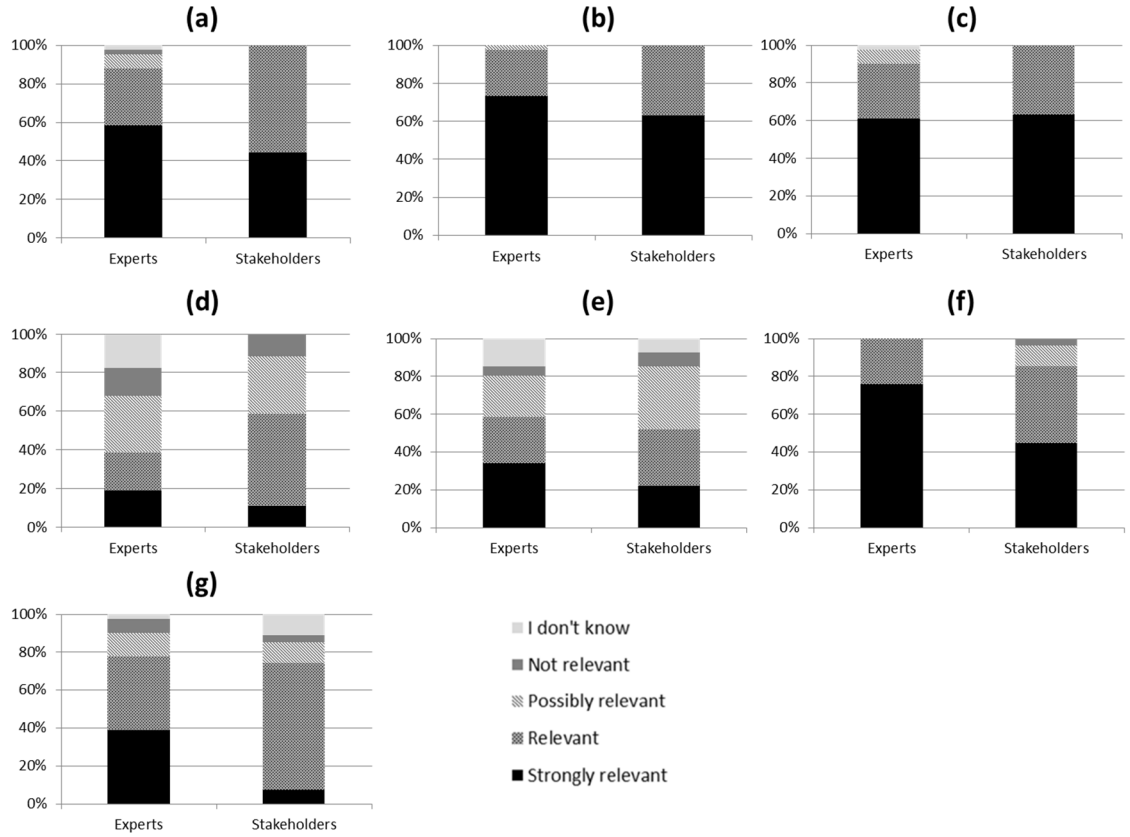

Figure 2. Sectors of interest: Experts' *versus* stakeholders' points of view: (**a**) households; (**b**) agriculture and livestock; (**c**) fishing/hunting/forest residues collection; (**d**) industry/transport/services; (**e**) energy; (**f**) environment and biodiversity; and (**g**) tourism.

Based on Fisher's exact tests, we cannot reject the null hypothesis (that there is no difference between expert and stakeholder distributions) for five sectors, namely households, agriculture and livestock, fishing/hunting/forest residues collection, industry/transport/services and energy. For these five sectors, the opinion elicited from experts matches that of local stakeholders quite well. Using Fisher's exact tests, we reject the null hypothesis (no difference between experts and stakeholder distributions) for the tourism and environment/biodiversity sectors. Only 3.7% of stakeholders consider tourism to be strongly relevant for the Mékrou River Basin, compared to 39% of experts. Environment/biodiversity is a top priority for 75.6% experts but only for 44.4% of stakeholders.

To get a better understanding of the differences in the opinions of experts and local stakeholders, we have run two logistic regressions, one on each subsample. Our dependent variable is equal to 1 if a respondent (either an expert or a local stakeholder) considers that the proposed sector is "strongly relevant". As explanatory variables, we introduce a set of dummy variables for each sector (the reference sector is industry). We then explain the probability of getting an overall "strongly relevant" result depending upon the sector considered, based on the subsamples of experts and local stakeholders, separately.

As can be seen in Figure 3, experts and local stakeholders agree that four sectors should be considered as being of great interest for the Mékrou River Basin (a high probability of getting a "strongly relevant" answer): agriculture and livestock, fishing/hunting/forest residues collection, ecosystem services/environment, and households.

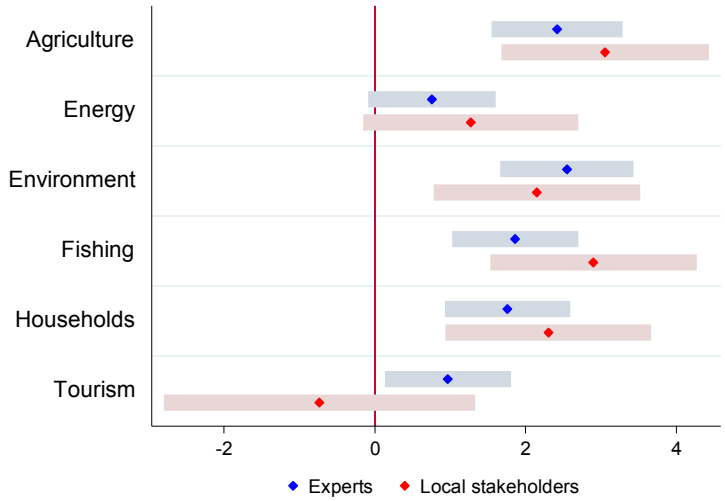

Figure 3. Points and confidence interval at 90% for coefficients estimated using a logistic regression analysis. The dependent variable is equal to 1 if the respondent considers that the proposed sector is strongly relevant (the reference sector is industry). The independent variables are dummy variables per proposed sectors. The logistic regressions are estimated separately for the expert subsample (in blue) and for the local stakeholder subsample (in red).

Experts and local stakeholders also agree that the energy sector and the industry/transport/services sectors (the reference sector in the logistic regression) should be considered to be of limited interest for the Mékrou River Basin (low probability of getting a "strongly relevant" answer in both sub-samples).

The tourism sector stands out in the sense that experts and local stakeholders do not agree on its degree of relevance. However, we should stress that there is a lot of heterogeneity in the local stakeholder sample (wide confidence interval).

From a policy perspective, this first result is very important. Since the views of experts and local stakeholders coincide quite well with regard to defining the sectors of greatest interest for the Mékrou River Basin, we expect that some form of consensus may be easily achieved by these two groups, especially for prioritizing the domain of investigation of a water management program. We also believe that smooth and constructive interactions between experts and local stakeholders are possible on these topics.

4.2. Expert and Stakeholder Views Related to Priorities Per Sectors

For each economic sector, we have proposed a list of possible priorities, see Table S1 (Supplementary Material). This list of priorities has been discussed and validated by two experts from Burkina Faso and from Benin.

Each respondent was then asked to assess the pertinence of the proposed priorities for the specific case of the Mékrou River Basin, using the same 5-level scale (not relevant, possibly relevant, relevant, strongly relevant, and I don't know). The exact wording of this question was "We now offer you a number of priorities or issues for each of the seven sectors. Can you indicate whether you think these priorities or issues are relevant in the basin of the Mékrou?". In Table 1, we compare the opinions of experts and stakeholders with respect to the proposed priorities for each sector.

Table 1. Priorities by sector: Expert *versus* stakeholder points of view.

Priority	Fisher-Test	Experts			Stakeholders		
	p-Value	A	B	C	A	B	C
Priority for households							
Minimal Water	0.129	73.2	90.2	2	55.6	96.3	3
Minimal Income	0.081	46.3	87.8	8	33.3	96.3	10
Vulnerability to Extreme Event	0.010	70.7	95.1	3	40.7	100.0	8
Access to Water	0.048	82.9	100.0	1	59.3	100.0	2
Food Security	0.028	68.3	87.8	4	44.4	92.6	7
Health of Population	0.689	63.4	90.2	6	55.6	88.9	3
Urban Water	0.483	41.5	78.0	9	51.9	96.3	5
Urban Wastewater	0.430	41.5	70.7	9	51.9	92.6	5
Rural Water	0.760	65.9	92.7	5	63.0	100.0	1
Rural Wastewater	0.102	61.0	85.4	7	37.0	88.9	9
Priorities for the agricultural livestock sector							
Climate Change	0.122	78.0	97.6	1	55.6	92.6	2
Land Water Access	0.285	63.4	87.8	4	59.3	100.0	1
Irrigation	0.189	56.1	90.2	6	51.9	100.0	3
Collective Water	0.872	51.2	92.7	7	48.1	88.9	4
Livestock	0.083	48.8	87.8	8	40.7	92.6	6
Sustainable Agriculture	0.016	65.9	100.0	2	33.3	96.3	10
Productivity of Agriculture	0.204	58.5	92.7	5	44.4	100.0	5
Organic Production	0.061	34.1	58.5	9	37.0	88.9	8
Sustainable Consumption	0.713	34.1	82.9	9	37.0	92.6	8
Development of Agriculture	0.197	48.8	85.4	8	40.7	96.3	6
Natural Hazards	0.043	65.9	97.6	2	37.0	92.6	9
Priorities for fishing, hunting and residuals collection							
Impact on Environment	0.051	39.0	70.7	2	44.4	92.6	2
Food Security	0.942	48.8	87.8	1	48.1	85.2	1
Priorities for industry, transport and services							
Water Security	0.802	17.1	43.9	4	22.2	55.6	2
Reduce Pollution	0.483	43.9	65.9	1	25.9	59.3	1
Develop Industry	0.162	19.5	43.9	3	11.1	55.6	4
Develop Service	0.273	29.3	65.9	2	18.5	74.1	3
Priorities for energy							
Production Security	0.893	31.7	73.2	2	29.6	81.5	1
Renewable Energy	0.006	61.0	82.9	1	25.9	85.2	2
Priorities for environment							
Minimum Flow	0.643	53.7	82.9	5	40.7	81.5	3
Value Ecosystems	0.002	68.3	95.1	1	25.9	85.2	6
Anthropogenic Impact	0.057	61.0	97.6	2	33.3	88.9	5
Park W	0.572	56.1	90.2	3	44.4	85.2	2
Extreme Events	0.708	46.3	85.4	6	40.7	81.5	3
Deforestation	1.000	56.1	90.2	3	59.3	96.3	1
Priorities for tourism							
Economic Growth	1.000	39.0	90.2	6	40.7	92.6	4
Sustainable Tourism	0.636	46.3	95.1	2	44.4	88.9	1
Environmental Impact	0.499	46.3	82.9	2	44.4	88.9	1
Park W	0.808	41.5	82.9	4	37.0	92.6	5
Extreme Events	0.428	41.5	82.9	4	25.9	81.5	6
Security	0.839	48.8	90.2	1	44.4	88.9	1

The second column reports the *p*-value of the Fisher exact test. The null hypothesis is "no difference between expert and stakeholder distributions". We do not reject the null hypothesis in the case of high *p*-values (typically *p*-values greater than 0.05 or 0.1).

A: percentage of respondents that consider the priority to be strongly relevant.
B: percentage of respondents that consider the priority to be strongly relevant or relevant.
C: ranking of priorities based on the proportion of "strongly relevant" answers.

There is quite a high level of consensus among experts and local stakeholders regarding *priorities for households* in the Mékrou River Basin. The distribution of answers is not significantly different between expert and stakeholder samples for seven priorities: Minimal Water, Minimal Income, Health of Population, Urban Water, Urban Wastewater, Rural Water and Rural Wastewater. Access to rural water infrastructure, access of the poor to water services, and safe minimum levels of drinking water were considered top priorities for the two groups of respondents. There is also good consensus among experts and local stakeholders regarding the least relevant priorities (access to urban water infrastructure and access to urban sanitation). Not surprisingly, the highest priorities for households are very similar across expert and stakeholder samples. In particular, developing access of the poor to water services and insuring a safe minimum level of drinking water should be the first objectives of a project dedicated to water management in the Mékrou River Basin. In addition, there is a need to focus on rural populations, for which access to basic water services is still an issue. These results clearly identify the population at risk, namely poor households and those located in the most rural parts of the river basin.

There is a quite high level of consensus among experts and local stakeholders with regard to the *priorities for agriculture* in the Mékrou River Basin. The distribution of answers significantly differs between expert and stakeholder samples only for two priorities, namely sustainable agriculture and natural hazards. Sustainable Agriculture is considered to be "strongly relevant" for 65.9% of experts, and for only 33.3% of stakeholders. If we add the two categories "strongly relevant" and "relevant", opinions of experts and stakeholders regarding Sustainable Agriculture match quite well. Among the five priorities that received the highest proportion of "strongly relevant" answers for experts and stakeholders, three were commonly chosen by the two samples: adaptation to climate change, access to land and water for poor farmers, and increase of yield productivity. One should stress that, in terms of the share of "strongly relevant" answers, adaption to climate change is the first priority for experts and the second for local stakeholders. The perception that climate change is a major challenge for agriculture and for livestock in the Mékrou River Basin is jointly shared by experts and by local stakeholders. Organic production and sustainable food consumption are the two priorities that received the lowest proportion of "strongly relevant" answers both from experts and from local stakeholders.

The impact of *fishing, hunting and residues collection activities* on the food security of the poorest populations is strongly relevant for the Mékrou River Basin, both for experts and stakeholders. Almost half of the respondents consider this priority to be strongly relevant, and for more than 80% it is either relevant or strongly relevant. Again, there is a quite high level of consensus among experts and local stakeholders with regard to *priorities for industry, transport and services* in the Mékrou River Basin. For the four proposed priorities, the distribution of answers does not differ significantly between expert and stakeholder samples. Reducing industrial pollution is ranked as being the highest priority for both experts and stakeholders. However, only 43.9% and 25.9% of experts and stakeholders respectively consider industrial pollution to be a "strongly relevant" issue for the Mékrou River Basin. Securing water for industry and developing industries within the river basins appear to be the least relevant options (in terms of percentage of "strongly relevant" responses) for experts and stakeholders, respectively. These results reflect the strong dependence of the local economy on agriculture.

For the *priorities for the energy sector*, the distributions of answers by experts and local stakeholders regarding securing energy production are not statistically different. However, they do differ with regard to the development of renewable energies. Although 61% of experts consider the development of renewable sources of energy (biofuel or hydroelectricity) to be "strongly relevant" for the Mékrou River Basin, only 25.9% of the stakeholders agree.

Concerning *priorities for environment*, we observe some large discrepancies between experts and local stakeholders. The two priorities that received the highest proportion of "strongly relevant" answers from experts—identifying and measuring ecosystem services (68.3%), and evaluating negative anthropogenic impacts on environment (61.0%)—received the lowest share of "strongly relevant" answers from the local stakeholders (25.9% and 33.3%, respectively). For the six proposed priorities, the percentage of respondents that chose "strongly relevant" was on average 56.9% of the expert sample and only 41.4% of the local stakeholder sample. Although it is difficult to formally explain these different views of experts and stakeholders, a possible driver may be that the expert sample has a strong background in environmental sciences. Although experts view the environment as an asset that must be preserved, environmental conservation may still be considered by some local stakeholders as a constraint to economic development. It could also be that stakeholders have biased perceptions of environmental issues. Indeed, while our proposed priorities for the environment typically focus on the long-term outlook, some recent studies, including Dupas [24], have shown that households in Africa tend to exhibit present-biased preferences. As a result, local stakeholders may be tempted to under-invest in long-term assets such as the environment.

There is quite a high level of consensus among experts and local stakeholders regarding *priorities for tourism*. The distribution of answers is not significantly different across expert and stakeholder

samples for all the proposed priorities. In addition, the percentage of respondents that consider each priority as being "strongly relevant" for the Mékrou River Basin is quite similar across the expert and stakeholder samples. Table 2 shows that ensuring the security of tourists is of primary concern, both for experts and for stakeholders.

Table 2. Long-term issues: Expert *versus* stakeholder points of view.

Long-Term Issue	Fisher-Test	Expert			Stakeholders		
	p-Value	A	B	C	A	B	C
Urbanization	0.043	14.6	53.7	9	25.9	92.6	9
Demography	0.022	24.4	63.4	8	29.6	74.1	8
Conflicts	0.589	39.0	90.2	7	40.7	81.5	4
Climate Change	0.516	56.1	92.7	3	44.4	88.9	2
Water Scarcity	0.363	53.7	78.0	4	37.0	81.5	5
Water Pollution	0.395	48.8	75.6	6	48.1	81.5	1
Ecosystem Degradation	0.948	53.7	85.4	4	44.4	81.5	2
Extreme Events	0.044	58.5	92.7	2	33.3	85.2	7
Regional Cooperation	0.080	61.0	90.2	1	37.0	88.9	5

A: percentage of respondents that consider the priority to be strongly relevant.
B: percentage of respondents that consider the priority to be strongly relevant or relevant.
C: ranking of priorities based on the proportion of "strongly relevant" answers.

4.3. Expert and Stakeholder Views Related to Long-Term Drivers

In the two previous sections we identified some sectors of interest for the Mékrou River Basin, together with a list of relevant priorities for each sector. The ordering of these priorities may change in the future due to exogenous long-term drivers such as demographic change, urbanization of population or climate change.

To address these issues, nine long-term drivers were put to experts and local stakeholders: urbanization of population ("Urbanization"), demographic development ("Demography"), risks of conflicts ("Conflicts"), climate change ("Climate Change"), risk of water shortage ("Water Scarcity"), water pollution ("Water Pollution"), degradation of ecosystems ("Ecosystem Degradation"), extreme natural hazards ("Extreme Events") and regional cooperation ("Regional Cooperation"). Each respondent was then asked to assess the level of pertinence of the proposed long-term issues for the specific case of the Mékrou River Basin, using a 5-level scale (not relevant, possibly relevant, relevant, strongly relevant, and I don't know).

In Table 2, we compare the opinions of experts and local stakeholders for each proposed long-term driver. To formally compare the distributions across the expert and the local stakeholder samples, Fisher's exact tests were performed. The distribution of answers is not significantly different between experts and stakeholders for five proposed long-term issues: Conflicts, Climate Change, Water Scarcity, Water Pollution and Ecosystem Degradation. Experts and stakeholders have different views concerning the issues of extreme events, regional cooperation, urbanization and demographic development (Table 2.).

4.4. Assessing Heterogeneity of Opinion within Groups

In this section, we explore the heterogeneity of opinions within groups. Due to the transboundary nature of the Mékrou River Basin, we focus here on divergences of opinion according to the nationality of the respondents. Since all local stakeholders are from Benin, we restrict our analysis to the expert sub-sample.

In Figure 4, we explore the links between the experts' nationalities and sectors that they considered to be strongly relevant to the Mékrou River Basin.

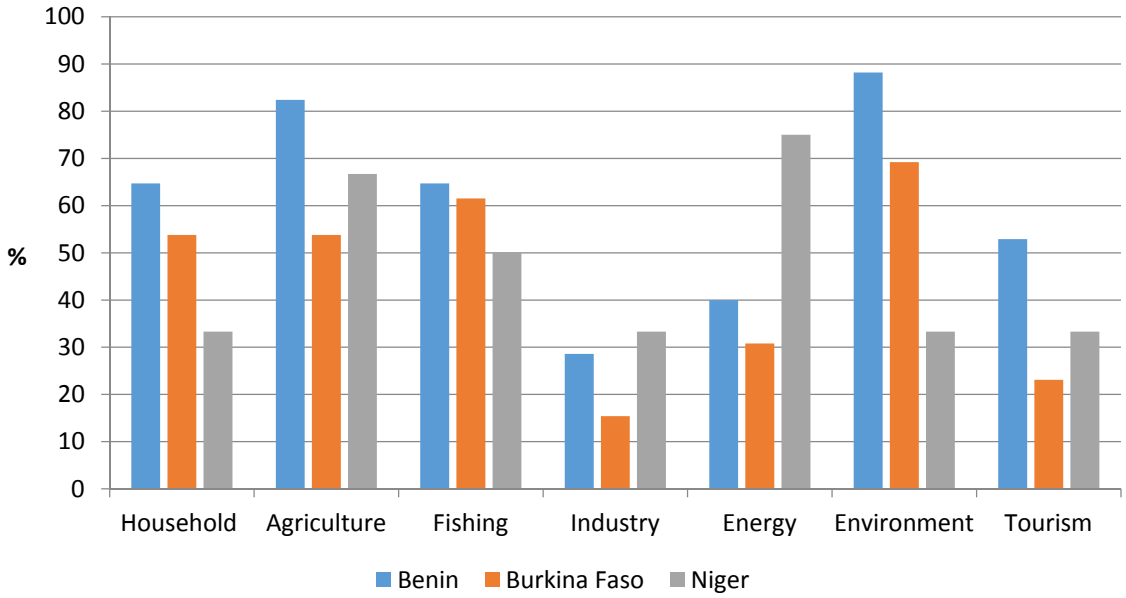

Figure 4. Percentage of experts that consider the seven proposed sectors to be strongly relevant for the Mékrou River Basin, according to the country to which the experts belong.

For three sectors (agriculture, fishing and industry), there are no substantial differences between countries, although Benin ranks first for each sector in terms of percentage of "strongly relevant" answers.

Interestingly, the opinions of Niger's experts differ from the other country experts when it comes to energy, environment and households. Whereas only 40% and 30.8% of experts in Benin and Burkina Faso consider the energy sector to be strongly relevant, this percentage reaches 75% when considering experts in Niger. These specific preferences of Nigerien experts with regard to the energy sector may be a result of increased awareness due to the Dyodyonga electricity dam project in the W Park on the section of the Mékrou River that forms the border between Niger and Benin. Following a warning from the World Heritage Committee concerning the potential negative impacts of this dam on the W Park, the project was finally abandoned by Nigerien authorities. Preferences of Nigerien experts also appear to be quite specific with regard to the environmental sectors. Although the environment is a high priority for experts in Benin and Burkina Faso (rated as "strongly relevant" by 88.2% and 69.2%, respectively), only 33.3% of experts in Niger considered the environment to be "strongly relevant" for the Mékrou River Basin. This could be related to the fact that the Nigerien part of the Mékrou River Basin represents only 10% of the total river basin area. It also appears that experts from Benin have a specific interest in the tourism sector (52.9% for Benin compared to 23.1% and 33.1%, respectively, for Burkina Faso and Niger). This difference may be related to the fact that a large part of the W Park belongs to Benin (around 80%), and that some projects of community-based eco-tourism exist in several villages located around the Beninese part of the W Park (Karimama, Banikoara, Kandi and Malanville).

The fact that experts from the different countries may have different views raises some interesting policy issues. Although it is usually assumed that experts have an objective view driven by scientific facts, models and methods [9], we demonstrate here that their opinions may be (partially) driven by specific national interests. Also, the divergent opinions on some sectors (energy, environment, households) may indicate the potential risk of conflicts or at least a risk of disagreement between the riparian countries. This calls for a reinforcement of the cooperation between these countries, possibly through the implementation of an international river basin management plan.

5. Discussion

In this study, we explored the opinions of two population groups that are relevant to water management issues in the Mékrou River Basin: a group of national experts and a group of local stakeholders. We used a survey where respondents were asked to state their preference and their ranking for predefined water policy sectors and priorities. The results of this survey are further analyzed at a practical level in order to define the priorities of an international water management project that aims to enhance development through the more efficient use of the water resources in this basin.

This survey, including the consultation process for developing the questionnaire, not only helped prioritize policy measures but also actively involved local institutions in the project design, through a participatory approach. However, due to time and financial resource constraints it was a once-off exercise that targeted a limited number of experts and stakeholders. In ideal conditions, such an approach should be further extended, periodically eliciting opinions by carrying out surveys and applying other methods such as discourse analysis, discussion platforms and forums. Selecting the appropriate means of eliciting opinions depends on the specific political and socioeconomic conditions of each geographic region. In regions where scientific information is limited for important issues such as water management, a participatory expert and stakeholder elicitation approach can be extremely informative for designing and applying development cooperation projects and identifying water management policies. Expert and stakeholder opinions can be used at any stage of project implementation and decision making by incorporating those opinions in other tools such as multicriteria analysis. Nevertheless, the extent to which these opinions can contribute to more sustainable water management in developing countries depends on the establishment of parallel participatory conditions that take into account everyday and scientific knowledge when designing the relevant policies.

In terms of results, the different views expressed by experts and local stakeholders have consequences on the design of public water management policies. They raise the issue for public authorities regarding how to act when people (stakeholders) may have a different vision to that of experts. The answer to this question depends fundamentally upon what drives the divergences of opinions. Most of the questions we asked were directly related to water, a typical environmental asset. As mentioned by Greenstone and Jack [25], environmental goods in developing countries are intrinsically characterized by multiple market failures (*i.e.*, common property, presence of externalities, problems related to lack of land, credit, and labor markets). In this context, it is likely that individual preferences (reported by local stakeholders) may not reflect the full social value of the environmental asset being studied. Local stakeholders' preferences should therefore be considered by the public authorities with caution. Citizens may also have biased preferences. In our specific context, households that were recently flooded may attribute a greater weighting to the risk of flooding (this type of biased risk perception has often been documented, see among others Eckel *et al.* [26]. According to the existing literature, whether or not public authorities should respond to stakeholders' (possibly biased) beliefs raises a puzzling question with two different views. The tenants of the paternalistic view consider that differences in perceptions reflect differences not in values but in the understanding of facts, and that a public policy should be based on these facts rather than on people's misperceptions. For instance, when designing water management policies to manage extreme floods and droughts, the cost-benefit analysis made by public authorities should be based on expert judgments rather than on those of laypeople. On the contrary, the tenants of the populist view hold that public authorities' choices should be based on consumer preferences, even if these are biased. The appropriate view greatly depends upon the context [27]. In both cases, designing efficient water policies will at some point require that an effort be made to try to reconcile the views of experts and stakeholders.

6. Conclusions

Public authorities are concerned about the quality and the quantity of their water resources, and decision makers need reliable information about effects and prioritization of the management options they may consider. Bringing the scientific knowledge of experts and the practical experience of stakeholders into decision-making is therefore crucial for designing efficient water management policies. This is particularly true for transboundary river basin areas and in developing countries.

Although water management has traditionally been influenced by water experts from governmental and research organizations, supplementing this information with the local knowledge and experience of stakeholders has only recently emerged as a field of investigation. The main rationale is that experts and stakeholders may have different perspectives, values, priorities and motivations, leading to different forms of knowledge [8]. The consideration of these different perspectives is likely to lead to a more efficient design of water management policies. It is also a way to improve our understanding of complex natural and social systems and processes and develop as well more effective and sustainable plans.

Stakeholders' involvement is particularly relevant for designing water management policies in developing countries. Indeed, local stakeholders (*i.e.*, households, farmers' representatives and village representatives) are often more familiar with the "real" problems in a given area because they have to deal with them in their everyday lives [21]. In addition, it is essential to involve local stakeholders in order to achieve a wide consensus and to increase the likelihood of having the water planning measures proposed within the project ultimately accepted by local populations. Experts, due to their scientific knowledge, may provide a more in-depth view on long-term and more complex issues, whereas stakeholders may mainly focus on short- to mid-term processes, which are related to the direct impacts of water availability and management policies. The latter can explain some important findings of our survey. We have noticed that both experts and stakeholders similarly evaluate sectors such as agriculture, household and fishing/hunting, which have direct impacts on the society and the economy, as being "highly relevant". However, when evaluating more complex sectors such as the environment and tourism, which are related to the long-term preservation of the natural environment and biodiversity services, experts value these as having a much higher levels of relevance than do stakeholders. This result may also be potentially driven by the specialization in environmental sciences of experts.

Involving experts and stakeholders in decision-making has often been cited as essential if participatory processes are to lead to high quality and durable decisions [1]. In our case, the participatory approach was taken at the earliest stage of the project "Water for Growth and Poverty Reduction in the Mékrou (funded by DG DEVCO of the European Commission" in order to identify sectors of interest and priorities in the Mékrou River Basin, a transboundary River Basin in West Africa, where the availability of objective knowledge related to water issues is very limited. We believe that by taking local interests and concerns into account at such an early stage, the project will help put into practice specific water policy measures and analytical tools in line with local needs and priorities and based on solid scientific knowledge. In general, we have found that there is largely consensus among experts and stakeholders about the main sectors of water management in the Mékrou River Basin. Our analysis therefore included the sectors of agriculture, households, environment, tourism and fishing/hunting, which were considered as being highly relevant. Regarding the various priorities within each sector, we have generally observed quite homogenous views, but there were still some differences of opinion between experts and stakeholders.

Engagement with stakeholders at such an early stage of the decision-making process (the project preparation and identification phase) is not an easy task for stakeholders or for scientists. Indeed, stakeholders are asked to provide feedback and to be part of a project which is not yet fully delineated. In addition, it may be difficult to motivate them to engage in a decision-making process that is only expected to deliver results in the medium- or in the long-run. For scientists, the involvement

of stakeholders at such an early stage requires very open minds and high levels of adaptation, in particular with regard to the modeling tools expected to be developed at later stages of the project.

At a more technical level, such an approach requires a good sampling strategy to be developed in cooperation with key local institutions. Although our sample, both of experts and of stakeholders, is small in absolute numbers, it covers various fields of expertise and it is characterized by a satisfactory response rate. A strong advantage of this approach is its low implementation cost. However, the implementation needs may vary depending on sample size and type of interview (in person, by email, and web survey). Overall, our approach may be used to define the policy and research priorities at the design phase of water management projects in developing countries, where relevant information is lacking but where a participatory framework is well established.

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