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Drought vulnerability indicators for global-scale drought risk assessments

Global expert survey results report

Meza I., Hagenlocher M., Naumann G., Vogt J. V., Frischen J.

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The survey is a joint effort between United Nations University, Institute for Environment and Human Security (UNU-EHS) within its GlobeDrought project and the Global Drought Observatory (GDO) hosted by the European Commissions' Joint Research Centre. GlobeDrought is a three year project (08/2017–07/2020) funded by the German Federal Ministry of Education and Research (BMBF) through its Global Resource Water (GRoW) funding initiative (grant no. 02WGR1457C). It aims to develop a web-based drought risk information system for comprehensively characterizing drought risk and sectoral drought impacts with a focus on agricultural systems and domestic water supply at global and regional levels (incl. case studies in South Africa, Zimbabwe, Eastern Brazil, Western India, and the Missouri River Basin of the United States). The Global Drought Observatory (GDO) provides sector-specific exposure and vulnerability information for assessing the risk of drought impacts for different sectors. Since January 2018, GDO is part of the Copernicus Emergency Management Service (EMS). The authors would like to thank the experts who participated in the survey.

1 Summary

Droughts are complex, multifaceted hazards that affect multiple regions of the world and cause severe environmental and social impacts. The vulnerability to droughts, however, is complex to assess and strongly depends on the sectoral focus as well as on the geographical context of the assessment. This report presents the results of an expert survey that was conducted to weigh drought vulnerability indicators according to their relevance for agricultural systems and domestic water supply. Indicators originate from multiple dimensions (social, economic, infrastructure, crime and conflict, environmental and farming practices) and are grouped into four subcategories: social susceptibility, environmental susceptibility, lack of coping capacity and lack of adaptive capacity. The findings underline that the relevance of indicators strongly varies depending on the sector which is susceptible to the negative impacts of drought. Hence, the most relevant indicators for agricultural systems differentiate significantly from the most important ones for domestic water supply. The results are used in the GlobeDrought project to include expert judgement in the vulnerability assessments. This information will be compiled together with drought hazard and exposure information into a global drought risk assessment.

2 Background

Drought risk and its related impacts depend not only on the drought hazard, but also on the exposure and vulnerability of the different socioeconomic sectors (e.g. agriculture, domestic water supply, energy production, waterborne transport, tourism) or ecosystems (e.g. wetlands, forests) (IPCC, 2014, UNDRR, 2019, Vogt et al., 2018). Cross-sectoral and impact-specific assessments of who and what (e.g. people, agricultural land) is at risk to what (e.g. meteorological or soil moisture drought), as well as where and why, can provide relevant baselines for the identification of targeted risk reduction and adaptation strategies (UNCCD, 2016).

Vulnerability is a key component of any drought risk assessment, indicating which sectors, populations or ecosystems are particularly susceptible to suffer negative impacts, but also the level of their capacity to cope with and adapt to droughts (IPCC, 2014). According to the Fifth Assessment Report (AR5, Working Group II) of the Intergovernmental Panel on Climate Change (IPCC, 2014) vulnerability, defined as the propensity or predisposition to be adversely affected, has three components: susceptibility, coping capacity and adaptive capacity. Thereby, susceptibility is defined as the likelihood of damage in an extreme natural event (describes the structural conditions of ecosystems and society characteristics), coping capacity as the capacity of a system to properly face adverse consequences in the short term, and adaptive capacity as a longer-term process which includes adjustments in the system as part of a learning, experimentation, and change process. When assessing vulnerability in the context of droughts, it is important to go beyond the social, economic, or political dimensions of societal vulnerability, and to also take into consideration factors determining the vulnerability of natural ecosystems. Vulnerability assessments support mid- and long-term preparedness actions and water resources planning for targeted sectors and sensitive populations.

Over the past years, indicator-based approaches have been promoted as useful tools to assess, compare, and monitor the complexity of drought risk from local to global scales (e.g., Carrão et al., 2016; Blauhut et al., 2016). However, the contribution of the individual indicators to explain drought vulnerability and ultimately the risk of sectoral drought impacts is often only weakly understood. As a result, the majority of assessments, notably at the global scale (e.g. Carrão et al., 2016), are based on equal weights for all indicators. In order to address the limitation of using equal weights, a global expert survey on vulnerability indicators for global-scale, sectoral drought risk assessments was conducted from November to December 2018 as a joint effort between JRC's Global Drought Observatory (GDO) and United Nations University (UNU-EHS). The objective was to identify and weigh relevant drought vulnerability indicators with regard to potential impacts of drought hazards on agricultural systems and domestic water supply.

This report summarizes the results of the "Drought Global Expert Survey", and provides a general overview of the most relevant vulnerability indicators according to expert judgement. In addition, in-depth information on the indicator relevance is provided broken down by expert's years of experience, gender, world region, and sector. The results will inform sectoral global drought vulnerability and risk assessments for agricultural systems and domestic water supply within the GlobeDrought project and the Global Drought Observatory (GDO).

3 Methodology

The survey was conducted using the e-encuesta online software [1]. The list of drought vulnerability indicators was derived from both a systematic literature review (Hagenlocher et al., 2019) and through expert consultations. In total, **64 indicators for agricultural systems and domestic water supply** were identified and included in the online survey.

In order to be able to synthesize expert knowledge on relevant indicators for assessing and mapping drought vulnerability at the global scale, experts from around the world were selected based on their publication track record and expertise in the field of drought risk, following the relevant literature selection proposed by Hagenlocher et al., (2019). In total, 124 experts were identified and contacted. A pre-test was run during the JRC European Drought Observatory (EDO) User Meeting 2018 which took place in October 2018 in Ispra, Italy (Spinoni et al., 2018). The pre-test has resulted in minor modifications regarding the specific wording of some of the questions.

In the online survey, experts were asked to weigh each indicator based on its relevance for drought vulnerability and the risk of negative impacts of drought on agricultural systems (incl. people, crops, livestock, etc.) and domestic water supply (survey questions are presented in the Annex 7). A rating scale from zero to four (0 = not relevant; 4 = highly relevant) defined the level of global relevance of the different statements. An "I don't know" option was provided for each indicator, however the answers were not considered for the assessment, since this option does not indicate the relevance of an indicator. In the online survey, experts were given the option to also suggest and weigh additional indicators.

The final selection of relevant indicators at the global level for agricultural systems and domestic water supply based on the survey results followed a two-step approach:

(1) Indicators were kept when more than 50% of the experts considered them a medium-high or highly relevant indicator
(2) Z-scores with a 95% confidence interval were applied to ensure that there was high level of agreement across experts.

The results were normalized to receive a value between 0 and 1 for each indicator. The amount of responses in each category was multiplied with the following values: not relevant=0, low relevance=0.25, low-medium relevance=0.5, medium-high relevance=0.75 and highly relevant=1. Finally, the sum was divided by the total number of answers given per indicator to obtain the average. Indicators with a value close to 1 are highly relevant, whereas indicators with a value close to 0 indicate lower relevance (Figure 1).

[1] https://www.e-encuesta.com/

4 Results

Out of the 124 experts that were initially contacted, 78 (63%) participated in the survey (incl. 45 complete and 33 partial responses). The results clearly show that the majority of experts works in academia (52%) or for governmental organizations (34%), and has more than 5 years of relevant work experience (>65%). Their geographic focus of work across continents is fairly balanced. A detailed overview about the participant's backgrounds, their experience, research fields and geographic focus of work is provided in Annex 1. In total, the experts ranked 64 indicators according to their relevance. Table 1 shows the total number of indicators categorized by different vulnerability dimensions (e.g. social, economic, infrastructure), and provides an overview of how many indicators were considered as relevant by the experts.

Table 1 Total number of indicators proposed according to the different vulnerability dimensions and the final list of relevant indicators after the selection process.

Vulnerability dimension	Indicators weighed (N)	Final list of relevant indicators for agricultural systems (N)	Final list of relevant indicators for domestic water supply (N)
Social	18	7	9
Economic	13	11	8
Infrastructure	7	6	6
Crime & conflict	2	1	1
Governance	10	8	8
Environmental	7	5	2
Farming practices	7	7	1
TOTAL	64	45	35

Following the break-down of vulnerability into its components, as proposed by the IPCC (2014), Table 2 shows the number of indicators for each vulnerability component (i.e. social susceptibility, environmental ecological susceptibility, lack of coping capacity, and lack of adaptive capacity), and provides an overview of how many indicators were considered as relevant by the experts.

Table 2 Total number of indicators proposed according to the different vulnerability components (social susceptibility, environmental susceptibility, lack of coping capacity, lack of adaptive capacity) and the final list of relevant indicators after the selection process.

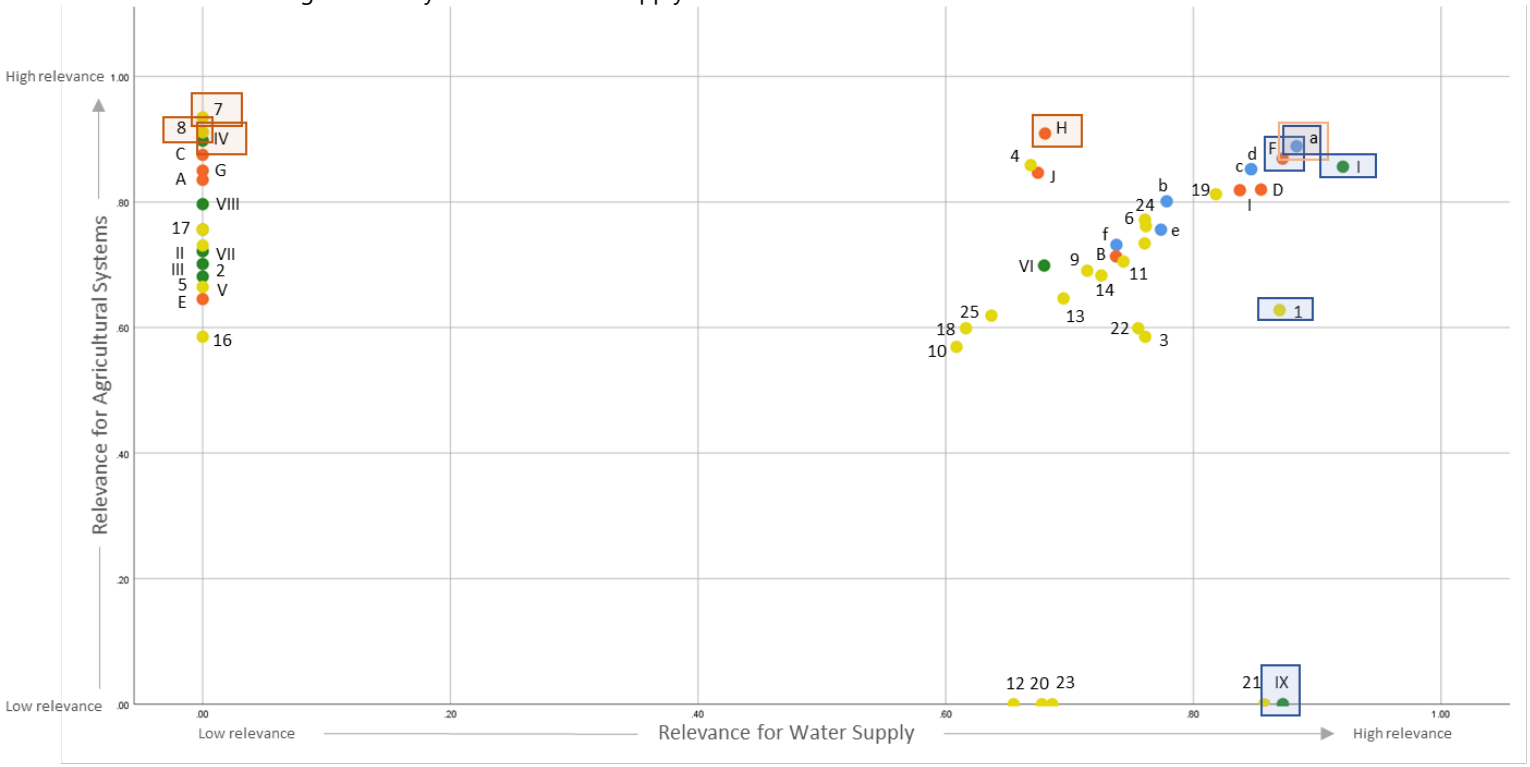
Vulnerability component	Indicators weighed (N)	Final list of relevant indicators for agricultural systems (N)	Final list of relevant indicators for domestic water supply (N)
Social susceptibility	30	21	20
Environmental susceptibility	10	8	3
Coping capacity	17	10	6
Adaptive capacity	7	6	6
TOTAL	64	45	35

Table 3 shows the most and least relevant indicators for agricultural systems and water supply. The indicator 'Existence of adaptation plans and policies' is highly relevant for both sectors (Agricultural Systems: rank 4 out of 45, Water supply: rank 2 out of 35). However, the degree of relevance among other indicators varied considerably. 'Access to clean water' is the fourth most important indicator for water supply, but only on rank 39 for agricultural systems. These results clearly indicate that the vulnerability indicator selection for drought risk assessments must always be adapted to the specific context in which drought risk is assessed. A detailed overview about all indicators for agricultural systems and water supply is provided in the following graphs and in Annex 4 and Annex 5 respectively.

Table 3 Top five most relevant and least relevant indicators for agricultural systems and water supply.

	Agricultural Systems	Water Supply
Most relevant	1. Dependency on agriculture for livelihood	1. Baseline water stress
	2. Cultivation of drought-resistant crops	2. Existence of adaptation policies & plans
	3. Irrigated land	3. Water quality
	4. Existence of adaptation policies & plans	4. Government effectiveness
	5. Degree of land degradation and desertification	5. Access to clean water
Least relevant	41. Electricity production from hydroelectric sources	31. Expenditure on health
	42. Unemployment rate	32. Unemployment rate
	43. Population without access to (improved) sanitation	33. Population ages 15-64
	44. Population ages 15-64	34. Area protected and designated for the conservation of biodiversity
	45. Life expectancy at birth	35. Refugee population

Figure 1 Relevance of indicators for agricultural systems and water supply.



Social Susceptibility

1. **Access to clean water**
2. Access to fodder
3. Access to sanitation
4. Agricultural GDP
5. Agricultural machinery
6. Conflict and insecurity
7. **Dependency on agriculture**
8. **Drought-resistant crops**
9. GDP
10. Gender inequality
11. GINI index
12. Health expenditure
13. Hydroelectricity
14. Ill-health
15. Illiteracy
16. Life expectancy
17. Market fragility
18. Population ages 15-64
19. Poverty
20. Refugee population
21. Risk Perception
22. Rural population
23. Tourism
24. Undernourishment
25. Unemployment

Environmental Susceptibility

- I. **Baseline water stress**
- II. Fertilizer use
- III. Insecticides and pesticides
- IV. **Land degradation and desertification**
- V. Livestock health
- VI. Protected areas and biodiversity
- VII. Soil depth
- VIII. Soil organic matter
- IX. **Water quality**

Lack of Coping Capacity

- A. Access to credit
- B. Corruption
- C. Crop varieties
- D. Dam capacity
- E. Distance to markets
- F. **Government effectiveness**
- G. Insurance
- H. **Irrigated land**
- I. Retained renewable water
- J. Savings

Lack of Adaptive Capacity

- a. **Adaptation policies and plans**
- b. Adaptation projects
- c. Disaster prevention and preparedness
- d. Disaster risk policies
- e. Public participation in local policy
- f. Research and development expenditure

Most relevant indicators for Agricultural Systems

Most relevant Indicators for Water supply

Figure 2 Most relevant indictors for agricultural systems by region.

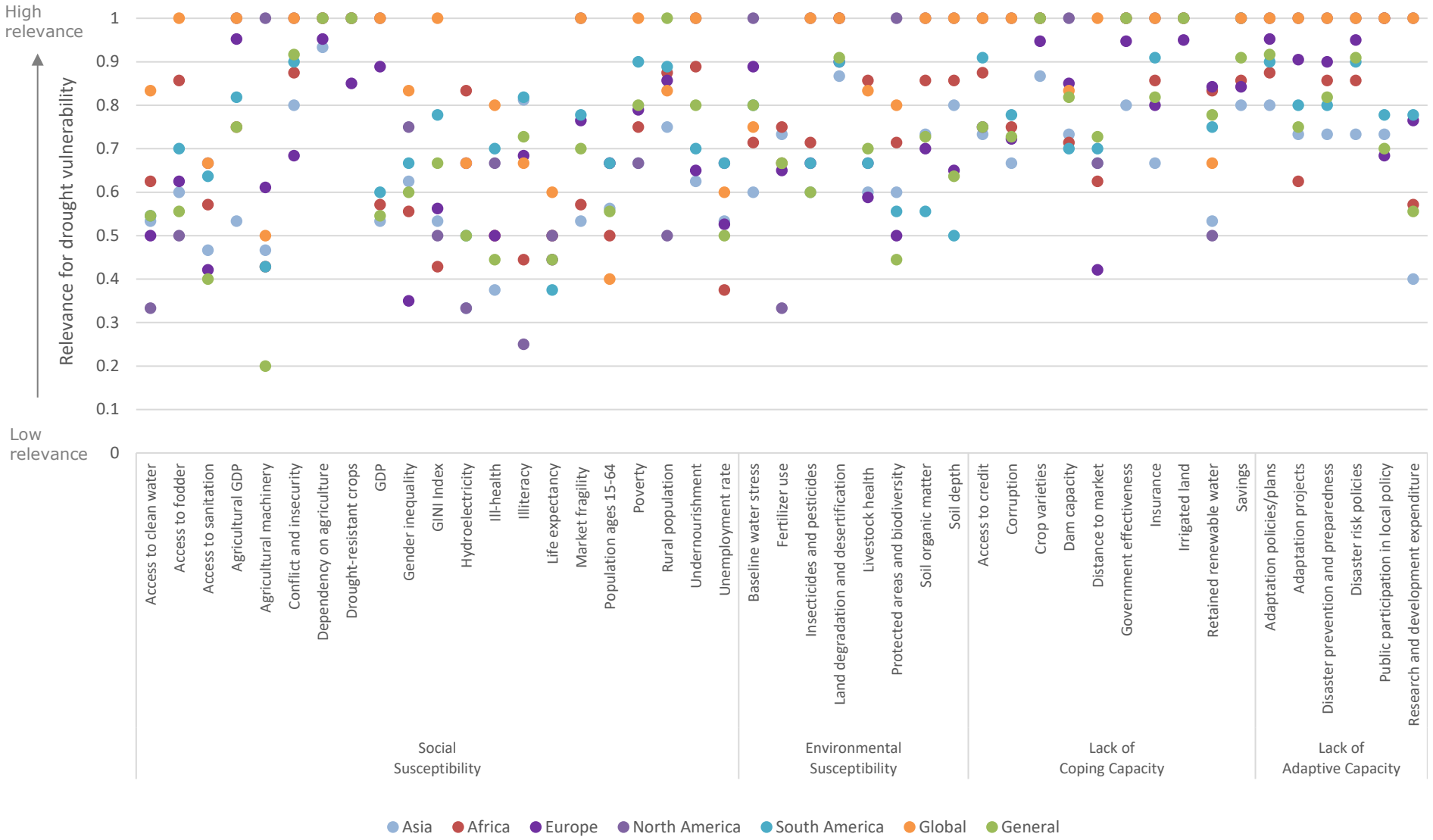
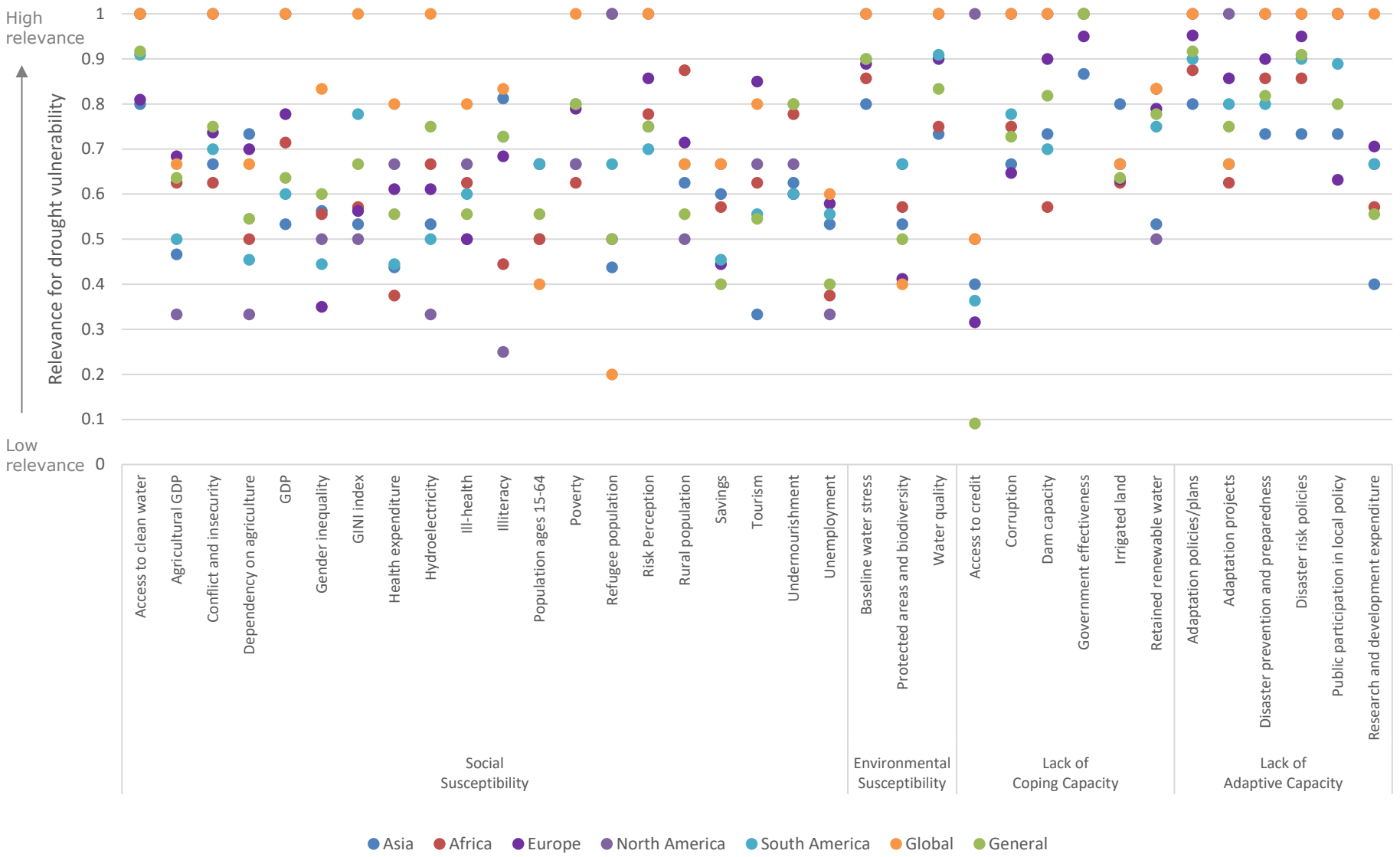


Figure 3 Most relevant indictors for water supply by region.



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Annexes

Annex 1. Background of experts

Background of experts who participated in the online survey

Gender Identity	**Quantity (N)**	**Respondents (%)**
Female	32	47.1
Male	36	52.9
Other	0	0
Sector	**Quantity (N)**	**Respondents (%)**
Academia	38	52.1
Government	25	34.2
International Organization	5	6.8
Private	2	2.7
NGO	2	2.7
Other	1	1.4
Years of experience working on drought	**Quantity (N)**	**Respondents (%)**
No previous experience working on vulnerability and risk	1	1.4
1-2	5	6.9
3-5	19	26.4
6-10	18	25.0
10+	29	40.3
Geographic focus of work	**Quantity (N)**	**Respondents (%)**
Australia	0	0.0
Asia	23	20.9
Africa	12	10.9
Europe	31	28.2
North America	8	7.3
South America	11	10.0
Global	7	6.4
General/ theoretical (e.g. methods oriented)	18	16.4
Research field	**Quantity (N)**	**Respondents (%)**
Agricultural sciences	7	17.5
Anthropology and development	1	2.5
Climate Change	3	7.5
Climate science/services	3	7.5
Drought hazard assessment and disaster risk analysis	2	5
Environmental policy	1	2.5
Geography	4	10.0
Health	2	5.0
Hydrology	7	17.5
Interdisciplinary	2	5.0
Sociology	1	2.5
Soil and Water Conservation	1	2.5
Economics	3	7.5
Water resources management	3	7.5

Annex 2: Relevant Indicators for Agricultural Systems

Relevant indicators for agricultural systems vulnerability assessments at global level. Experts ranked the indicators according to the categories not relevant, low relevance, low-medium relevance, medium-high relevance and highly relevant. The results were normalized to receive a value between 0 and 1 for each indicator. The amount of responses in each category was multiplied with the following values: not relevant=0, low relevance=0.25, low-medium relevance=0.5, medium-high relevance=0.75 and highly relevant=1. Finally, the sum was divided by the total number of answers given per indicator to receive the average. Indicators with a value close to 1 are highly relevant, whereas indicators with a value close to 0 indicate lower relevance. However, in this overview, only indicators are included that more than 50% of the experts considered as medium-high or highly relevant. An indicator or proxy indicator can be positively or negatively correlated with the vulnerability assessment; this correlation is represented on the column "direction". Additionally, the standard deviation shows the variation of agreement and disagreement among the experts. High values indicate a higher range of opinions, whereas low values represent a high level of agreement.

Indicator	Direction	Relevance Weighted relevance	Standard deviation
Social Susceptibility			
Access to fodder (kg purchased per year)	-	0.731	10.00
Agriculture (% of GDP)	+	0.859	16.18
Agricultural machinery in use (#)	-	0.665	9.13
Dependency on agriculture for livelihood (%)	+	0.935	18.62
Electricity production from hydroelectric sources (% of total)	+	0.646	8.87
GDP per capita, PPP	-	0.690	10.33
Gender inequality (categorical)	+	0.569	9.22
GINI index (income inequality)	+	0.705	9.71
Illiteracy rate (%)	+	0.734	11.98
Life expectancy at birth (years)	-	0.585	7.98
Market fragility	+	0.756	10.77
Population ages 15-64 (% of total population)	-	0.599	8.92
Population below the national poverty line (%)	+	0.813	13.41
Population undernourished (%)	+	0.772	13.15
Population with ill-health (%)	+	0.683	10.03
Population without access to clean water (%)	+	0.628	9.50
Population without access to (improved) sanitation (%)	+	0.585	8.65
Prevalence of conflict/insecurity	+	0.762	12.05
Rural population (% of total population)	+	0.799	13.78
Unemployment rate (%)	+	0.619	8.70
Environmental Susceptibility			
Baseline water stress (ratio of withdrawals to renewable supply)	+	0.856	14.13

Area protected and designated for the conservation of biodiversity (%)	-	0.699	9.37
Degree of land degradation and desertification	+	0.898	16.01
Use of fertilizer (ton)	-	0.722	10.97
Insecticides and pesticides used (ton/ha)	-	0.681	9.64
Livestock health	-	0.701	9.87
Soil organic matter (g*kg)	-	0.797	12.68
Soil depth (mm)	-	0.756	10.86
Lack of Coping Capacity			
Distance to closest market (km)	+	0.645	9.27
Corruption (e.g. Corruption Perception Index)	+	0.713	10.34
Farmers use different crop varieties (%)	-	0.875	14.15
Farmers with crop, livestock or drought insurance (%)	-	0.850	15.67
Farmers/laborers without access to bank loans/(micro-) credits (%)	+	0.835	14.09
Farmers/laborers without savings (%)	+	0.847	14.35
Government effectiveness	-	0.869	14.46
Irrigated land (% total arable)	-	0.909	16.20
Total dam capacity (m^3)	-	0.820	13.18
% of retained renewable water	-	0.819	12.10
Existence of adaptation policies/plans (yes/no)	+	0.889	16.92
Public participation in local policy	+	0.756	11.12
Cultivation of drought-resistant crops (%)	-	0.911	17.69
Lack of Adaptive Capacity			
National investment in disaster prevention & preparedness (US$/Year/capita)	-	0.852	15.04
Disaster risk taken into account in public investment and planning decisions (yes/no)	-	0.852	14.68
Number of (drought-related) adaptation projects in the past 10 years	-	0.801	13.00
Research and development expenditure (% of GDP)	-	0.732	10.53

Annex 3: Relevant Indicators for Water Supply

Relevant indicators for water supply vulnerability assessments at global level.

Experts ranked the indicators according to the categories not relevant, low relevance, low-medium relevance, medium-high relevance and highly relevant. The amount of responses in each category was multiplied with the following values: not relevant=0, low relevance=0.25, low-medium relevance=0.5, medium-high relevance=0.75 and highly relevant=1. Finally, the sum was divided by the total number of answers given per indicator to receive the average. Indicators with a value close to 1 are highly relevant, whereas indicators with a value close to 0 indicate lower relevance. However, in this overview, only indicators are included that more than 50% of the experts considered as medium-high or highly relevant. An indicator or proxy indicator can be positively or negatively correlated with the vulnerability assessment; this correlation is represented on the column "direction". Additionally, the standard deviation shows the variation of agreement and disagreement among the experts. High values indicate a higher range of opinions, whereas low values represent a high level of agreement.

Indicator	Direction	Relevance Weighted relevance	Standard deviation
Social Susceptibility			
Population without access to clean water (%)	+	0.870	11.67
Agriculture (% of GDP)	+	0.669	4.60
Dependency on agriculture for livelihood (%)	+	0.717	6.26
Electricity production from hydroelectric sources (% of total)	+	0.695	4.79
GDP per capita, PPP	-	0.714	5.61
Gender inequality (categorical)	+	0.609	4.72
GINI index (income inequality)	+	0.744	5.64
Expenditure on health (out-of-pocket) (%)	+	0.655	4.10
Illiteracy rate (%)	+	0.761	7.18
Population ages 15-64 (% of total population)	-	0.616	4.53
Population below the national poverty line (%)	+	0.818	8.48
Population undernourished (%)	+	0.761	7.44
Population with ill-health (%)	+	0.726	5.70
Population without access to (improved) sanitation (%)	+	0.761	6.88
Prevalence of conflict/insecurity	+	0.762	6.96
Refugee population (% of total population)	+	0.678	4.94
Risk perception (% of population who has experienced droughts in the past 10 years)	+	0.856	12.10
Rural population (% of total population)	+	0.755	6.89
Tourism (% of GDP)	+	0.686	5.89
Unemployment rate (%)	+	0.637	3.88
Environmental Susceptibility			
Area protected and designated for the conservation of biodiversity (%)	-	0.679	5.23

Baseline water stress (ratio of withdrawals to renewable supply)	+	0.921	12.80
Water quality (categorical)	-	0.872	11.32
Lack of Coping Capacity			
Corruption (e.g. Corruption Perception Index)	+	0.738	5.83
Farmers/laborers without savings (%)	+	0.674	4.30
Government effectiveness	-	0.872	10.81
Irrigated land (% total arable)	-	0.680	5.79
Total dam capacity (m^3)	-	0.855	9.78
% of retained renewable water	-	0.838	8.89
Existence of adaptation policies/plans (yes/no)	-	0.883	12.28
Public participation in local policy	-	0.774	6.42
Lack of Adaptive Capacity			
Disaster risk taken into account in public investment and planning decisions (yes/no)	-	0.847	9.74
National investment in disaster prevention & preparedness (US$/Year/capita)	-	0.847	10.22
Number of (drought-related) adaptation projects in the past 10 years	-	0.778	8.09
Research and development expenditure (% of GDP)	-	0.738	5.51

Annex 4: Detailed sector analysis for agricultural systems

Social dimension

Most experts identified the following indicators as globally relevant: Illiteracy rate (%), gender inequality (categorical), population undernourished (%), population with ill-health (%), life expectancy at birth (years), rural population (% of total population) and population ages 15-64 (% of total population).

The top relevance indicators for female experts (population undernourished (%) and rural population (% of total population)) are also the top for male experts. The most significant discrepancy between genders is the life expectancy at birth indicator where only 28% of women consider it relevant in contrast to 53% of males.

The gender inequality indicator is highly relevant for male experts, people with more than six years of experience, respondents from the academia and NGO sector, and experts with focus on Asia, North America, South America, global and general/theoretical.

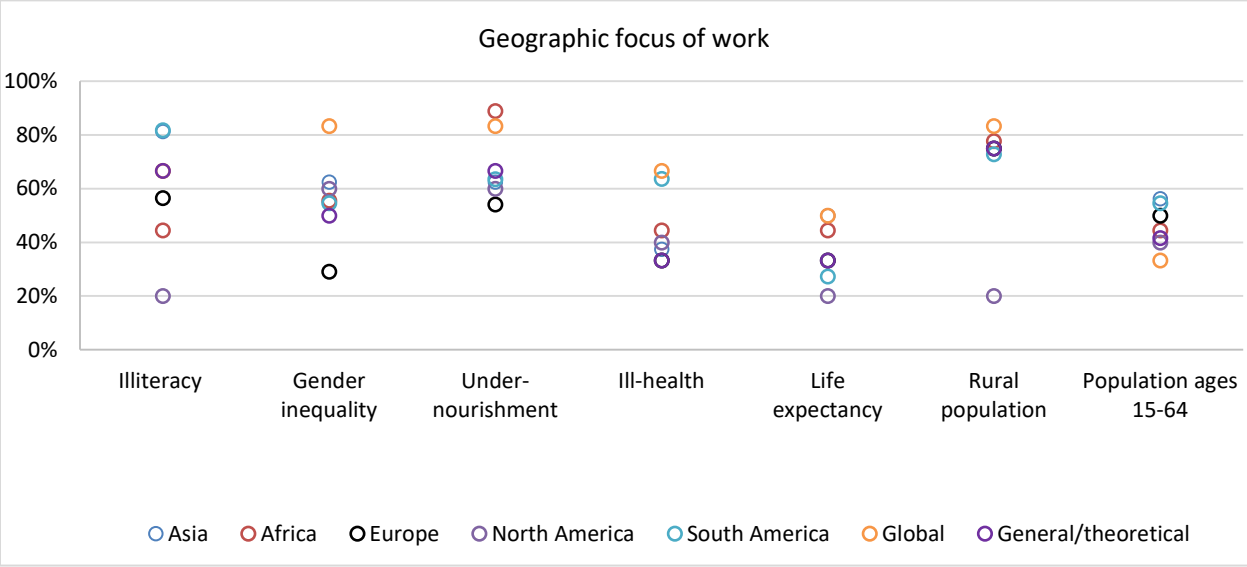

Figure 4 Proportion of experts who consider the indicators globally relevant depending on their geographic work focus.

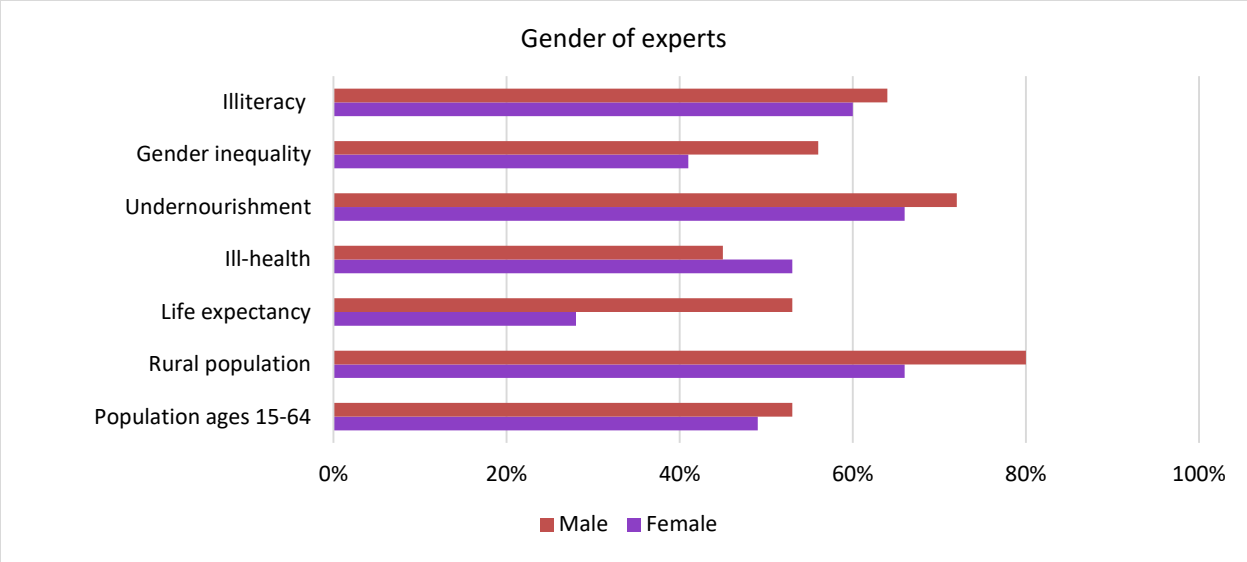

Figure 5 Proportion of experts who consider the indicators globally relevant depending on their gender.

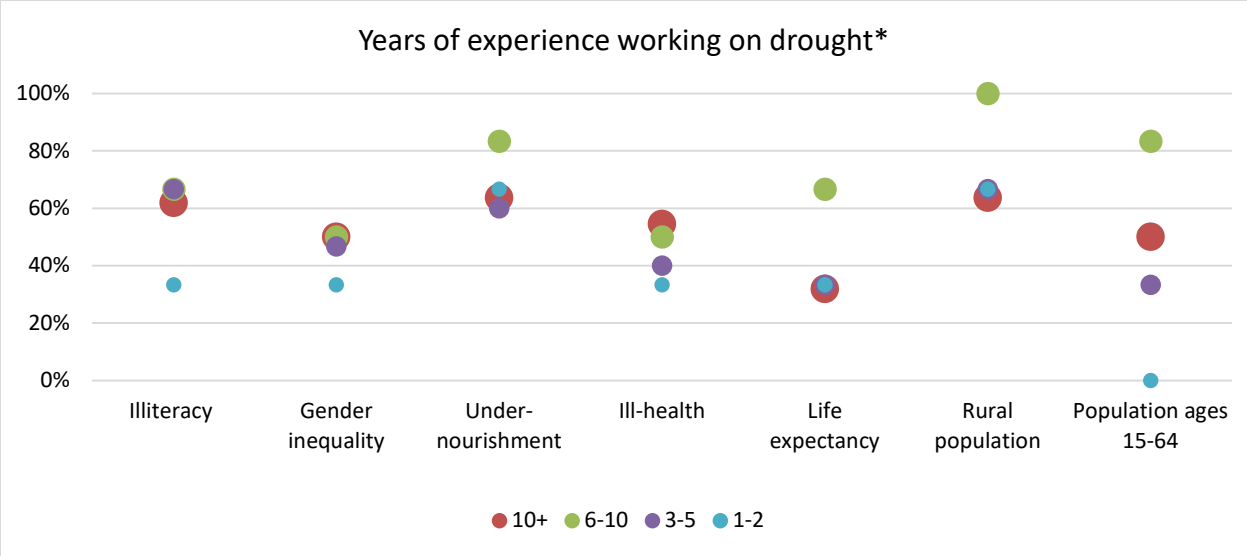

Figure 6 Proportion of experts who consider the indicators globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

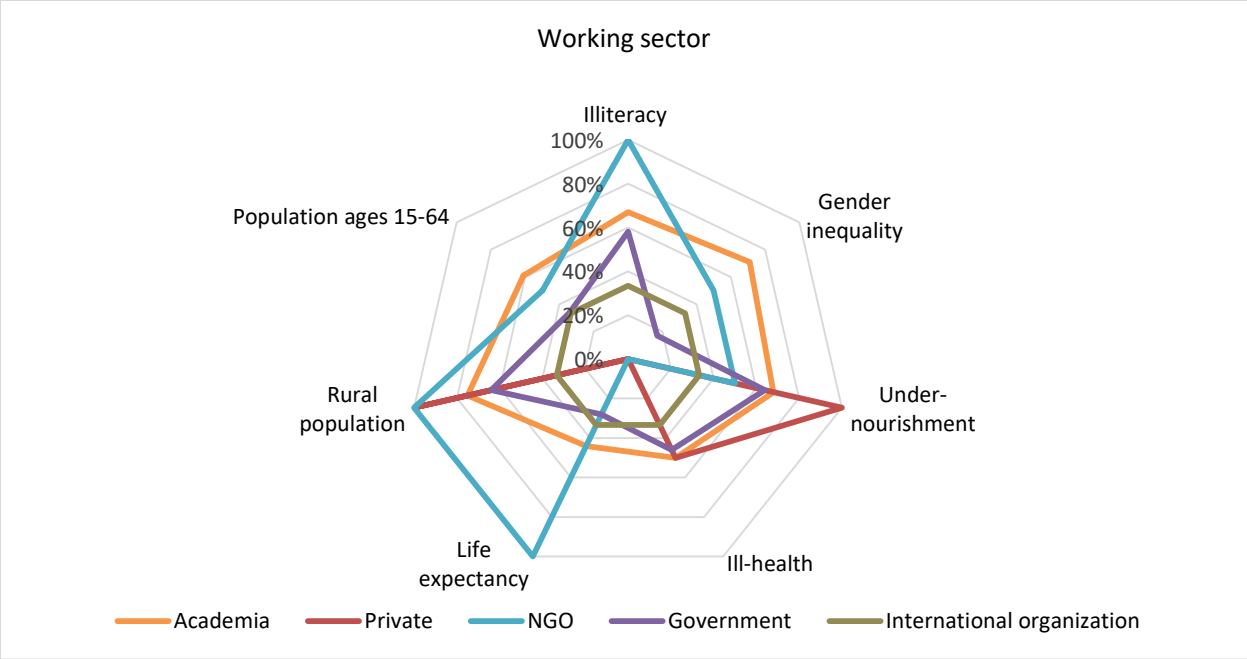

Figure 7 Proportion of experts who consider the indicators globally relevant depending on their working sector.

Economic dimension

In the economic dimension, there was more consensus according to the indicators that are considered applicable at the global level. Eleven indicators were identified as globally relevant: dependency on agriculture for livelihood (%), agriculture (% of GDP), population below the national poverty line (%), unemployment rate (%), GDP per capita, GINI index (income inequality), farmers/labourers without savings (%), farmers/labourers without access to bank loans / (micro-) credits (%), distance to closest market (km), market fragility and farmers with crop, livestock or drought insurance (%).

Experts working in drought for more than six years identified as the top three relevant indicators dependency on agriculture for livelihood (%), farmers/labourers without savings (%) and farmers with crop, livestock or drought insurance (%). Experts from all the geographic areas agreed on the relevance to consider agriculture (% of GDP), population below the national poverty line (%), GDP per capita, and market fragility in global drought vulnerability assessment on agricultural systems.

More than half of the experts working in academia highlight the relevance of the unemployment rate. Market fragility and distance to closest market were identified as for all the different sectors as relevant; only the private sector classified these indicators as low to low medium relevance.

Income inequality is a higher vulnerability relevance for experts that work in Asia, South America, global and general/theoretical focus.

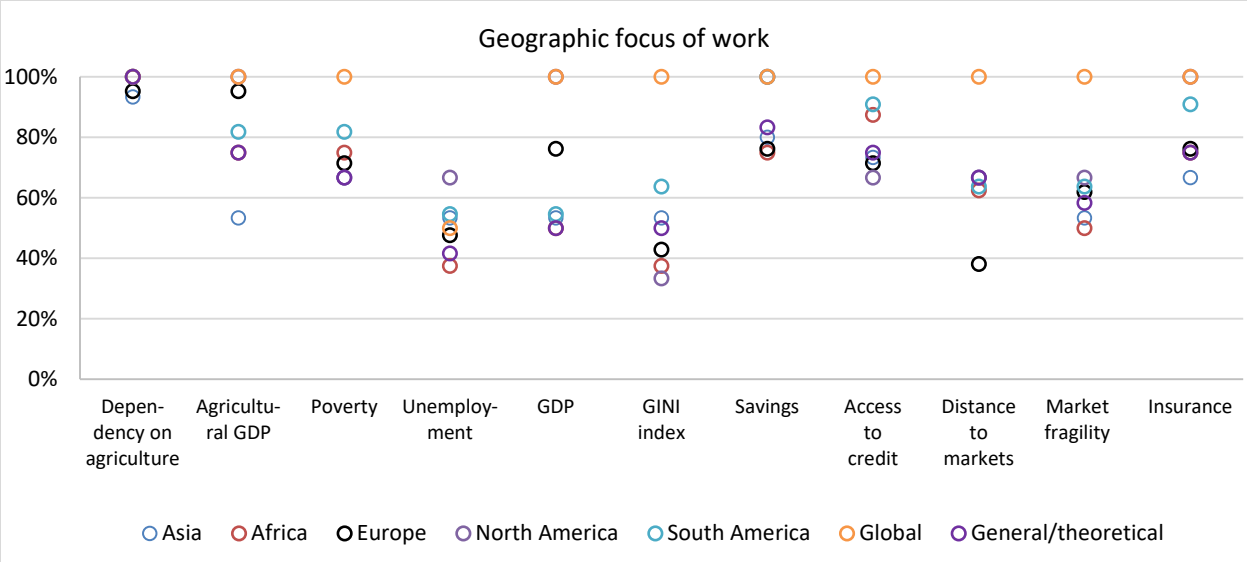

Figure 8 Proportion of experts who consider the indicators globally relevant depending on their geographic work focus.

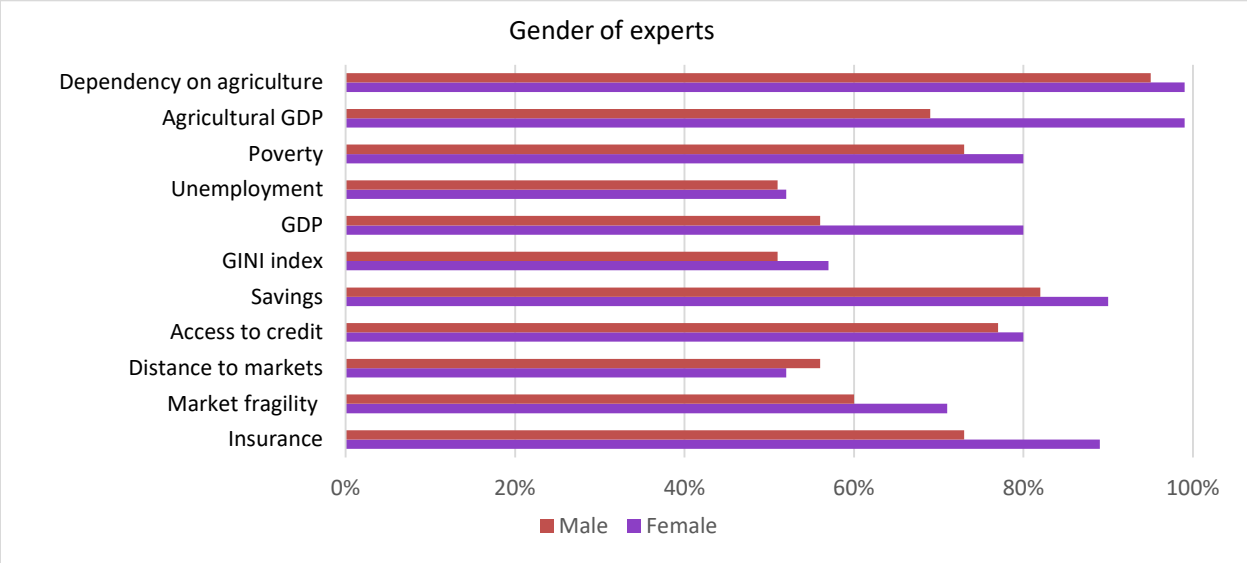

Figure 9 Proportion of experts who consider the indicators globally relevant depending on their gender.

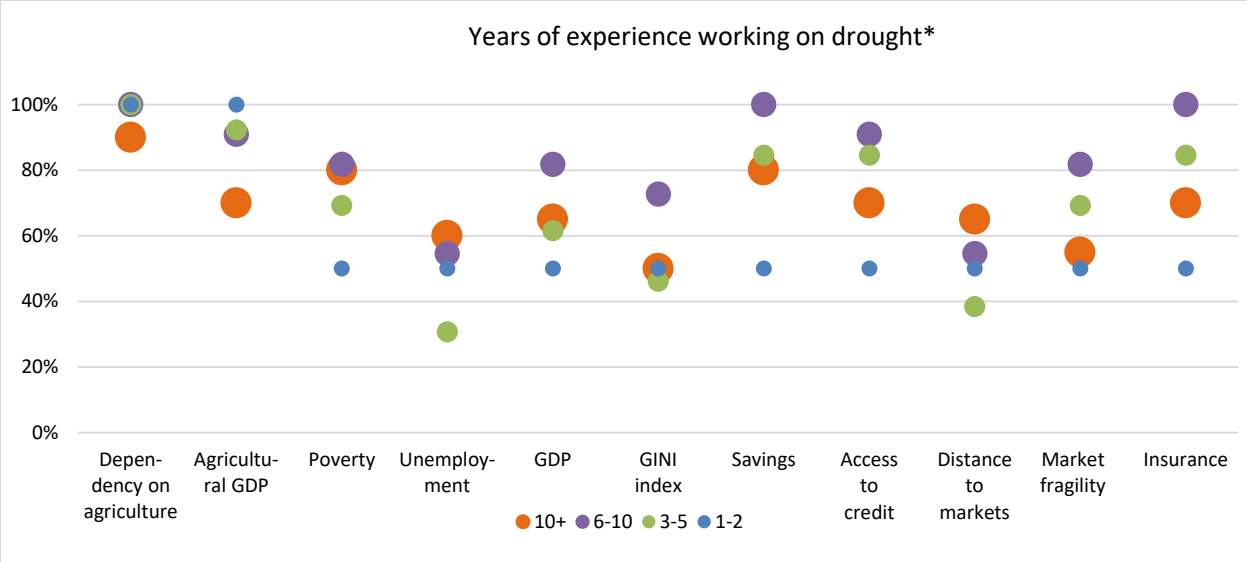

Figure 10 Proportion of experts who consider the indicators globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

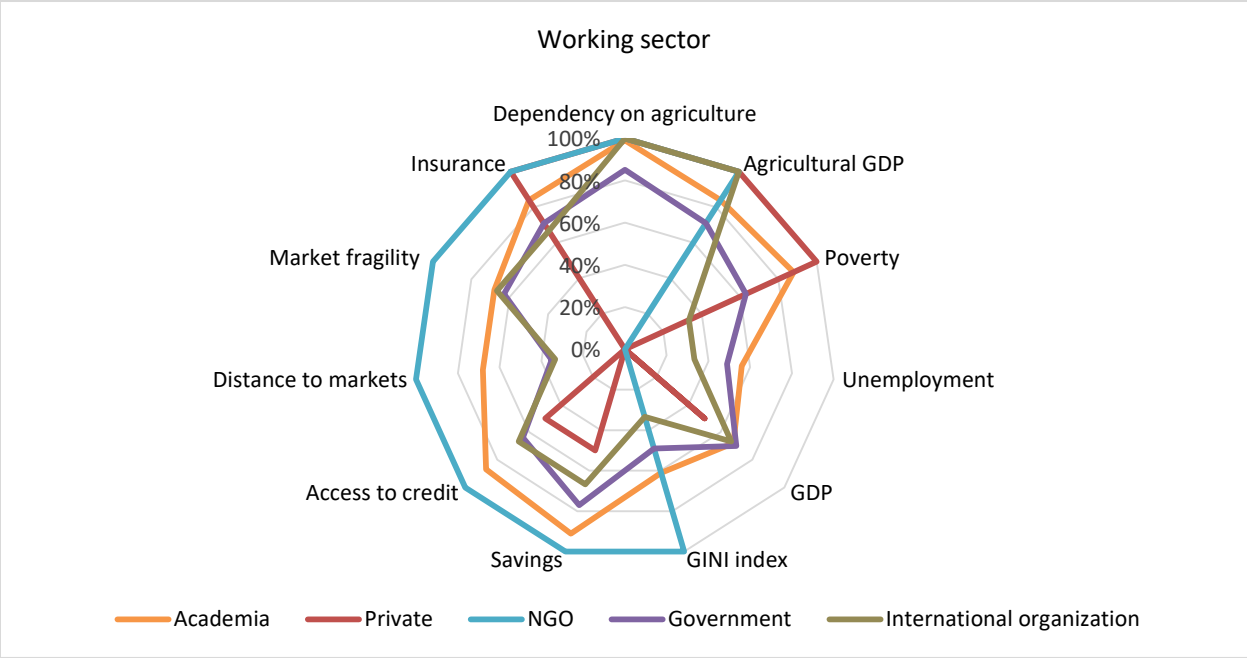

Figure 11 Proportion of experts who consider the indicators globally relevant depending on their working sector.

Infrastructural dimension

All the experts agreed that the most relevant indicators for the infrastructure dimension are "water quality (categorical)", total dam capacity (m^3) and % of retained renewable water.

The indicator population without access either to clean water or to improved sanitation was considered more relevant by female experts compared to male experts. Further, these indicators were selected as relevant for experts with more than ten years of experience. Around 40% of the experts whose work is focused on Europe consider them relevant on a global level.

Electricity production from hydroelectric sources (% of total), is relevant for experts from private, NGO's and governmental sector. However, for experts focusing on America and Asia, there are other more relevant indicators such as water quality or total dam capacity.

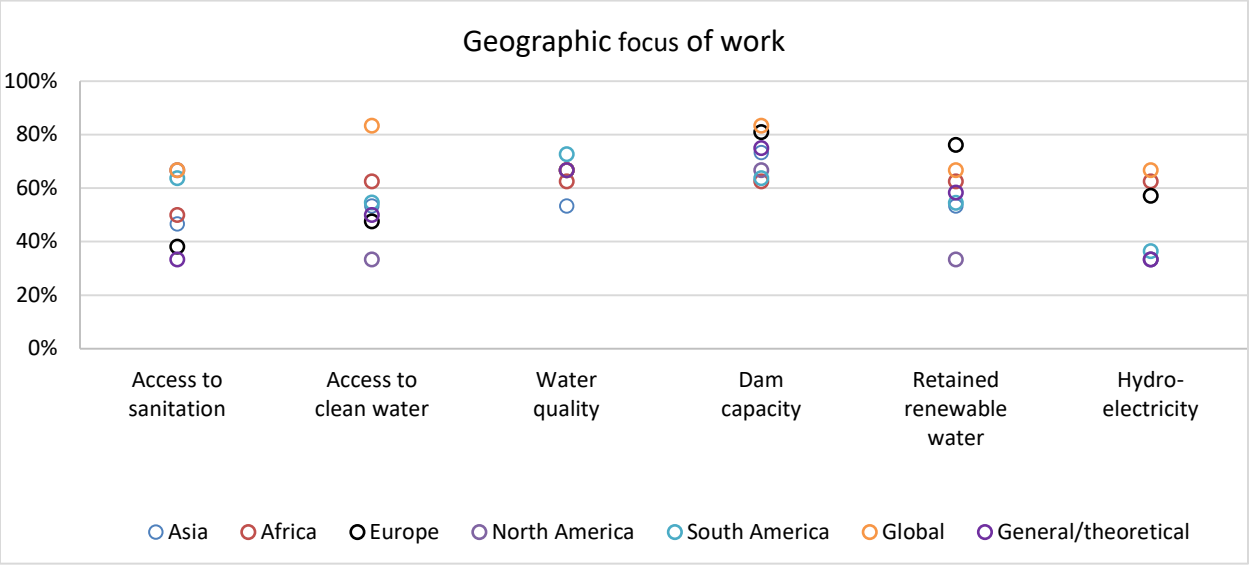

Figure 12 Proportion of experts who consider the infrastructural indicators globally relevant depending on their geographic work focus.

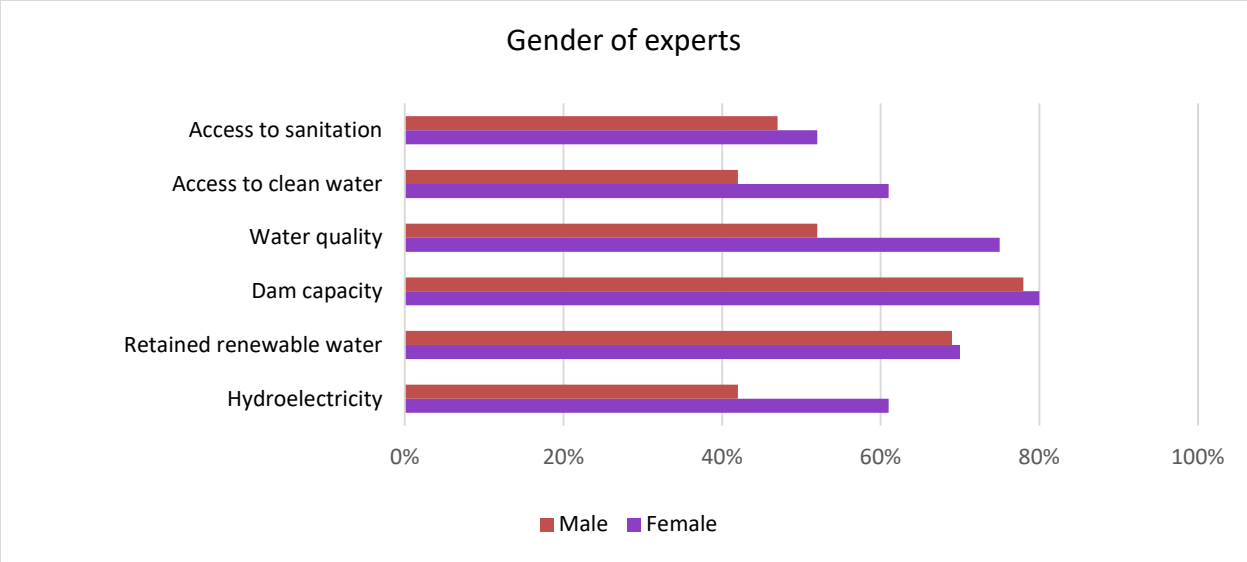

Figure 13 Proportion of experts who consider infrastructural indicators globally relevant depending on their gender.

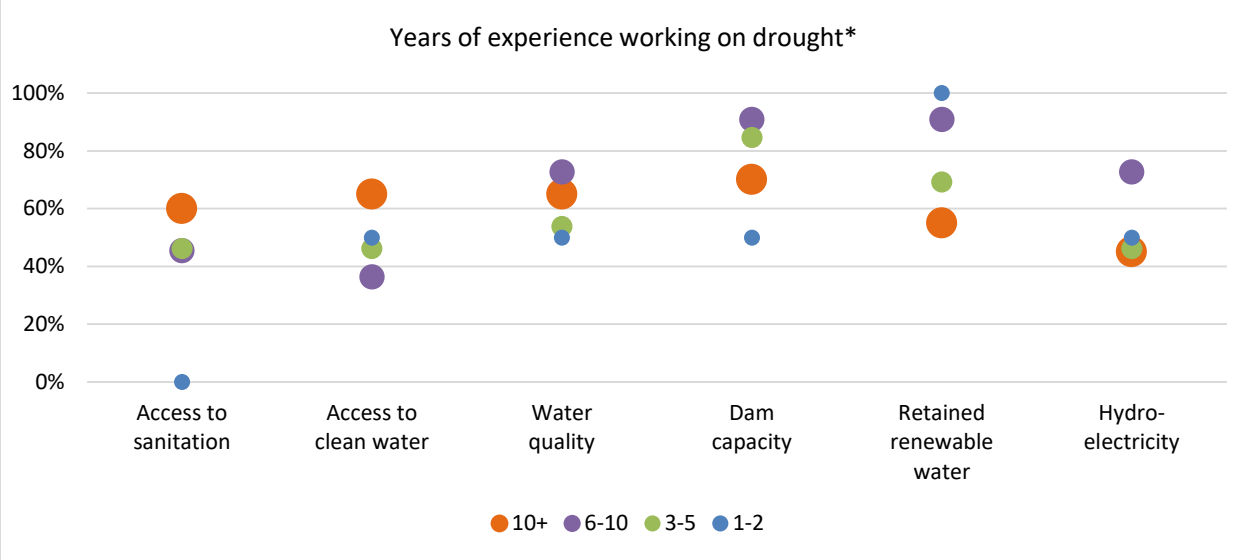

Figure 14 Proportion of experts who consider the infrastructural indicators globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

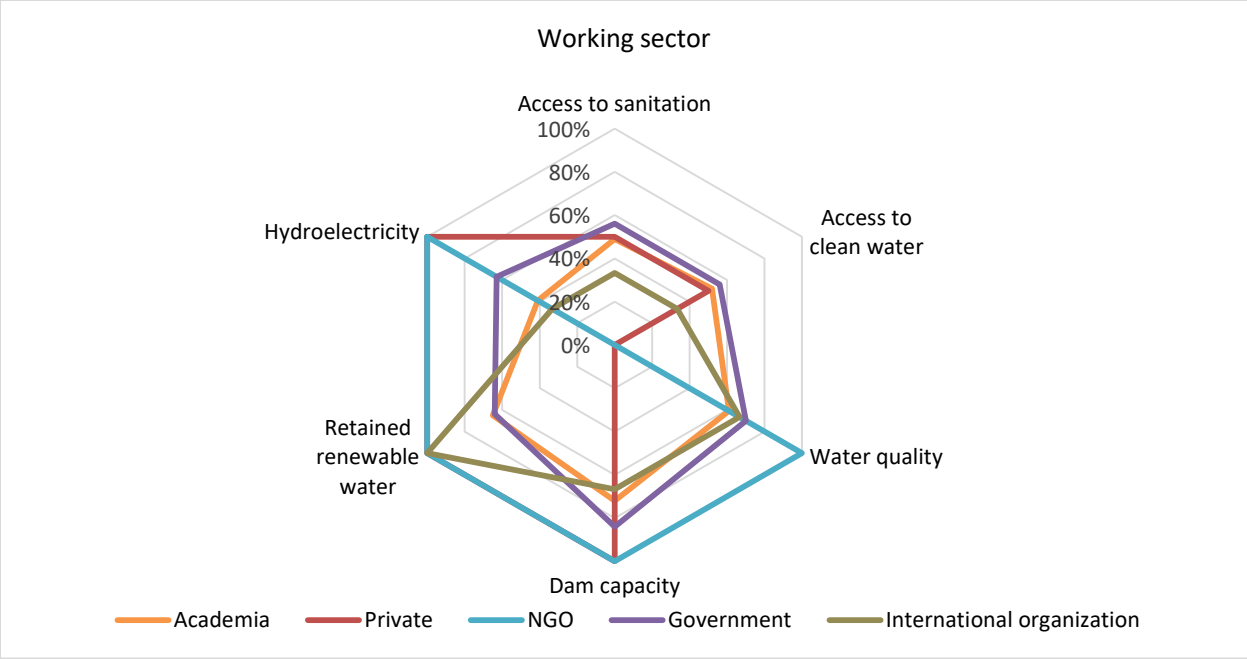

Figure 15 Proportion of experts who consider the infrastructural indicators globally relevant depending on their working sector.

Crime and Conflict

The prevalence of conflict/insecurity was the only indicator where more than 50% of the total experts considered it relevant at the global level. The only group in which less agreement was found was among people working in the government sector. For this sector, 14% considered the indicator not relevant, low relevant or low-medium relevant for 28% of the experts, the prevalence of conflict/insecurity is medium-high relevant and is highly relevant to 21% of respondents.

Figure 16 Proportion of experts who consider the prevalence of conflict/insecurity as a globally relevant indicator, depending on their geographic work focus.

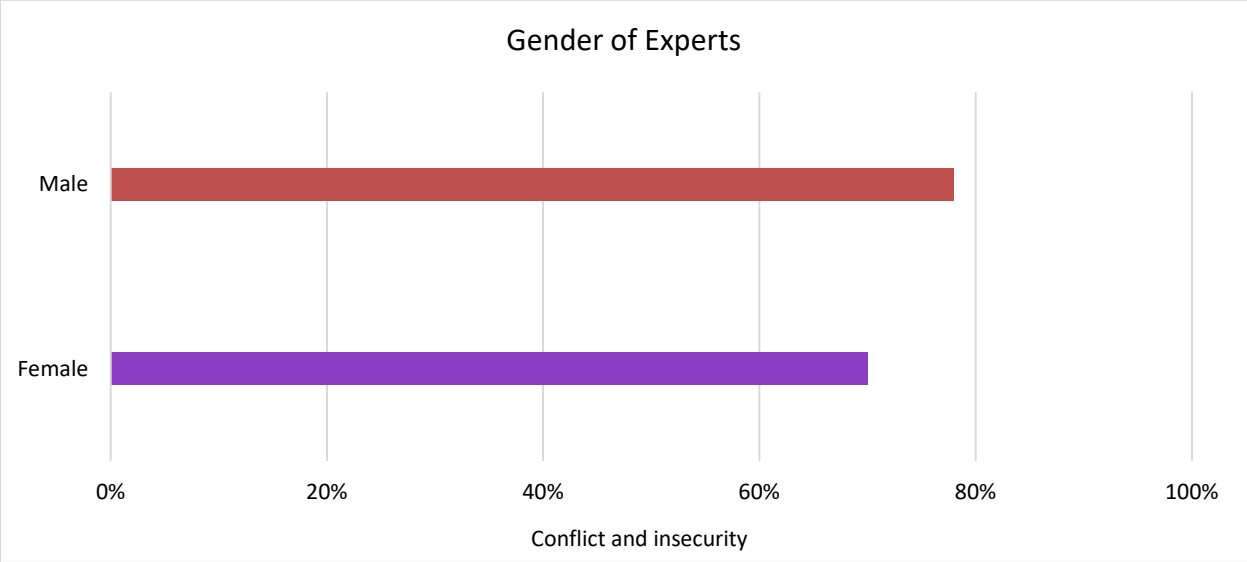

Figure 17 Proportion of experts who consider the prevalence of conflict/insecurity globally relevant depending on their gender.

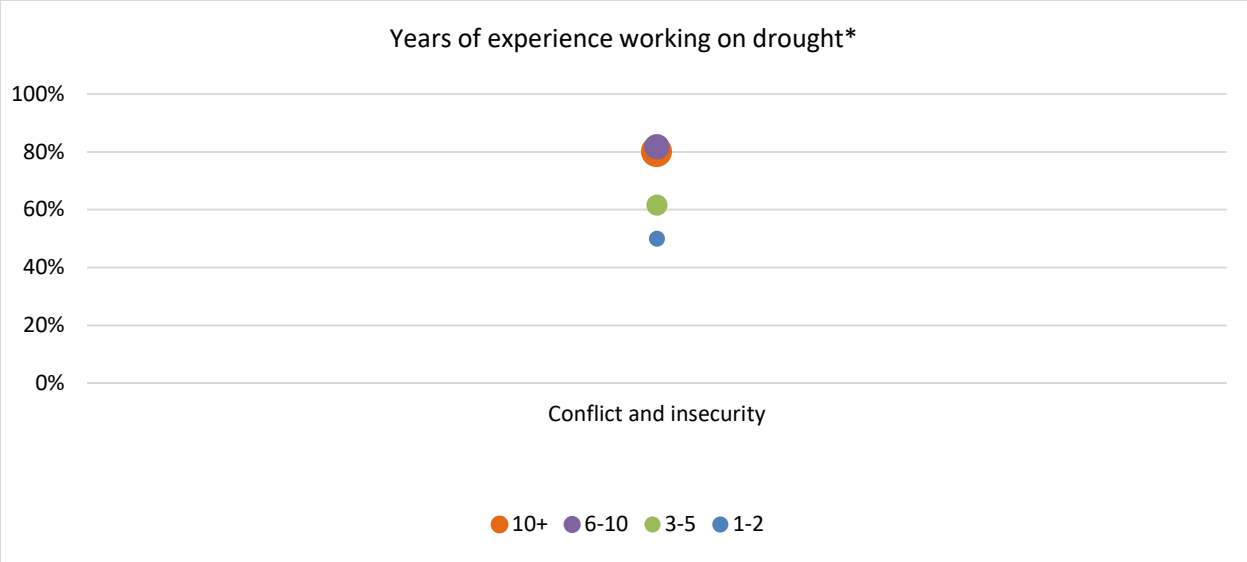

Figure 18 Proportion of experts who consider the prevalence of conflict/insecurity globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

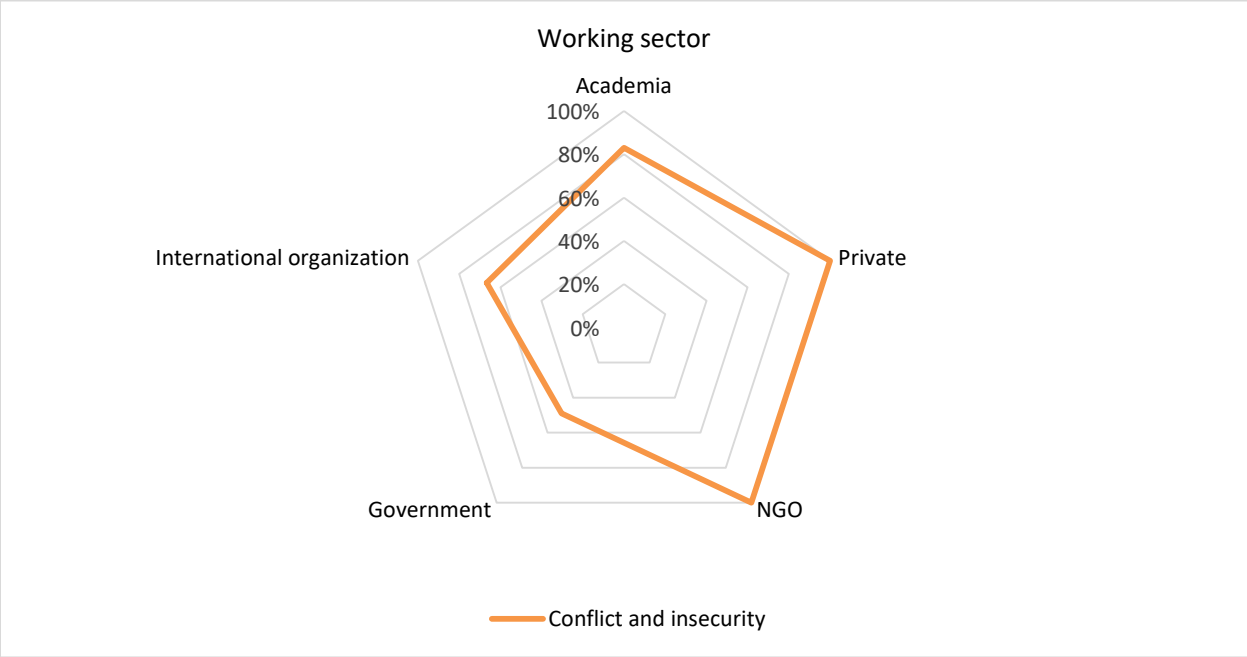

Figure 19 Proportion of experts who consider the prevalence of conflict/insecurity globally relevant depending on their working sector.

Governance

In the governance dimension, eight indicators were chosen as the most relevant at the global level (disaster risk taken into account in public investment and planning decisions (yes/no), national investment in disaster prevention & preparedness (US$/Year/capita), existence of adaptation policies/plans (yes/no), government effectiveness, number of (drought-related) adaptation projects in the past 10 years, corruption, public participation in local policy and research and development expenditure (% of GDP)). The expert's gender and the number of years working with drought did not show any difference among the selected indicators. All indicators were classified as relevant in the different groups and categories.

The number of (drought-related) adaptation projects in the past ten years and corruption indicators are relevant to all experts except those in the private sector for whom these indicators are of low relevance. Less than half (40%) of the respondents that work on Asia or general/theoretical topics considered "research and development expenditure (% of GDP)" as a relevant indicator.

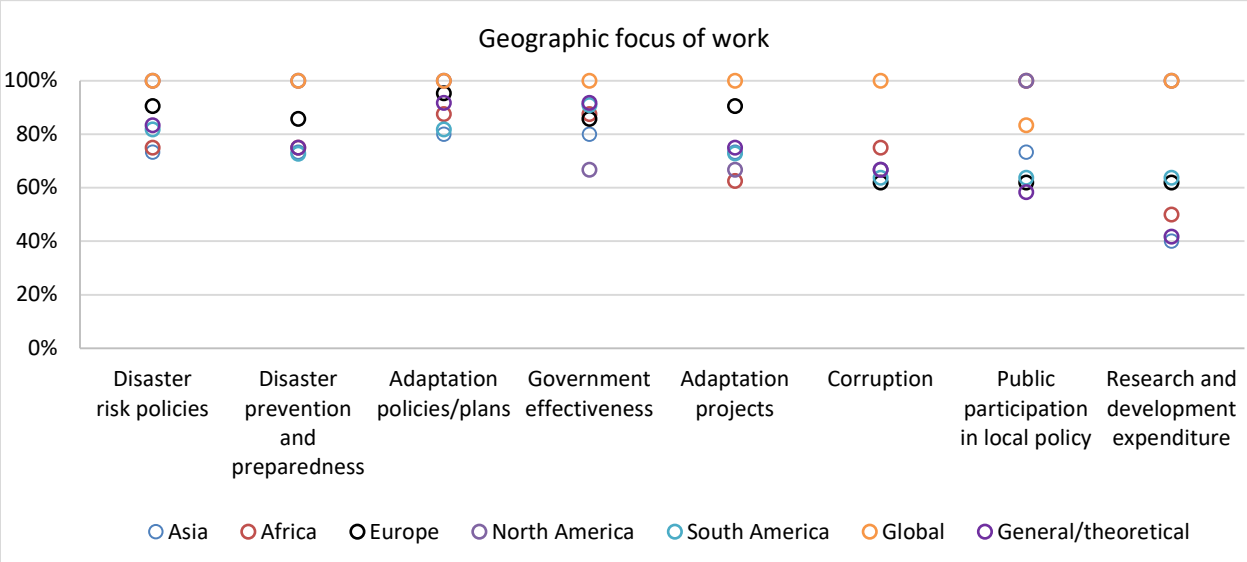

Figure 20 Proportion of experts who consider these governmental indicators globally relevant depending on their geographic work focus.

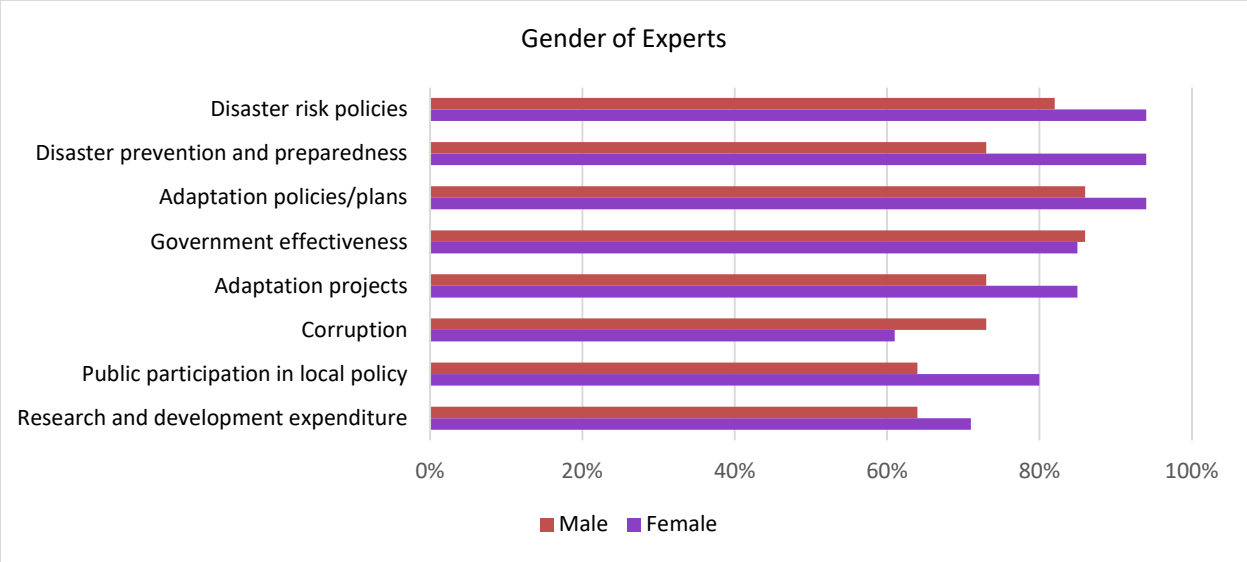

Figure 21 Proportion of experts who consider the governmental indicators globally relevant depending on their gender.

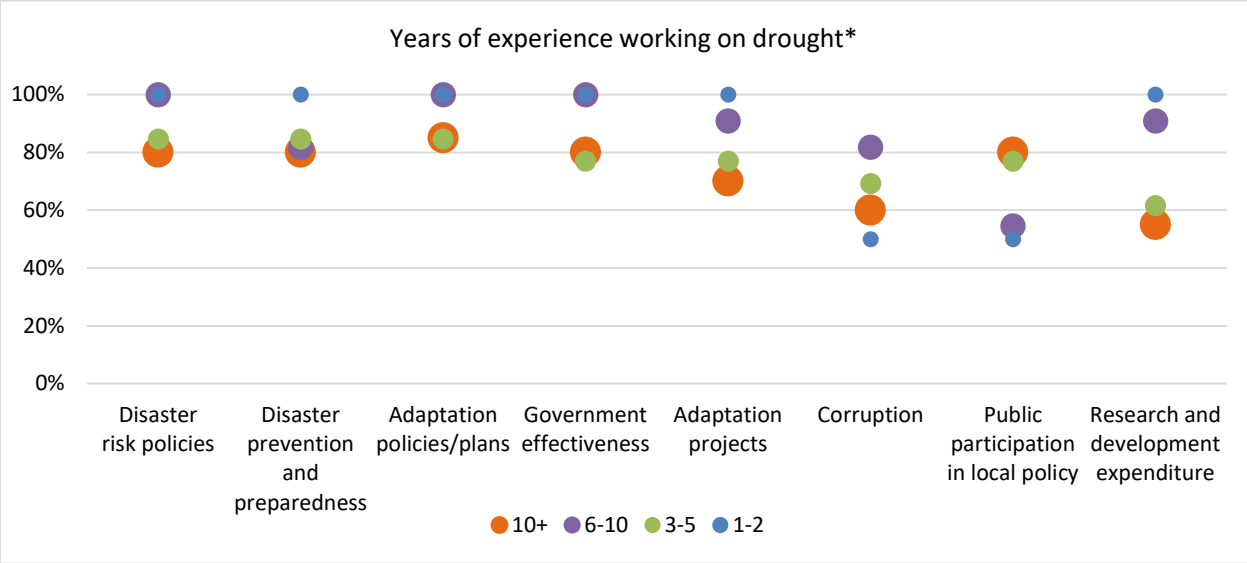

Figure 22 Proportion of experts who consider the governmental indicators globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

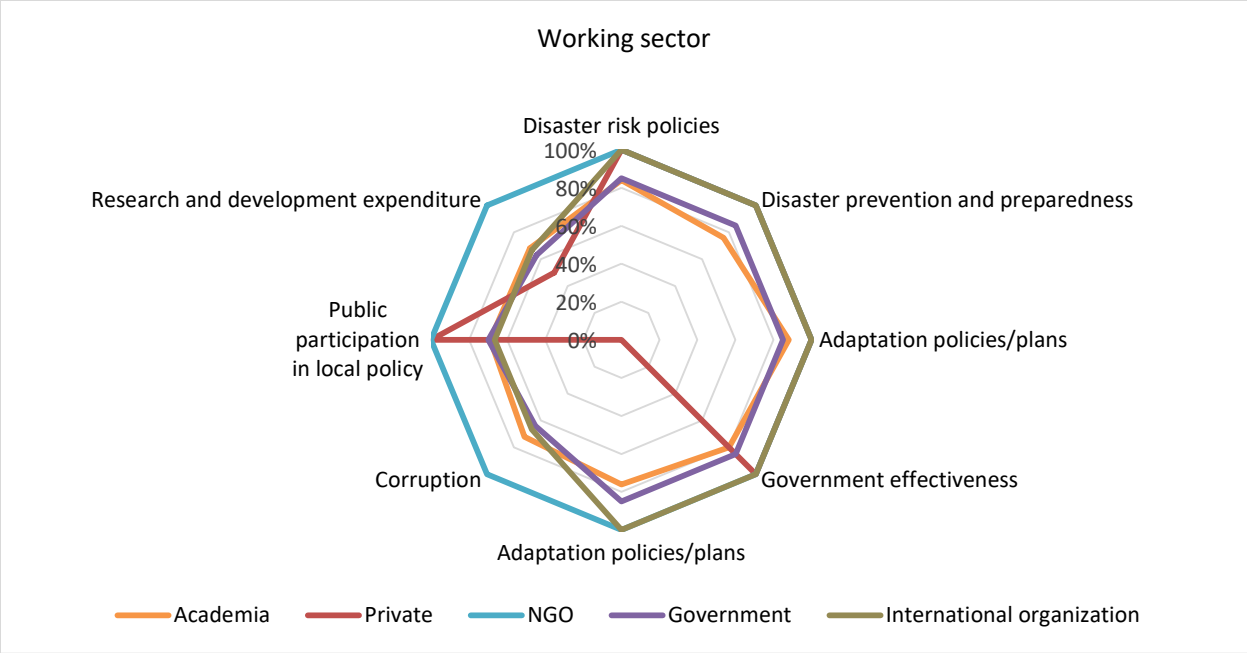

Figure 23 Proportion of experts who consider these governmental indicators globally relevant depending on their working sector.

Environmental

Soil depth (mm), degree of land degradation and desertification, area protected and designated for the conservation of biodiversity (%), livestock health and baseline water stress (ratio of withdrawals to renewable supply) are currently perceived as a relevant indicators to measure vulnerability to drought at global level. The degree of land degradation/ desertification and the baseline water stress are the most relevant according to all the different categories and groups.

There was also plurality of eight out of ten global experts (83%) that rates the livestock health as relevant, close by 75% Africa focus experts, while almost half (48%) of experts focused on Europe considered it relevant. The percentage of area protected is considered relevant by people who have been working on drought topic for more than three years.

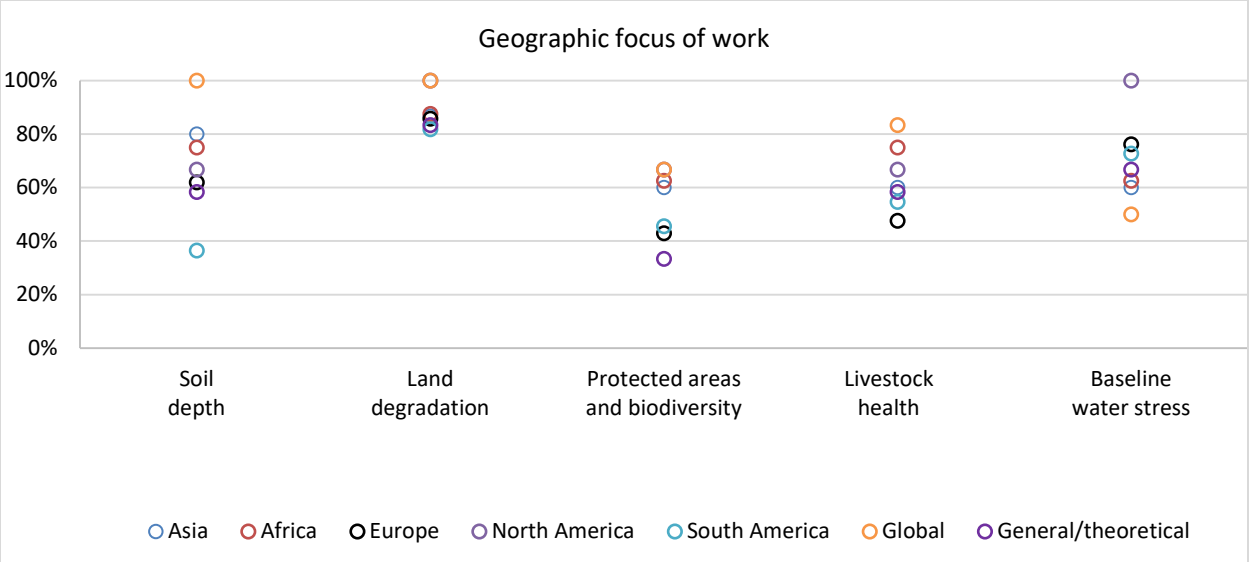

Figure 24 Proportion of experts who consider the environmental indicators globally relevant depending on their geographic work focus.

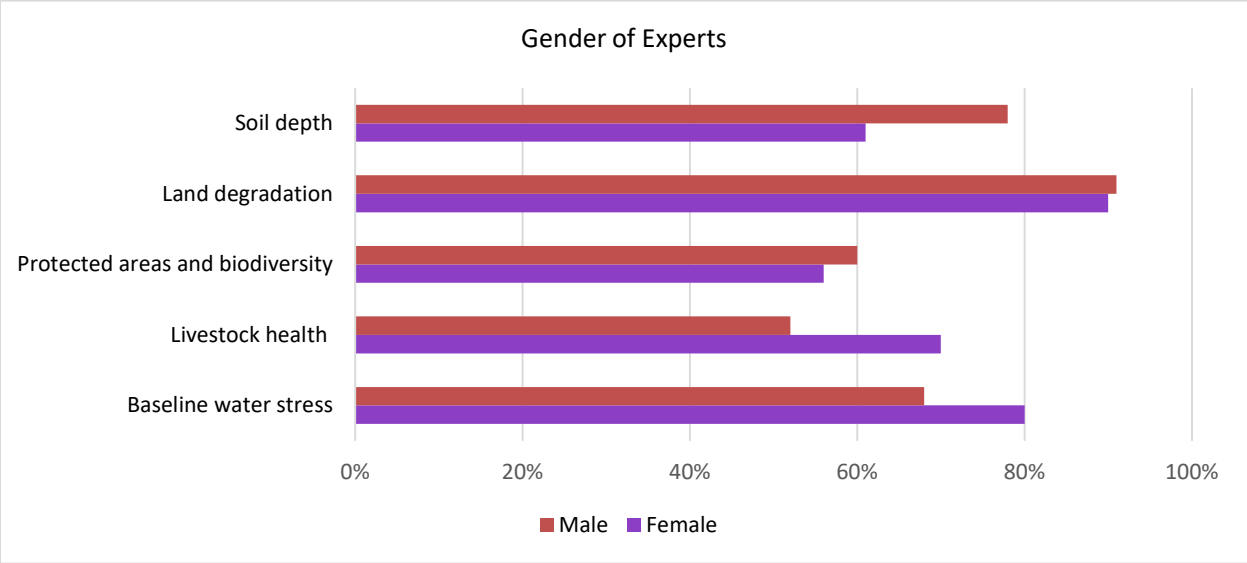

Figure 25 Proportion of experts who consider the environmental indicators globally relevant depending on their gender.

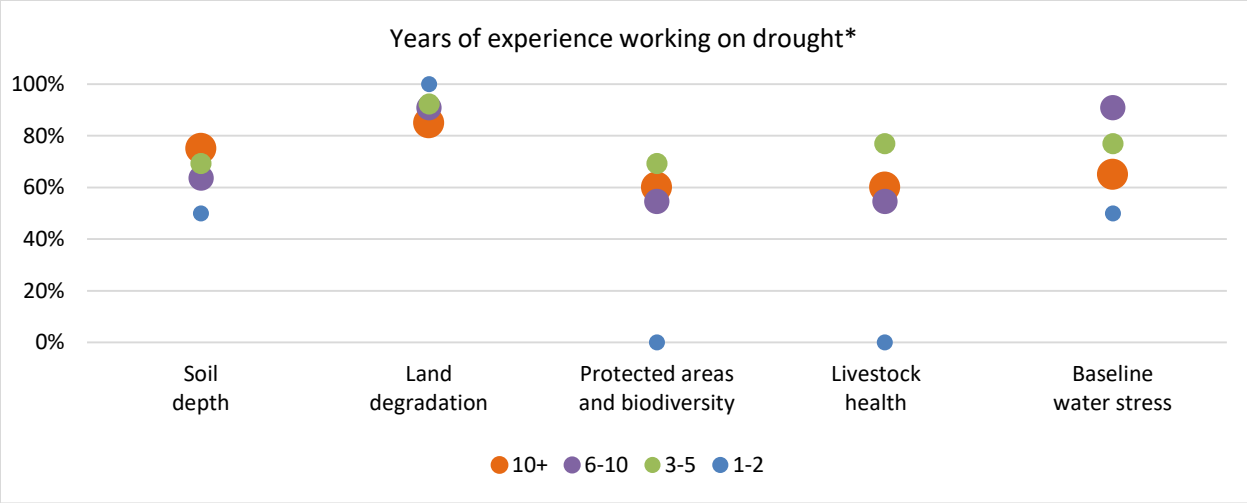

Figure 26 Proportion of experts who consider the environmental indicators globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

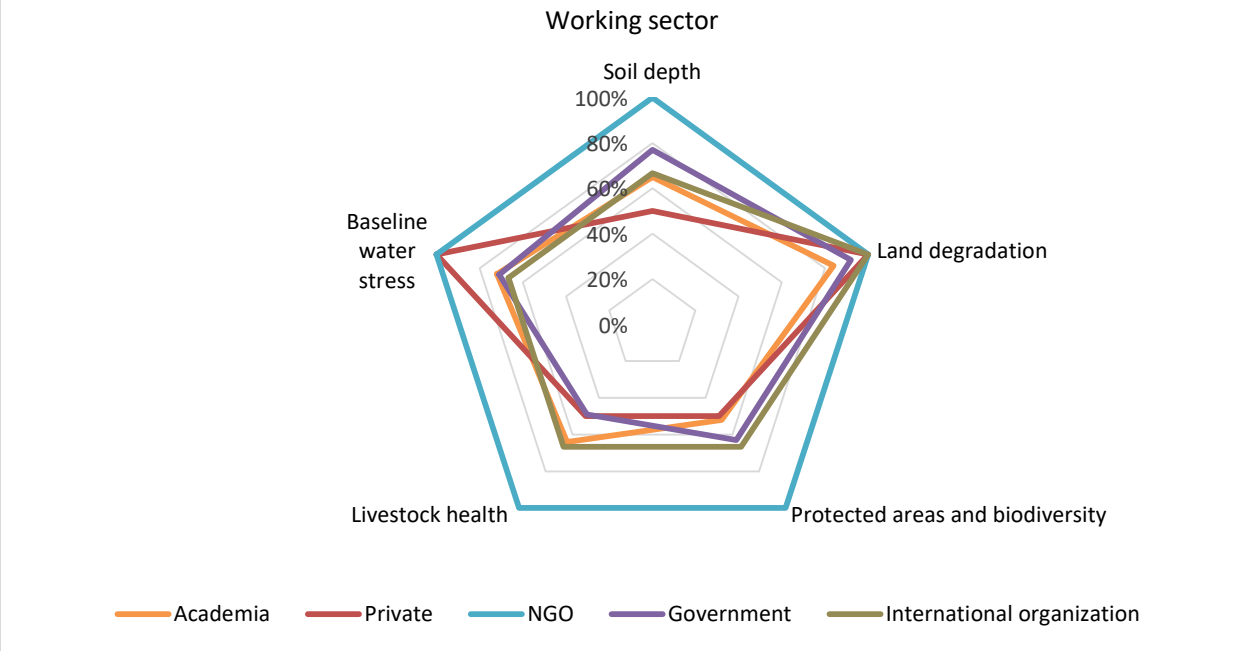

Figure 27 Proportion of experts who consider the environmental indicators globally relevant depending on their working sector.

Farming practices

Farming practices was the only dimension of vulnerability where all indicators were considered relevant for agricultural systems at the global level. Looking at the different working sectors, it was found that most of the experts working in academia and in the government sector express greater relevance than private, NGO's and international sectors about the agricultural machinery in use (#) indicator. This indicator was also weighed as the least relevant in the dimension of agricultural practices.

Those more likely to score insecticides and pesticides used (ton/ha) as medium-high or highly global relevant include: female experts, six to ten years of working experiences, global geographic focus of work, and, experts from non-governmental organizations.

The use of different crop varieties (%) and the cultivation of drought-resistant crops (%) are considered ecosystem-based approaches to drought risk reduction (Kloos and Renaud 2016). These indicators were equally relevant for female and male experts. However, the cultivation of drought-resistant crops (%) was considered by 95% of the experts with more than ten years of experience as a global relevant indicator. In contrast, 85% of experts considered farmers use different crop varieties (%) as globally relevant. This pattern is repeated throughout the various working sectors and geographic focus areas, where the cultivation of drought-resistant crops (%) was catalogued as relevant by more experts than the cultivation of drought-resistant crops.

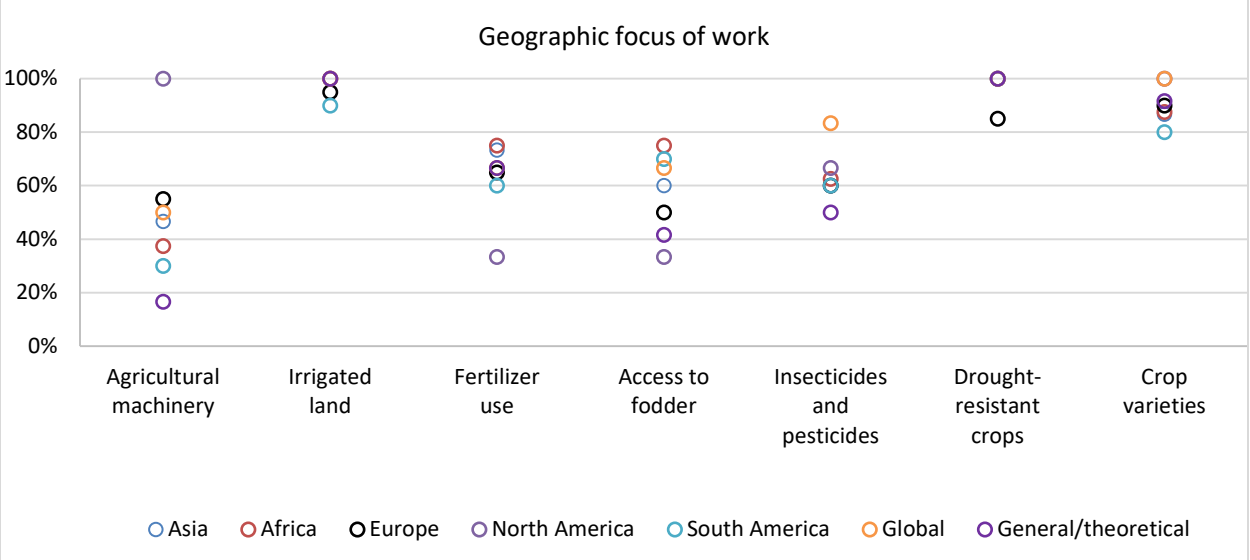

Figure 28 Proportion of experts who consider farming practices indicators as globally relevant depending on their geographic work focus.

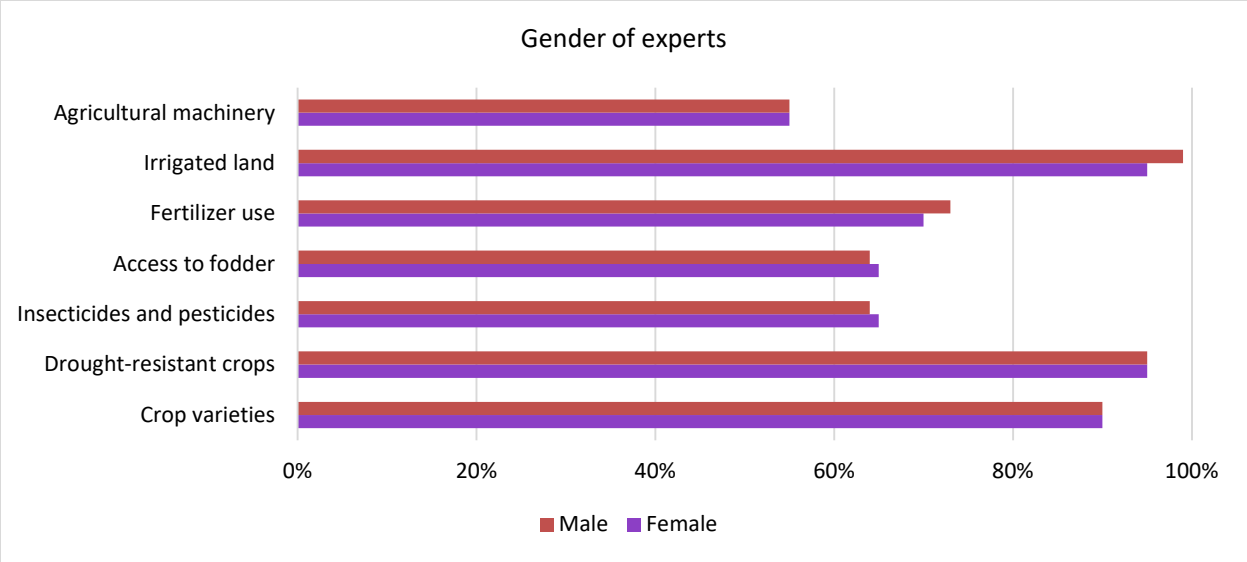

Figure 29 Proportion of experts who consider farming practices indicators globally relevant depending on their gender.

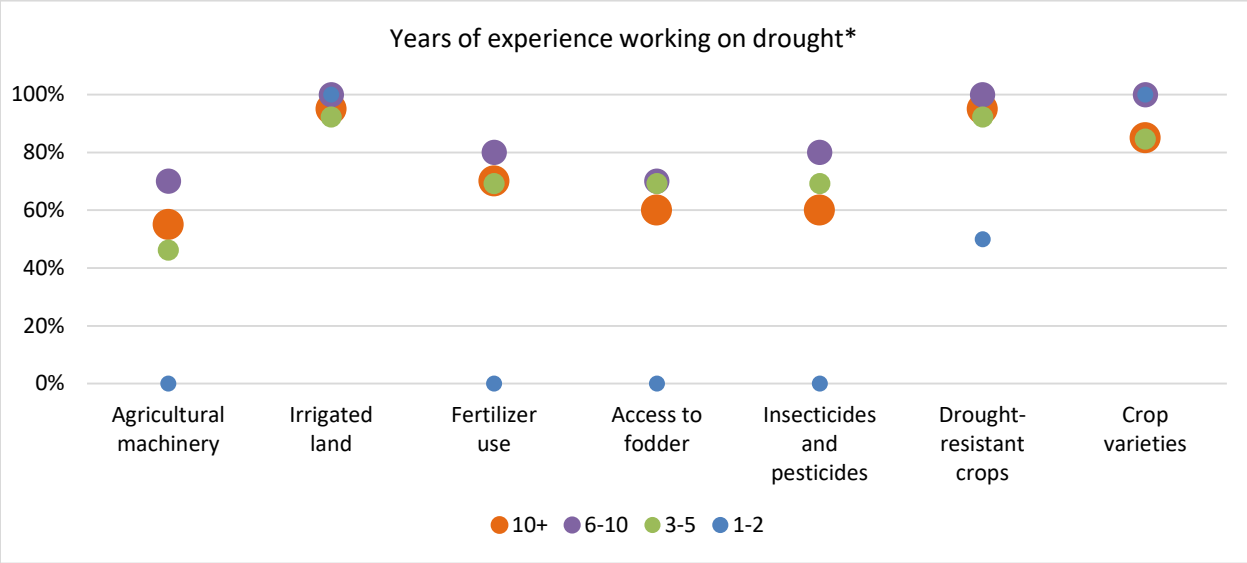

Figure 30 Proportion of experts who consider farming practices indicators globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

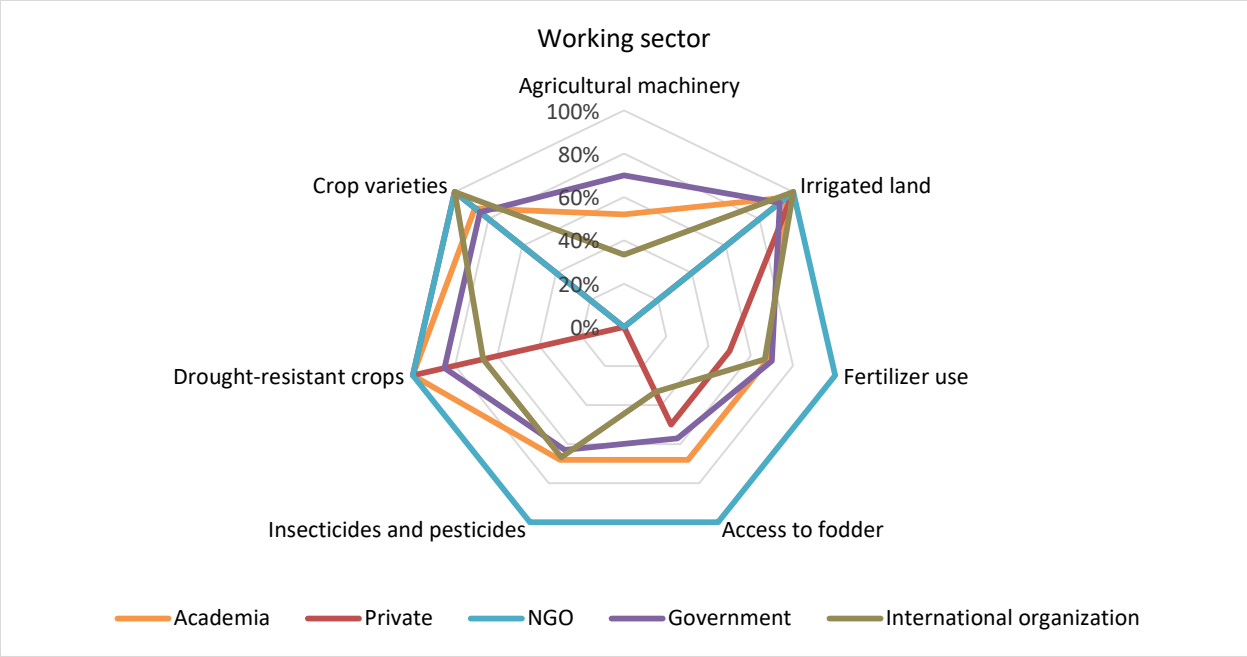

Figure 31 Proportion of experts who consider farming practices indicators globally relevant depending on their working sector.

References:

Kloos J., Renaud F.G. (2016). Overview of Ecosystem-Based Approaches to Drought Risk Reduction Targeting Small-Scale Farmers in Sub-Saharan Africa. In: Renaud F., Sudmeier-Rieux K., Estrella M., Nehren U. (eds) Ecosystem-Based Disaster Risk Reduction and Adaptation in Practice. Advances in Natural and Technological Hazards Research, vol 42. Springer, Cham.

Annex 5: Detailed sector analysis for Water Supply

Social dimension

In the online survey, the experts agreed on the global relevance of seven indicators for the vulnerability's social dimension. More than three-quarters of experts strongly agree that risk perception is an essential indicator of global drought vulnerability assessments. Those who are more certain than others that risk perception plays a crucial role in drought vulnerability assessment to water supply are: female experts that have six to ten years of experience working on drought, with a main geographic focus in Africa or on global assessments and experts that work on NGOs or private sectors.

The top relevance indicator by gender in the social dimension is risk perception (% of population who has experienced droughts in the past 10 years) and illiteracy rate (%). Gender inequality was scored as relevant for 57% of male experts, while just 36% of female experts weighed this indicator as globally relevant.

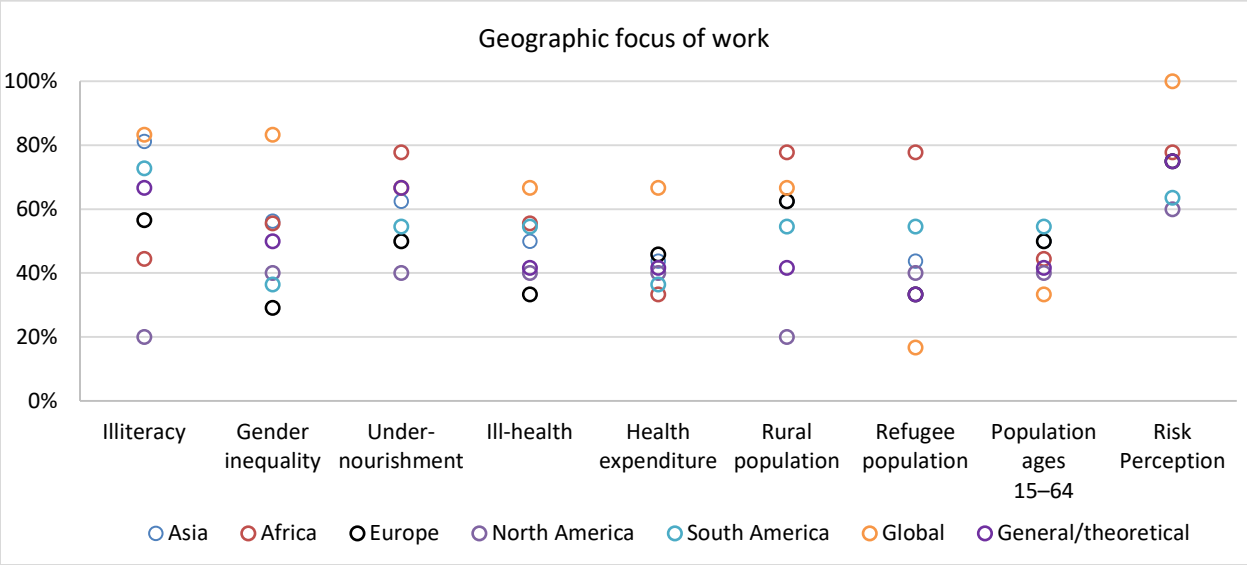

Figure 32 Proportion of experts who consider the indicators globally relevant depending on their geographic work focus.

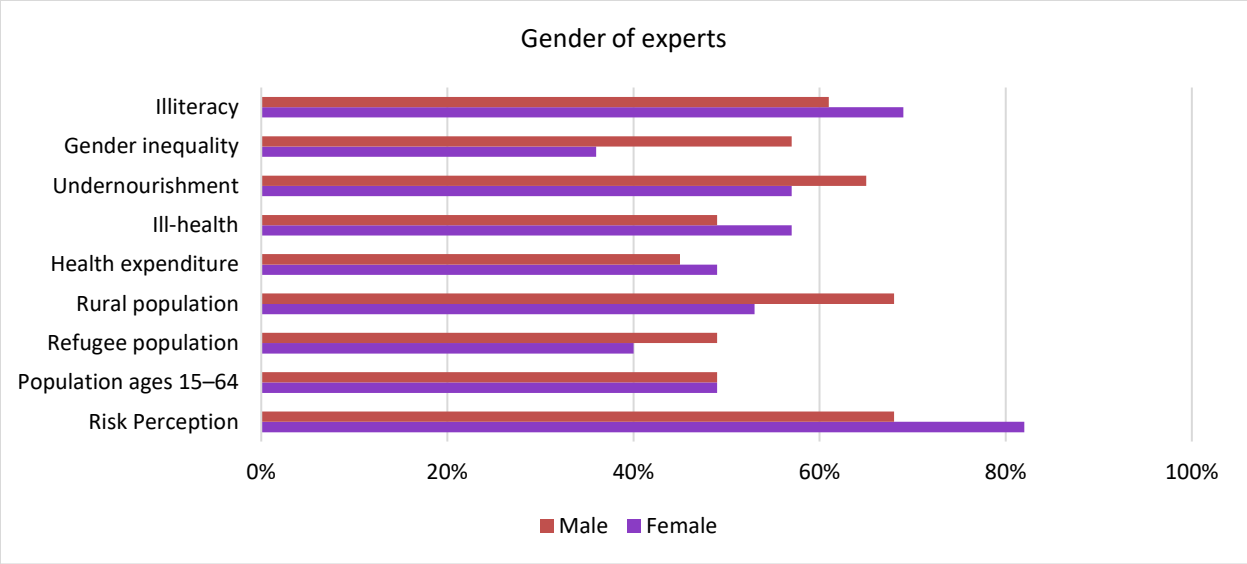

Figure 33 Proportion of experts who consider the indicators globally relevant depending on their gender.

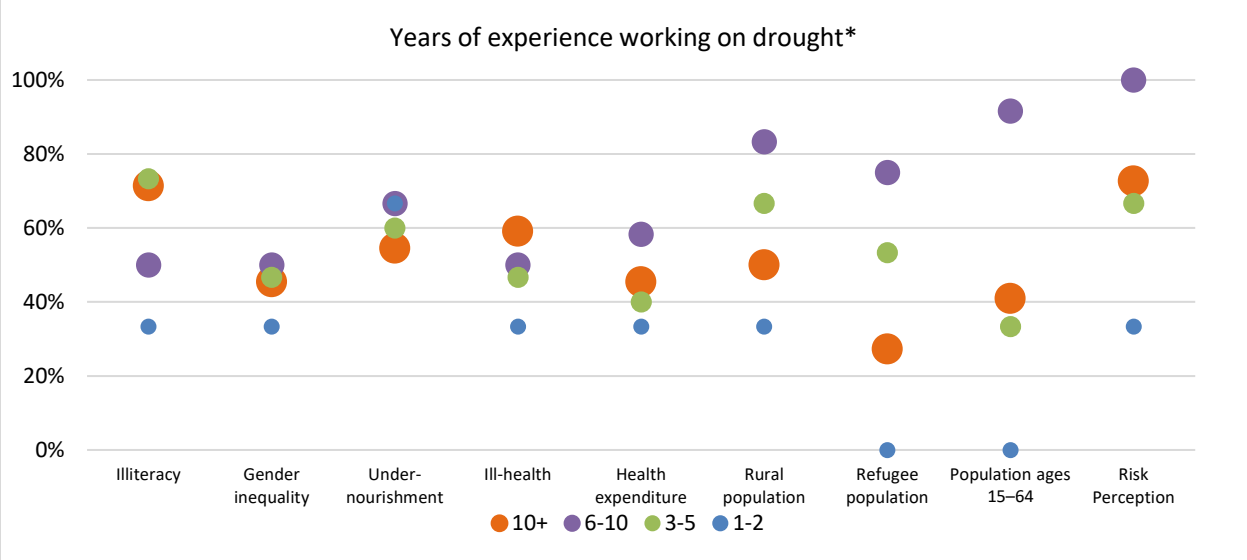

Figure 34 Proportion of experts who consider the indicators globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

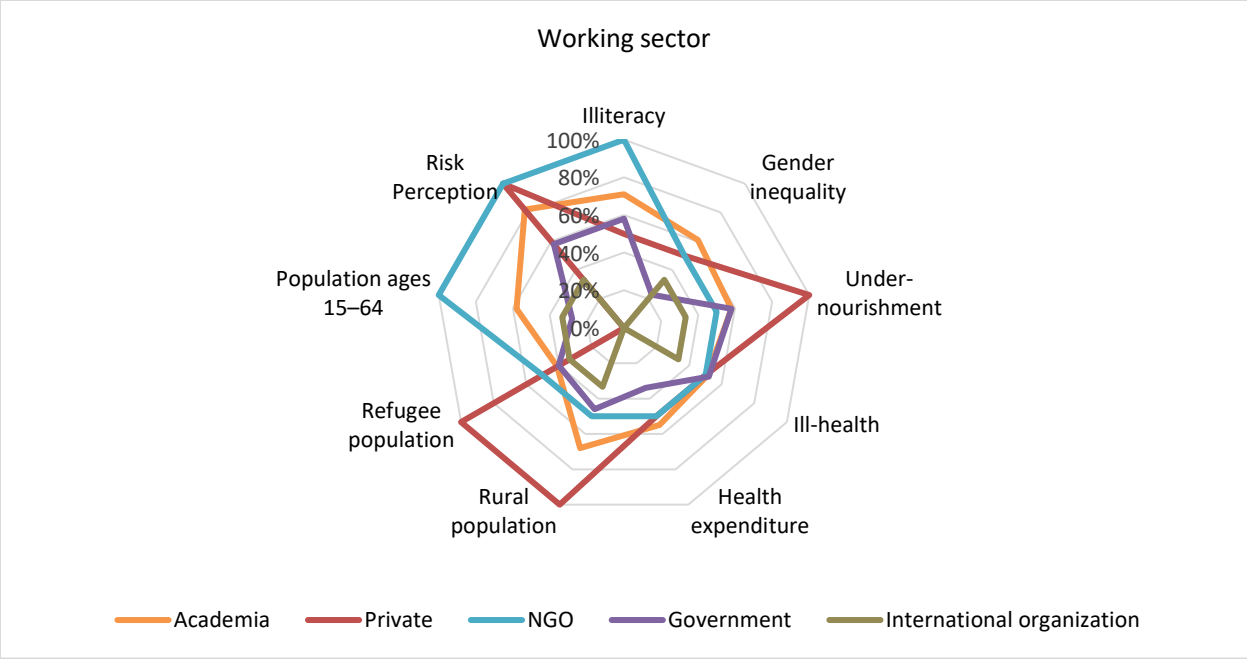

Figure 35 Proportion of experts who consider the indicators globally relevant depending on their working sector.

Economic dimension

The majority of experts agreed on eight indicators with relevance at the global level for the economic dimension of vulnerability. For 80% of female experts, the GDP per capita is relevant, in contrast to 51% percent of male experts.

The unemployment rate (%) was one of the indicators with more discrepancy between the different categories. It was catalogued as relevant by less than half of the male experts, respondents with no experience working on drought or with 3 to 5 years of experience, for the private and NGO, and international sectors and experts that focus on Africa, North America, South America and in general/theoretical areas.

Almost seven in ten (65%) agree on the relevance to consider tourism (% GDP) as an indicator. Those most likely to agree with this include: female experts, one to ten years of experience, NGO, international organization and private sectors and Europe focus experts.

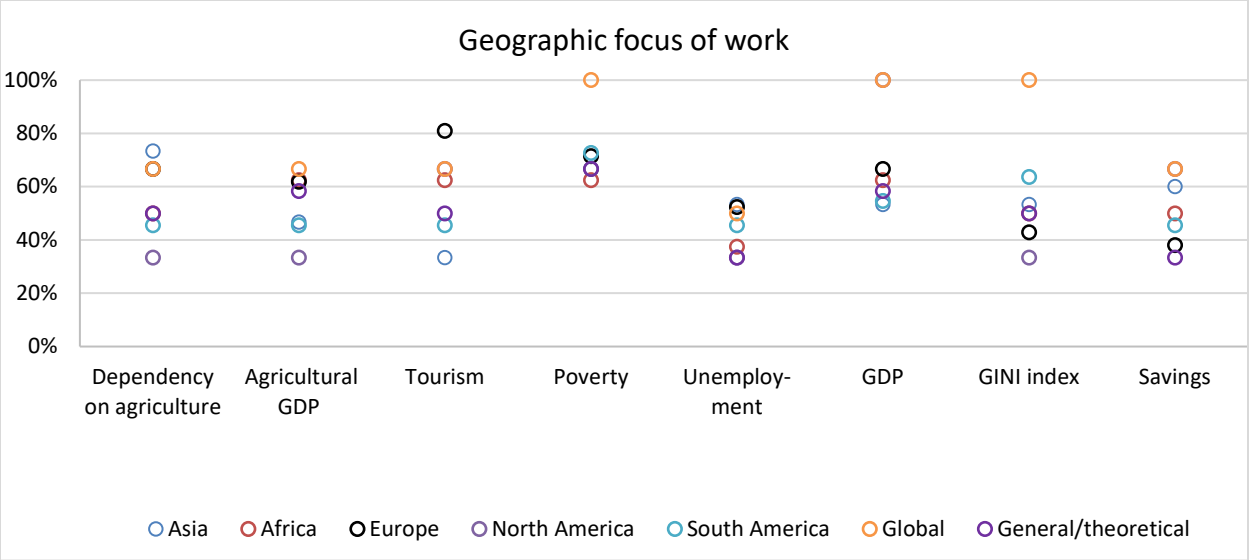

Figure 36 Proportion of experts who consider the indicators globally relevant depending on their geographic work focus.

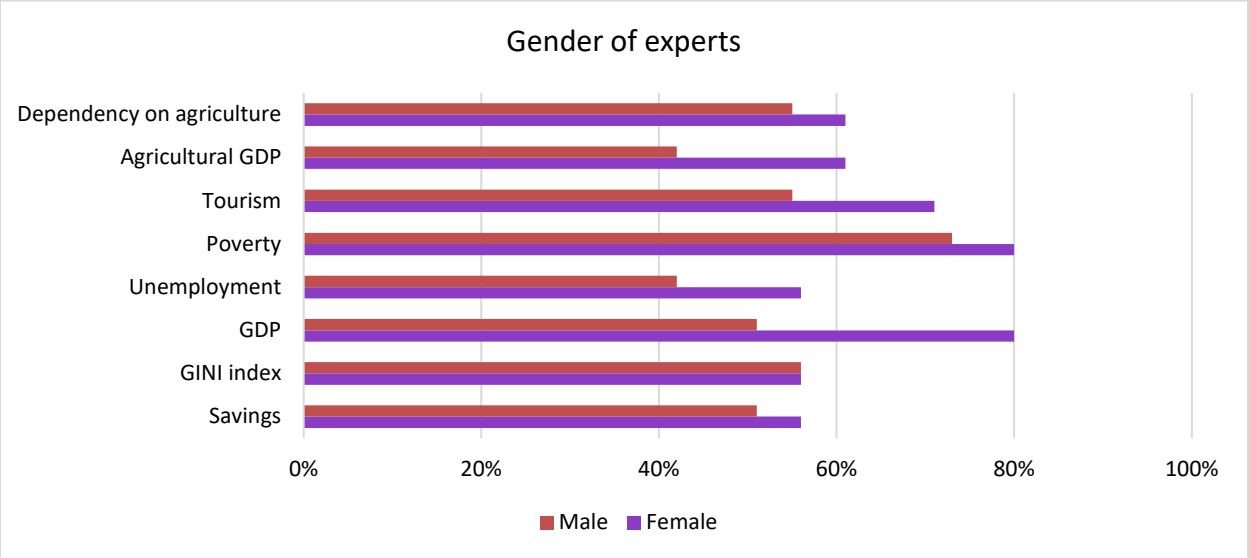

Figure 37 Proportion of experts who consider the indicators globally relevant depending on their gender.

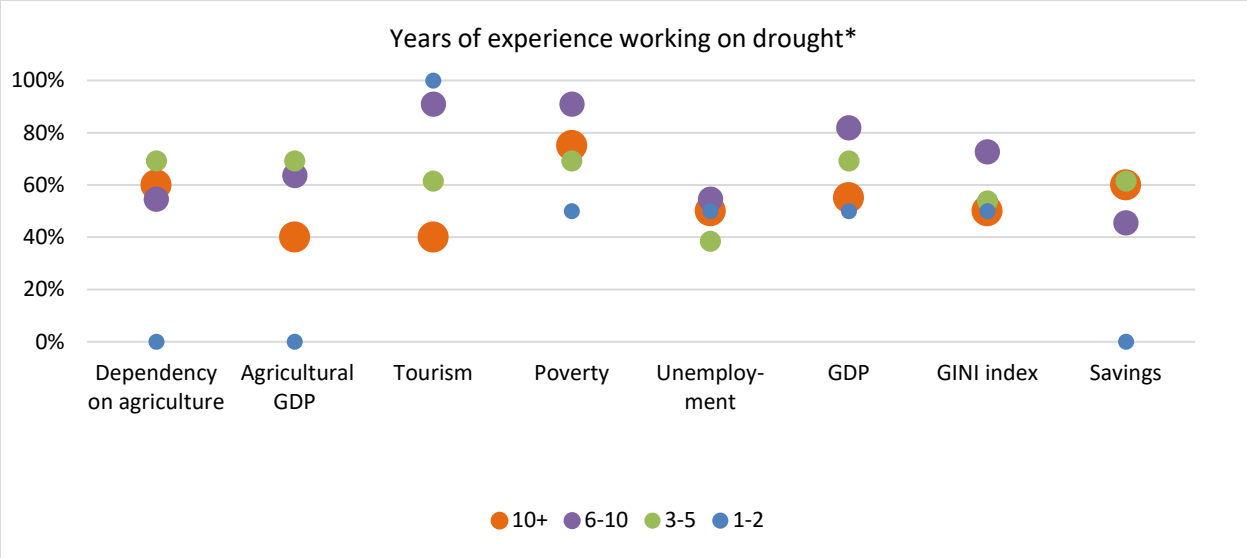

Figure 38 Proportion of experts who consider the indicators globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

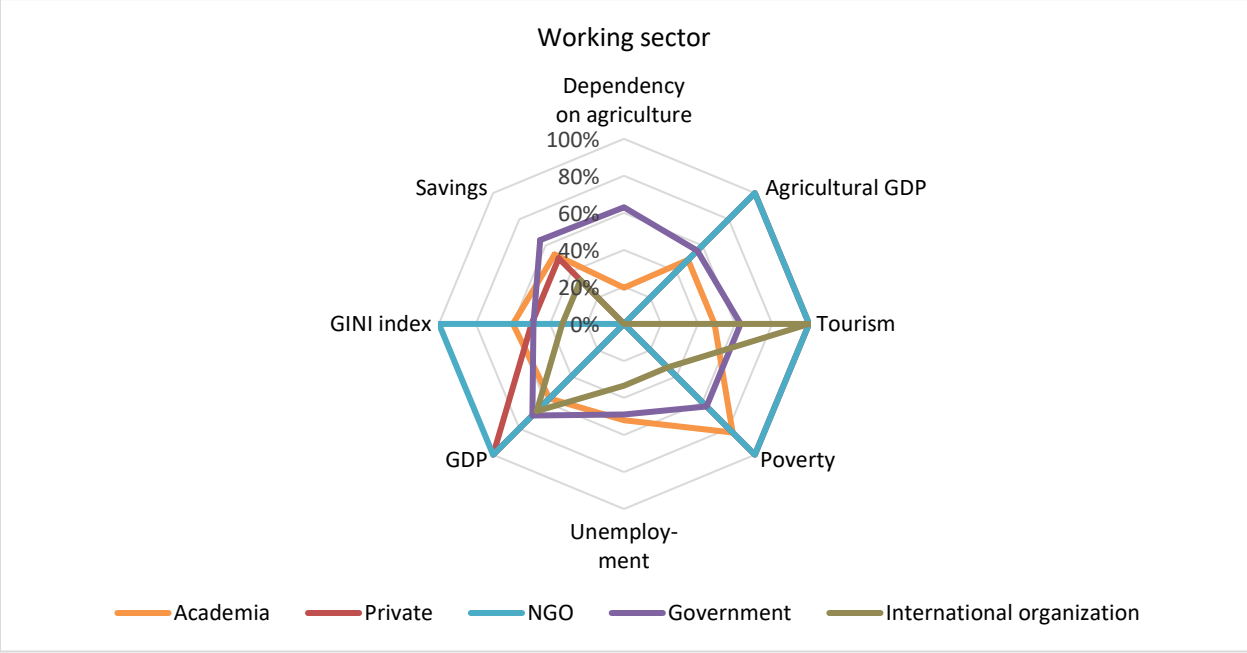

Figure 39 Proportion of experts who consider the indicators globally relevant depending on their working sector.

Infrastructural dimension

More than 50% of the experts agreed on the relevance of population without access to (improved) sanitation (%), population without access to clean water (%), water quality (categorical), total dam capacity (m^3), % of retained renewable water and electricity production from hydroelectric sources (% of total) as global drought vulnerability indicators to impacts in domestic water supply.

Sixty-one percent agree that electricity production from hydroelectric sources (% of total) is globally relevant. Male experts, people that focus on America (North and South) and international organization are the less likely to consider this indicator highly or medium-high relevant.

There is little disagreement among experts working in different sectors about the relevant indicators; however the highest variation is found among the geographical focus.

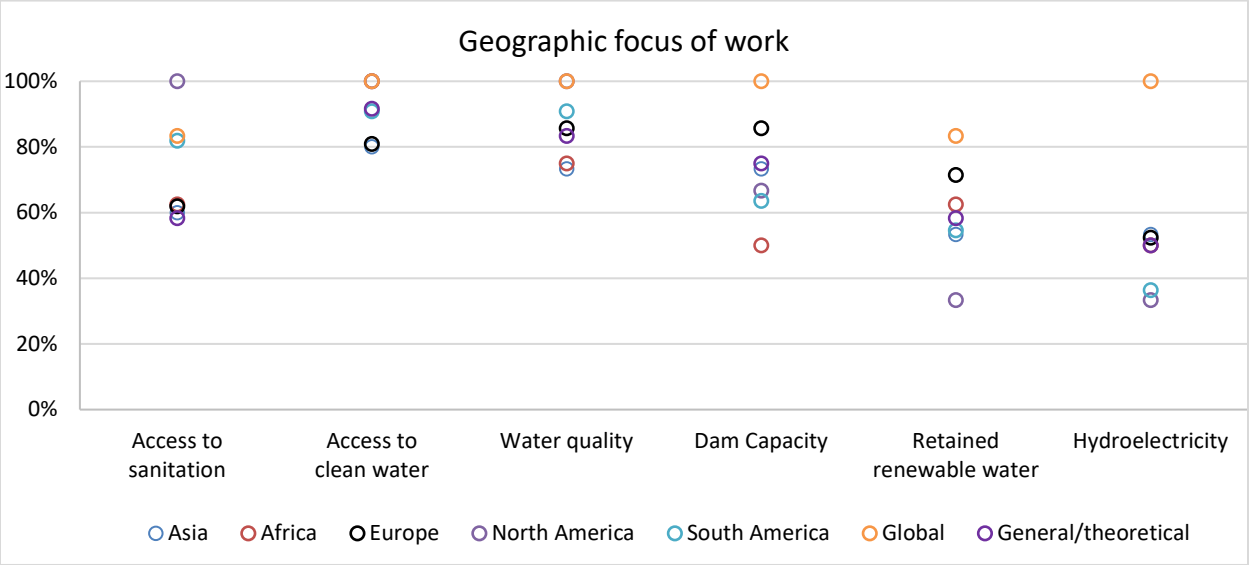

Figure 40 Proportion of experts who consider the infrastructural indicators globally relevant depending on their geographic work focus.

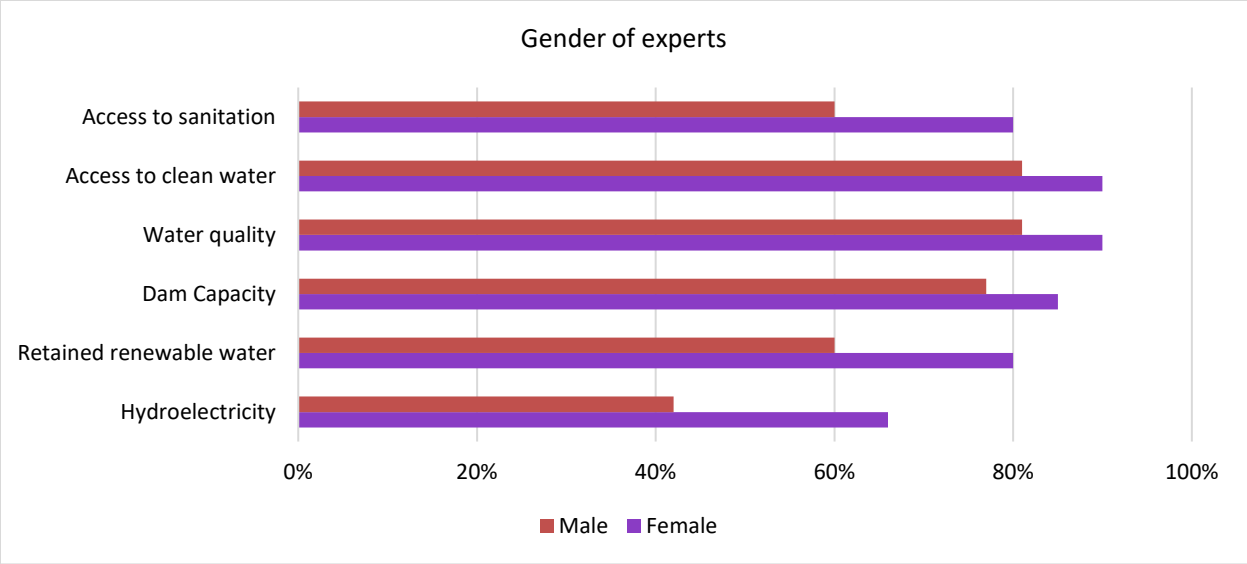

Figure 41 Proportion of experts who consider infrastructural indicators globally relevant depending on their gender.

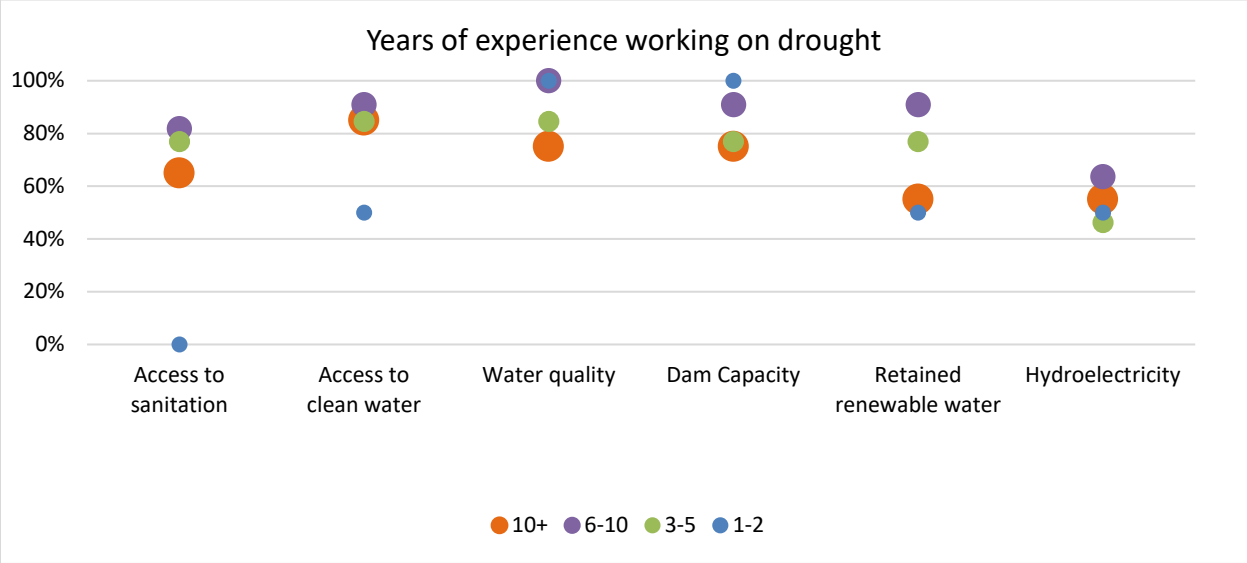

Figure 42 Proportion of experts who consider the infrastructural indicators globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

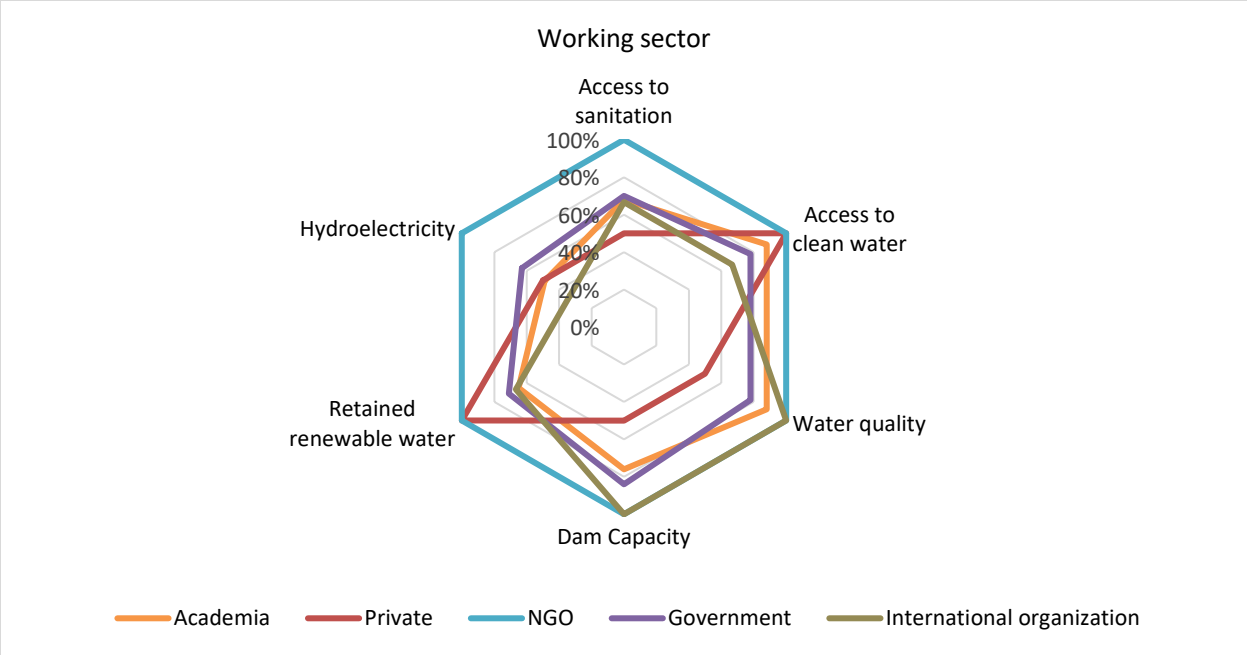

Figure 43 Proportion of experts who consider the infrastructural indicators globally relevant depending on their working sector.

Crime and Conflict

The prevalence of conflict/insecurity was the only indicator that the experts selected as relevant at the global level. All the different categories agreed on this indicator, only six experts working on drought for more than three years weighed it as not relevant or low relevance. Some female experts, private sector, NGO or experts from international organizations identified this indicator as not relevant at all.

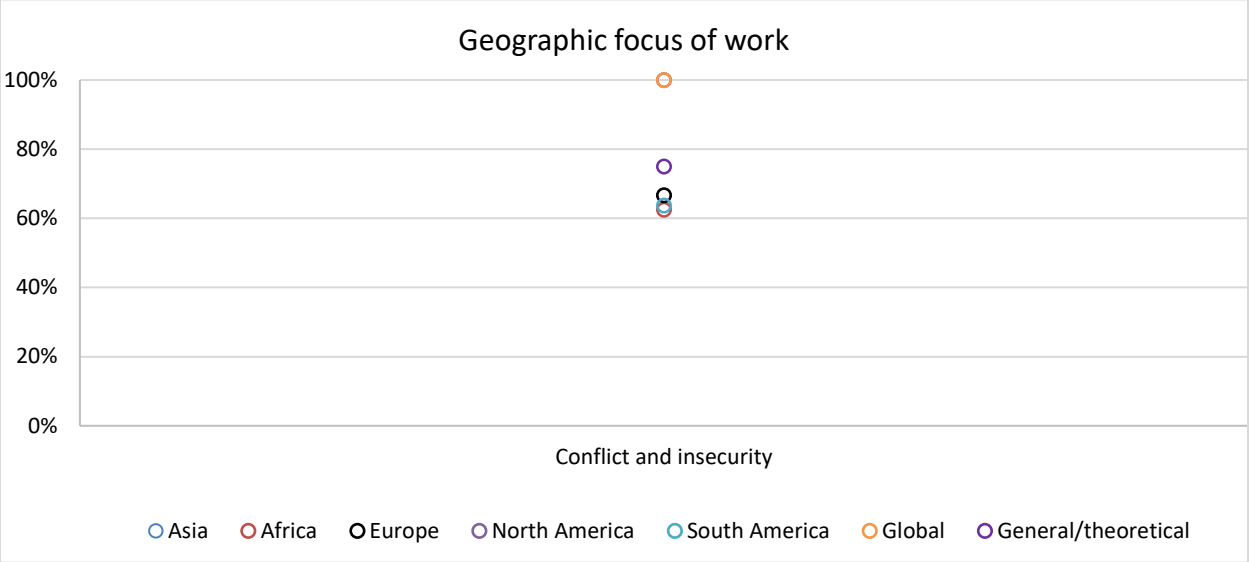

Figure 44 Proportion of experts who consider the prevalence of conflict/insecurity as a globally relevant indicator, depending on their geographic work focus.

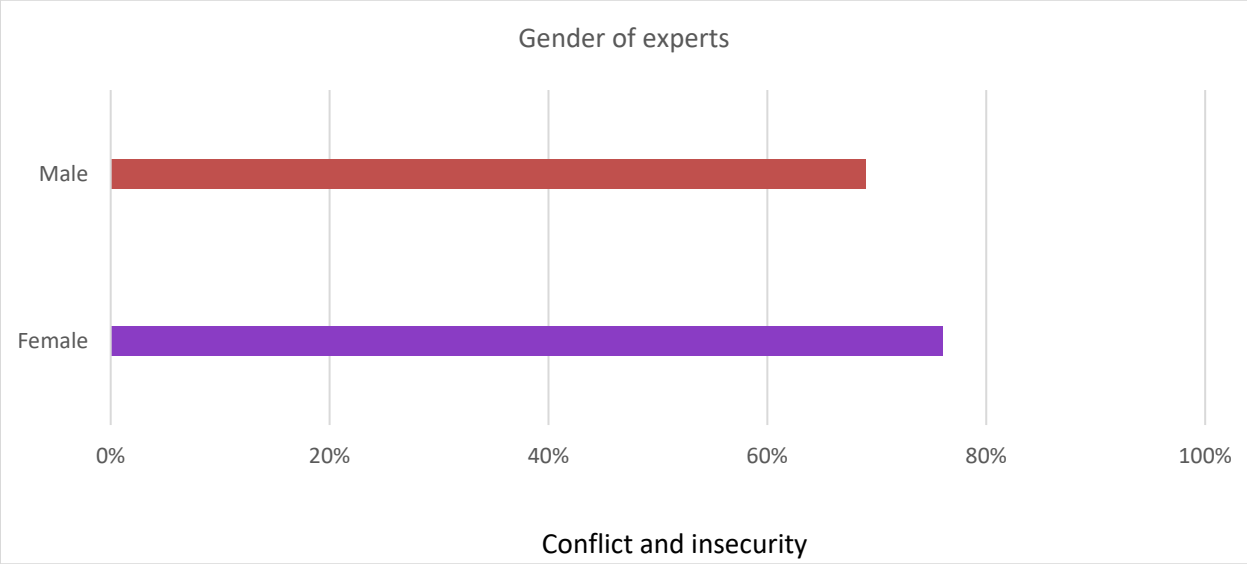

Figure 45 Proportion of experts who consider the prevalence of conflict/insecurity globally relevant depending on their gender.

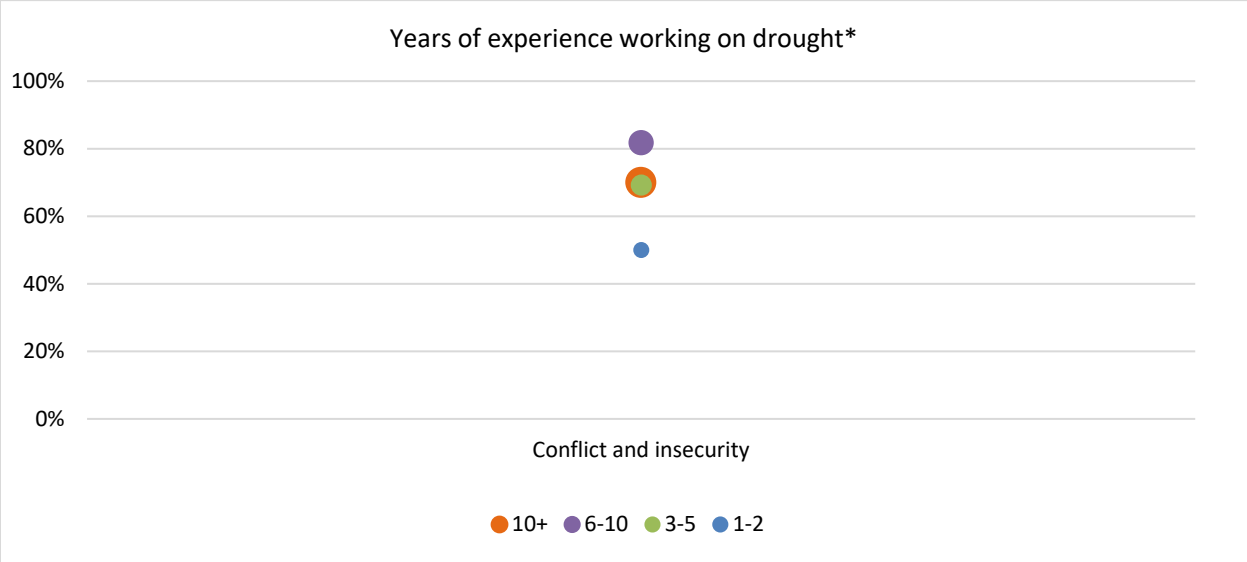

Figure 46 Proportion of experts who consider the prevalence of conflict/insecurity globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

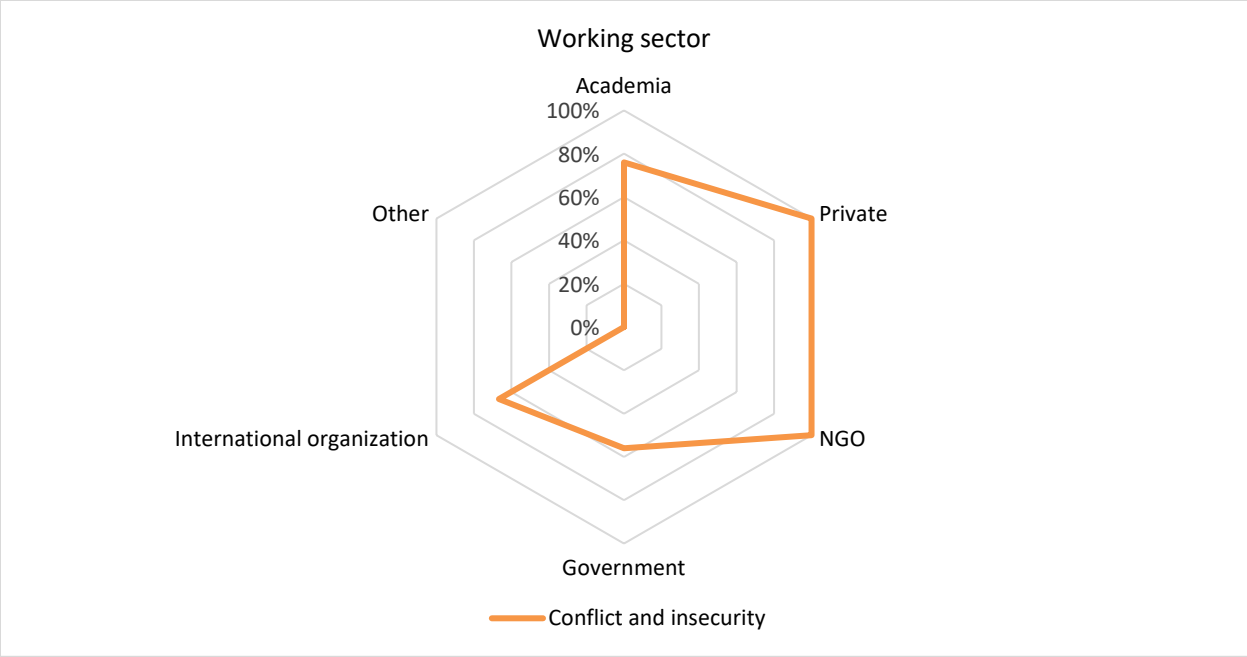

Figure 47 Proportion of experts who consider the prevalence of conflict/insecurity globally relevant depending on their working sector.

Governance

The top three indicators identified for the governance dimension among the different categories were: existence of adaptation policies/strategies (yes/no), government effectiveness and disaster risk taken into account in public investment.

Similar to the agricultural systems, the number of (drought-related) adaptation projects in the past ten years and corruption indicators are relevant to all experts except for some in the private sector for whom these indicators are of low relevance. Less than half (40%) of the respondents that work in Asia on general/theoretical considered "research and development expenditure (% of GDP) as a relevant indicator.

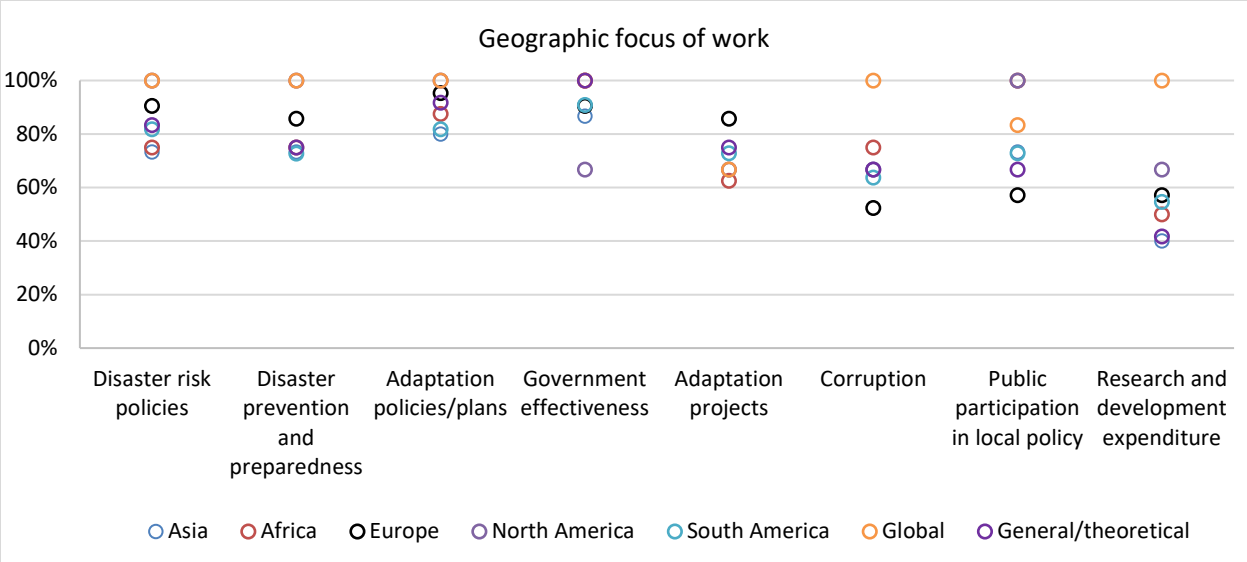

Figure 48 Proportion of experts who consider these governmental indicators globally relevant depending on their geographic work focus.

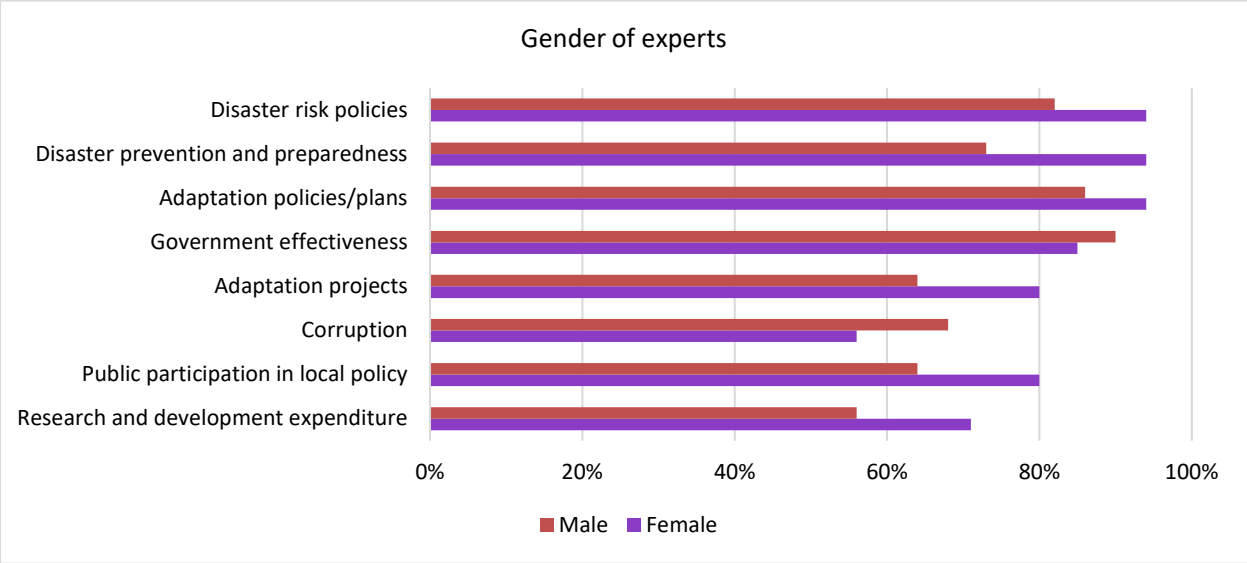

Figure 49 Proportion of experts who consider the governmental indicators globally relevant depending on their gender.

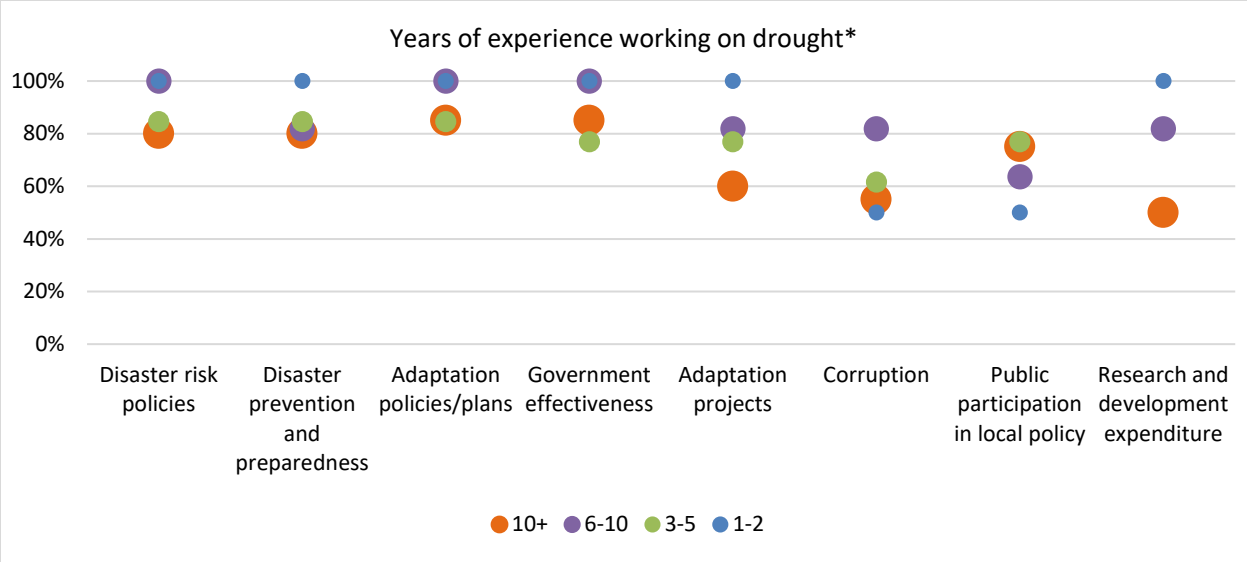

Figure 50 Proportion of experts who consider the governmental indicators globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

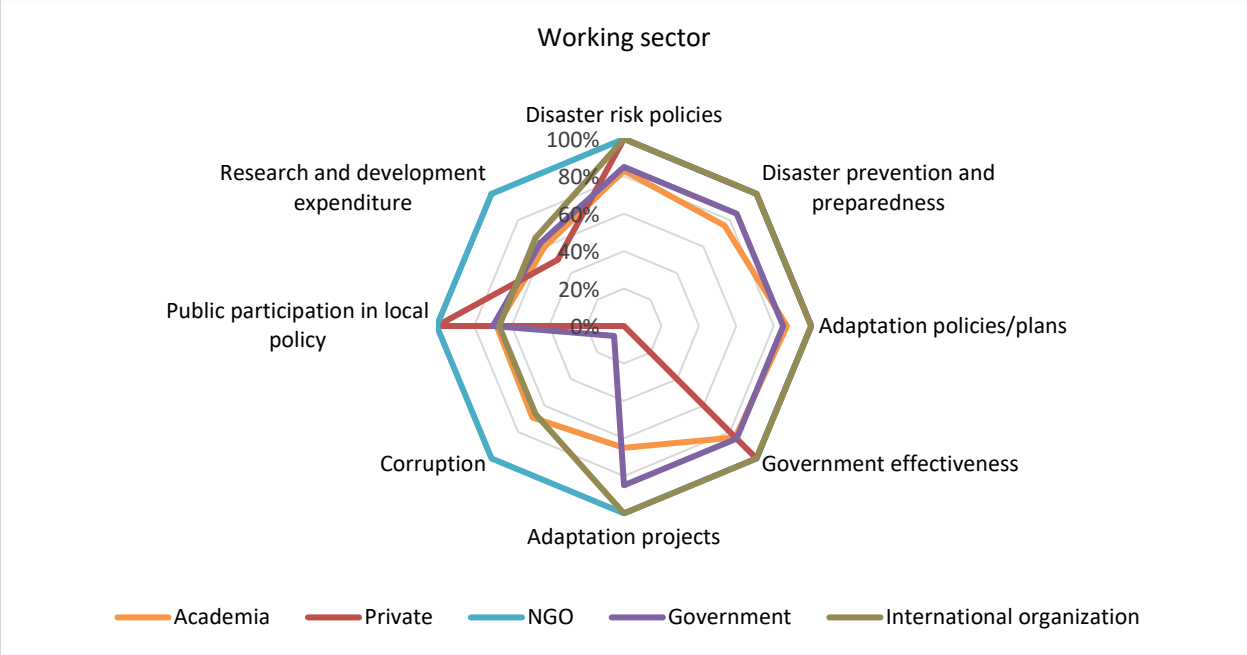

Figure 51 Proportion of experts who consider these governmental indicators globally relevant depending on their working sector.

Environmental

Two out of seven indicators were selected as globally relevant: The area protected and designated for the conservation of biodiversity (%) and the baseline water stress (ratio of withdrawals to renewable supply). This last indicator was selected as relevant for more than 50% of the experts in all the different categories.

The percentage of area protected and designated for the conservation of biodiversity was less relevant for people with less than two years of experience working on drought, experts from the private sector, and those who focus on global, general and Europe assessments.

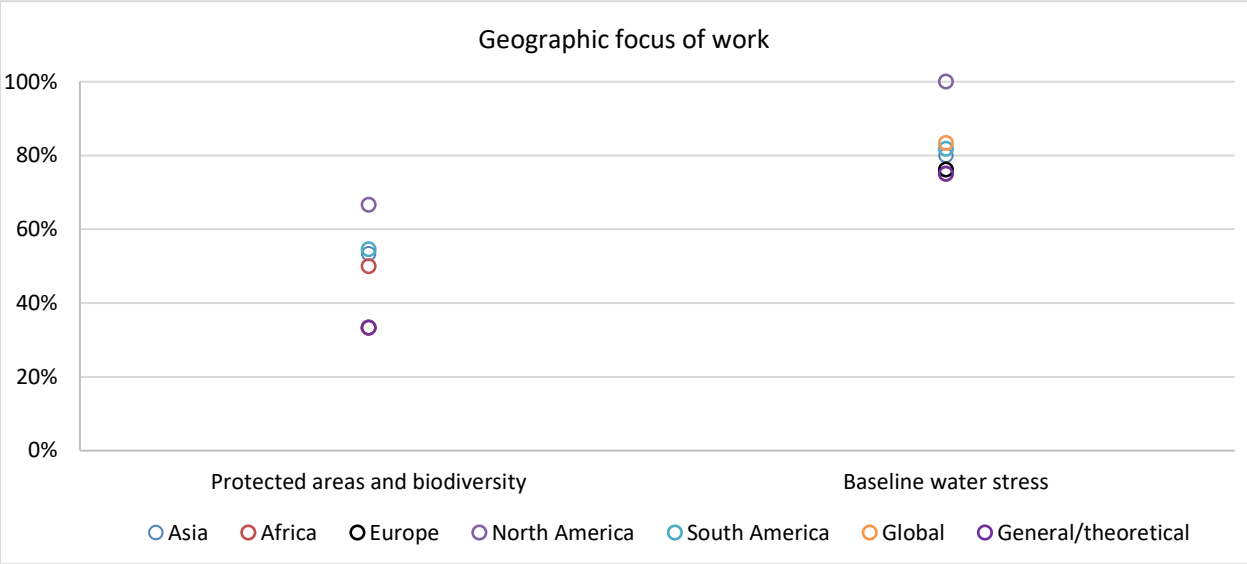

Figure 52 Proportion of experts who consider the environmental indicators globally relevant depending on their geographic work focus.

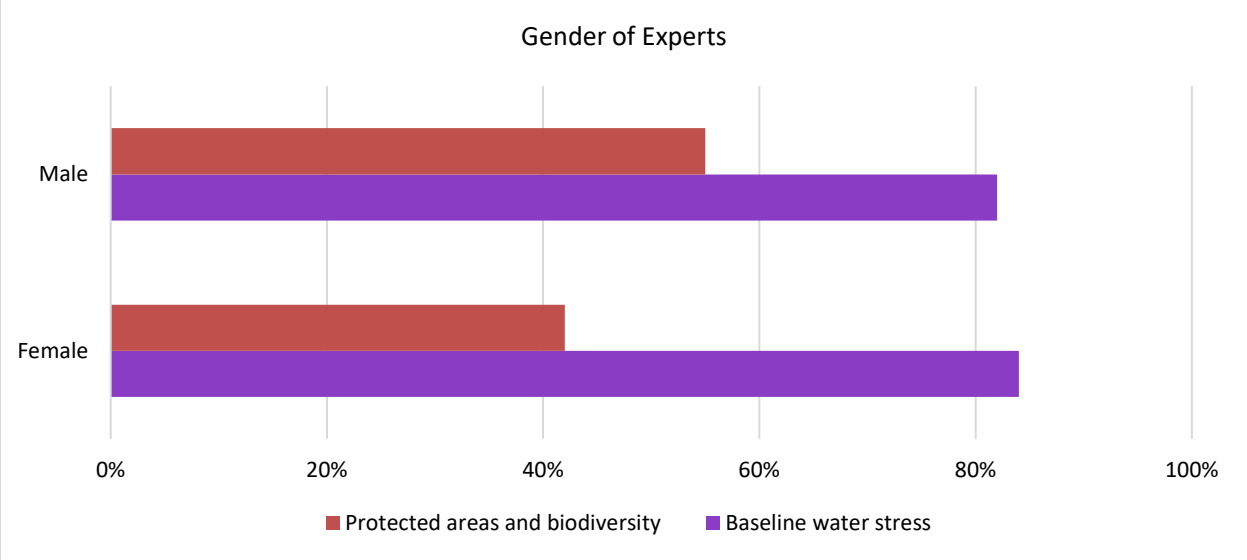

Figure 53 Proportion of experts who consider the environmental indicators globally relevant depending on their gender.

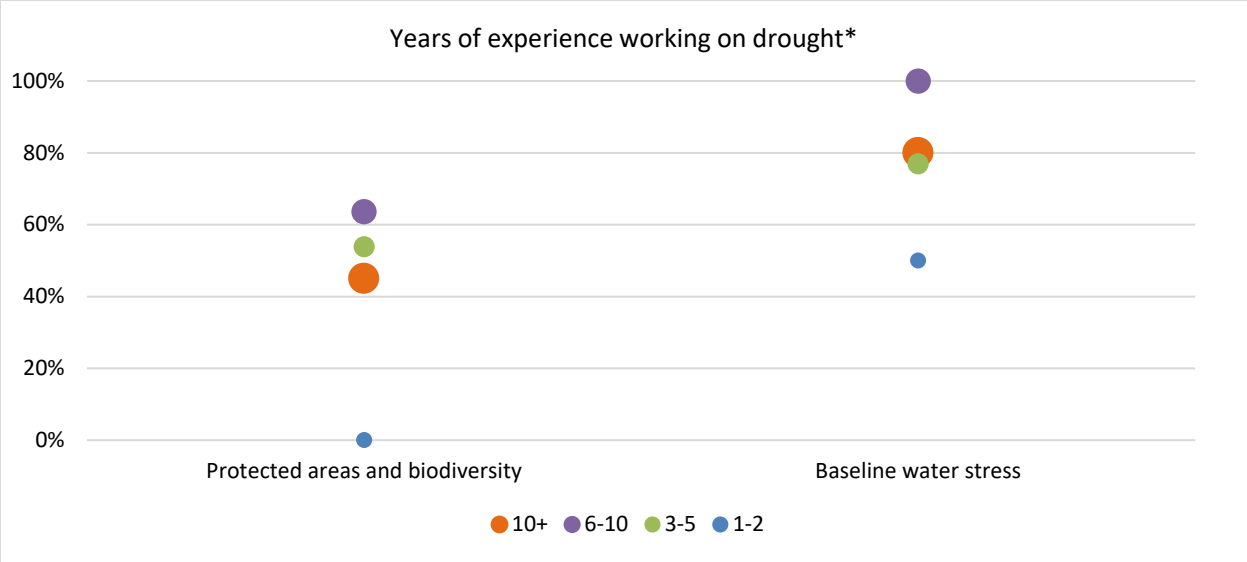

Figure 54 Proportion of experts who consider the environmental indicators globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience.

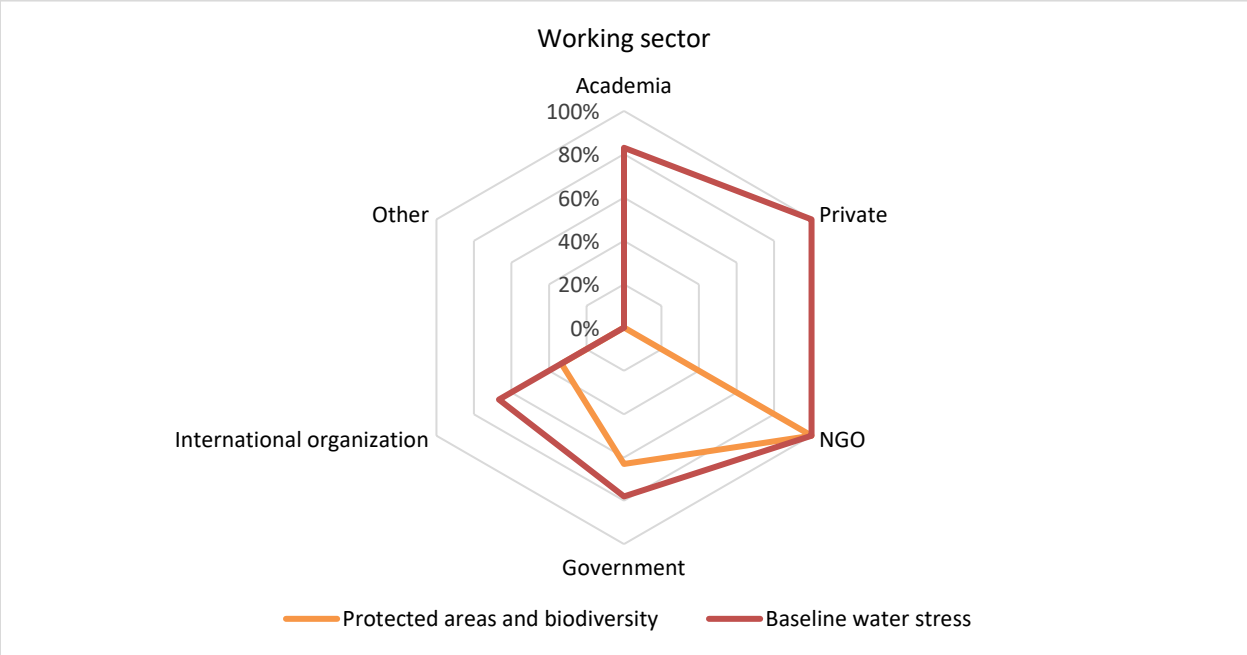

Figure 55 Proportion of experts who consider the environmental indicators globally relevant depending on their working sector.

Farming practices

Farming practices got one relevant indicator at the global level "Irrigated land (% total arable)". This indicator was in particular considered by male experts, experts with more than three years of experience working in drought, Asia focus experts and NGOs. A quarter of respondents with more than ten years of experience working in drought considered this indicator not relevant at all. Same for 12% of academics, all private sector respondents, and 7% of experts from the governmental sector.

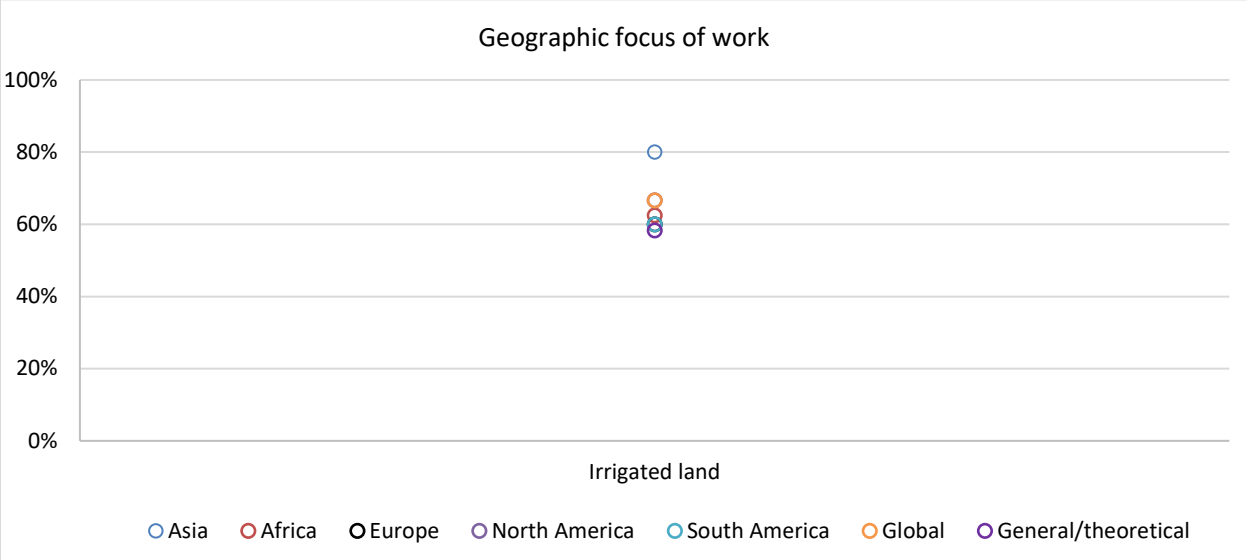

Figure 56 Proportion of experts who consider farming practices indicators as globally relevant depending on their geographic work focus.

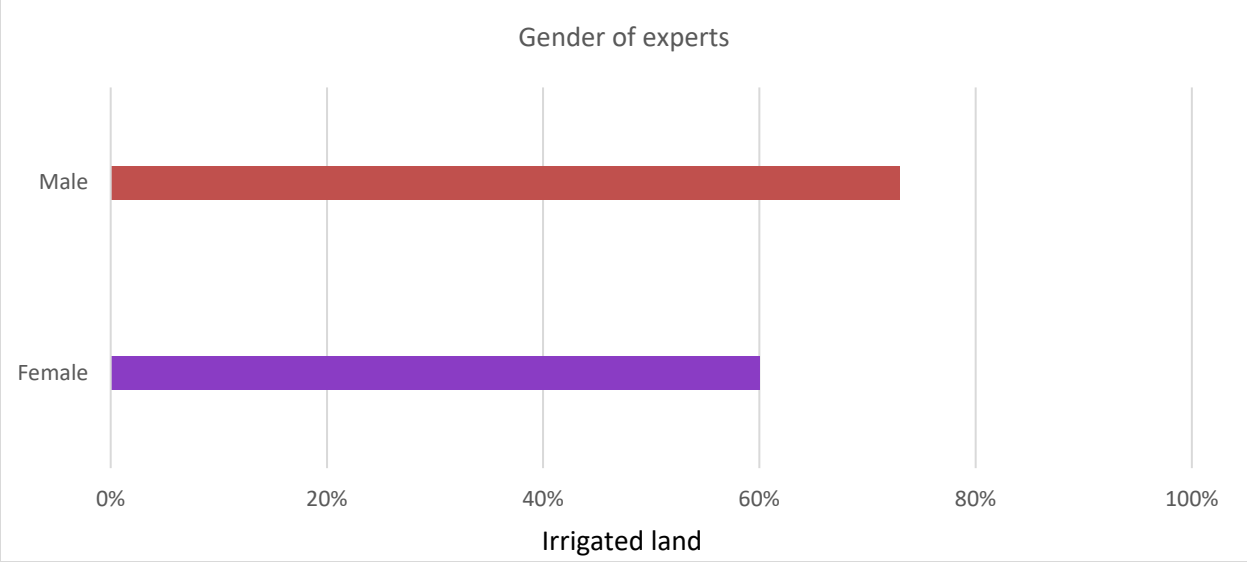

Figure 57 Proportion of experts who consider irrigated land globally relevant depending on their gender.

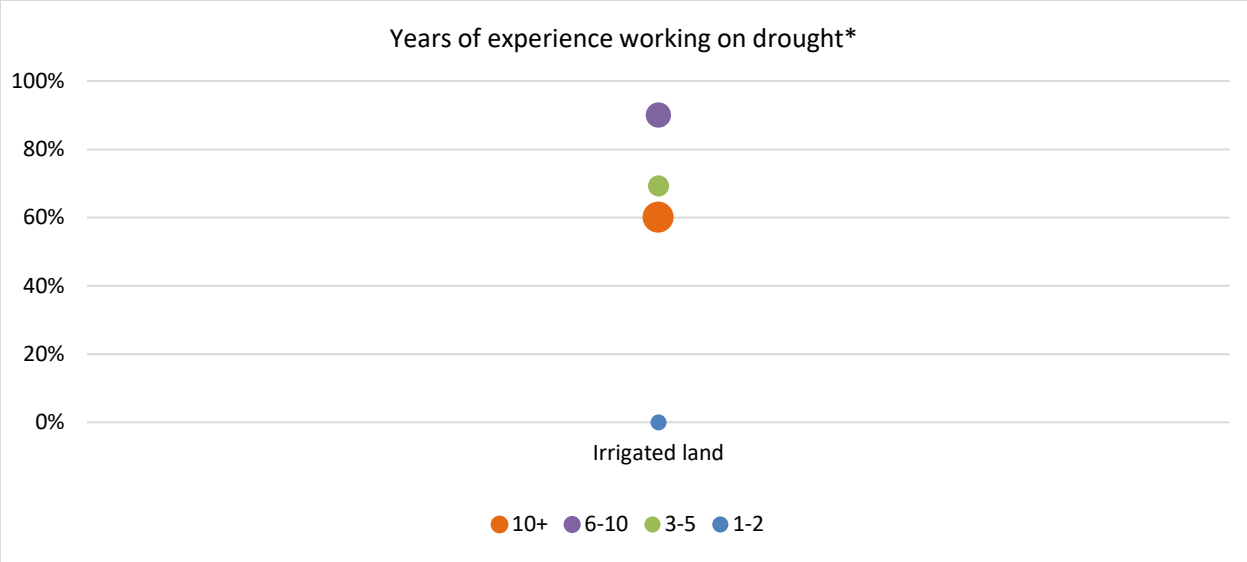

Figure 58 Proportion of experts who consider farming practices indicators globally relevant depending on their years of experience working with drought. *Dot size represent the years of experience

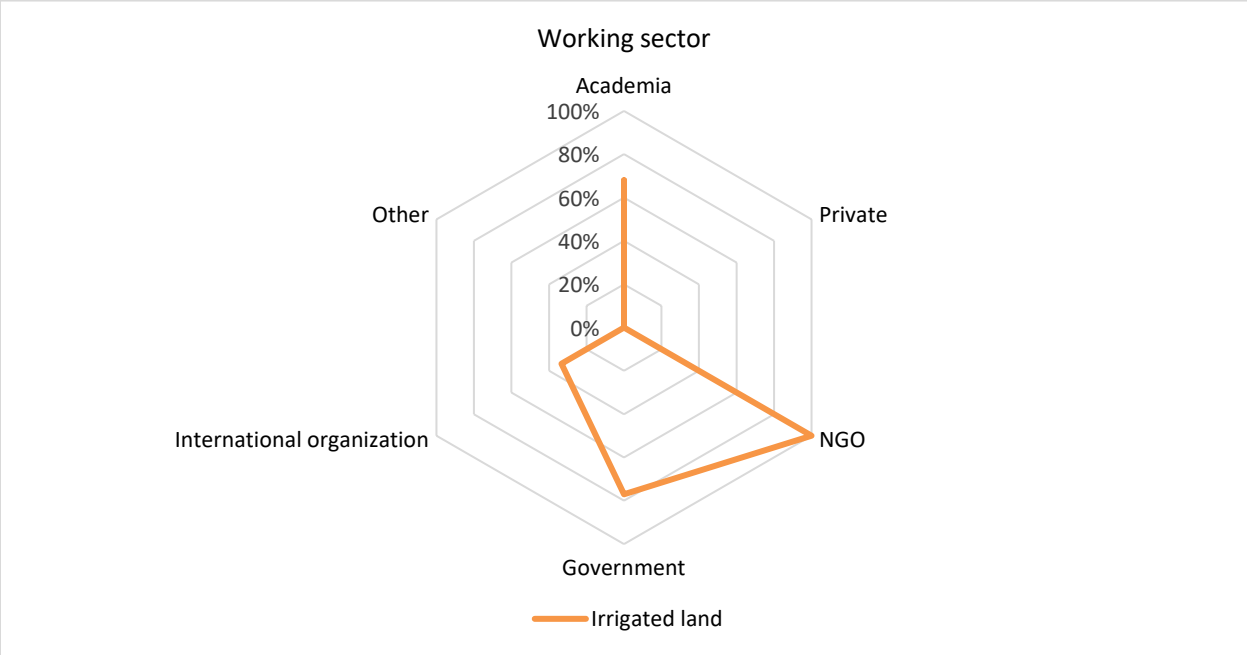

Figure 59 Proportion of experts who consider farming practices indicators globally relevant depending on their working sector.

Annex 6: Contingency Table

Gender identity (Optional)			Working sector						Years of experience working on drought					Geographic focus of work						
Research field (optional)	***Fem***	***Male***	***Academia***	***Gov.***	***Int. Org***	***NGO***	***Other***	***Private***	***1-2***	***3-5***	***6-10***	***10 +***	***No prev experience***	***Asia***	***Africa***	***Europe***	***North America***	***South America***	***Global***	***General/ theoretical***
Agricultural sciences	0	7	4	2	0	0	0	1	0	2	1	4	0	4	2	0	0	1	0	0
Anthropology and development	0	1	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	1
Climate Change	0	3	2	1	0	0	0	0	0	1	2	0	0	2	0	0	0	1	0	2
Climate science/services	2	1	0	3	0	0	0	0	0	1	1	1	0	1	0	3	0	1	0	1
Drought hazard and disaster risk assessment	0	2	0	1	0	1	0	0	0	0	1	1	0	2	0	0	0	0	0	2
Economics (Water, environmental)	0	3	2	0	0	0	1	0	0	1	1	1	0	3	1	1	0	0	1	3
Environmental sciences	1	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
Geography	1	3	3	1	0	0	0	0	0	0	2	2	0	1	0	2	1	0	1	0
Health	2	0	2	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	1	0
Hydrology	5	2	2	2	2	1	0	0	0	4	2	1	0	1	1	4	1	1	0	2
Interdisciplinary	1	1	2	0	0	0	0	0	0	0	0	2	0	1	1	1	0	1	0	1
Sociology	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1
Soil and Water Conservation	0	1	1	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0
Water resources management	2	1	1	0	1	0	0	1	1	0	1	1	0	0	0	3	0	1	0	1
Geographic focus of work	***Fem***	***Male***	***Academia***	***Gov.***	***Int. Org***	***NGO***	***Other***	***Private***	***1-2***	***3-5***	***6-10***	***10 +***	***No prev exp***							

Asia	6	17	15	4	1	2	1	0	0	5	5	13	0
Africa	4	8	6	2	2	0	0	2	1	3	3	5	0
Europe	19	10	12	15	3	0	0	1	4	8	8	11	0
North America	4	3	4	4	0	0	0	0	0	2	2	3	1
South America	6	5	8	3	0	0	0	0	0	3	4	4	0
Global	3	3	7	0	0	0	0	0	2	2	1	2	0
General/ theoretical (e.g. methods-oriented)	7	11	9	5	1	1	1	1	2	5	5	6	0

Years of experience working in drought	***Fem***	***Male***	***Academia***	***Gov.***	***Int. Org***	***NGO***	***Other***	***Private***
1-2	1	4	2	2	1	0	0	0
3-5	13	5	8	8	1	1	0	1
6-10	5	12	8	5	3	1	1	0
10+	13	14	20	8	0	0	0	1
No previous experience working on vulnerability/risk	0	1	0	1	0	0	0	0

Sector	***Fem***	***Male***
Academia	16	20
Government	12	11
International Organization	2	2
NGO	1	1
Other	0	1
Private	1	1

Annex 7: Complete list of questions and indicators weighed on the online survey

Respondent background information

Name (optional)

Email (optional)

Gender identity

Sector

Years of experience working on drought

Years of experience working on vulnerability and risk

Drought vulnerability indicators

SOCIAL

1. Population with at least completed post-secondary education (%)
2. Illiteracy rate (%)
3. Gender inequality (categorical)
4. Social capital (categorical)
5. Alcohol consumption litres per capita (people aged 15 years and older)
6. Disabled persons (%)
7. Population undernourished (%)
8. Population with ill-health (%)
9. Life expectancy at birth (years)
10. Number of physicians per 1,000 inhabitants
11. Out-of-pocket expenditure on health (%)
12. Households without health insurance (%)
13. Rural population (% of total population)
14. Refugee population (% of total population)
15. Age dependency ratio (% of working-age population)
16. Risk perception (% of population who has experienced droughts in the past 10 years)
17. Availability of a drought early warning system (yes/no)
18. Households/farmers with access to information (radio/TV/internet) (%)
19. Please add any additional indicators you feel are missing

ECONOMIC

1. Dependency on agriculture for livelihood (%)
2. High dependence on tourism for income and employment (% of GDP)
3. Agriculture (% of GDP)
4. Population below the national poverty line (%)
5. Unemployment rate (%)
6. GDP per capita, PPP

7. GINI index (income inequality)
8. Farmers/labourers without savings (%)
9. Farmers/labourers without access to bank loans / (micro-) credits (%)
10. Distance to closest market (km)
11. Market fragility
12. Farmers with crop, livestock or drought insurance (%)
13. Energy consumption per capita
14. Please add any additional indicators you feel are missing

INFRASTRUCTURE

1. Road density (km of road per 100 sq. km of land area)
2. Population without access to (improved) sanitation (%)
3. Population without access to clean water (%)
4. Poor water quality
5. Total dam capacity
6. % of retained renewable water
7. Electricity production from hydroelectric sources (% of total)
8. Please add any additional indicators you feel are missing

CRIME & CONFLICT

1. (Livestock) theft (%)
2. Prevalence of conflict/insecurity
3. Please add any additional indicators you feel are missing

GOVERNANCE

1. Disaster risk taken into account in public investment and planning decisions (yes/no)
2. National investment in disaster prevention & preparedness (US$/Year/capita)
3. Existence of national adaptation policies/plans (yes/no)
4. Government effectiveness
5. Number of (drought-related) adaptation projects in the past 10 years
6. Corruption (e.g. Corruption Perception Index)
7. Strength of legal rights
8. Public participation in local policy
9. Food aid (US$ per capita)
10. Research and development expenditure (% of GDP)
11. Please add any additional indicators you feel are missing

ENVIRONMENTAL

1. Soil organic matter (g*kg)
2. Soil depth (mm)
3. Degree of land degradation and desertification
4. Area protected and designated for the conservation of biodiversity (%)
5. Veterinarians and veterinary para-professionals (per capita)
6. Livestock health

7. Water stress
8. Please add any additional indicators you feel are missing

FARMING PRACTICES

1. Agricultural machinery in use (#)
2. Irrigated land (% total arable)
3. Use of fertilizer (ton)
4. Access to fodder (kg purchased per year)
5. Tonnes of active ingredients of insecticides and pesticides used
6. Cultivation of drought-resistant crops (%)
7. Farmers use different crop varieties (%)
8. Please add any additional indicators you feel are missing

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