Drought: Research and Science-Policy Interfacing – Andreu et al. (Eds)
© 2015 Taylor & Francis Group, London, ISBN 978-1-138-02779-4

Impact of drought on the inhabitants of the Cuvelai watershed: A qualitative exploration

R. Lütkemeier & S. Liehr
Institute for Social-Ecological Research (ISOE), Frankfurt am Main, Germany
Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL), Windhoek, Namibia

ABSTRACT: Drought is a recurring threat to the inhabitants of the Cuvelai watershed in Namibia and Angola. This is especially true for rural households whose livelihood depends on subsistence agriculture. This paper presents the results of a qualitative household survey to understand the impact of drought and identify key parameters that determine households' vulnerability. This paves the ground for a follow-up quantitative assessment. Within the survey, 26 semi-structured interviews were conducted to shed light on (i) local water use patterns, (ii) the impact of drought in rural and urban environments and (iii) coping strategies in drought situations. The results show primary impacts on households' ability to meet water and food requirements. Impacts of this kind lead to second-order effects on physical and mental health, social life and livelihood maintenance. Furthermore, several coping mechanisms could be identified on the individual-, community- and national level. Based on our results, we outline the general structure of a tool to quantify drought impact—the Household Drought Vulnerability Index.

1 INTRODUCTION

Seasonal variation in water availability is a common hydrological feature of Southern Africa. However, when it comes to extraordinary reductions of seasonal and inter-annual water availability, even those societies adapted to semi-arid conditions are being threatened. For instance, Namibia as one of the driest countries in Sub-Saharan Africa (World Bank 2014) recently declared more than 460.000 citizens (approx. 22% of total population) as food insecure as a result of the far below-average rainy season 2012/2013 (DDRM 2013, NSA 2013). Similar patterns were observed in southern Angola in early 2013 showing significantly below-average harvests due to reduced water availability. For that reason, the Angolan provinces Namibe and Cunene were rated as 'stressed' on the Integrated Food Security Phase Classification (FEWS NET 2013). The transnational Cuvelai watershed stretches from southern Angola to central-northern Namibia and thus covers both of the above mentioned drought-prone areas. Semi-arid climate conditions with high spatio-temporal rainfall variability, a lack of perennial rivers and high salinity of groundwater resources challenge the inhabitants on both sides of the border. Local livelihoods depend on subsistence agriculture in terms of crop farming and livestock herding. Water availability determines local ecosystem conditions and is thus important to sustain the inhabitants' livelihoods. However, recent societal developments such as population growth, urbanization and lifestyle changes as well as extensive, largely uncontrolled livestock grazing increase the pressure on land and water resources (Mendelsohn et al. 2013).

This study investigates the impact of drought on the inhabitants of the Cuvelai watershed in order to support the development of sustainable solutions for drought adaptation and mitigation. The main research questions are (i) how households are affected by and respond to drought events, (ii) which social-ecological parameters determine the severity of the impact and (iii) how to quantify the impact of drought in spatial and temporal terms.

2 METHODOLOGY

2.1 *Research approach*

In order to investigate the impact of drought, we need to understand the local water-related interactions between society and nature. For this purpose, we apply the framework of Social-Ecological Systems (SES) that serves as a heuristic tool to handle the problem's complexity by structuring our initial and evolving knowledge (Hummel et al. 2011, Liehr et al. submitted). However, for analytical purposes the SES framework requires specification. The impact analysis needs to integrate (i) the hazard's properties, (ii) an object's affectedness and (iii) its ability to handle the situation. Therefore, we incorporate the concept of vulnerability that covers the dimensions exposure, sensitivity and coping capacity (Adger 2006). The review of recent scientific literature reveals a number of studies on water- and/or drought vulnerability (Babel et al. 2011, Notenbeart et al. 2013, Pandey et al. 2010, Shahid & Behrawan 2008, Shiau & Hsiao 2012, Sullivan 2011). Most approaches follow an integrative perspective with biophysical and social variables to quantify an object's vulnerability. Nevertheless, to the present day the variety of available approaches is high as Plummer et al. (2012) point out. They review 55 studies and identify 50 different ways of determining water vulnerability. Furthermore, the authors uncover that 40% of all instruments do not build upon primary empirical data, but are rather conceptual in nature. This raises the question of reliability and thus the necessity to explore the concept of vulnerability to drought in the local context. Qualitative socio-empirical methods suite this purpose (Friedrichs 1990) and enable us to put the scheduled quantitative follow-up survey on a profound basis.

2.2 *Survey design and analysis*

The household survey was conducted in central-northern Namibia in early 2014 with a total of 26 respondents. The study sites, as depicted in figure 1, were identified in cooperation with local water management authorities to cover environmental (water availability and vegetation) and societal (rural and urban) gradients. With the assistance of an Oshiwambo-speaking interpreter semi-structured interviews were carried out to receive information on (i) structural household parameters, (ii) water utilization patterns in the rainy and dry season as well as (iii) perceptions of drought impact and suitable coping strategies. Each interview

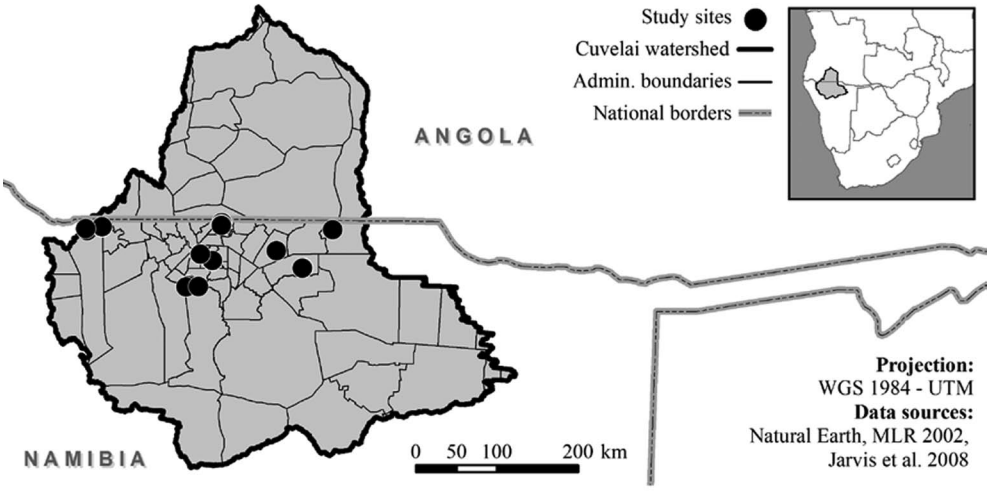

Figure 1. Cuvelai watershed, generated from SRTM data, indicating study sites of the household survey.

was recorded and subsequently transcribed. The transcripts were double checked by a second interpreter to identify misinterpretations and omissions. Case-specific interpretative inventories (Kruse 2010) were created using water use patterns and the dimensions of vulnerability as analytical guidelines.

3 RESULTS

The way households utilize water is key to understand the social-ecological system in the Cuvelai watershed and the impact of drought. Therefore, we will first present water use patterns to elaborate the role of water as part of the inhabitants' livelihoods.

3.1 *Water utilization*

To capture the complexity of household water utilization, we follow Falkenmark & Rockström (2006) by distinguishing between blue- and green water. Considering the use of blue water, households rely on a variety of traditional and modern sources to cover domestic-, agricultural- and economic needs. Domestic activities include drinking, cooking, personal hygiene, cleaning, dish washing, laundry and dust prevention. Although traditional grain farming is rain-fed, some households practice irrigated small-scale horticulture and fruit production, but the most important water consumer of subsistence agriculture remains livestock. In economic terms, some households are self-employed and utilize water for cooking-, baking- and brewing products for sale as well as brick-making. Since the reliable estimation of water volumes is challenging and requires special methodological considerations (Nauges & Whittington 2008), we regard benchmark values reported in the literature as reasonable estimates for the local conditions (DWA 1992, FAO 1986, Savva & Frenken 2002, WHO 2013).

If we take a closer look at where water is taken from, it becomes obvious that households use several water sources in a combined way. Despite the availability of tap water to most inhabitants of central-northern Namibia (NSA 2013), 81% of our respondents keep on utilizing unreliable traditional water sources that are prone to contamination and water shortage. Nevertheless, 50% use traditional water sources in a combination with tap water. In this regard, two patterns of utilization can be identified. On the one hand, tap water is only used for high quality activities such as drinking, cooking and personal hygiene. This practice is carried out without any changes throughout the year. On the other hand, tap water is regarded as a backup resource that is only used as soon as quantity and/or quality of traditional water sources are depleted. This is especially true in the dry season which highlights the importance of considering intra-annual changes of utilization patterns.

Considering the use of green water, rainfall and resulting soil moisture are necessary for plant growth and thus relevant for people's nourishment. Rural smallholders cultivate pearl millet as staple food mainly for own household consumption. According to the respondents, the amount of harvestable grain depends on a range of factors: (i) volume of rainfall, (ii) timing of field preparation, (iii) health/strength of farmer to till the field, (iv) money to pay workforce and (v) the availability of fertilizers such as dung. If the stated requirements are fulfilled, the grain harvest can sustain the household nourishment for more than one or even several years. If the harvest is not sufficient to cover the demand until the next harvest, food has to be purchased at local markets. It must be noted that not only the rural population depends on locally produced food. Although an urban dweller's livelihood is different from a farmer's one, people living in towns have close relations to relatives in the villages. These relatives provide a certain share of food to the urban people. In other words, even the urban population is affected by drought, since a reduced food supply from relatives needs to be compensated by higher spending for the purchase of groceries.

In essence, water utilization is characterized by a complex seasonal utilization of blue water and an important use of green water for plant growth and thus human and animal nourishment.

3.2 *Drought impact*

As outlined above, households are closely connected to the hydrological system via the consumption of water and food. Thus, drought events threaten people's livelihoods, defined as "the capabilities, assets […] and activities required for a means of living" (DFID 1999:1). The challenged satisfaction of people's needs brings about problems that can be best described as second order effects. Due to the lack of drinking water and food, the inhabitants of the research area state health problems such as malnutrition and general weakness. Combined with higher workload e.g. by longer walking distances, physical fitness is being challenged. The drought situation creates continuous mental stress since especially older persons have serious concerns and ruminate. These factors contribute to social tensions (e.g. crime and disputes) both within a household and among neighbors. Furthermore, the lack of water and food impairs some households in the practice of their profession for income generation. Thus, the situation creates a budgetary bottleneck, since income is reduced while expenditures for food, water, medical treatments etc. increase.

3.3 *Coping strategies*

Above, we carved out the way households suffer in the event of drought. In the following lines, we will take a closer look at how people deal with drought situations. The coping mechanisms households apply can be attributed to different scales from the individual via the community to the regional or national level.

On the individual household level, people are busy with income generating activities. This can assume very different shapes starting from casual work, selling of livestock, horticultural and/or handicraft products to the support from relatives (e.g. cash remittances). These strategies are being applied in the short-term as an immediate emergency response. On the longer term, households apply adaptation measures such as improved farming practices (e.g. intercropping, application of machinery, livestock specialization, application of fertilizers) or water management activities (e.g. diversification of water sources, quality-specific utilization).

On the community level, neighborly help is a common mechanism. This often assumes the shape of food and water donations. However, the respondents indicate that this practice can only be pursued a certain number of times. If requests are addressed to a neighbor more often, the donor asks for payment, either in kind or cash, since water sources such as shallow and deep wells are located on private property, which means that the owner is entitled to restrict access.

Considering higher societal levels, larger scale mechanisms can be identified that mainly focus on food aid. The government purchases grain surpluses from local farmers after good harvests and stores it as a backup resource. In combination with other sources of e.g. millet, maize, rice and fish, this is being distributed to the population during drought years as the governmental drought relief. In addition to that, strongly affected households are able to request a special quota of food aid on the constituency level. In this respect, clear village-level hierarchies exist that are similar to societal relief instruments in place before and during colonial times.

4 DISCUSSION

Based on the empirical findings, we will now try to derive an overarching theory of vulnerability to drought in the following sub-chapters. In doing so, we will first describe vulnerability on a qualitative basis with special reference to the dimensions exposure, sensitivity and coping capacity. Building upon this, we will outline the general structure the Household Drought Vulnerability Index (HDVI) as one option to quantify drought vulnerability.

4.1 *Exposure*

Analyzing an object's vulnerability has always to be done with respect to a specific hazard (Gallopin 2006). In our case, this hazard is the spatio-temporal reduction of water due to

natural (e.g. rainfall decline) and/or societal (e.g. conflict over access) reasons. All of these processes may result in reduced temporal water availability for downstream water users who are thus potentially vulnerable. No doubt, beside drought there are hazards like floods, pests and diseases that are also affecting the inhabitants of the Cuvelai (Amunyela et al. 2008). However, these hazards require special analytical perspectives within the concept of vulnerability and are thus not our focus.

Specification is also required with respect to the object that is being affected by the hazard. Private households require special attention since they are the building blocks of the Cuvelai society on each side of the border. Therefore, the object we focus on is the domestic sector with the subsistence economy surrounding it, respectively. Now, we will specify a drought situation in more detail. We do not want to solely focus on the amount and quality of blue water at a specific location, but rather intend to expand our analytical consideration to the amount of green water, as well. This is essential to cover people's sensitivity to water shortage in terms of the physical lack of drinking water and the lack of food, simultaneously.

In summary, a household's exposure to drought is characterized by the spatio-temporal availability of blue- and green water.

4.2 *Sensitivity*

The domestic sector is being affected by drought in terms of a challenged satisfaction of a household's basic needs. People's relation to nature (Becker & Jahn 2006) is characterized by a strong unidirectional dependency for survival and the maintenance of livelihoods (DDRM 2010). In other words, the SES takes the shape of a supply system (Hummel et al. 2011), since households heavily rely on a continuous flow of ecosystem services to ensure human well-being.

The reduced spatio-temporal availability of water can be perceived as a decreased capacity of the ecosystem to provide blue- and green water in sufficient amount and quality. Households in the Cuvelai, even the rural and urban inhabitants of central-northern Namibia who have an extensive tap water system available, utilize a multi-resources mix of water to cover their needs. If the amount of blue water above and below ground is reduced, people are forced to switch to the technology-driven water supply that is not free of charge. The same is true for a reduction in the amount of green water. If precipitation decreases, a household's own food production is not sufficient to cover the nutritional requirements of its members.

In summary, a household's sensitivity to drought is characterized by its level of self-subsistence with respect to blue and green water consumption. In other words, the point at which coping mechanisms have to be applied is determined by a household's dependence on specific drought-affected water resources.

4.3 *Coping capacity*

Having discussed the exposure and sensitivity of a household, we will now focus on their ability to cope with a situation of drought. The empirical results show that the inhabitants of central-northern Namibia apply a wide range of strategies that stem from the individual via the community level up to the national sphere. Despite the diversity of activities we can identify a common ground which can be generally described as the shift from a self-subsistence supply system to an external supply system. In other words, people fall back on larger scale coping infrastructures of water and food supply. These infrastructures are not available for everyone since access is being regulated via economic mechanisms. This means that households have to make economic means available via a number of activities in order to access these coping infrastructures.

It should be noted that in kind support provided by neighbors and/or relatives is a common practice, but it seems as if this strategy cannot be pursued for a longer period of time. This is mainly due to restrictions of the donors' capacities, because they find themselves in a similar situation of a shortage of food and water. Thus, economic means are essential on the individual household level to cope with drought.

If we move from the individual and community level to the regional and national sphere, further societal coping mechanisms are in place like the governmental distribution of food aid and water purification tablets. However, this kind of coping mechanism is outside the range of a household's influence and should not be seen as a common part of their coping capacity.

In summary, a household's coping capacity in the event of drought is characterized by its ability to make social and economic means available to access larger scale coping infrastructures of the external supply system.

4.4 *Composite indicator*

The discussion of the study results carved out key parameters that determine the vulnerability to drought. Now, our primary aim is to use this knowledge to develop an instrument for drought vulnerability quantification. We need to keep in mind that the solution must (i) give a spatially differentiated representation of vulnerability and its constituting components, (ii) be able to indicate change over time, and (iii) be kept as simple as possible to ensure applicability.

One way forward is the construction of a composite indicator. This practice is frequently being followed in the scientific literature to quantify vulnerability (Babel et al. 2011, Malcomb et al. 2014, Pandey et al. 2010, Shahid & Behrawan 2008, Shiau & Hsiao 2012, Sullivan 2002, Sullivan 2011). One of the most relevant indicators is the Water Poverty Index (WPI), developed by Sullivan (2002). Herein, five key components (resources, access, capacity, use and environment) describe the water scarcity situation and contribute to set priorities of water management and planning as well as monitoring (Sullivan 2002).

Nevertheless, criticism is often being leveled to composite indicators due to their low level of empirical evidence (Malcomb et al. 2014, Plummer et al. 2012). In contrast with most studies, the index proposed in the following sub-chapter builds upon qualitative empirical evidence from the research area itself and is thus more legitimate than literature based indices.

4.5 *Household Drought Vulnerability Index*

The composite index proposed herein, the Household Drought Vulnerability Index HDVI, is not supposed to quantify vulnerability in absolute terms, but should rather be a relational measure to compare regions to one another and show change over time. The overall index

Table 1. General structure of the proposed Household Drought Vulnerability Index.

Dimension	Component	Definition
Exposure	(i) Societal and (ii) Environmental drivers of drought	Probability of occurrence of a spatio-temporal reduction of blue- and green water availability in terms of quantity and/or quality e.g. due to rainfall decline, water contamination or conflicts over access
Sensitivity	Resource dependence for (i) Survival and (ii) Livelihood maintenance	Dependence on a drought-affected resource (e.g. water, food, energy) for survival (e.g. minimal nutritional requirements) and livelihood maintenance (e.g. basic needs)
Coping capacity	(i) Potential coping mechanisms and (ii) Capability to access	Potential mechanisms to cope are embedded in local knowledge, practices, institutions and technology (Hummel et al. 2011). Nevertheless, the capability of people to access these mechanisms via appropriate human-, social-, financial-, natural- and physical capital endowment (DFID 1999) is necessary

structure is predefined by the three dimensions of vulnerability and further subdivided into constituting components that are indicated in table 1. Each of the components is supposed to be populated with appropriate indicators, keeping in mind that the selection of indicators is always a compromise between suitability and availability of data. For instance, in a data scarce environment such as Southern Africa, a pragmatic selection of indicators is inevitable.

The dimension of 'Exposure' is made up of two components that characterize the hazard of drought. Reductions in blue- and green water do not solely stem from natural processes but rather have their origin in societal processes or a combination of both, as well. 'Sensitivity' describes an object's dependence on a drought-affected resource. For instance, the impact of drought on drinking water and food is not necessarily universally valid. If we consider an industrialized country, a reduction in water availability might rather impact hydropower plants and thus the energy supply a household depends on. 'Coping capacity' as the third dimension of vulnerability acknowledges the importance of access. Although, a range of coping mechanisms exist, not every household is able to apply them due to insufficient capital endowment.

5 CONCLUSION

This study explores the impact of drought on the inhabitants of the Cuvelai watershed on a qualitative basis. We take the social-ecological system framework as the overall guidance and apply the vulnerability concept for detailed analysis. Qualitative socio-empirical methods are used to answers three research questions. First, our results show that drought events affect households in their ability to satisfy basic needs such as drinking water and food demands. Coping mechanisms exist on several societal levels, but the fallback on water and food market infrastructures on larger scales is pivotal. Second, in particular those households are sensitive to drought that have a high dependence on drought-affected resources for survival and livelihood maintenance. Regarding this, the use of traditional water sources and high levels of subsistence agriculture are the constituting parameters. Third, a composite indicator is a frequently used tool to measure drought impacts. Therefore we propose the Household Drought Vulnerability Index and outline the general structure of the instrument, based on our qualitative insights. This instrument will be further developed and applied in a structured follow-up household survey. The results of that research phase will be published in Lütkemeier et al. (in prep.).

ACKNOWLEDGEMENTS

This research project is part of the Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL) and funded by the German Federal Ministry for Education and Research (BMBF). The authors thank the inhabitants of central-northern Namibia for their participation and hospitality.

REFERENCES

Adger, W.N. 2006. Vulnerability. Global Environmental Change 16: 268–281.

Amunyela, A., Michelow, M. & Montembault, S. 2008. An assessment of the impact of the flood and other natural disasters on food security of rural households in areas of northern Namibia.

Babel, M.S., Pandey, V.P., Rivas, A.A. & Wahid, S.Md. 2011. Indicator-based approach for assessing the vulnerability of freshwater resources in the Bagmati River Basin, Nepal. Environmental Management 48: 1044–1059.

Becker, E. & Jahn, T. 2006. Soziale Ökologie. Grundzüge einer Wissenschaft von den gesellschaftlichen Naturverhältnissen. Frankfurt am Main: Campus Verlag.

Department for International Development (DFID) 1999. Sustainable livelihoods guidance sheets.
Department of Water Affairs (DWA) 1992. Re-evaluation of water demand norms for planning purposes. Windhoek.
Directorate of Disaster Risk Management (DDRM) 2010. Namibia national food security and vulnerability assessment and monitoring report. Windhoek.
Directorate of Disaster Risk Management (DDRM) 2013. Namibia drought relief response plan. Windhoek.
Falkenmark, M. & Rockström, J. 2006. The new blue and green water paradigm: Breaking new ground for water resources planning and management. Journal of Water Resources Planning and Management 132(3): 129–132.
Famine Early Warning System Network (FEWS NET) 2013. Angola drought assessment special report.
Food and Agriculture Organization of the United Nations (FAO) 1986. Water for animals AGL/MISC/4/85. Rome.
Friedrichs, J. 1990. Methoden empirischer Sozialforschung. Westdeutscher Verlag, Opladen.
Gallopin, G.C. 2006. Linkages between vulnerability, resilience, and adaptive capacity. Global Environmental Change 16: 293–303.
Hummel, D., Jahn, T. & Schramm, E. 2011. Social-ecological analysis of climate induced changes in biodiversity. Outline of a research concept. Knowledge Flow Paper 11. Frankfurt am Main: Biodiversität und Klima Forschungszentrum.
Jarvis, A., Reuter, H.I., Nelson, A. & Guevara, E. 2008. Hole-filled seamless SRTM data V4. International Centre for Tropical Agriculture (CIAT). Available from http://srtm.csi.cgiar.org.
Kruse, J. 2010. Reader. "Einführung in die qualitative Interviewforschung". Freiburg: University of Freiburg.
Liehr, S., Röhrig, J., Mehring, M. & Kluge, T. (submitted). Addressing water challenges in central northern Namibia: how the social-ecological systems concept can guide research and implementation.
Liverman, D.M. 1990. Vulnerability to global environmental change. In: Kasperson (ed.) Understanding Gglobal environmental change: The contributions of risk analysis and management, 27–44. Worcester.
Malcomb, D.W., Weaver, E.A. & Krakowka, A.R. 2014. Vulnerability modeling for sub-Saharan Africa: An operationalized approach in Malawi. Applied Geography 48: 17–30.
Mendelsohn, J., Jarvis, A. & Robertson, T. 2013. A profile and atlas of the Cuvelai-Etosha Basin. Windhoek: Raison and Gondwana Collection.
Ministry of Land and Resettlement (MLR) 2002. Geospatial data. Provided by the directorate of Surveys and mapping.
Namibia Statistics Agency (NSA) 2013. Namibia 2011. Population and housing census main report. Windhoek.
Nauges, C. & Whittington, D. 2008. Estimation of water demand in developing countries: an overview. In: Lerna working papers 08.20.264. University of Toulouse.
Notenbart, A., Karanja, S.N., Herrero M., Felisberto, M. & Moyo, S. 2013. Derivation of a household-level vulnerability index for empirically testing measures of adaptive capacity and vulnerability. Regional Environmental Change 13: 459–470.
Pandey, R.P., Pandey, A., Galkate, R.V., Byun, H.R. & Mal, B. 2010. Integrating hydro-meteorological and physiographic factors for assessment of vulnerability to drought. Water Resources Management 24: 4199–4217.
Plummer, R., De Loe, R. & Armitage, D. 2012. A systematic review of water vulnerability assessment tools. Water Resources Management 26: 4327–4346.
Savva, A.P. & Frenken, K. 2002. Crop Water Requirements and Irrigation Scheduling. Harare: Food and Agriculture Organization of the United Nations.
Shahid, S. & Behrawan, H. 2008. Drought risk assessment in the western part of Bangladesh. Natural Hazards 46: 391–413.
Shiau, J.T. & Hsiao, Y.Y. 2012. Water-deficit-based drought risk assessment in Taiwan. Natural Hazards 64: 237–257.
Sullivan, C.A. 2002. Calculating a water poverty index. World Development 30 (7): 1195–1210.
Sullivan, C.A. 2011. Quantifying water vulnerability. A multi-dimensional approach. Stochastic Environmental Research and Risk Assessment 25: 627–640.
The World Bank 2014. World development indicators. Average precipitation in depth. http://data.worldbank.org/indicator/AG.LND.PRCP.MM.
World Health Organization (WHO) 2014. How much water is needed in emergencies? Technical notes on drinking-water, sanitation and hygiene in emergencies.