‘BRAVE’ GROUNDWATER FUTURES FOR BURKINA FASO: CRITICAL PLANNING FOR THE WATER SECTOR

LOCATION: Ouagadougou, Burkina Faso
ORGANIZATIONS INVOLVED: Walker Institute, Climate Analytics
DATE: 13 November 2019

On 13th November 2019, the Walker Institute, in collaboration with Climate Analytics and British Geological Survey, ran a workshop attended by government departments, NGOs and academic representatives from the Burkina Faso Water Sector. The purpose of this workshop was to bring together relevant experts working across the water sector to explore the results from the BRAVE project and identify concrete actions to include in a national action plan for the water sector.

WIWR0320/01

ACKNOWLEDGEMENTS

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Conceptualization of the Workshop on Scenario Planning:
Prof. Rosalind Cornforth (Walker Institute, Director), Dr. David Macdonald (Head of Section, British Geological Survey) and Dr. Sarah D'haen (Scientific Advisor and Scientific Coordinator, Climate Analytics).

Coordination and Logistics:
Dr. Sarah D'haen, Dr. Djibril S. Dayamba (Climate Change Impacts and Adaptation Expert, Climate Analytics) and Jacob Myers (Knowledge Management Officer, Walker Institute)

Report Writing:
Jacob Myers and Prof. Rosalind Cornforth

The contributions of staff members below towards making the workshop and the production of this report a success is also acknowledged.

Walker Institute: Luisa Ciampi, Dr. Henny Osbahr, Prof. Anne Verhoef, Prof. Emily Black, Dr. Peter Cook.

British Geological Survey: Dr. Matt Ascott

BRAVE project team members: Dr Jean-Pierre Sandwidi (University of Fada N'Gourma, Burkina Faso), Dr. William Ageykum and Dr. Collins Okrah (CSIR-Water Research Institute, Ghana), Hannah David, Hannah Clark and Cristina Talens (Lorna Young Foundation); Narcisse Gahi (Associate, IRC Burkina Faso) and Shani Haruna (Associate, University of Ghana)

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Disclaimer

To access the 'BRAVE' Groundwater Futures
Cornforth, Rosalind J, Macdonald, David M. J., Osbahr, Henny, Ciampi, Luisa, Myers, Jacob, Verhoef, Anne, … Haruna, S. (2019, November 8). Possible futures for groundwater in Burkina Faso under a changing climate (Version 1.0). Zenodo. http://doi.org/10.5281/zenodo.3533108

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Ouagadougou, Burkina Faso
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INTRODUCTION

On the 13th November 2019, the Walker Institute, in collaboration with Climate Analytics and British Geological Survey, ran a workshop attended by government departments, NGOs and academic representatives from the Burkina Faso Water Sector. The purpose of this one-day workshop was to engage with prominent Burkinabe stakeholders including representatives from the Departments of Water and Sanitation, Environment and Sustainable Development along with academic institutes such as the University of Fada, civil society organizations and development partners to explore the "Groundwater Futures" from the BRAVE project. The workshop provided an opportunity to propose measures and identify concrete actions which could be included in a National Action Plan for the Water Sector.

The Burkinabe government plans to review their NAP in 2020 and this workshop provided a space for open and collaborative discussion not only with the water sector, but multiple other departments and organizations.

The BRAVE project

BRAVE, one of five projects of the UPGro consortium, has been working in Ghana and Burkina Faso since 2015 to improve the national, sub-national and local understanding around the management, monitoring and modelling of groundwater resources in the face of the future climate changes. By successfully integrating the three main areas of investigation; physical science, social science and governance, BRAVE is able to support behaviour change and investment into groundwater from community through to policy level.

Through BRAVE, better ways to model and communicate the complex environmental changes in the Sahel region of West Africa have been modelled and results are being used to improve the long term planning of groundwater supplies and help provide early warnings of groundwater shortages so that marginalized rural communities are more resilient to drought and unpredictable, changing rainfall.

www.upgro.org

As part of the BRAVE project, the Walker Institute developed "Possible futures for Groundwater in Burkina Faso under a changing climate", a narrative that describes three possible future scenarios for water resources in Burkina Faso along with the human and socio-economic impacts that might be experienced by people living in rural areas. This document formed a core part of the dialogue during the workshop. The Walker Institute also used Scenario Planning and Use Case Narratives as part of the workshop methodology. The Walker Institute has since used this method in Ghana, January 2020.

OPENING

Dr. Sarah D’haen, Scientific Coordinator (Sub-Saharan Africa) for Climate Analytics, delivered the first opening remarks. She noted that the workshop was held as part of a series of activities around water resource management organised with the Minister of Environment in Burkina Faso and stakeholders involved in the water sector and disaster management, under the **IMPACT Project** - a cross-cutting, multi-faceted project to strengthen capacities in Small Island Developing States (SIDS) and Least Developed Countries (LDCs) to develop and implement transformational climate adaptation and mitigation strategies; enhance access to international climate finance; and better equip SIDS and LDCs in engaging in UNFCCC negotiations**.**

Figure 1: Dr. Sarah D'haen (Climate Analytics) opening the Scenario Planning Workshop

Professor Rosalind Cornforth, Director of the Walker Institute and Principal Investigator of the BRAVE project, reflected on insights gained over the 5-year project from the groundwater modelling work, as well as implications for integrated water resource planning from the social science analyses (https://upgro.files.wordpress.com/2019/07/2019-brave-social-science-activity-report-february-2019.pdf) and the work with the communities to monitor groundwater integrated with the farmer voice radio (http://www.walker.ac.uk/about-walker/news-events/brave-lorna-young-foundation-radio-extension-project-in-ghana-and-burkina-faso-is-underway/). She concluded that BRAVE has improved understanding of how water moves through catchments representative of the Volta River Basin. Output from land surface and groundwater models, has led to new scientific knowledge available for supporting planning - from basin-scale, to seasonal community management of groundwater supplies and emergency planning

Figure 2: Dr David MacDonald (BGS) presenting the results from the BRAVE groundwater modelling

KEY RESULTS FROM BRAVE

Dr David MacDonald, Senior Hydrogeologist and Head of Section at the British Geological Survey, presented the key results from the innovative coupled groundwater and climate modelling carried out under the BRAVE project that has informed the Groundwater Futures that will be discussed at the workshop. *Professor Rosalind Cornforth* concluded the opening session by highlighting key results from BRAVE and the implications of the Groundwater Futures for people’s livelihoods to set the scene for the scenario exploration process.

1. The project has highlighted the value of local and national-scale monitoring data.

The localised nature of groundwater resources in areas underlain by weathered and fractured hard rock is a key factor in management. Community-based management is more appropriate than top down approach in these environments. The project has highlighted the value of local and national-scale monitoring data. In particular, *long records of GW data in Burkina Faso (Fig. 1) enabled reconstructions of past GW levels to validate models and then forward-looking future projections to support the government planning (NAP) processes for the Water Sector.*

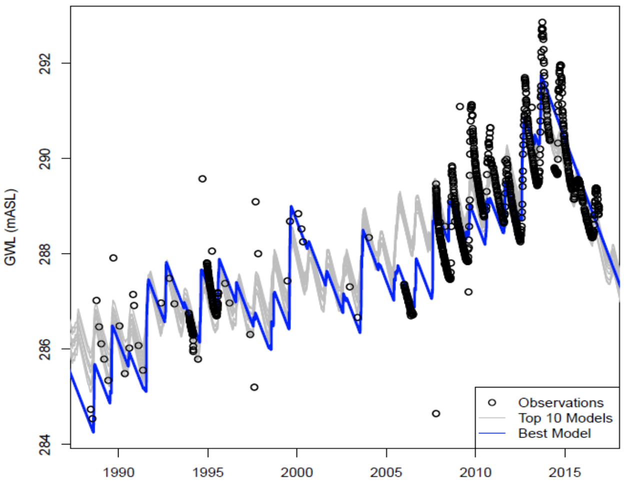

Figure 3: Long term groundwater level monitoring data collected from a. Burkina Faso network of more than 50 sites, with time series of ~30 years in over 10 of these sites

2. Sharing of Information, knowledge and interpretation is by strategic and operating partners – partners that are co-developed and locally owned.

Different decision domains span different planning horizons. Farmers needs for weather forecasts are among the shortest.

Small variable groundwater abstractions have low prominence in the measures identified in the White Volta Basin Planning, even though they are widespread. They are not treated in the same way that regionally extensive aquifers exploited by large public water supplies or commercial operations might be.

Groundwater information was communicated through weekly radio programmes with content determined by the Farmer Listening Groups, with local radio partners and the Lorna Young Foundation.

Appropriate choice of communication channels for effective information sharing are essential.

Figure 4: BRAVE Farmer’s Listening Group in action

3. RAINWATCH was key to informing farmers of risk and opportunity because of enabling rigorous assessments of rainfall and resource shortage (drought conditions).

Using the open source RAINWATCH platform, BRAVE is collecting real-time rainfall data to support community monitoring of groundwater and national-scale decision-making (GW Futures).

RAINWATCH visualises the ‘season-to-date’ daily rainfall and compares this with historical rainfall data to support seasonal/sub-seasonal agricultural planning decisions. RAINWATCH showed the value of monitoring alongside forecasting to communities and decision-makers. Note, although fully operationalised by 15 NHMS across Africa, Burkina Faso remains without a fit-for-purpose system. The monitoring shown below in Fig. 5 is from 2014 when Rainwatch was last operating in Burkina Faso by the national metrological service (DMN) Burkina.

https://doi.org/10.5281/zenodo.3366368

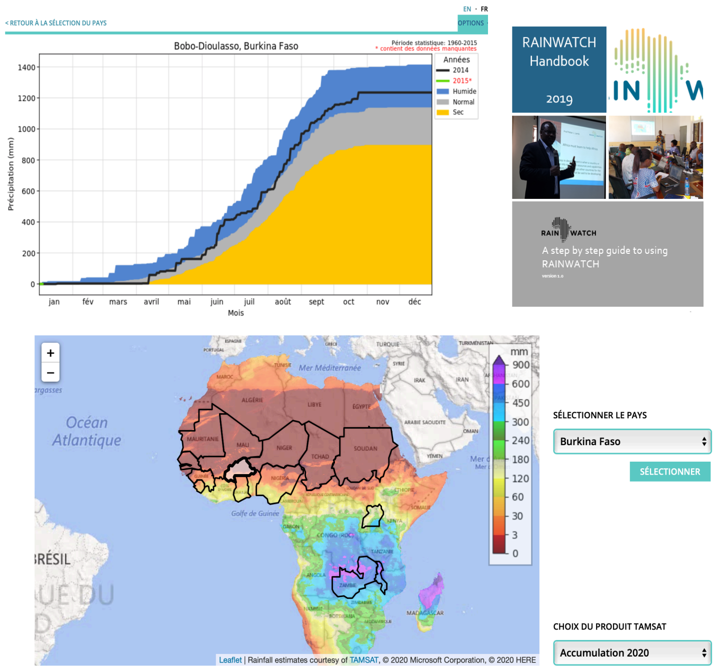

Figure 5: Screenshots from the RAINWATCH Monitoring Platform (www.rainwatch-africa.org)

4. Explaining long-term groundwater records in terms of long-term rainfall and weather data gives a platform for creating scenarios of future groundwater responses to changing climate to support national-scale planning.

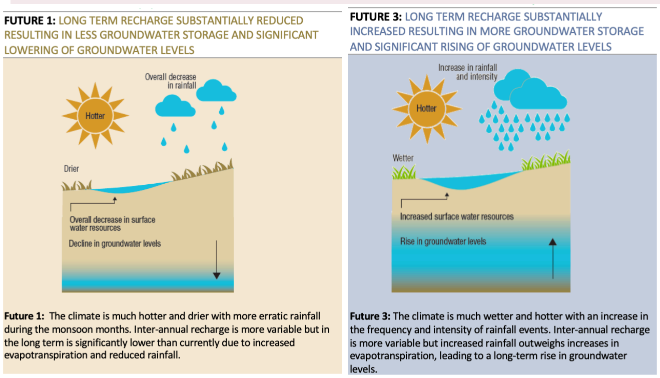

Figure 6: BRAVE Groundwater Futures 1 and 3 for Burkina Faso (http://doi.org/10.5281/zenodo.3533108)

5. People are influenced by diverse factors and forces that shape their current and future decisions and actions about water governance locally.

Some people will be better able to manage their resources and participate in the strategy to use groundwater effectively for cropping and livestock, and some people will not.

It is important to understand people’s livelihoods locally and what characterizes their vulnerability to water scarcity.

SCENARIO EXPLORATION AND TIME HORIZON ANALYSIS

Breaking into four groups, ensuring a range of government decision makers, researchers and users of climate information were represented in each, participants focused on using Groundwater Future 2 (See Fig. 7 and Annex D) to envisage what 2040 would look like in a future where communities were resilient to climate and environmental change. This led on to a discussion around what the Burkina Faso Water Sector needed to have achieved through the NAP by 2020, 2030 and 2040.

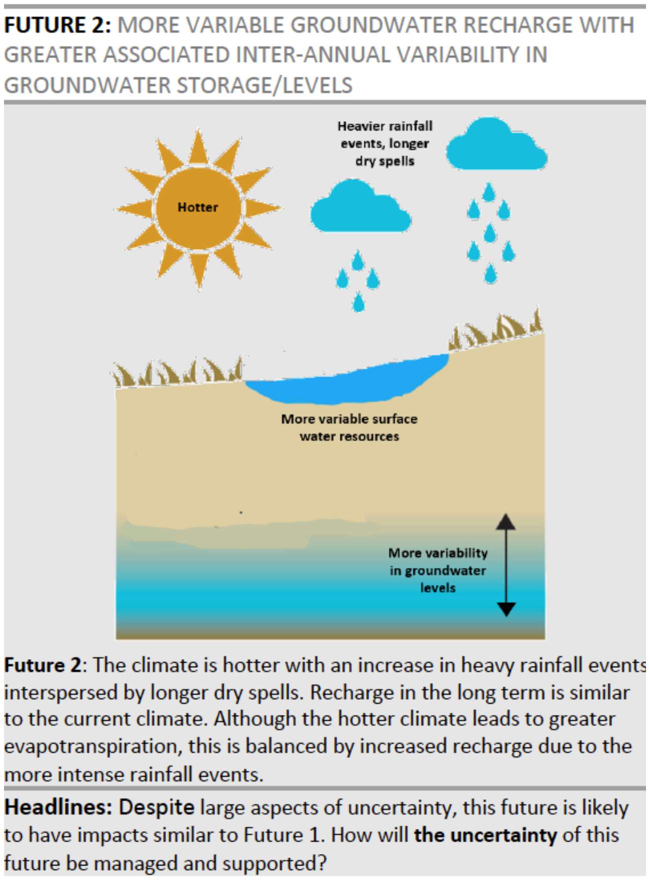

Figure 7: BRAVE Groundwater Future 2 (see also http://doi.org/10.5281/zenodo.3533108)

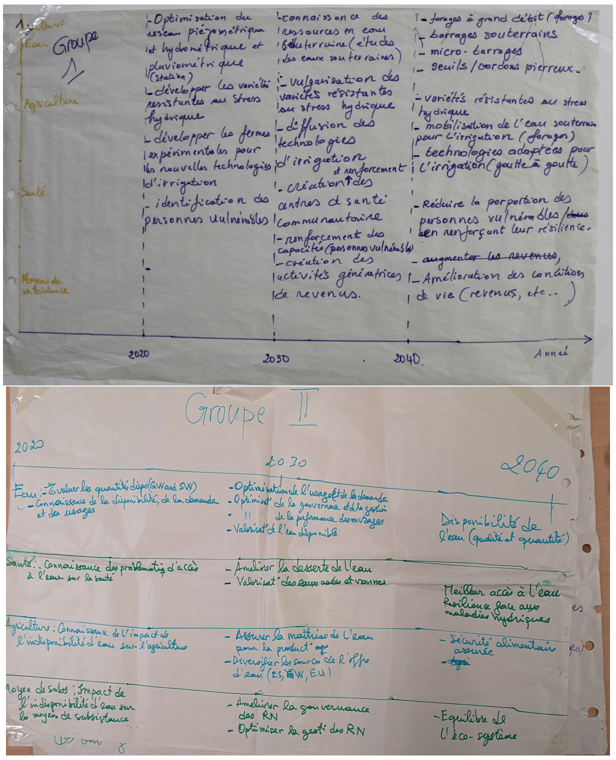

Figure 8: Group 1 (top) and Group 2 (bottom) Timelines

In the plenary, Group 1 (Fig. 8) envisaged a future in 2040 with capacity for:

- Large scale drilling of boreholes; and
- The establishment of large-scale infrastructure projects such as dams, including underground and micro-dams.

In order to be able to do this, Group 1 identified the following sets of priorities for the Burkinabe Water Sector over the next 20 years :-

By 2020:

- Optimize and increase usage of networks (hydro-met, rainfall, piezometric)
- Develop large scale tests for water stress
- Develop test farms for new irrigation technologies
- Identification of vulnerable populations

By 2030:

- Access to improved knowledge on available water resources (Both Surface and Groundwater)
- Popularization of crop varieties resistant to water stress
- Diffusion of new irrigation technologies across Burkina Faso
- Creation & strengthening of community health centers
- Capacity building on integrated water management for identified vulnerable populations.

For all four group's feedback on the timeline activities, please refer to Annex E.

USE CASE ANALYSIS

Following the feedback discussion, the Timelines created in Task 1 were used to derive a set of decisions

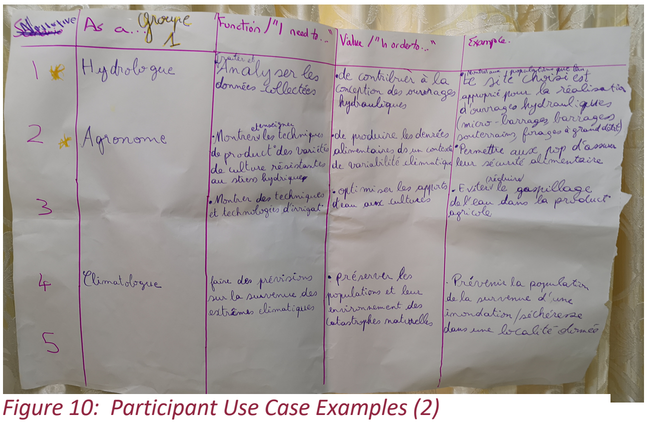

Figure 10: Participant Use Case Examples (2)

and actions participants would need to take forwards 'tomorrow' to reach the 2040 goals identified in Task 1.

Figure 9: Participant Use Case Examples (1)

The use case structure is illustrated below:
The use cases developed can be found in Annex F.

ANALYSIS OF RESPONSE OPTIONS

The final step in the scenario planning workshop was to consider the opportunities and limitations the water sector faced in Burkina Faso in reaching the desired goals for 2040. The participants worked in 4 groups in a carousel and framed their needs under the following headings: Capacity Building, Data & Technology, Research and Governance. Prompt questions were used to invite participants to reflect on issues such as: "*Where should we prioritize future data gathering to add most value*".

Figure 11: Participants considering barriers to progress

Examples from the 'Data & Technology' considerations are included below for interest. Further details may be found in Annex G.

Data & Technology Gaps:
Where should we prioritise future data gathering and research to add most value?

- Satellite imagery
- Further research on weather extremes
- Creation of a regional platform for data gathering and dissemination on climate information/ Creation of an 'IPCC' for the region

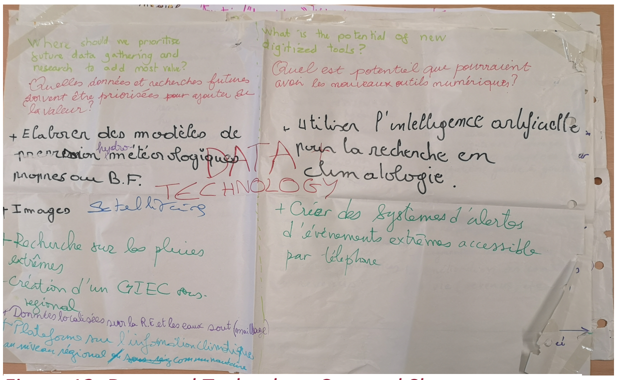

Figure 12: Data and Technology Carousel Sheet

WHAT CAN REASONABLY BE DONE

To close the workshop, a goldfish bowl was carried out with four participants representing different communities within the water sector to reflect on the day's learnings through addressing a number of thematic questions. The remaining participants observed the process to provide a space for frank conversations.

Figure 13: Frank discussions to assess what can reasonably be done

KEY MESSAGES FROM THE SCENARIO PLANNING WORKSHOP FOR THE NAP

For ease of reference these are summarized using the headings from the policy option analysis.

Research Gaps

- Identify how best to mobilize and exploit groundwater resources for agriculture
- Instigate new in-depth interdisciplinary research on groundwater that integrates physical and social sciences
- Establish a central hub of data, research and knowledge around water resource management, particularly groundwater

Capacity Building

- Build the capacity of technicians and communities for the collection of data on groundwater and to enable the scaling up of local community groundwater management

Governance

- Align the groundwater targets with the SDGs in 2030 and ensure equitable access to groundwater and surface water
- Identify the champions within government, NGOs, and academia that have the necessary influence and energy to facilitate real change
- Better store, manage and govern existing water resources
- Institutionalize water and water resource management and embed within the national strategy and cascade down through all the department strategies
- Enable all sectors to unite and better exploit water resources to boost their development
- Advocate for and create opportunities to foster cross-sectoral collaboration across government departments, research institutes and NGOs. Access to data and information should not be a competition between for example, the Department of Water and the Department for Sanitation and Environment.

Data & Technology

- Establish a network of different datasets available in Burkina Faso on groundwater, surface water, hydrology, livelihoods information etc.
- Validate existing data on groundwater resources

Key Actions to Enable Better Adaptation

- Improving the groundwater monitoring network
- Improving knowledge and uptake of sustainable land management techniques
- Increasing understanding of water pollution practices (e.g. organic v. chemical fertilisers)
- Providing training and Information on the potential of groundwater to help build more resilience livelihoods
- Improving research and knowledge around water resources (at all levels)
- Improving the availability of qualitative and quantitative data on groundwater and surface water
- Improving Water Resource Management including adaptation techniques and a review of current strategies

CLOSING STATEMENT

The BRAVE/IMPACT Scenario Planning Workshop was organised with the Minister of Environment in Burkina Faso and stakeholders involved in the water sector and disaster management. Participants were invited to contribute to the closing statement of the workshop. A number of these are captured below:

- *“Water is an issue for everybody here today, which is how we created and proposed a series of recommendations, we need institutes in charge of water resources in our country and (to) provide information that is useful to all relevant departments. This workshop has been very useful for us all today, especially as we our water NAP, these are elements that are essential. The NAP should relate the ambitions we have as a country and bring these into the changing climate”*
- *“This workshop helped better coordinate at policy level with regards to climate change and the NAP. Water is transdisciplinary and needs to be taken that way.”*
- *“The policies we need to improve our water resources is far beyond this workshop, it includes politics at multiple levels. We are acting as technicians/institutions but we are governed by politics. This aspect needs to be considered.”*

ANNEX A: PARTICIPATING ORGANIZATIONS

ORGANIZATION	NAME
AUTORITE DU BASIN DE LA VOLTA - *ABV*	M. H. Faride Kone
AGENCE NATIONALE DE LA METEOROLOGIE - *ANAM*	1
DIRECTION GENERALE DES RESSOURCES EN EAU / DIRECTION DES ETUDES ET DE L'INFORMATION SUR L'EAU – *DGRE/DEIE*	1 participant
SECRETARIAT PERMANENT DU CONSEIL NATIONAL POUR LE DEVELOPPEMENT DURABLE - *MEEVCC/SP-CNDD/DCCI*	Kouka Ouedraogo
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE ET TECHNOLOGIQUE - INSTITUT DE L'ENVIRONNEMENT ET DE RECHERCHES AGRICOLES - *CNRST-INERA*	1 participant
DIRECTION GENERALE DES AMENAGEMENTS HYDRAULIQUES ET DU DEVELOPPEMENT DE L'IRRIGATION – *DGAHDI/DAH*	Brahima Gneme T. Joel Sawadogo
DIRECTION GENERALE DES ESPACES ET DES AMENAGEMENTS PASTORAUX – *DGEAP/MRIPH*	Zéphirin Zoma
DIRECTION GENERALE DES ETUDES ET DES STATISTIQUES SECTORIELLES – *DGESS/MEA*	Salifou Kabore
MINISTERE DE L'EAU ET DE L'ASSAINISSEMENT - *GIRE*	Hilaire W. Ilboudo
MINISTERE DE L'ENVIRONNMENT, DE L'ECONOMIE VERTE ET DU CHANGEMENT CLIMATIQUE - *MEEVCC /SG*	1 participant
DIRECTION GENERALE DES INFRASTRUCTURES HYDRAULIQUES – *DGIH/DMOH*	Koudougou Achille Segda
MINISTERE DES ENSEIGN SUP ET RECHERCHE - AGENCE NATIONALE DE VALORISATION DES RESULTATS DE LA RECHERCHE - *ANVAR*	1 participant
LABORATOIRE MATERIAUX ET ENVIRONNEMENT – *LAME/UJKZ*	Prof. Zougmoré Francois Lucien Damiba
L'OBSERVATEUR NATIONAL DU DEVELOPPEMENT DURABLE - *MEEVCC/ONDD*	Bouneima Sadiguida
PARTENARIAT NATIONAL DE L'EAU - *PNE*	1 participant
Université De Fada N'gourma	Dr Jean Pierre Sandwidi
IRC – Burkina Faso	Dr. Narcisse Gahi
Ministère De L'Eau - *SG*	1 participant

LEAD INSTITUTES	Name
Climate Analytics	Dr. Sarah D'haen Dr. Djibril Dayamba Jean David Coulibaly Tessa Möller Amen Eklou
Walker Institute	Prof. Rosalind Cornforth Jacob Myers
British Geological Survey	Dr. David Macdonald

ANNEX B: WORKSHOP PROGRAMME

Venue: La Palmeraie, Ouagadougou, Burkina Faso
Date: Wednesday 13th November, 2019; Time: 09:00 – 17:30
The 'BRAVE' Groundwater Futures for Burkina Faso programme was facilitated by Prof. Rosalind Cornforth, Director, Walker Institute.

TIME	SESSION NAME
09.00	Welcome and introductions
09:45	Establish the Scenario Exploration process
10:00	Introduce Groundwater Futures – main drivers of change and assumptions, possible trends, main uncertainties
10:45	Coffee break
11.15	Implications of scenarios on livelihoods
11.45	Use case development – generate qualitative set of stories about the future based on identified drivers
12:30	Lunch
13.30	Time horizon analysis
14:15	Analysis of response options (Part 1) – quantitative information/research, tools and datasets
15:30	Coffee Break
16:00	Analysis of response options (Part 2) - capacities, infrastructure and regulatory frameworks
16:45	Summary assessment of what can reasonably be done; Close

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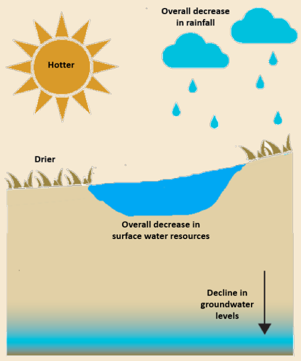
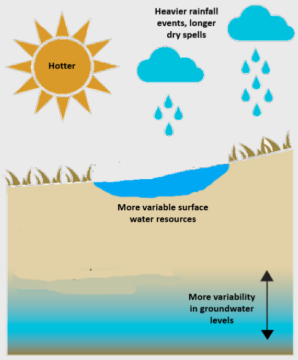
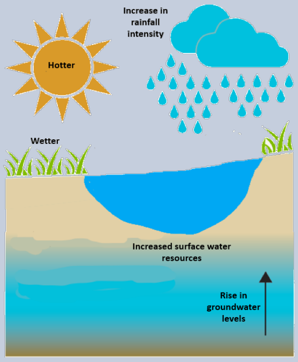
ANNEX C: PHOTO GALLERY

ANNEX D: GROUNDWATER FUTURES

www. http://doi.org/10.5281/zenodo.3533108

Possible futures for groundwater in Burkina Faso under a changing climate

This narrative*describes three possible future scenarios based on 2050 models for water resources in Burkina Faso, and the human and socio-economic impacts that might be experienced by people living in rural areas. The narratives aim to stimulate discussion towards realistic policy responses and the decision support tools needed to assist future planning needs. It is important to recognise that the scenarios do not represent every outcome projected by climate models and the resulting impacts will be contextualised by local circumstances. For more information about BRAVE and UPGro: upgro.org/consortium/brave2/.

FUTURE 1: GROUNDWATER RECHARGE SUBSTANTIALLY REDUCED RESULTING IN LESS GROUNDWATER STORAGE AND SIGNIFICANT LOWERING OF GROUNDWATER LEVELS	**FUTURE 2:** MORE VARIABLE GROUNDWATER RECHARGE WITH GREATER ASSOCIATED INTER-ANNUAL VARIABILITY IN GROUNDWATER STORAGE/LEVELS	**FUTURE 3:** SUBSTANTIALLY INCREASED GROUNDWATER RECHARGE RESULTING IN GREATER GROUNDWATER STORAGE AND HIGHER GROUNDWATER LEVEL
		
Future 1: The climate is much hotter and drier with more erratic rainfall during the monsoon months. Inter-annual recharge is more viable but in the long term is significantly lower than currently.	**Future 2**: The climate is hotter with an increase in heavy rainfall events interspersed by longer dry spells. Recharge in the long term is similar to the current climate. Although the hotter climate leads to greater evapotranspiration, this is balanced by increased recharge due to the more intense rainfall events.	**Future 3:** The climate is much wetter and hotter with an increase in the frequency and intensity of rainfall events. Interannual recharge is more variable but increased rainfall outweighs increases in evapotranspiration, leading to a long-term rise in groundwater (GW) levels (GWL).
Headlines: Increased poverty with impact extending to urban communities as well as rural, agricultural dependant areas. What other national **alternatives are there for supporting adaptation**?	**Headlines:** Despite large aspects of uncertainty, this future is likely to have impacts similar to Future 1. How will **the uncertainty** of this future be managed and supported?	**Headline Impacts:** Improved agricultural production if the market can be managed effectively. How will **equal economic growth be maximised** in this future?

***Key:** GW/Groundwater; GWL/Groundwater Levels

BRAVE

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IMPACTS

	FUTURE 1	FUTURE 2	FUTURE 3
Water	» Reduced surface water resources lead to widespread abandonment of shallow GW sources » Rain-fed agriculture is less viable with increasing dependency on GW for irrigation. This Increased GW use lowers the water table and extraction is difficult and wells/boreholes fail more often. » As communities are relying on fewer GW sources, time to collect water increases and incidences of water-borne diseases rise. » People with more power/resources are capitalising on remaining water sources increasing gender and inter-community tensions. » Water quality deteriorates as older mineralised GW is abstracted. » Urban water supplies are under pressure due to widespread GW depletion through increased abstraction rates.	» Reduced reliability in surface water supplies and rainfed crop production leads to a greater dependency on GW sources with similar impacts to those presented in Future 1, especially in times of low rainfall. » Depending on the length and frequency of dry periods, tensions over water access and use are rising.	» The potential for abstraction increases as GW becomes shallower and more accessible. » Rain-fed cropping is more secure as surface water increases. » Conflict over water use is reducing as water is more readily available. However, the growing population, improved abstraction technology and greater economic opportunities are introducing new competition for water resources. » Flooding and waterlogging increases putting people and their livelihoods at risk. This flooding is geographically variable.
Disease	» Poor diet due to water constraints and reduced yields, is exacerbating nutritional deficiencies and impacting heavily on the poorest people in the community as well as pregnant women, children, adolescent boys and the elderly. » Incidences of water-borne diseases are rising because communities are relying on fewer GW sources.	» The long dry periods are reducing yields with knock-on impacts for poor diet and associated nutrition and health difficulties. Pregnant women, children, adolescent boys, the elderly and the poor are struggling the most.	» Pollution in water sources is spreading rapidly due to higher water levels and WASH issues increases as well as diseases such as cholera. » The high GW table is increasing waterlogging and flooding. Stagnant water is increasing the risk of water-borne diseases (e.g. malaria, cholera). Vital medicines are in short supply.
Agriculture	» Staple crop harvests are reducing due to limited water and increased incidences of pests. Some staples are failing completely. » Cash crops such as onions and dolo (local beer) are difficult to produce and livestock are dying due to lack of water and fodder. » Financial stress is exacerbating food security as households have less income for additional consumption goods to compensate for the poor staple crop harvests. » Some households are adopting more drought resistant crops despite the cultural barriers and related additional costs. » Poverty is rising as people lose vital assets and seek to diversify their livelihoods out of agriculture.	» The hotter, drier periods are triggering similar impacts as Future 1. » Rain fed agriculture is uncertain and has to be supplemented with GW due to the variable and unpredictable nature of the climate. » Food production and food security is decreasing, particularly in recurrent drought years.	» Vegetables and fruit harvests are plentiful as communities optimise their use of rain-fed cropping and irrigation, as well as increase staple crop production. » There is more waterlogging, so communities are changing to crops which grow better in wetter soils, such as rice. » Livestock are struggling with the increase in the number of floods and rising temperatures. Lifespan is decreasing. » As production increases, more communities are turning away from family labour and mechanising their production processes. They are keen to invest at other stages in the value chain such as in soil quality and conservation.
Livelihood	» Migration increases into the urban centres as people turn away from agriculture and look for cash work and temporary labour. Urban infrastructure, sanitation and housing are under pressure with an increase in of poor peri-urban areas. » Migration south to wetter lands is increasing tensions and water competition. Concern increases for people entering the informal economy which lacks social safety nets. » Community bonds are eroding as historical commercialization success reduces. Tensions rise with the competing demands. » Financial constraints are limiting people's ability to adapt and increase reliance on social protection strategies. » Marginalised rural communities are experiencing greater poverty and the number of ultra- poor are increasing dramatically.	» Due to the variability of this future, periods of low and/or high income are likely. This income unpredictability will leave people more risk averse. » Those with access to private wells will be more able to cope than those without which will exacerbate inequalities.	» People are enjoying better diets with the increase in choice and availability of food. Market prices are falling. » People are struggling more with heat stress. » Communities look for more financial support systems such as insurance as flood events increase in frequency and intensity. » Increased heat and economic pressures are reducing the availability of manual labourers to keep up with production. » The transition to mechanisation is leaving a group of people behind who cannot afford this. Inequality is increasing.

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POSSIBLE RESPONSES

	FUTURE 1	FUTURE 2	FUTURE 3
Water	• Investments are increasing in regional and national (deeper groundwater sources, improved abstraction technology, supply to urban areas and domestic sources) infrastructure. • GW extraction is managed more equitably so that abstraction is sustainable and marginalised groups can access water. • Monitoring and management of water usage and the pollution of private wells and community water sources is in place. • There is a better understanding of the causes of borehole failure and guidelines have been introduced to ensure investment in infrastructure is not wasted.	• Management of GW is in place to compensate for the increased rainfall variability. • Large-scale investment in infrastructure has improved exploitation and management of GW resources that are available. People are able to deal with uncertainty and shocks to ensure continual supply. • GW monitoring is enabling people to plan ahead and manage their own resources. • Investment in education and access to integrated information services supports people’s livelihood choices. • Communities and farmers have adopted a more flexible approach to sourcing water and productive use of water.	• Investments have been made in water management systems such as irrigation and monitoring to support commercialisation, together with training of smallholders and extensions services. • Policies are in place to ensure sustainable development of water-related livelihoods and the substantial exploitation of water resources.
Disease	• Investment in public services have made these more available to deal with the increases in health issues and disease epidemics. • Investment in adaptive social protection services are helping to manage crises more effectively for the marginalised and vulnerable groups.	• Investment in adaptive social protection measures are helping to overcome the health issues relating to the longer dry spells and heavy flood events.	• There is much more investment and management of water borne diseases. • Adaptive social protection measures are helping to overcome health issues related to frequent and heavy flood events. • Household income has increased which is improving access to medication and better nutrition. • Governments are investing in in flood protection, flood resistant rural roads and disaster response, as well as public health strategies to deal with heat stress.
Agriculture	• The national government has invested in financial and technical support to marginalised people to help introduce more drought resilient staple crops and livestock and avoid financial difficulties. • An intensive focus on environmental management by planting trees, using agro-forestry techniques and conducting conservation agriculture has increased soil moisture and limited run-off. • Increased regulation of the market has increased food imports.	• The investment in extension services is building diversity into livelihoods and supporting policy is enabling a people to diversify crop varieties grown, implement improved irrigation systems and access better information provision systems. • People who cannot access wells are receiving greater support with policies in place to establish equitable access to water despite the high number of private wells in agriculture.	• More extension services are in place to support the increase in commercialisation needed and bridge the information gaps. Crop quality and diversity is increasing as a result with people able to access markets better. • Investment in training for farmers is helping people to manage throughout the value chain and increase their necessary communication/coordination skills. • Policies are in place to ensure that the agricultural intensification is sustainable and that the growth process is equitable, so marginalised groups are not left behind.
Livelihood	• Policies are in place to better manage the increases in destructive livelihoods (such as increased charcoal use witnessed in Ghana) and their associated impacts as livelihoods become unsustainable. • Adaptive social protection measures are supporting people’s livelihoods, in parallel with investments in monitoring, data collection and control, and the implementation of legislation mechanisms across the different governance levels.	• The provision of training to farmers by extension services, NGOs and government departments is increasing their confidence in flexing their agriculture practice and helping to support alternative income streams and avoid potential issues.	• Economic growth is being managed by ensuring the market is monitored, the whole value chain is accessible and supported as people become less risk averse and increase diversification and invest further in agriculture. • Adaptive social protection measures are actively promoted to support the increasing flood risk.

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ANNEX E: GROUP TIMELINES

Group 1 Timeline

Group 1							
2020	Optimisation of the piezometric/ hydro met and rainfall networks	Development of tests for water stress	Develop test farms for new irrigation tech	Identify vulnerable populations			
2030	Improve knowledge of all water resources (SW and GW)	Popularisation of crop varieties resistant to water stress	Diffuse new irrigation technologies	Creation and strengthen community health centres	Capacity building of vulnerable populations	Creation of income generating activities	
2040	Large scale drilling of boreholes	Underground dams	Micro dams	Crop varieties resistant to water stress	Mobilisation of GW for irrigation	New irrigation technology	Improving people's livelihoods (revenues, yields etc.)

Group 2 Timeline

Group 2					
2020	*Water*	Assess the quantities of GW and SW available			
	Health	Improve knowledge around problems of access for water on health			
	Agriculture	Knowledge on impact of unavailability of water on agriculture			
	Livelihoods	Understand impact of unavailability of water on livelihoods			
2030	*Water*	Improve governance of GW/SW	Optimise usage and demand of GW/SW	Optimise performance of current infrastructure	Validation of available resources
	Health	Improve water supply	Improve wastewater systems & pipes		
	Agriculture	Diversify water supply sources (GW, EU, ES, SW)			
	Livelihoods				
2040	*Water*	Availability of water (quality and quantity)			
	Health	Better access to water, resilience to waterborne disease			
	Agriculture	Improve food security			
	Livelihoods	Balance between livelihoods & Ecosystem			

Group 3 Timeline

Group 3					
2020	Research on the knowledge of water resources (availability of data, options and options for groundwater and surface water resources	Train communities in of data generation	Review IWRM and take into account adaptation actions	Review policies, strategies and programmes in context of climate change	
2030	Strengthen validity of DEIE data in a core research unit	Develop and improve water security failures	Develop hydraulic infrastructure		
2040	Achieve 100% cover and access of SW and GW	Develop adapted seeds to future	Develop groundwater infrastructure	Food security - Reduce reliance on rain-fed agriculture	Strengthen the DGPVs capacity

Group 4 Timeline

Group 4					
2030	*Water*	Improve knowledge on RED, sustainable water management and recovery of other water sources			
	Health	build irrigation equipment			
	Agriculture	Substantial seed improvement	Improve agricultural research	Put in place insurance services	
	Livelihoods	Goof governance required			
2040	*Water*	Improve accessibility & visibility of RES	Sustainable management of water points	Improve records of rainfall monitoring	Wastewater recovery
	Health	Use of irrigation to increase production	Education in nutrition, malnutrition and waterborne diseases	Support for infrastructure	
	Agriculture	Promote the use of new climate adaptation	Put in place climate insurance	Technological improvements for agriculture	Mechanisation of agriculture
	Livelihoods	Climate insurance / crop insurance			

ANNEX F: GROUP USE CASES

Group 1	As a…	I need to…	In order to…	Example…
1	Hydrologist	Analyse collected data	contribute to the design of hydrological works	to ensure chosen sites are suitable for chosen infrastructure
2	Agriculture	Create techniques for producing crop varieties resistant to drought	produce food under climate variability	to allow people to insure their crops
		show irrigation techniques and technologies	optimise water supplies	to avoid wasting water in agricultural processes
3	Climatologist	forecast and monitor extreme climate events	preserve populations and their environments from	

Group 2	As a…	I need to…	In order to…	Example…
1	Livestock advisor	educate farmers and breeders about sanitation	protect the animals health	to instruct farmers how to vaccinate livestock
2	Water resources planner	create projections of figures on the availability of water	match usage and demand to annual availability	
3	Manager (Basin Authority)	organise users of boreholes	prioritise usage depending on availability	from 6am-7pm for human consumption, from 7pm-4am for animals
4	Researcher	make relevant information available to decision makers	help them make informed decisions by scientific	e.g. give them information on projections of rainfall

Group 3	As a…	I need to…	In order to…	Example…
1	DEIE Staff	provide expertise on water data analysis and climate change	validate data available for people to take correct adaptations	
2	SP/CNDD	coordinate the revised NAP / include scientific information from the	take into account the water security angle in our NAP	setting up a platform for the current NAP
3	SP/GIRE	coordinate the implementation of the IWRM programme	take into account the dimension of climate change in the programme	
4	DGAHDI	coordination and implementation of policies in the area of aquaculture development	take into account climate change dimension in aquaculture	
5	DGPV	coordinate the policy for improving crop/plant production	take into account dimension of climate change in crops/plants	

Group 4	As a…	I need to…	In order to…	Example…
1	Environmentalist	Reverse the trend of land degradation	Increase agricultural production	Equip producers on adapted sustainable management
		Reduce CO2 emissions related to deforestation	reduce global warming	
		fight against water pollution	protect aquatic ecosystems	Switching from chemical to organic fertilisers
2	Meteorologist	improve accessibility (channels of communication,	provide users with accurate weather information	plan information accordingly (crop calendar, agriculture
			facilitate understanding on uses of the	

ANNEX G: GAP ASSESSMENT

Capacity Building				
Question	Answers			
What critical skills and or capacities are missing that would make a real difference to policy implementers?	Expertise on climate change	Training on new techniques, equipment and methodologies	Expertise on best practice climate and hydro-geo modelling	Planning for climate change and water resources

Data & Technology				
Questions	Answers			
Where should we prioritise future data gathering and research to add most	Satellite Imagery	Creation of an IPCC for the region	Further research on weather extremes	Regional platform of data gathering on climate information
What is the potential of new digitized tools?	Using analytical methods for climatology research	Use of warning systems of extreme events accessible by		

Governance								
Question	Answer							
What legislation and/or infrastructure is needed to develop water resources sustainable and promote equitable access? (wrt gender)	Legislation	Take into account climate change in the SNE	Legislate on the matters of water usage and drainage					
	Infrastructure	Reduce evaporation	Purifying stations. Works (Dams, protection etc) Groundwater and surface water	Perimeter protection areas on recharge zones	Network of government departments	Hydro met stations		

Research								
Question	Answer							
What research and/or decision support tools are needed to support desired adaptation pathways	Policy briefs for decision makers	Water pollution/quality research	Rainfall uncertainty	Studies into potential of **new water sources**. **Freshwater levels and recharge zones** research Biodiversity research	Actualising PNA Delivering NDCs	Sharing results of research more widely	Studies of vulnerability on production systems in face of climate change (Agro/Hydro/ Pastoral)	

Learning together with Burkina communities during BRAVE