ANNUAL REPORT 2017

WASCAL
West African Science Service Centre on Climate Change and Adapted Land Use

SPONSORED BY THE

Federal Ministry of Education and Research

Combat Climate Change. Improve Livelihoods

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Capacity Building Programme

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DONOR'S REMARKS

Since the foundation of WASCAL, together with our African partners, we have made tremendous progress and are proud of the achievements in the field of Capacity Building and Research. We wish to congratulate the Board and the Executive Management for the hard work, passion and dedication in ensuring that WASCAL remains a relevant and giant player in the fight against climate change in West Africa.

As the unique funder of WASCAL, the German Federal Ministry of Education and Research has invested more than fifty millions euros (€50M) in Research, Capacity Building and Infrastructures to bring the West African region in the position to conduct this fight against the effect of Climate Change properly and self-confident. When we look today at the success stories , it gives us great hope to be proud of our engagement and our commitment to Africa as a platform where German and African scientists together as equal partners work for a better future of our planet. . The results have been phenomenal. This constitutes for us an additional motivation to continue our engagement for the next years by allocating news funds for the new Research Program WRAP 2.0 designed by our African partners according to the needs of the region and for the Capacity Building Programs as investments in Human capital.

After the consolidation phase, the year 2017 exposed the institution to a strategic phase of the institution, with all the events, activities and impact stories that were geared towards combatting climate change and improving livelihoods were all deepened.

West Africa remains one of the most affected region in the world as far as the negative effects of climate change is concerned and is one of our research priorities at the Ministry. Therefore, it seemed right to address climate change by developing regional scientific cooperation and collaboration, as we are doing now in the framework of WASCAL is a great step in the right direction.

It gives us great hope to be proud of our engagement and our commitment to Africa as a platform where German and African scientists together as equal partners work for a better future of our planet. . The results have been phenomenal.

We look forward to brighter years ahead, with even greater success stories. BMBF is still committed to providing the necessary support. . Let me take the opportunity to once again thank the entire Governing Board of WASCAL, all our partners in the WASCAL countries and in Germany for their strong and assiduous dedication they have exhibited over the years.

Assuredly, I know that WASCAL is on the right way to become a Regional Centre of Excellence and a Reference Research Centre which my ministry has immensely contributed to establish. I wish everyone associated with WASCAL a great success in all their endeavours in 2018 and beyond.

Thank you!

Wilfried Kraus
Federal Ministry of Education and Research, Germany

REMARKS FROM BOARD CHAIR

Climate change remains one of the severe challenges to Africa in this century. The situation demands a critical need to develop innovative and proactive measures to deal with the problem. To do these research is fundamental. The purpose of scientific research is to inform action by contributing to knowledge and progress, this we do at WASCAL.

The importance of WASCAL cannot be over emphasized in the glaring manifestations of the impacts of Climate Change on key sectors of the economies in West Africa. Food security is threatened and fresh water bodies our source of life are drying up and getting depleted. Prolong droughts are making the tilling of land difficult for peasant farmers and animals are starving as they cannot have a place to graze. I can go on and on. Climate research and capacity building is even more crucial at this point as we strive to achieve the Sustainable Development Goals and the Paris Agreement.

From a humble beginning in 2012, WASCAL has grown to be a competitor in the area of excellence for climate science and research in the region. In the last 5 years we have chalked tremendous success in the area of Capacity Building and have produced 258 graduates in PhD and Masters level in 10 schools across various countries in West Africa who are serving in different capacities both within the region and outside. Most of them in research institutions, international Banks and in Ministries, Departments and Agencies in the region and beyond.

We have been able to support national institutions with observatory equipment including automated weather stations to Ghana, Gambia, Nigeria, Mali, Togo and Senegal. More are on the way to other countries. The core research programme is picking up with the completion of WRAP 2.0 and our scientists have contributed to knowledge in diverse areas on climate change. Through international competitive processes we continue to hire high caliber staff to Mann the affairs of WASCAL and i use this opportunity to welcome DR Moumini Savadogo, Executive Director to WASCAL.

Dr Savadogo bring with him visionary and forward-looking leadership coupled with great experience in research and management. To achieve the expected heights for WASCAL a lot more has to be done. The countries must demonstrate more commitment and ownership of this noble institution. We need to diversify funding to WASCAL to be sustainable and financially robust. We must strengthen our relations and cooperation with partners within and outside the Africa region. We need to complete the process of getting the remaining five (5) countries Guinea, Guinea Bissau, Liberia, Sierra Leone and Cape Verde on Board WASCAL

Food security is threatened and fresh water bodies our source of life are drying up and getting depleted.

to make it truly an ECOWAS programme.

I wish to thank members of the Governing Board, the BMBF, PT-DLR and the hardworking staff of WASCAL for their dedication .I further call on national governments, all development partners, the Private sector, fellow Africans in and outside Africa and the international community at large to support the growth of or dear noble institution for mutual benefit and cooperation.

To all who have made us proud I say congratulations! I thank you and God bless us all.

MESSAGE FROM THE EXECUTIVE DIRECTOR

A Year of Transition

Dear Valued Reader,

WASCAL over the past years have grown from its embryonic stages into a beautiful bubbling bud with great prospects for the future. I would like to say a big thank you to my predecessors who have contributed their quota with diverse leadership qualities to bring WASCAL to its current status. I take a cursory look at 2017, to me it typifies a year of transition.

As an international organization, dedicated to becoming one of Africa's leading institutions in the provision of climate services, capacity building and research, in and for West Africa, there was the need to identify and maximize trending and potential partnerships with towards the realization of our objectives

The outfit positioned itself towards embracing the challenges that lay ahead through the Long-Term Sustainability Workshop held to lay the foundation for the creation of a platform for strategic planning and actions for the future stability. It was a momentous time, considering the team that was gathered to deliberate, discuss and step forward with ideas regarding the drafting and implementation of a Resource Mobilization Strategy.

There were other strategies that were drafted in the course of the year and are under finalization. These included the new research plan, Information Technology Strategy as well as the Communication Strategy. These documents holistically spelt out practical ways of moving WASCAL forward. Again, WASCAL strengthened its visibility efforts through the intensification of institutional partnerships with akin organizations in a bid to work collaboratively to champion the cause of mitigating and adapting to the

I believe strongly that with the grounds having been well fertilized and watered, WASCAL, under my leadership, and with the commitment of the governing Board and its committees, the contribution of our partners across at regional and international levels, the motivated staff across all the WASCAL countries, we will have a fruitful time in the coming year.

challenges of climate change in West Africa.

For instance the co-organization of World Café'- Climate research made in West and Southern Africa" in partnership with its Southern African counterparts, SASSCAL and German partners Center for Development Research(ZEF), held inside the Climate Planet in Bonn during the Conference of Parties (COP 23) brought together over 150 international students and partners from across the world to discuss very critical climate issues that have unbridled the West and Southern Africa sub regions "Topics such as How to build human and academic capacities in Africa; How to share and disseminate knowledge in Africa Research in Africa and Climate services in Africa: How to produce and deliver them", were discussed.

In the area of Capacity Building, it was a great feat, especially with the announcement of our donor, BMBF's commitment to sponsoring the 4th batch of Graduate students. The transition of the Masters Programmes into doctoral programmes to allow for a more tailor made and relevant studies was also a great highlight. The first in-service training took off, with fifteen participants from Ghana, Togo and Nigeria, participating in the maiden edition

The WASCAL Research Action Plan 2018-2021 (WRAP 2.0) was drafted. The document is designed to serve as a roadmap to a service provision centre by delivering key demand-driven climate and environmental services to be taken up by policymakers, decision makers and other stakeholders, including smallholders. The document was also designed to generate sound, evidence-based knowledge and information, and devise tools, including software to support decision-making and provide policy information and support for developing climate and environmental risk management, building resilient socio-ecological landscapes, and attaining sustainable agricultural production and food security

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The WASCAL Host Country Agreement with the Republic of Ghana was finally signed to fully give WASCAL its international status in Ghana, where its headquarters is situated. We are grateful to the government of Ghana.

With such highlights and many other impact stories this report presents, I want to specially thank our main funder, the BMBF for the belief in WASCAL, and the investment made to ensure that the organization becomes the leading name in tackling issues relating to climate change in West Africa. To DLR-PT, KfW/GITEC the partnership with you has been worth it all these years. Thank you for your support; I want to specially thank ZEF for the outstanding work they have done from the inception for WASCAL, to this date. To the governing board, SAC committee, management and staff, a lot of hard work, dedication and teamwork were conspicuously exhibited to firmly keep the anchor of the year. Let's keep the fire burning.

I believe strongly that with the grounds having been well fertilized and watered, WASCAL, under my leadership, and with the commitment of the governing Board and its committees, the contribution of our partners across at regional and international levels, the motivated staff across all the WASCAL countries, we will have a fruitful time in the coming year.

Thank you all

Dr. Moumini Savadogo
Executive Director

OUR VISION

WASCAL seeks to become one of Africa's leading institutions in the provision of climate services in and for West Africa.

OUR MISSION

WASCAL seeks to provide information and knowledge at the local, national and regional levels to its West African member countries to cope with the adverse impacts of climate change. We do this through Capacity Building support to young West African Scholars in fields of natural and social sciences and by strengthening West African universities and climate service departments in WASCAL member countries.

WHAT WE DO

CLIMATE SERVICE DEPARTMENT

Providing climate services to West African governments, regional economic bodies and basin authorities amongst other to feed into the development of climate change mitigation and adaptation strategies. This is achieved through data collection and dissemination, capacity building, translation of climate related data and scientific information from monitoring systems and models into customized products such as projections, forecasts, information, trends, economic analysis, assessments and guidelines on best practices.

OUR RESEARCH PROGRAMME

Connecting regional partners in data gathering networks and providing them with the infrastructure and the expertise to analyse the impact of climate change (CC) and develop management strategies and policies;

Translating the scientific-based outputs of WASCAL scientists, partners and others into adequate formats to support policy and decision-making in the region

Fostering outreach, communication and networking within West Africa and beyond

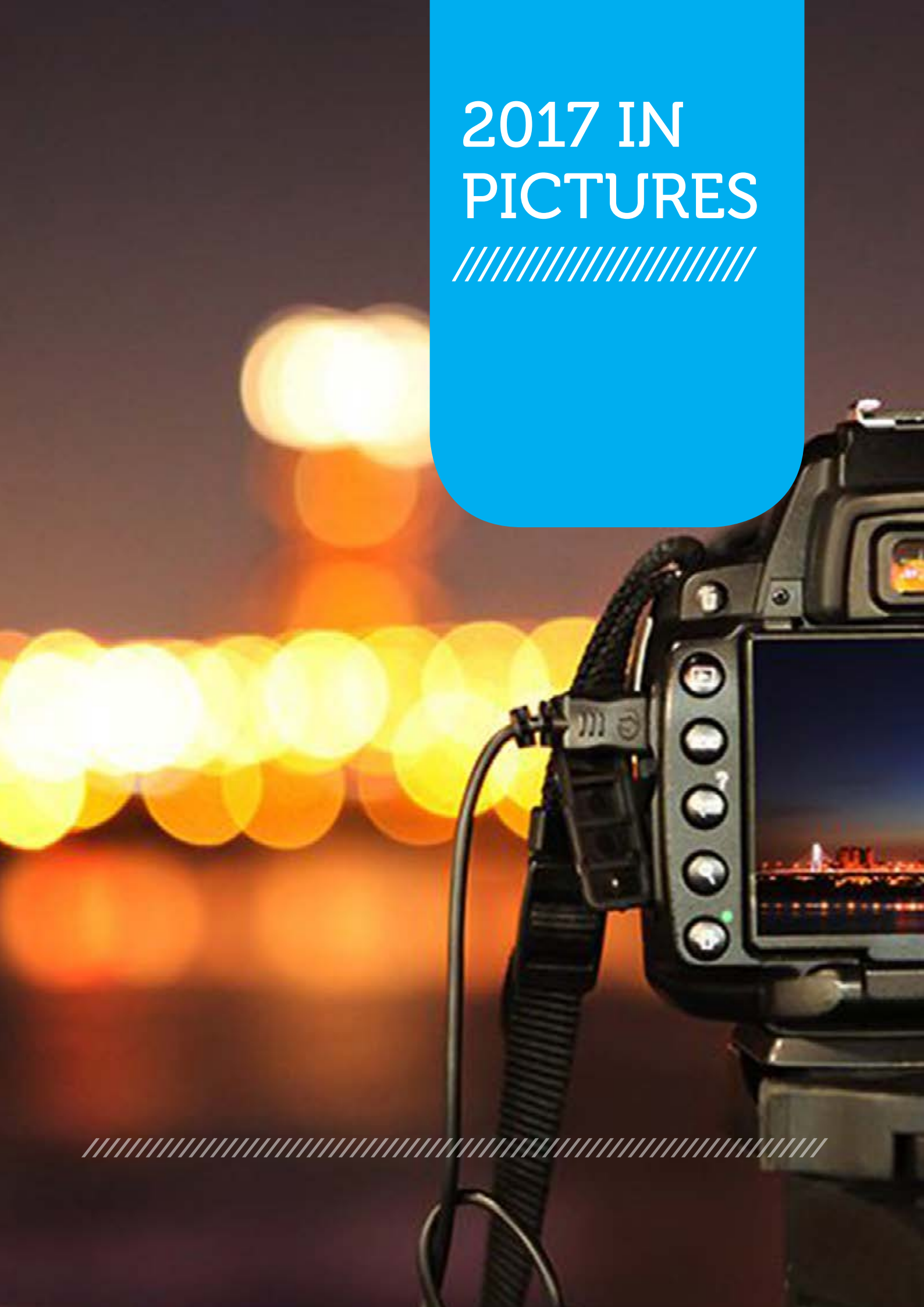
Fostering scientific collaboration with regional organizations and national decision-making institutions to formulating sound policies that enable the mainstreaming of CC issues in development policies and programmes.

OUR CAPACITY BUILDING PROGRAMME

Comprising the Graduate Studies Programme, which helps educate the next generation of scientists attain an intimate knowledge of different climate related issues in order to help the region develop suitable management strategies. This is done through the awarding of full scholarship to the Doctoral and Masters Students in all the lead Universities with comprehensive training and research support. The German partner universities collaborate with the Doctoral and Master's Programmes in the areas of curriculum development, visiting Lecturers and co-supervision of graduate students.

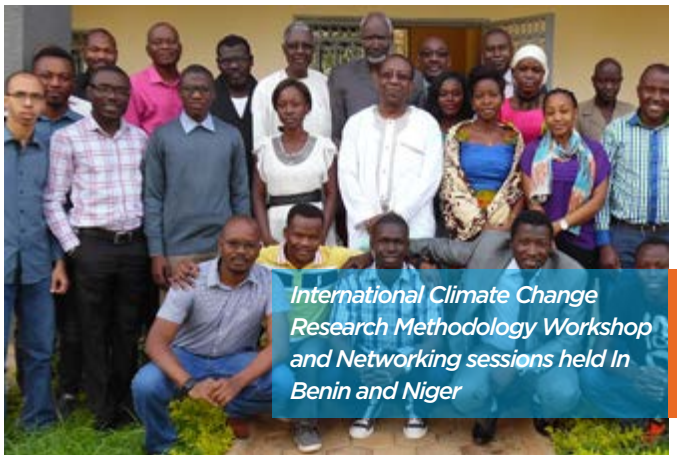
The department also runs the In-Service Training Programme which strengthens the existing human capacity of member countries to allow them to participate in the on-going global discourse on climate change and respond to current and future adaptation or mitigation challenges.

2017 IN PICTURES



WASCAL signs MOU with government of Burkina Faso

WASCAL schools West African climate managers and scientists



International Climate Change Research Methodology Workshop and Networking sessions held In Benin and Niger

WASCAL committed to providing innovative solutions to cimate change and water related needs in africa

WASCAL wins Excellence and Productivity Award

Nine Doctoral Students from WASCAL Graduate In Climate Change and Biodversity

First Batch Of Climate Change and Agriculture Phd Students Graduate

Climate research results must be practical - Prof. Rene Haak at Cop 23

Long-term sustainability planning workshop in Accra

Ghana government assures WASCAL of its support

Collaboration with NASA to school West African climate students

BMBF Pledges to Fund 4th batch of graduate studies programme of WASCAL

3 West African countries receive 14 automatic weather stations from WASCAL

World Café' jointly organized by WASCAL-SASSCAL at COP 23

WASCAL participates In Germany-Ghana 60th Anniversary Event




COP 23 IN PICTURES




IMPACT STORIES

3 West African countries receive 14 automatic weather stations from WASCAL

The stations are to serve as improvement of the sub-region's 150 operational Synoptic Weather Stations since according to the World Meteorological Organization, West Africa needs 2000 of the stations to help close meteorological data gaps in West Africa. The countries are Ghana, Togo and Benin.

WASCAL schools West African Climate managers and scientists

WASCAL organised a five-day intensive workshop on climate change impact, mitigation and adaptation for fifteen scientists drawn from the ministries and government departments of environment, agriculture, water resources, meteorology, space and environmental protection agencies from fifteen West African managers and scientists in relevant government agencies were drawn from Ghana, Benin, Togo and Nigeria to participate in a 5-day workshop on the implications of climate change variability on livelihood, adaptation and mitigation strategies in West Africa The workshop was part of the organization's strategic vision to extend its capacity building beyond its graduate studies programmes run in partnership with ten lead universities in West Africa.

Collaboration with NASA to School West African Climate students

WASCAL in collaboration with National Aeronautics and Space Administration (NASA) and the University of Missouri – Kansas City, organized a 12- Day Capacity Building Workshop on Interdisciplinary Remote Sensing, Modeling, and Validation of Environmental Processes. This workshop was sponsored by the International Committee on Space Research (COSPAR) and WASCAL, with supplementary funding support from African Development Bank (AfDB), aimed at equipping students with knowledge in space-based interdisciplinary remote sensing and modelling, which is in its infancy in West Africa.

WASCAL graduates more students

Nine (9) Doctoral students have graduated in Climate Change and Biodiversity from the University Felix Houpouet Boigny, Cote d'Ivoire. It is the first batch of students since the inception of the programme in Cote d'Ivoire in 2012.

The first batch of the Doctoral students who pursued WASCAL's programme in Climate Change and Agriculture at Institut Polytechnique Rural de Formation et de Recherche Appliiquee de Katibougou (IPR/ IFRA), Mali in collaboration with the University of Science and Technology, Mali and University of Cape Coast(UCC), Ghana have graduated.

Telling the WASCAL story at Cop 23

WASCAL and SASSCAL with the support of BMBF, PT-DLR and ZEF, leveraged the strategic role that Germany played as the host country of COP 23 to profile both organizations through a side event World Café. The event brought together more than 200 international students and stakeholders to deliberate on issues pertaining to climate change in West Africa.

Planning Workshop to sustain WASCAL

A 2-day workshop on the Long-Term Sustainability of WASCAL was held to develop and implement a three-year global resource mobilization effort with the support of its current donor (BMBF, Germany) and other institutions, both national and the private sector, and the need to see WASCAL beyond 2020. The workshop was also to create the platform for strategic planning and actions for the future sustainability of WASCAL. Invitation was extended to the sister organization SASSCAL in the hope of establishing a framework for joint efforts of sustainability. There was a follow up workshop to finalize the resource mobilization.

Some Communication Activities

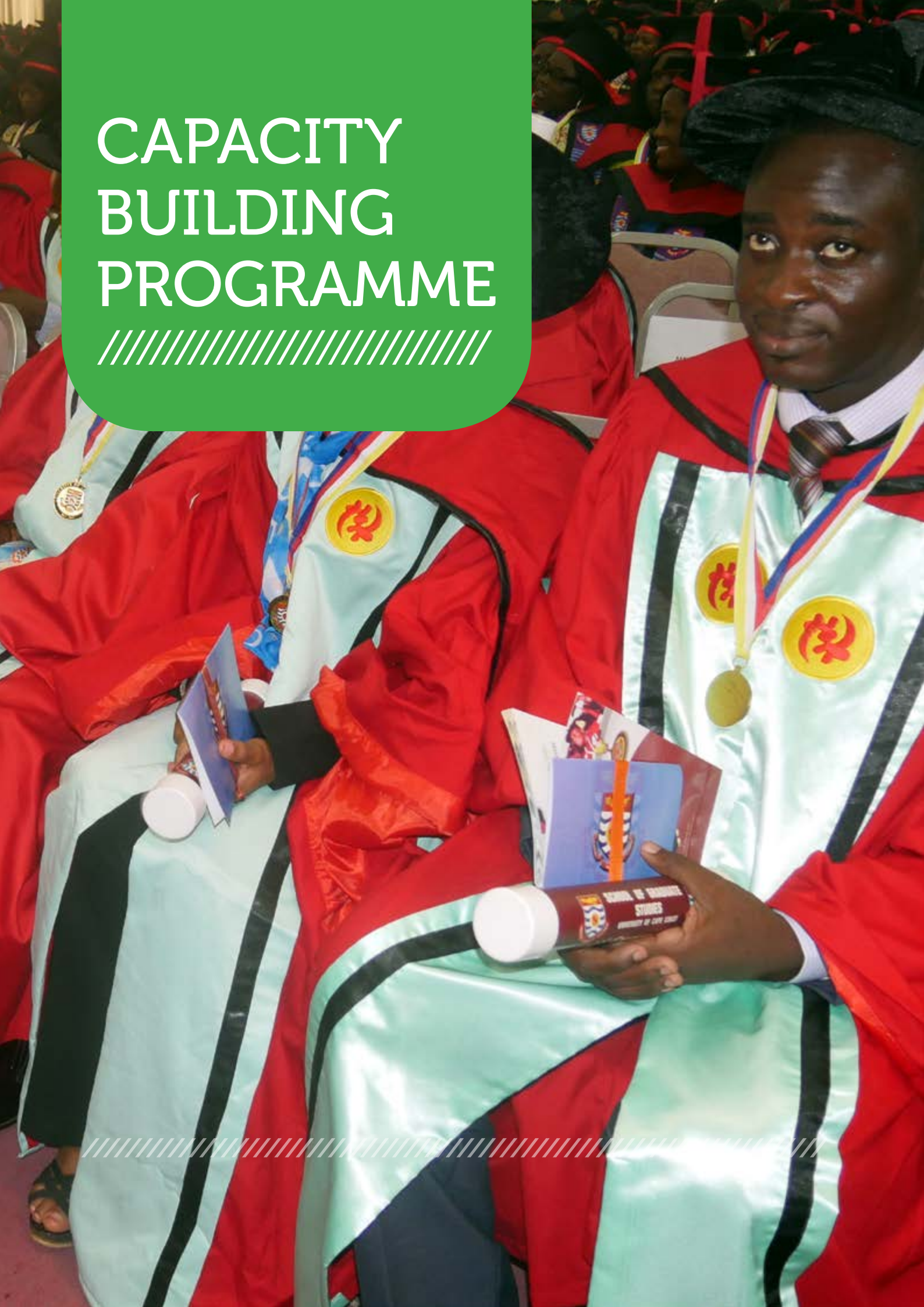
GH Headlines

Graphic Online

Business Ghana

Myjoyonline

CAPACITY BUILDING PROGRAMME



3 batches of students

ADMITTED TO GRADUATE SCHOOL SINCE 2012. **TOTAL 258 STUDENTS**

INVESTMENT

9.8million euros

PHASE 1: 2012 - 2016

4,802,598.58 euros

Phase 2: March 1, 2016- December 31, 2017 has been expended on the graduate schools. The funding commitment for the batch C graduate schools from start to finish is 6 million euros.

154 Graduated students

60 MASTERS RESEARCH PROGRAMME
94 DOCTORAL GRADUATE RESEARCH PROGRAMME

104 students studying

40 MASTERS RESEARCH PROGRAMME (MRP)
64 DOCTORAL GRADUATE RESEARCH PROGRAMME (DRP)

In-Service Training

WASCAL organized its first In-Service training from February 6 - 10. There were fifteen participants from Ghana, Nigeria, Togo and Benin. The workshop, titled, "Climate Change Impact, Mitigation and Adaptation Level 1 Course" is designed for scientists working in Government Ministries in West Africa.

Collaborative workshop

• WASCAL organized two concurrent seminars for PAUWES and WASCAL students of Climate Change and Energy and Water Resources at the WASCAL MRP Climate Change and Energy Center, Universite Abdou Moumouni in Niamey, Niger and at WASCAL GRP Climate Change and Water Resources Center at the Universite d'Abomey Calavi, Abomey Calavi, Benin from February 27 to March 10, 2017. It was followed by a two- month internship by the ten students of PAUWES and three students of WASCAL at the Competence Centre in Burkina Faso. A follow-up workshop was held at PAUWES University of Tlemcen in Algeria for twenty WASCAL and twenty PAUWES students in September, 2017.

The collaborative workshops were organized in partnership with ZEF/Unibonn and the Pan African University - Institute of Water and Energy Sciences (PAUWES). The project was funded by the Germany Federal Ministry of Environment (BMZ) through

ZEF/Unibonn.

Number of Beneficiaries Per

The Gambia	17
Senegal	21
Cote D'ivoire	24
Burkina Faso	24
Niger	25
Togo	26
Mali	27
Benin	28
Nigeria	33
Ghana	33

Country as at end of 2017 Introducing New Graduate Schools in Ouagadougou And Cape Verde

Informatics for Climate Change (INFORMCC)

Plans for the 11th Graduate School of WASCAL Informatics for Climate Change (INFORMCC) to be run in collaboration with the University of Ougadougou1 Prof Joseph Ki-Zerbo, Ouagadougou, Burkina Faso has been finalized. The MRP which is set to kick start in 2018 is aimed at developing a strong human capacity in Informatics for climate change, bridge the large data hole in West Africa as well as provide the needed scientific computing skill in climate science and climate data management.

Climate Change and Marine Sciences

Another Graduate School on Climate Change and Marine Sciences expected to be jointly managed by University of Cape Verde, GEOMAR and WASCAL has been proposed. The new graduate school on Climate Change and MArine Sciences is expected to commence in 2018 with funding from the BMBF in the framework of GEOMAR.

GSP Review Meeting

BMBF pledged its continuous support to fund the fourth batch of students of the Graduate Studies Programme of WASCAL. This was revealed at the GSP Review Meeting with Directors of the various Graduate School Programme as well as their Vice Chancellors within West Africa. Representatives from the various German Partner Institutions and WASCAL's sister organization, SASSCAL also attended the workshop.

Representatives from proposed Graduate Schools in Cape Verde and Burkina Faso were also in attendance. Resolutions for the reforms were made and a committee, tasked to access the extent of implementation of resolution and report back to participants.

Mid-term Review of GSP

• A mid-term review of the GSP was done by KfW evaluation department in May 2017. It was underscored that the GSP is a jewel of WASCAL, highly impactful and of great relevance. Among others, KfW recommended the upgrade of four (4) Master's Research Programmes (MRPs) to Doctoral Research Programme (DRP).

These are:

MRP Climate Change and Human Security University of Lome, Togo.

MRP Climate Change and Education, University of The Gambia, The Gambia.

MRP Climate Change and Energy, University Abdou Moumouni, Niamey, Niger and

MRP Climate Change and Adapted Land Use, Federal University of Technology, Minna, Nigeria.

DRP Students

The DRP students are either undergoing fieldwork or on scientific visits. Sixteen students are currently on scientific visits to Germany, France, Italy, Kenya, and the USA.

WASCAL Graduates are all employed at various sectors, including NGOs, public sector, international organizations and academia

MASTER STUDENTS

100 TOTAL CUMULATIVE NUMBER	**39** CURRENT NUMBER
60 GRADUATED NUMBER	**1** DROPPED OUT FROM CC EDUCATION

Visiting Scholars Programme

Visiting Scholars Programme (VSP) commenced in April 2017. Three scholars benefitted for the 2016/2017 academic year.

The scholars who also doubled as members of the management team of WASCAL GSP are: Dr. Julien Adounkpe, Director, CC WR, UAC Benin, Dr. Vincent Ajayi, Deputy Director, WACS GSP, FUTA Nigeria and Dr. Ibrahim Saratu Usman, Deputy Director, CC ALU GSP, FUT MINNA Nigeria. The spent three months at NASA in the United States of America.

Under this programme, WASCAL gives qualified scholars an opportunity to work on research topics related to Climate Change Adaptation and Mitigation issues, and to distill a publishable journal article from their recent research or to visit a laboratory abroad for data analysis.

Thesis Grant

Thesis grant was awarded to thirteen non-WASCAL Doctoral students and five non-WASCAL Master's students writing their thesis on climate change thematic areas in 2017.

RESEARCH ACTIVITIES

PUBLICATIONS, TRAININGS AND MENTORSHIP

WASCAL CoC scientists conducted frontline research activities leading to international publications with high level international standards. More than 15 peer-reviewed journal articles were published.

The CoC scientists also coordinated capacity building events and supervised Master and PhD students from WASCAL Graduate Schools and other universities of the region.

In June, the CoC collaborated with the TIGER Capacity Building Facility (TCBF), the University of Twente, Netherlands and the University of Energy and Natural Resources (UENR), Ghana, to organize a regional stakeholder training workshop in WASCAL's headquarters in Accra. This training event was attended by geospatial professions in Ghana and Nigeria.

Similarly, in August 2017, the CoC collaborated with the TCBF, the University of Twente and the University of Wuerzburg to organize another training event for geospatial professionals in governmental and non-governmental organizations in Ouagadougou, Burkina Faso. In both events, emphasis was laid on the use of open access earth observation data (e.g. from Landsat mission, Copernicus – Setinel-1, 2, etc.) and software (e.g. QGIS, SNAP, GRASS, etc.) in natural resource management.

RESEARCH CLUSTERS

RESEARCH CLUSTER 1
Climate Change and Variability (2CV)
Development of climate scenario data

The research cluster initiated high resolution RegCM4 climate change simulations to complete the WASCAL ensemble experiment. This consists of WRF (from KIT), CCLM (from KIT) and RegCM4 (from CoC) downscaling the Coupled Model Intercomparison Project, Phase 5 (CMIP5) ESMs (Earth System Models) being HadGEM2-ES, MPI-ESM and GFDL-ESM2M. This is performed at 12 km for the historical and future periods. These consider the Representative Concentration Pathways with a forcing of 4.5 by 2100 (i.e. RCP4.5). Currently 15% of the simulations are completed.

In addition, we are currently developing a climate service product entitled "Climate change information for ECOWAS states in 1.5oC and 2oC global warming scenarios (i.e. based on the Paris Agreement)". The objective for the year 2017 was to complete the first phase being the development of the scenarios data. To date, all the required data have been generated and the development of the scenarios completed. Nine CORDEX regional climate models output for a total of 20 simulations are now available for RCP4.5, a Reference Period (i.e. 0.5oC of global warming), a first Future Period with 1.5oC of global warming and another Future Period with 2oC of global warming. This is in the form of NetCDF data, a publication to be featured in the Nature Scientific Report is currently under revision. An example of results obtained are presented in Figure 1 highlighting how dry spells of different periods are changing in 1.5oC and 2oC of global warming scenarios.

Research activities

One of the key research topics of 2017 was the devastating flooding events that occured in many capital cities of West African countries. A co-authored scientific publication on floods in West Africa entitled WASCAL perspective on floods in West Africa was compiled and will be published soon. The introductory paper features WASCAL and AMMA scientists and analyses the intensity of the 2017 rainy season in West Africa with particular focus on the characteristics of the precipitation events as well as the propagating Mesoscale Convective Systems (MCSs). This analysis was done to provide a context for the multiple flood events that occurred in most West African capital cities in 2017. It revealed that the entire West African region experienced above normal precipitation between June and September compared to the last 35 years as a consequence of increased overall intensity of the monsoon season. Specifically, the flood events recorded in Conakry (Republic of Guinea), Freetown (Sierra Leone), Kidal (Mali),

Niamey (Niger), San Pedro (Cote d'Ivoire) and Port Hartcourt (Nigeria) resulted from the occurrences of more frequent and more intense precipitation events than usual (Figure 2). While in Lagos (southwestern Nigeria) and Accra (southern Ghana), the recent flooding seems to be linked to more extended length of consecutive wet days which is in turn linked to

Figure 1: Projected changes in maximum dry spell length (upper panels), number of dry spells of more than 5 days (middle panels), number of dry spells of more than 10 days (lower panels) for 1.5oC (left panels) and 2oC (right panels)

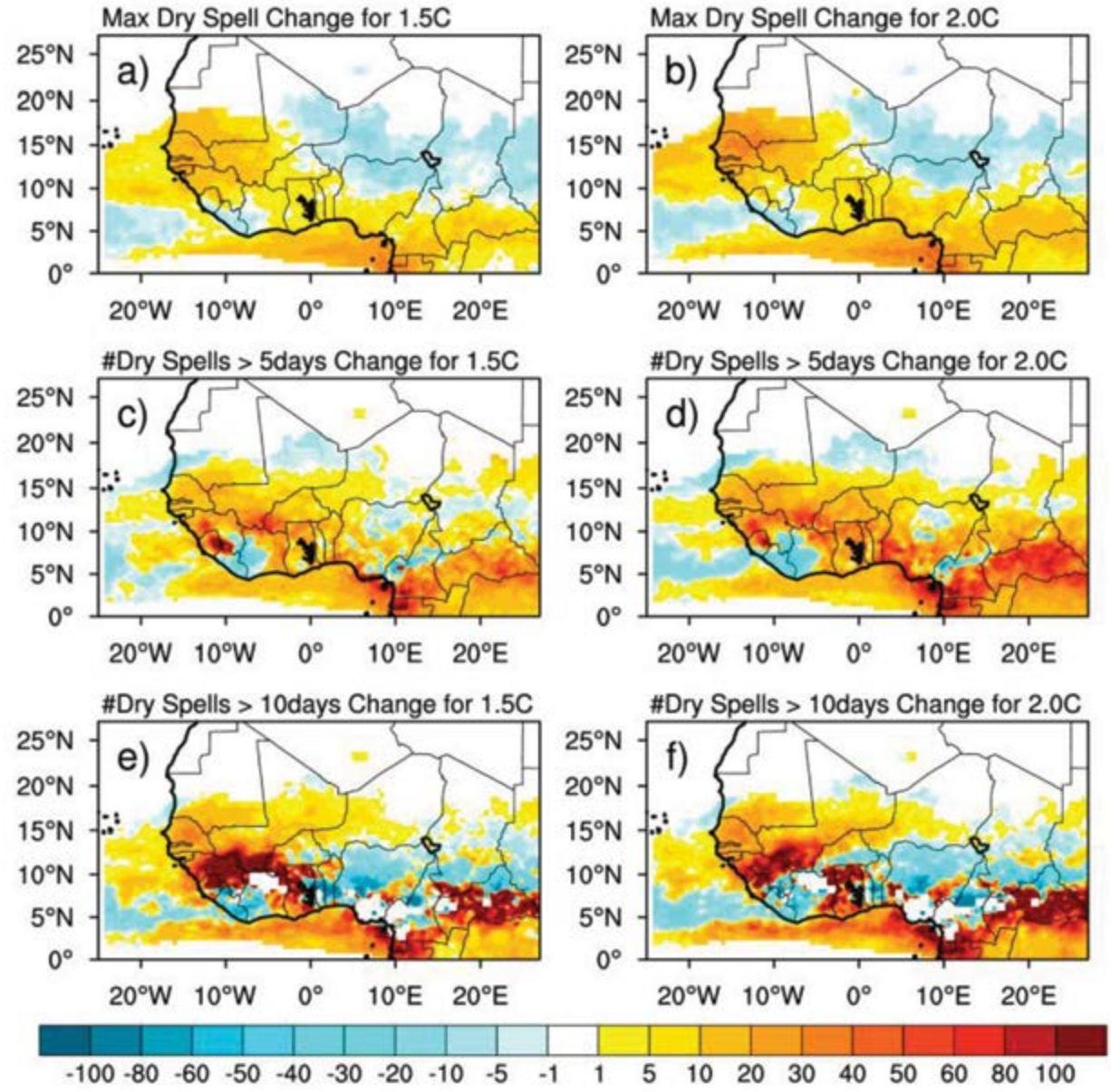
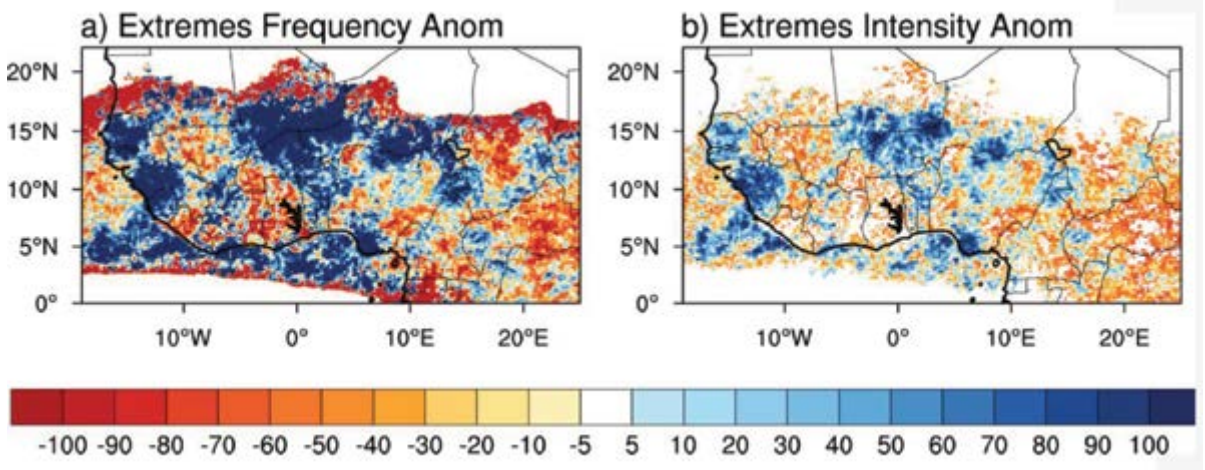


Figure 2: Anomalies (June-September 2017 minus June-September 1983-2017) for a) Very wet days (i.e. mean number of precipitation events above the 95th Percentile b) Intensity of very wet days



more intense and larger Mesoscale Convective Systems (MCSs) propagating across the region. Since numerous climate projections over West Africa suggest the situation may exacerbate in future climate, stronger disaster management, early warning systems and adequate flood-control infrastructures are needed to combat the consequences of these intense extreme precipitation events fueled by the changing climate regime.

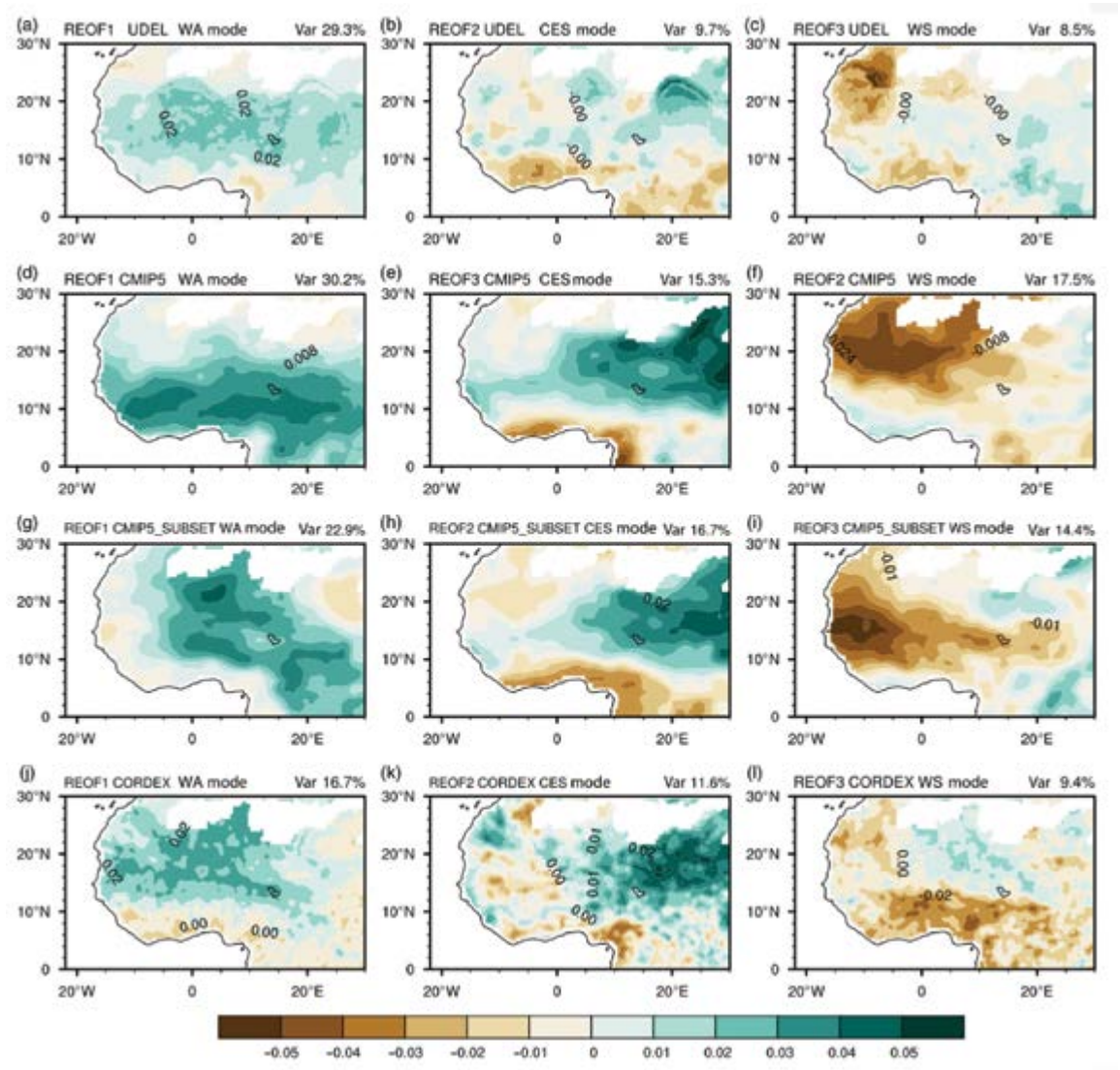
Another important topic we have focused on this year is the evaluation of regional climate models used to derive the 1.5oC and 2oC of global warming scenarios. This assessment (published in the International Journal of Climatology) highlights strengths and weaknesses as well as the added value of these simulations compared to the CMIP5 over West Africa (Figure 3 for precipitation). This is of key relevance to assess the quality of the projections over the region. Therefore, the mean climatology, inter-model variability and spatio-temporal patterns of temperature and precipitation over West Africa from Coupled Model Intercomparison Project 5 (CMIP5), CMIP5_SUBSET [ensemble of global climate models driving COordinated Regional Climate Downscaling EXperiment (CORDEX)] and CORDEX multi-model ensembles are evaluated and intercompared for the monsoon season (June–September). We find that, while CORDEX fails to outperform the simulated mean climatology of temperature by the CMIP5 ensembles, it substantially improves precipitation and provides more realistic fine-scale features tied to local topography and land use. This improved performance over the region is found to depend more on the internal models' physics than the driving boundary conditions and results from a more consistent and realistic simulation of monsoon precipitation across the various regional climate models (RCMs). Rotated empirical orthogonal function (REOF) analysis indicates that the CORDEX ensemble captures better the spatio-temporal variability of both temperature and precipitation (first REOF mode), in particular depicting the warming and Sahel precipitation recovery in recent decades over West Africa. On the other hand, the spatial patterns and associated time series of the last two REOF modes in CORDEX mostly follow the CMIP5_SUBSET pointing towards a strong role of the boundary forcing in the RCM simulation of precipitation variability.

There are many more topics studied this year (see list of publications), in this report however, we finalize only the example with the application of the 1.5oC and 2oC of global warming scenarios to help quantify the potential of West African river basins. At UNFCCC's 21st Conference of Parties (COP 21) held in Paris in 2015, a new international climate agreement was adopted with the aim to keep global warming below 2oC relative to pre-industrial levels and to further explore efforts to limit the increase to 1.5oC. How the hydroclimatology of the West African major river basins will respond in such a world is yet to be investigated. Changes in crop water demand, irrigation water need, water availability and the difference between water availability and irrigation water needs is referred to as basin potential. The basin potential of ten major river basins covering the whole of West Africa are presented. The 2oC scenario enhanced crop water demand causes the irrigation water need to increase substantially in the entire region with the basins along the Gulf of Guinea experiencing the most significant changes. Such increases prevail over the projected water availability although the latter exposes regionally heterogeneous (positive and negative) features. This implies that West African river basins will face severe freshwater limitations to sustain irrigated agriculture and a general decline in basin potential under 2oC global warming. Reducing the warming to 1.5oC decreases the impacts by as much as 50% suggesting that the region stands to benefit by the enhanced mitigation.

RESEARCH CLUSTER 2: Hydrology and Water Resources Management (HYREM)

Activities of RC2 focused mainly on the GENERIA project "Managing new risks and opportunities of agricultural development of African

Figure 3: REOFs of the first three modes for JJAS mean precipitation from UDEL (a)–(c), CMIP5 (d)–(f), CMIP5_SUBSET (g)–(i) and CORDEX (j)–(l). The percentage of variance explained by each mode is labelled. The different modes of variability are also labelled as WA (West African mode), CES (Central-Eastern Sahara mode) and WS (Western Sahara mode)



floodplains"

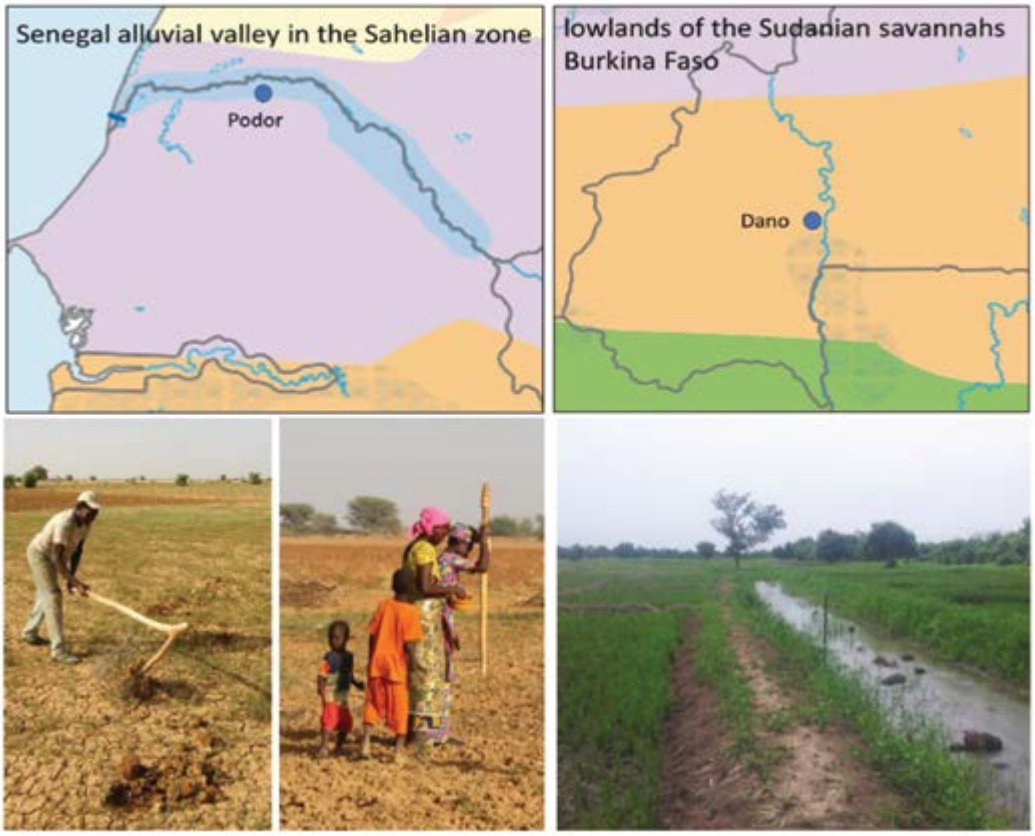
The objective of the project is to assess new risks and opportunities related to climate change for agricultural development of floodplains, assess the impact of policies, adaptations of farms and communities to gain safety, and to participate in policy change and co-construction of new adaptation options.

The GENERIA project targets two major flood ecosystems in the region (Fig. 4): alluvial floodplains in the Sahel (Podor in Senegal) and inland valleys of the Sudanian savannas (Dano, Burkina Faso). For instance, the Dano Region in Burkina Faso counts about 68,490 hectares of lowlands, of which 36,334 hectares can easily be developed or improved (DPASA, 2015). Among others, the following investigations were conducted:

Drivers of rice production and consumption in lowlands: Case of small-scale rice producers in Dano

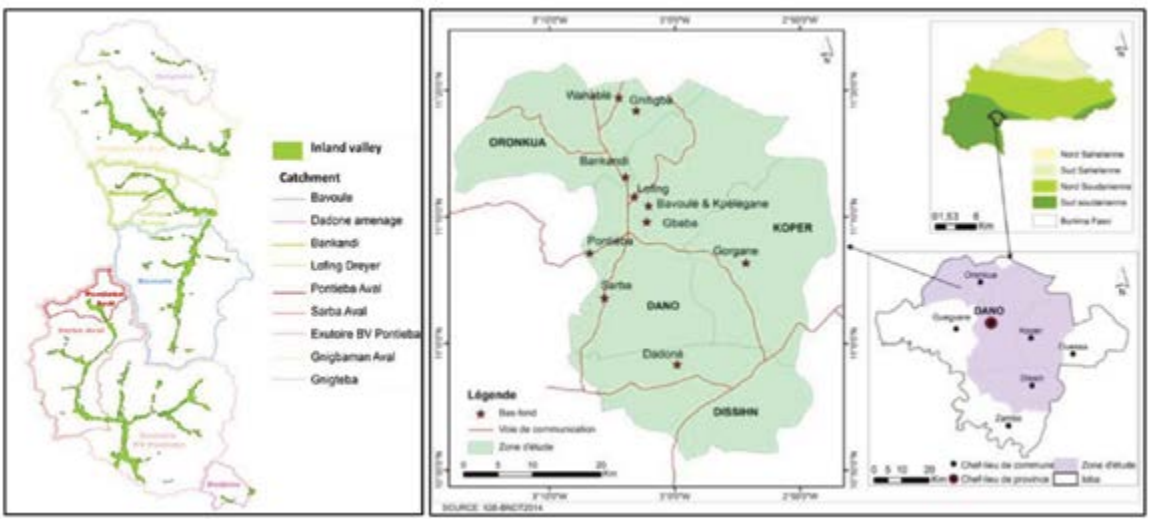
This investigation examines the factors that impact farmers' production decisions in lowland and the use of the output. To this end, 16 lowlands (developed and undeveloped) located in four

Figure 4. Investigation areas: two climatic zones, two edaphic situations (Senegal and Burkina Faso).



rural communes of the province of Ioba were purposely selected (Fig. 5). Both statistical and econometric analysis were applied. The statistical analysis reveals that rice yields differ significantly between developed and undeveloped lowlands rice producers, and between male and female farmers; implying "lowland development effect" on one the hand and "gender effect" on the other hand. For the econometric analysis, the Heckman probit model were used to avoid sample selection bias. The regression results indicate that farmers' behaviours in improved lowland is gender neutral; while in the other side, in unimproved lowland, gender plays a significant role on farmers decision. Indeed, the study found that, when given a chance to have their own plot, women can perform as well as men. As hypothesized, the results reveal that access to extension services significantly and positively drives rice production in improved lowlands; while its effect in unimproved lowland is non-significant. It comes out from the investigations,

Figure 5. GIS based inventory of Inland valleys and their drainage areas of Dano Province.

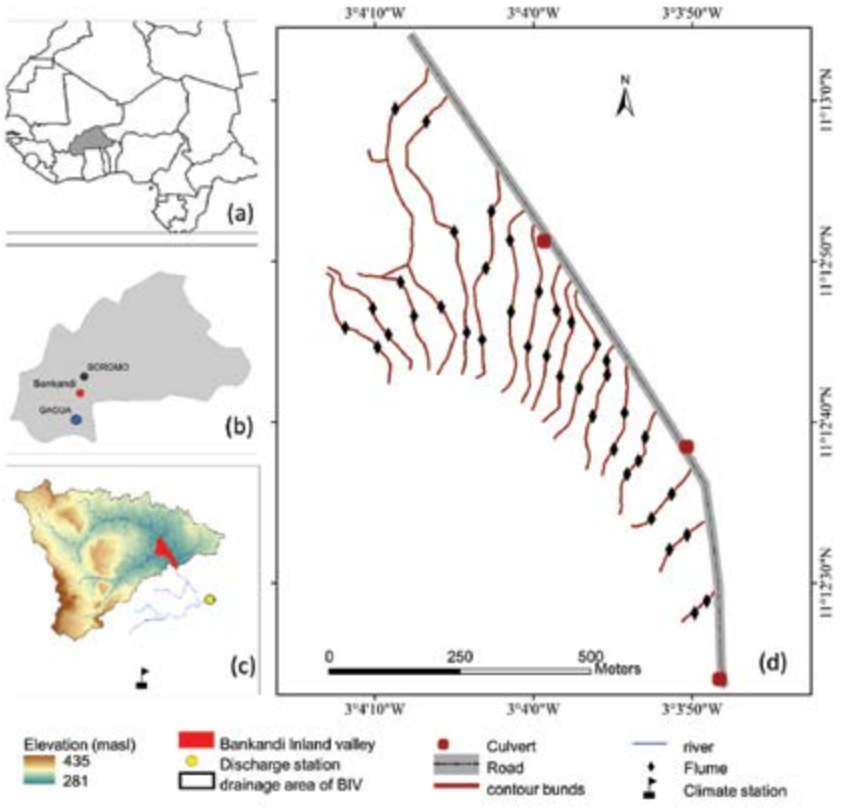


that farmers are consuming their production because of local market failure probably due to price instability and/or lack of outlets for output.

Failure of inland valleys development: a hydrological diagnosis of the Bankandi valley in Burkina Faso

West African inland valleys are expected to play a key role in boosting rice production. After decades of development plans and programs, still the rate of rice production increase is insufficient to meet consumption. Many developed inland valleys for rice production have been abandoned. Such failures are among others deemed related to poor design or implementation of inland valley development infrastructures. The investigations of the failure of the Bankandi inland valley development (Fig. 6) due to waterlogging, highlights flaws in the system such as (i) the non-compliance with contour lines in the implementation of contour bunds, (ii) the under-sizing of drainage flumes, and (iii) a non-optimal location of flumes. Compared to the topographic survey data, that supports the choice of flumes location, publicly available remote sensing digital elevation products are less reliable on the location of flume and contour bunds. However, despite their coarse native resolution and accuracy, free to download remote sensing products provided valuable information on the number of flumes to be implemented. Further investigations show that failure of the Bankandi inland valley development is not related to changing hydro-climatic conditions within the study area. The overall diagnostic of the development of the Bankandi inland valley entails conducting basic hydrological investigations for the design of drainage infrastructures prior to implementation and a proper land leveling work during the development of West African inland valleys. To achieve sustainable development of West African inland valleys, enforcement authorities must ensure that these basic recommendations are met.

Figure 6. Location map. Part (a) locates Burkina Faso in West Africa, part (b) situates the Bankandi inland valley in Burkina Faso, part (c) shows the drainage area of the Bankandi inland valley, and part (d) depicts the design of the development of the inland valley.



RESEARCH CLUSTER 3: Sustainable Land Use & Agriculture

One of the key activities of the RC focused on assessing the "Impacts of 1.5 verses 2.0°C on cereal yields in the West Africa Sudan Savanna".

To reduce the risks of climate change, governments agreed in the Paris Agreement to limit global temperature rise to less than 2.0°C above pre-industrial levels, with the ambition to keep warming at 1.5°C. In this context, we quantified the impacts of 1.5° versus 2.0°C global warming on (1) mean yield levels and (2) inter-annual yield variability maize, pearl millet and sorghum, the main staple food crops, in the Sudan Savanna region of West Africa for current crop varieties and management. As a second step, we examined possible interactions of various drivers of yield losses (e.g. growing season duration, CO2 fertilization effects, sowing dates and heat stress), the level of intensification (e.g. current fertilizer case versus intensification case with fertility not limiting) and the two warming scenarios. Two crop models, DSSAT and SIMPLACE, calibrated to local varieties and conditions, were combined with the output of three GCMs to assess relative yield changes. The study region considered falls within latitude 8.9° to 12.9°and longitude -8.6° to 4.1° and was so defined based on availability of crop management data and dataset availability for crop model calibration.

Results

Across sowing dates and with current fertilizer rates, both maize and sorghum yields were projected to decrease for the entire WASS by 2% for 1.5°C warming versus 5% for the 2.0°C warming scenario (Fig. 7). Millet yields were not projected to change with either warming scenario. The intensification case resulted in greater yield losses for all crops and warming scenarios in the intensification case. With unlimited fertilizer use, the differences in losses between the two warming scenarios increased for maize and millet. For maize, the difference increased to 4% units and to 1% unit for millet. For sorghum, the difference between 1.5° and 2.0°C scenarios remained unchanged from the current fertilizer case at 2% units.

Averaged across GCMs and sowing dates, there is fairly limited spatial variation across the study region for the average yield changes for maize and millet under the current fertilizer rates (Fig. 8 and 9). In contrast, sorghum yield changes exhibit more spatial variation, particularly in Northern Benin and Northern Ghana. Yield changes were more variable in the intensification case (Fig. 9), though the main spatial patterns between regions were the same as in the current fertilizer case, with the exception of the Burkina-centre sub-region, where yields seem to be more negatively impacted than surrounding regions, as compared to the current fertilizer case. To conclude, by quantifying the impact of 1.5°C versus 2.0°C of warming on grain yields of the three main staple crops in the Sudan Savanna of West African, this study provides an important piece of information needed to assess risks to food security of an additional half-degree of global warming. Extending these results to infer implications for food security is critical and must include economic and risk assessment to better assess the interactions between vulnerability to yield variability and intensification.

Figure 7. Simulated impact of 1.5°C (blue bars) and 2.0°C (red bars) warming on maize, millet and sorghum yields for the West African Sudan Savanna region relative to the current baseline period (2006 – 2015). Impacts are shown for systems with current fertilizer levels and for fully fertilized case (intensified), considering the effects of elevated [CO2]. Uncertainty captured in the depth of the box-and-whisker plots covers three GCMs, two crop models and three sowing windows.

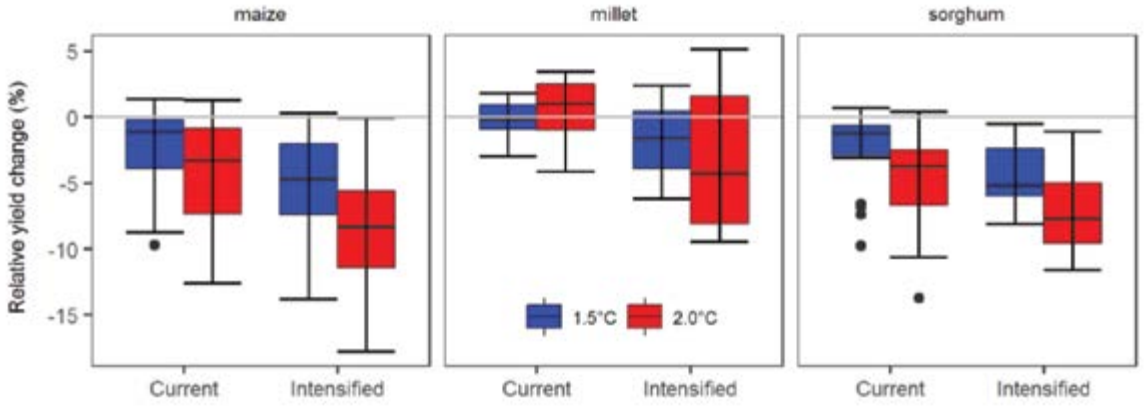


Figure 8. Simulated impact of 1.5°C and 2.0°C warming on maize, millet and sorghum yields for the West African Sudan Savanna region relative to the baseline period (2006 – 2015). Impacts are shown for systems with current fertilizer levels, and considering fertilization effects of elevated [CO2]. Mapped values are averaged across three GCMs, 200-years, three sowing dates and both crop models.

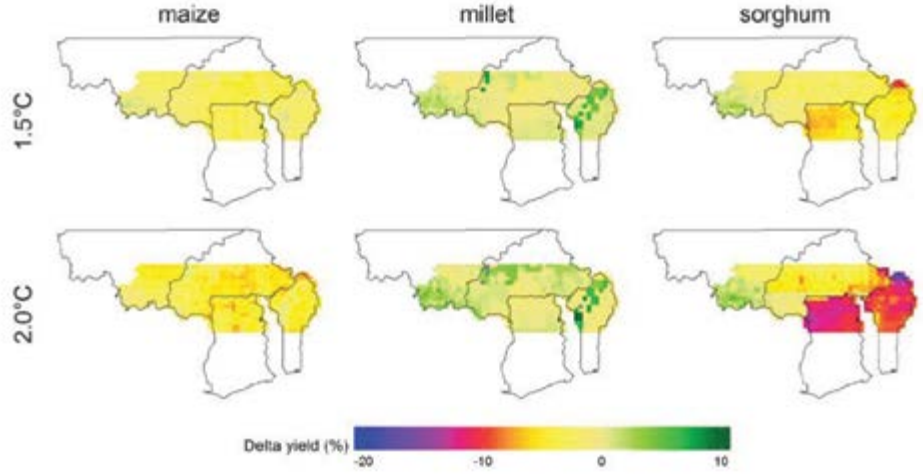
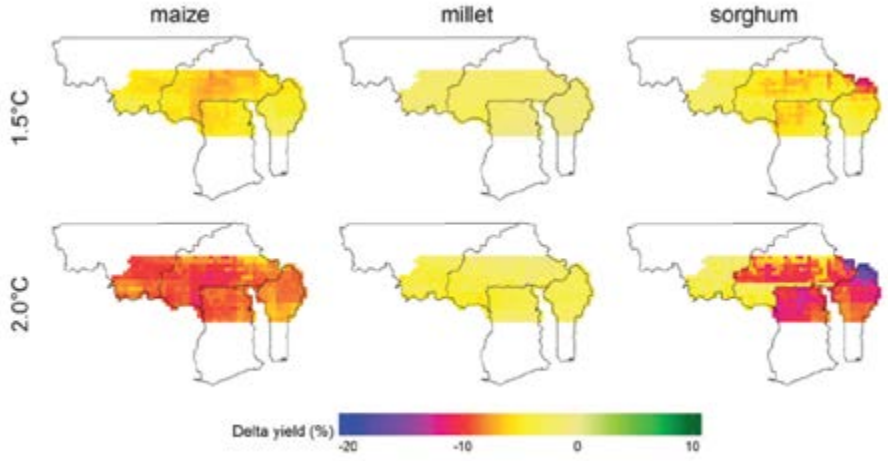


Figure 9. Simulated impact of 1.5°C and 2.0°C warming on maize, millet and sorghum yields for the West African Sudan Savanna region relative to the baseline period (2005 – 2015). Impacts are shown for systems with intensified fertilizer case, considering fertilization effects of elevated [CO2]. Mapped values are averaged across three GCMs, 200-years, three sowing dates and both crop models.



RESEARCH CLUSTER 4: Institutions, Governance and Socioeconomics

Institutional Mapping of Socioeconomic Climate Service Research Institutions and Programs in Five Selected West African Nations (Benin, Burkina Faso, Mali, Ghana and Senegal).

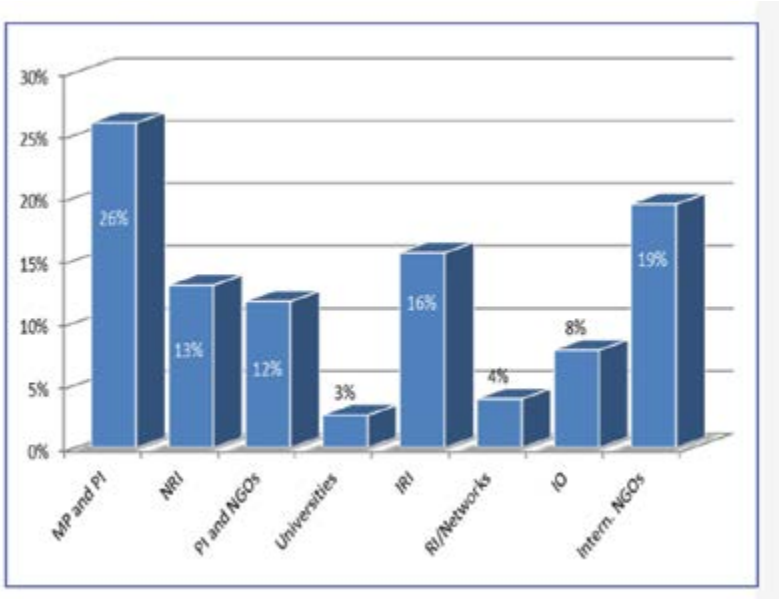
The main objective was to undertake an institutional mapping exercise of all existing socioeconomic climate service research institutions and programs in six selected West African countries, as well as to take stock of all existing (ongoing) green climate funds and potential opportunities existing within the West African region. Our overall goal was to build a strong institutional reference network for WASCAL with a view to support its ongoing socioeconomic climate service research flagship program as well as building a rich institutional database that will complement the activities of the other observation networks and WASCAL's partners and scientists.

Selection of institutions

A review of available literature, coupled with internet searches, was made to identify key institutions in the selected countries. A list of organizations with contact information was prepared; other institutions were identified on site in collaboration with WASCAL Graduate Research Programs staffs (Benin, Mali and Senegal) and Bolgatanga Basin coordinator (Ghana).

From a total of 171 institutions initially contacted, 98 organizations were visited. However, only 77 were able to provide valid and reliable information on their main activities of interest. These include 20 Ministries/Parastatals and Public institutions, 15 International NGOs, 12 International research institutions, 09 Private institutions and local NGOs, 10 National Research Institutes, 06 Intergovernmental Organizations, 03 Research Partnerships/Networks, 02 Academic Institutions as shown in Figure 2. Also, 05 Green Climate Fund National Designated Authorities were equally surveyed.

Figure 10. gyttytytytytytty



Results

The analysis of the availability of data in accordance with the type of data available shows that about 93.5% of institutions visited possess at least one data base; while about 54% of organisations in the sample have between 02 and 04 different types of database. With respect to the type of data collected by sample institutions, the results suggest that an overwhelming majority of the institutions visited have socio-economics data, followed by biophysical and agronomic data. Only about 19% and 16% of institutions reported having climate and hydrological databases, respectively. Furthermore, the results reveal that only about 16% of the institutions visited were unable to implement a single project over the last 5 years, 21% had more than 1 while over 27 had at least 2 projects as shown in Table 2.

Table 2: Numbers of project implemented over the last 5 years

	Benin	Burkina Faso	Ghana	Mali	Senegal
No project	40%	20%	0%	7%	15%
1 project	13%	13%	30%	14%	31%
2 projects	13%	47%	15%	43%	23%
3 projects	7%	20%	25%	14%	8%
More than 3 projects	27%	0%	30%	21%	23%
Total	100%	100%	100%	100%	100%

In table 3, we summarize the results of all ongoing climate change-related projects in the sampled countries. As observed, close to 127 projects were climate change related while over 213 projects were reported to have been implemented over the last five years.

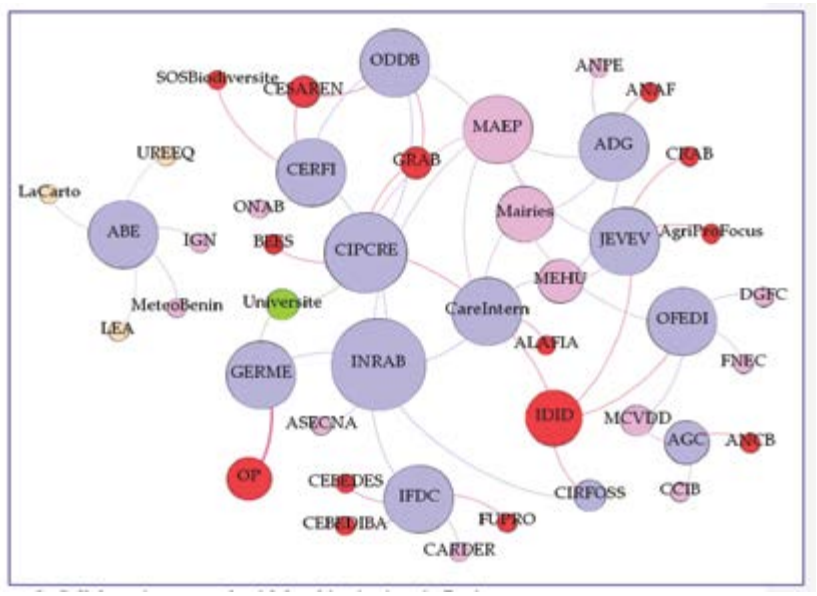
Table 3: On-going projects and projects implemented over the last 5 years period

	Benin	Burkina Faso	Ghana	Mali	Senegal	Total
Climate change projects	16	11	43	44	13	127
All projects implemented	28	26	58	78	23	213

Major Outputs:

- A comprehensive report highlighting the major findings of the scoping study to be published as a WASCAL working paper.
- Establishment of a catalogue of socioeconomic climate research institutions and programs including existing green climate funds in Benin, Burkina Faso, Ghana, Mali and Senegal to support scientific research and policy in West Africa.
- Elaboration of country database on socioeconomic research institutions involved in collecting household surveys in the selected countries.
- Well-documented information on existing challenges faced by Green Climate Fund National Designated Authorities (NDAs) in the selected countries.
- Mapping of cross-institutional collaboration network in the five selected countries: this exercise provides pictures of institutions that are well rooted the execution of projects and programs. As an illustration, the analysis collaboration with local institutes in Benin revealed that, among institutions involved in this study, entities such as INRAB, CIPCRE, CFEDI, ODDB, JEVEV and CERFI have a strong network and are involved in many projects/programs related to climate change (Figure 1).

Figure 11. Collaboration network with local institutions in Benin



Note: The nodes coloured in blue (dodgerblue) represent targeted institutions, while violet, red, chocolate , and green nodes respectively represent Public institutions, Private institutions and local NGOs, National Research Institutes and Universities with whom the targeted institution collaborate.

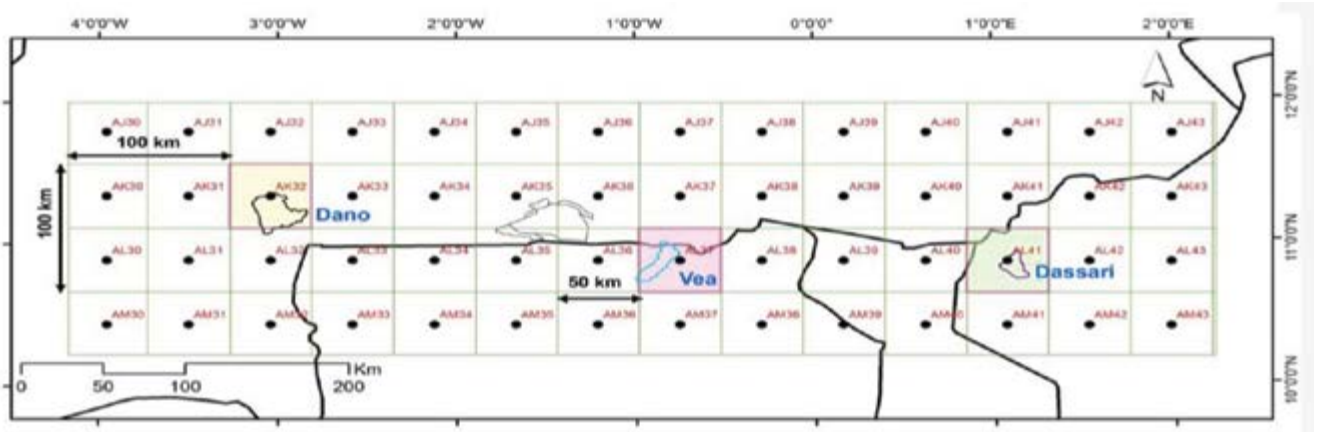
RESEARCH CLUSTER 5: Ecosystem Change and Services (ECOS)

Impact of climate variability and change on biodiversity and ecosystem services in semi-arid landscapes, West Africa.

Understanding the impact of climate change on biodiversity is a necessity for developing appropriate policies for the sustainable management of natural resources. The key activity of the ECOS during 2017 aimed to determine the impact of climate change and variability on the diversity of woody species and their carbon storage capacity. The results of the study are expected to be useful for the development of sustainable management strategies for forest resources in West Africa with a view to sustain their capacity to provide ecosystem services which are essential for nature and humans.

Data were collected in an area spanning the three WASCAL watersheds namely Dano, Bolgatanga and Dassari based on a netting of grid as shown by Fig. 12.

Figure 12. Network of grids in the three of Watersheds



Global flora of the woody vegetation in the three watersheds

Species richness

The vegetation of the three WASCAL watersheds comprises 169 woody species. These species are distributed over 112 genera and 43 families. The dominant families of this vegetation are Fabaceae-Mimosodeae (11.11%) followed by Combretacaea (9.94%), Malvaceae (8.77%) and Fabaceae-Caesalpinioideae (8.19%). An analysis of the distribution of woody flora per basin shows that the Vea (Bolgatanga) Basin has more woody species than other basins (Table 4). In fact, the Bolgatanga Basin has 130 ligneous species divided into 87 genera and 36 families. The woody flora of the Dano Basin is represented by 123 species and 84 genera in 36 families. One hundred and nine (109) woody species in 76 genera and 33 families were recorded in the Dassari Basin.

Table 4. Distribution of woody flora in river basins

Watershed	Species	Genera	Families
Vea	130	87	36
Dano	123	84	36

Floristic diversity

Combretaceae and Fabaceae-Mimosoideae, both with a proportion of 11.54% are the dominant families in the Vea Basin. They are followed by Fabaceae-Caesalpinioideae (9.23%), Anacardiaceae (7.69%) and Malvaceae (7.69%). The dominant families of the Dano Basin are in order of importance, Fabaceae-Mimosoideae (12,20%), Combretacaee and Fabaceae-Caesalpinioideae (10,57% each). They are followed by Anacardiaceae, Malvaceae and Rubiacaea, representing 6.50% each. The woody vegetation of the Dassari basin is dominated by Combretaceae (13.76%), Fabaceae-Caesalpinioideae (10.09%), Fabaceae-Mimosoideae (9.17%), Malvacaee (9.17%), Anacardiaceae (7.34%) and Rubiaceae (6.42%). The average number of species per plot does not vary significantly between basins (p-value = 0.7453). This is reflected on the diversity index of Shannon. Indeed, the p-value obtained for this parameter is 0.5421. The Piélou equitability index, meanwhile, varies significantly from one basin to another (p-value = 0.0007061).

WABES Project

West Africa Biodiversity and Ecosystem Services (WABES)) is a project funded by the German Ministry for Environment, Nature Conservation, Building and Nuclear Safety (BMUB) through its International Climate Initiative (IKI). It aims at supporting West African region contribution to the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES). The project is led by the Center for Development Research in collaboration with WASCAL and several partners.

The project main objective is to connect Biodiversity and Ecosystem Service (BES) experts from West African universities, research institutions and existing science-policy interfaces.

The project has three main components: (1) Annual Workshops with West African Biodiversity and Ecosystem Service (BES) experts; (2) Web-based Regional Information platform to link experts and to channel information; (3) A capacity Building program (a Master of Science – 'MSc in Managing the Science-Policy Interface on Biodiversity and Ecosystem Services for Sustainable Development in West Africa - IBES') on BES assessments. The first West African Experts Workshop was held from November 28 to December 3, 2017 in Abidjan, Cote d'Ivoire.

RESEARCH CLUSTER 6: Impact Analyses and Risks Assessment (IMARA)

Impact of climate change on the geographical distribution of carbon stock in Dano watershed

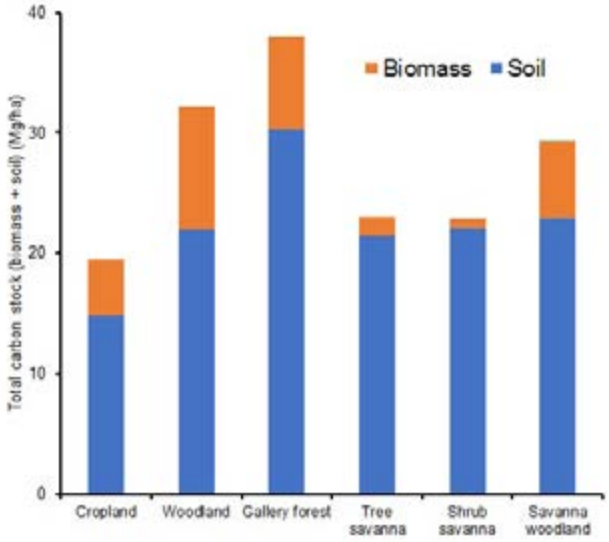
Near-natural vegetation and parklands have the potential to store carbon in semi-arid landscapes of West Africa. It's therefore important to assess carbon stocks and predict their spatial distribution under different scenarios and models. This study is mainly guided by the lack of

data on the spatial distribution of carbon storage in the Dano watershed and how climate change could affect its distribution under future climate conditions. To assess carbon stock potential in the Dano watershed, 2 types of data - vegetation data (diameter at breast height (DBH) and height of woody species) and soil data (in the main vegetation type and cropland encountered in the study area) were collected. The main vegetation types considered in this study are gallery forest, woodland, savanna woodland, tree savanna and shrub savanna. Non-destructive method was used to assess the aboveground biomass (AGB). The above- and below-ground carbon stocks were determined by applying the carbon fraction of 0.50. The total amount of carbon (biomass + soil) was calculated as the sum of C stored in the soil profile plus the total biomass C (AGB + BGB).

Four types of data were used: Geographical location records of total carbon stock (biomass + soil), satellite spectral data (Landsat OLI-TIRS spectral bands, nine soil and vegetation indices), terrain data (Digital Elevation Model (DEM), extracted from the 30m resolution ASTER GDEM, http://asterweb.jpl.nasa.gov/GDEM.ASP)), and bioclimatic variables. The projections were run under one of the four scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) in its Fifth Assessment Report (AR5): the mid-21st century RCP 8.5.

Results showed that in the entire study area, total carbon stock was the highest in gallery forest, average in woodland and lowest in croplands (Fig. 13). Total carbon stocks in gallery forest were about 2 times higher than in cropland. The distribution of carbon stocks between the soil and biomass (above- and below-ground) differed significantly ($p < 0.0001$) among LULC systems. In the plant communities as well as in croplands, more carbon was stored in the soil than in plant biomass (Fig. 1)..

Figure 13. Total amount of carbon (Biomass + soil) stored in LULC systems.



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RCP 8.5. To ensure integration with the Landsat data, the bioclimatic variables were resampled to 30 m resolution using the bilinear interpolation methods.

Figure 14 below shows the spatial distribution of total carbon stock (TCS) under current and future climate conditions in the Dano watershed. Based on the quantity of TCS obtained from the modeling results, three classes of suitability were defined. The quantity of TCS above 0.05 and below 75 Mg ha-1 was considered as poor suitable habitat. The quantity of TCS above 75 and below 150 Mg ha-1 was considered as moderately suitable habitat and quantity of TCS above 150 Mg ha-1 was considered as highly suitable habitat for carbon. The highly suitable habitat for TCS was mainly located in the area characterized by gallery forests and woodlands. The medium and poor suitable habitats were located in the cropland, tree and shrub savannas (Fig.14).

The projected trend in the suitable range of TCS under future climate in 2070 varied depending on the Global Circulation Model (GCM) used in the prediction. Future projections revealed considerable reduction under HadGEM2-ES and MPI-ESM-MR in the total range of suitable habitat of TCS compared to the current situation (Fig. 15). The decrease in the highly suitable range was more important under HadGEM2-ES (90.0%) and less under MPI-ESM-MR (89.4%).

Figure 14. Projected carbon stock mapped under current and future (HadGEM2-ES and MPI-ESM-MR for RCP 8.5) climatic conditions

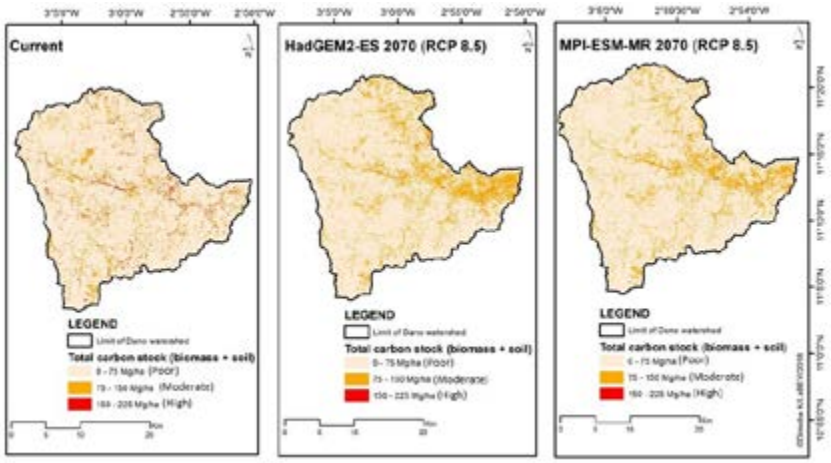
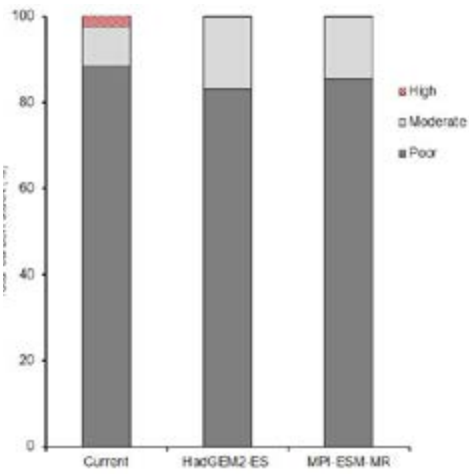


Figure 15. Suitable areas predicted under current and future climate models



Results of this study revealed that gallery forest and woodland are the two plant communities which stock more carbon than the other LULC types. Based on modeling results, maps of current and future distributions of total carbon stock (biomass + soil) were generated. It appears clearly that climate change might have an impact on carbon stock in 2070 by decreasing habitats which are currently suitable. These findings call for more sustainable land use management practices in the study area and also for socio-economic improvements in the lives of the population.

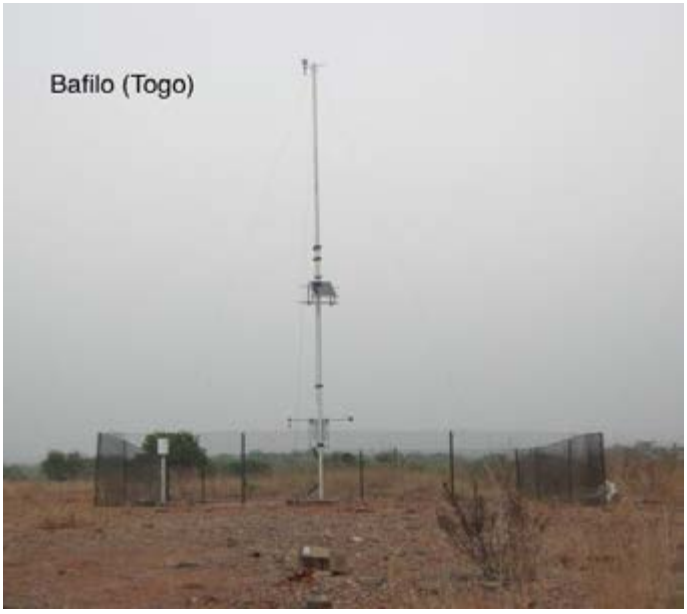
TRANSBOUNDARY OBSERVATION NETWORKS

WASCAL ONs include a transboundary climate observation (ReCON), a regional hydrology observation network (ReHON), a biodiversity observation network (BON), a regional socio-economics observation network (ReSON), a land surveys & remote sensing observation network (RSON). From the central coordination unit at WASCAL CoC, each observation network is led by a focal point (Fig. 16). The responsibility of each focal point includes successful execution of activities, reporting to and providing the central coordination unit with implementation plans, progress in milestones and deliverables. WASCAL ONs has two components: i) the research watersheds and project pilot sites and ii) transboundary or regional observations networks. Data collection at the research watersheds and in the project pilot sites as well as management of the sites are led by WASCAL. Data ownership and sharing is directly linked to

the WADI Geoportal (https://wascal-dataportal.org/wascal_searchportal2/) and governed by WASCAL's internal data sharing policy. The second component of the WASCAL ON, the transboundary or regional observations networks are co-shared with national and international expert institutions. The data collection and sharing process are governed by specific "third party" data sharing policies or memoranda of understanding (MoUs) signed by WASCAL and the contracting institution of each member country (Salack et al. 2018). WADI is used only as a dissemination platform for the metadata following the terms of use provided by the contracting partners.

Deployment and installations of automatic weather stations (AWS)

The process of buying fifty (50) AWS from BMBF/KfW funds started in March 2014 as a collaborative work between KIT/IMK-IFU, GITEC and WASCAL. On September 21, 2017, WASCAL (received all 50 AWS pieces supplied by NESA s.r.l. , the final winner of the GITEC open-bid for this equipment. Each AWS provides maximum and minimum temperatures, dew point temperature, rainfall, wind speed, wind direction, global radiation, sunshine hours, soil temperatures at 3 depths (5 cm, 10 cm, 50 cm). Records and all other statistics of these variables are provided every 10 mins. The equipment also has the ability to support four more sensors such as gas detectors, net radiation fluxes or soil moisture probes. These AWS are designed to provide synoptic variables typical of a primary weather station. In other words, the functionality of WASCAL's AWS is similar to the synoptic station whose data is contributed by the national meteorological and hydrological services of agencies (NMHS/As) on the global transmission system (GTS) of world meteorological organization (WMO). Between 2014 and 2016, the evaluation process conducted by WASCAL revealed that 173 primary stations are officially declared in West Africa but only 132 are working with basic functionalities. In fact, the 2017 report of WMO secretariat states that only 40% of those working primary stations do report regularly to the GTS. By commissioning and installing the 50 AWS in 2017, WASCAL is expected to increase and upgrade the classic synoptic stations network by 40%. A typical WASCAL AWS is shown by Fig. 16.



EARTH OBSERVATION APPLICATIONS UNIT

Water Productivity Mapping

Considering recent erratic rainfall distribution and a possible reduction in the lake's storage volume in the coming years, it is important to devise scientific approaches that will ensure the cultivation of more crops with the limited water resources available. But like most informal irrigation systems in the region, there's poor knowledge of the quantity of water used for irrigation vis-à-vis the crop productivity.

Crop water productivity mapping provides the required knowledge on optimal usage of water for agricultural production. Water productivity (WP) has been defined as the ratio of the net benefits from crops, forestry, fisheries, livestock and mixed agricultural systems to the amount of water used to produce those benefits. This

[1] GITEC Consult GmbH, Carlswerkstrasse 13d, 51063 Cologne, Germany, www.gitec-consult.de
[2] http://www.nesasrl.eu/
[3] http://www.wmo.int/pages/prog/www/TEM/GTS/index_en.html

research, therefore, aimed at developing a spatial model to map water productivity of irrigated crops around Lake Bam using multi-temporal Remote Sensing data, meteorological and ground data. Tomatoes, the dominant and economically viable cultivated crop, was the focus of this study.

The methodology entailed three main steps:

(i) Modelling the spatial distribution of tomato yield. Here, tomato cultivated areas were mapped using multi-temporal Sentinel-2 data acquired between November 2016 and May 2017 (i.e. 2016/2017 dry season cultivation). Then a multiple regression analysis with field collected tomato yield as dependent variable and RS variables (e.g. NDVI, LAI, fPAR) as predictors was performed to derive a predictive yield model.

(ii) Estimating water usage for tomato cultivation through actual ET calculation with the METRIC model.

(iii) Determining water productivity by dividing outputs of steps 1 and 2 above

Results

The RS analysis revealed a total irrigated area of 3163 ha around the lake in the 2016/2017 irrigation season. Twenty-seven percent (860 ha) of this area were cultivated with tomatoes. Figure 17 shows the spatial distribution of tomatoes and other irrigated crops around the lake.

The yield prediction model developed through regression analysis achieved an adjusted R2 of 54%, which means the model was able to explain 54% of the variance in the field collected yield data. Variations in soil fertility, water availability, and agronomic practices, contributed to the moderate adjusted R2 observed. The yield of tomato plots around the lake ranged from 0.01 to 100 kg/m2 with an average of 10.35. However, maximum frequencies of yield ranged from 5-20 kg m2.

Figure 17. Left: summary statistics of water productivity mapping. Right: spatial distribution of irrigated and tomato fields around the lake

Description	Value
Irrigated Area (ha)	
Total irrigated area	3163
Tomatoes only	860
Non-tomatoes	2303
Yield (Kgm^{-2})	
Minimum	0.01
Mean	10.4
Maximum	100
Water Use (MCM)	
All irrigated crops	4.82
Tomatoes	1.48
Water Productivity (Kgm^{-3})	
Minimum	0.01
Mean	1.24
Maximum	12

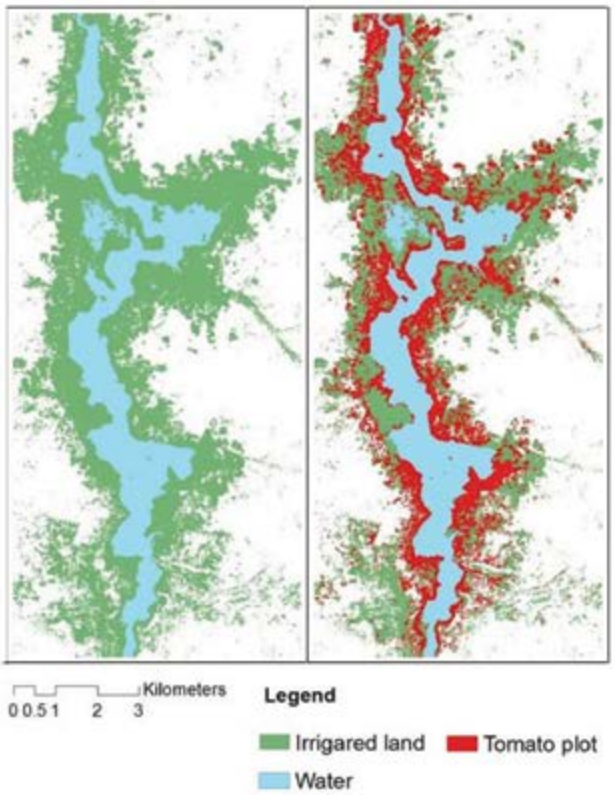
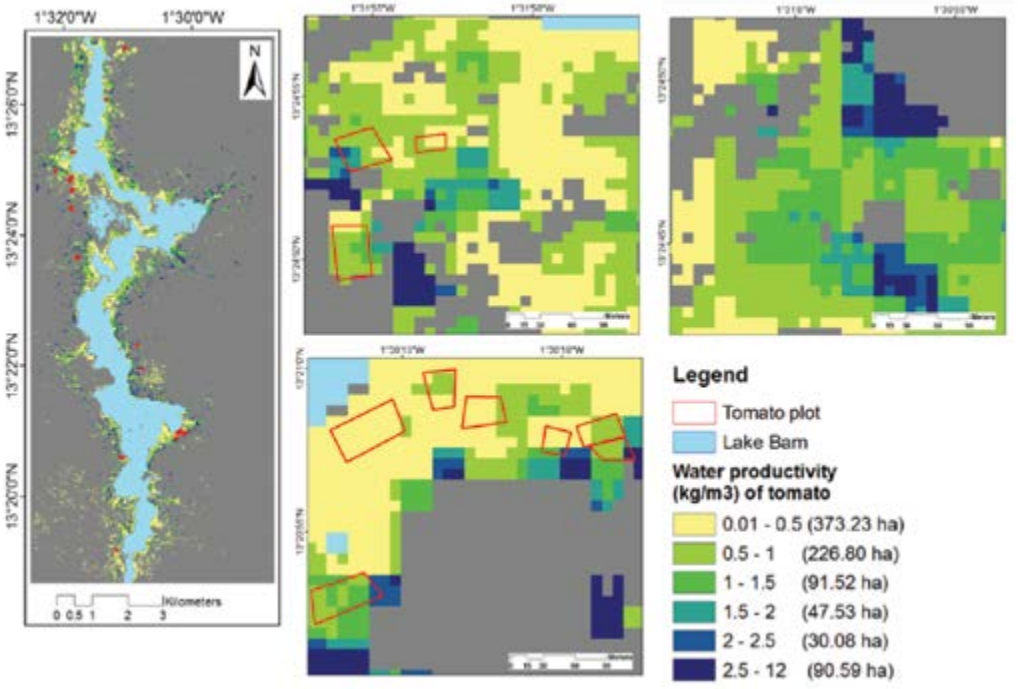


Figure 18. Spatial variability in water productivity of tomato fields around Lake Bam



Seasonal water use for all irrigated crops was found to be 4.8 Mm3 while that of tomatoes constitutes about 30% (1.48 Mm3). This figure (4.8 Mm3) comes close to the range of 5 - 10 Mm3 estimated by Ouedraogo and Home (2015) as water withdrawal from the lake for multiple purposes (irrigation, livestock, domestic, etc.)

Figure 18 shows the water productivity map of tomato fields around Lake Bam. The insert maps show high variability (intra- and inter-field) in WP, which ranged from 0.01 to 12 kgm-3, with a mean of 1.24 kgm-3. However, about 70% of all fields have a WP range of 0.01 and 1 kgm-3, while 90% falls in the category of low WP of 2.5 kgm-3 or less. The observed average WP of 1.24 falls far below the international reference of 10-12 for tomatoes as defined by the Food and Agricultural Organization. Results of this study indicate the need to improve water productivity around the lake through the implementation of effective water management strategies in order to produce more crops with the same amount of water.

DATA MANAGEMENT UNIT

DMICT unit mainly focused on the implementation of IT infrastructure necessary to deliver professional IT services and to support data management activities. Data sharing initiatives have also been conducted.

Substantial upgrade of internet connection bandwidth to support scientific activities

Since June 2017, thanks to the upgrade of the existing VSAT link from 4 Mbps to 5Mbps and its substantial reinforcement with a new fiber optic connection firstly at 8Mbps, and then at 20Mbps, the internet connection is now stable and strong enough to support current scientific activities. Currently, 0 to 2 complaints are registered per month.

This upgrade was made possible by putting into consideration the Observation Networks and DMICT budgets. This plan runs up to December 2018. Presently, we are searching for

sustainable funding for the internet to maintain this bandwidth. An upgrade will still be needed though, in the near future to support the full deployment of the future High-Performance Computing (HPC) equipment and the delivery of data computation services within the region.

Adoption of Internal data sharing policy and revision of third-party data sharing policies

The draft document has undergone several revisions from the data management council (Dr. Ralf Kunkel, M. Antonio and Dr. Belko Abdoul Aziz Diallo) before being submitted several times to the scientists of CoC for their individual feedback. A plenary meeting with the researchers was then organized to validate its content from the competence centre department. From the department of capacity building, an important part of the students' booklet on data Policy has been considered. The final document was handed over to WASCAL management for signature.
Its endorsement by the Interim Executive Director Prof. Jimmy Adegoke was a great step toward consolidating data governance at WASCAL and has made it possible to revise third-party data sharing policies with Observation Network Units which will in turned be signed by national meteorological services.

Setting up the local IT infrastructure necessary to Data Management and IT tasks

• The following IT infrastructure has been implemented:

• Implementation of a 5 to 10 TB local file server at the Competence center to ease the sharing of local data, documents and other files, and make copying scientific data from the computers of researchers to the server possible
• Implementation of a 1TB local file server at the Headquarters

• Purchase of a Network Attached Storage to increase the storage capacity at the competence center where we should also have a local mirror/ copy of all data and applications hosted online (e.g. WADI, WASCAL Website, and future online applications to be installed).

• Installation and configuration of a NESA server for automatic remote retrieval of data from the purchased 50 Automatic Weather Stations (AWS) being installed.

Implementation of a Cloud-based application server

To satisfy these needs of WASCAL Scientists and administration to have specific applications and data (not yet sharable on WADI) accessible online from anywhere, the DMICT unit has rented a cloud-based application server on which specific applications will be installed (Pro-report system, Automatic weather data collection server, accountancy software, dedicated webapps for scientists projects, procurement soft), and where internal scientist data and administrative documents could be stored and shared.

This server will also act as a cloud-based mirroring/backup server for the local scientific data at the CoC.

Extension of professional wascal.org emails and corporate applications to WASCAL schools

To harmonize the image of WASCAL and build "one WASCAL" cloud-based wascal.org email accounts associated with corporate applications (MS Word, Excel, PowerPoint, Access, OneDrive, etc.) were provided to GSP directors, staff and students. More than 120 accounts have been created.

PARTNERSHIPS & RESOURCE MOBILIZATION

WASCAL continueed to build strategic partnership with local, national, regional and international stakeholders in its pursuit to build a global brand as a West African key player in combatting climate change and improving livelihoods. WASCAL worked in partnership with diverse state institutions, donor agencies, civil societies, research institutions and other stakeholders in its programmes to achieve results. The essence of these partnerships was to enable the orgnaizationto identify the right stakeholders who can play pivotal roles in combatting climate change.

WASCAL is indebted to BMBF for its continuous support and investment in the operation of its core mandate. Through BMBF, WASCAL was able to successfully execute its outlined plan for the year.

Ongoing projects

- Applications des Prévisions climatiques et Pratiques agricoles dans la Traduction des Evènements pluviométriques Extrêmes du 21è siècle en zones à risques- (APTE 21). Funded by IRD and French Ministry of Foreign Affairs through AGRICORA
- Supporting EU-African Cooperation on Research Infrastructures for Food Security and Greenhouse Gas Observations (SEACRIFOG). Funded by European Union through H2020
- GENERIA funded by French Ministry of Foreign Affairs through AGRICORA
- AFRIALLIANCE funded by the European Union through H2020

New Projects

- Multi-scale Flood Monitoring and Assessment Services for West Africa (MiFMASS). Funded by the African Union Commission under the Global Monitoring for Environment and Security program.
- Climate information to support integrated renewable electricity generation (CIREG). Funded by the European Research Area for Climate Service (ERA4CS). Consortium led by PIK (Germany).
- Upscaling Site-Specific Climate-smart Agriculture and Land use practices to Enhance Regional production Systems in West-Africa (USPCALERS). Funded by AUC/EU

KEY PARTNERS

FINANCIAL REPORT

WEST AFRICAN SCIENCE SERVICE CENTER ON CLIMATE CHANGE AND ADAPTED LAND USE PROJECT NUMBER KFW 202060952

STATEMENT OF RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31 DECEMBER 2017

	Note	2017 EUR	2016 EUR
RECEIPTS			
KfW funds received	3	5,216,458	6,915,239
Exchange gain on translation		3,515	-
Total income		5,219,973	6,915,239
PAYMENTS			
Rents	4	102,115	45,124
Staff cost	5	2,441,309	2,435,140
Consumables	6	108,691	181,258
Office supply and communication	7	122,554	147,366
Workshops and meetings	8	199,601	325,302
Travel cost	9	231,605	322,271
Renovation WASCAL Office/Equipment	10	102,144	26,993
Competence center investment	11	3,504	28,777
Bank charges	12	17,778	39,971
Other administrative cost	13	54,998	55,344
Graduate Student Programme Operations	14	2,264,147	2,400,864
Climate observatory network	15	112,607	44,115
Competence center research support	16	105,330	-
		5,866,383	6,052,525
(Deficit)/Excess of receipts over payments		(646,410)	862,714
Opening cash balance		1,308,534	445,820
Prior year reconciling items	17	(34,645)	-
(Deficit)/Excess of receipts over payments		(646,410)	862,714
Closing fund balance		627,479	1,308,534
Represented by:			
Commerzbank		302,994	246,460
Ecobank Ghana Euro		51,512	249,612
Ecobank Ghana Cedi		51,540	19,297
Ecobank Ouagadougou		73,418	443,823
Stanbic Ghana Euro		141,301	348,859
Ecobank - Executive Director (WASCAL)		-	7
Cash on hand		6,714	476
		627,479	1,308,534

The Governing Board approved this statement on.....2018.

.....
EXECUTIVE DIRECTOR (WASCAL)

.....
BOARD AUDIT COMMITTEE CHAIR

APPENDIX

OUR STAFF

Headquarters

- Executive Director
- Director of Finance and Administration (1)
- Capacity Building Director (1)
- Finance Manager (1)
- Human Resource Manager (1)
- Public Relations Manager (1)
- Manager Board, Protocol and External Relations (1)
- Administrative and other support staff (10)

Competence Centre, Ouagadougou

- Scientists (13)
- Senior Scientists (8)
- Junior Scientists (5)
- Senior Data Manager (1)
- Systems Administrator (1)
- Geoportal Administrator (1)
- Administrative and other support staff (19)
- Staff members at Tanguieta Watershed Station, Benin (8)
- Staff members at Bolgatanga Watershed Station, Ghana (8)
- Staff members at Dano Watershed Stations, Burkina Faso (3)

Directors and Coordinators of Graduate School Programmes

- Prof. Janet O. Adelegan, Director, Capacity Building Department

West African Climate Systems GSP, FUTA

- Prof. Ogunjobi O. Kehinde Director
- Dr. Ajayi Vincent Deputy Director

CC Adapted Land Use GSP, FUT MINNA

- Prof. Appollonia Okhimamhe Director
- Dr. Ibrahim Saratu Usman Deputy Director

CC BIODIVERSITY, UFHB

- Prof. Koné Daouda Director
- Prof. Konaté Souleymane Deputy Director

CC Water Resource, UAC

- Dr. Adounkpe G. Julien Director
- Dr. Lawin A. Emmanuel Deputy Director

CC AGRICULTURE, IPR-IFRA

- Prof. Amoro Coulibaly Director
- Prof. Diakaridia Traore Deputy Director
- Dr. Benjamin Kofi Nyarko Deputy Director

CC ECONOMICS, UCAD

• Prof. Ahmadou Aly Mbaye	Director
• Prof. Ibrahima Thione Diop	Deputy Director

CC HUMAN SECURITY, UL

• Prof. Kouami Kokou	Director
• Prof. Kodjo Afagla	Deputy Director

CC LAND USE, KNUST

• Prof. Samuel Nii Odai	Director
• Dr. Wilson Agyei Agyare	Deputy Director

CC EDUCATION, UTG

• Dr. Sidat Yaffa	Director
• Dr. Momoudou Jain	Deputy Director

CC ENERGY, UAM

• Dr. Rabani Adamou	Director
• Dr. Inoussa Maman Maarouhi	Deputy Director

ACRONYMS & ABBREVIATIONS

AfDB - African Development Bank
AGB - Aboveground Biomass
AGRICORA – Agriculture et Gestion des RIsques Climatiques: Outils et Recherches en Afrique
AWS - Automatic Weather Stations
BMBF - German Federal Ministry of Education and Research
BON – Biodiversity Observation Network
CIREG - Climate information to support integrated renewable electricity generation
CMIP5 - Coupled Model Inter-comparison Project phase 5
CoC – Competence Centre
COP – Conference of Parties
CORDEX - Coordinated Regional Climate Downscaling Experiment
CORDEX – Coordinated Regional Climate Downscaling EXperiment
COSPAR – Committee on Space Research
DBH - Diameter at Breast Height
DLR-PT – Project Management Agency, German Aerospace Center
DRP - DOCTORAL GRADUATE RESEARCH PROGRAMME
ECOS - Ecosystem Change and Services
ERA4CS – European Research Area for Climate Service
ESMs – Earth System Models
FUT MINNA - Federal University of Technology, Minna
FUTA- Federal University of Technology, Akure
GCM - Global Circulation Mode
GITEC – GITEC Consult GMBH
GSP –Graduate Studies Programme
GTS - Global Transmission System
HPC - High-Performance Computing
HYREM – Hydrology and Water Resources Management
IMARA - Impact Analyses and Risks Assessment
IPCC - Intergovernmental Panel on Climate Change
IPR-IFRA- Institut Polytechnique Rural de Formation et de Recherche Apliquée,
KfW – Kreditanstalt für Wiederaufbau
KNUST- Kwame Nkrumah University of Science and Technology
MCSs - Mesoscale Convective Systems
MiFMASS - Multi-scale Flood Monitoring and Assessment Services
MPI-ESM-MR - Max-Planck Institute Earth System Model for Medium Resolution
MRP –Masters in Research Programme
NDAs - National Designated Authorities
PAUWES – Pan African University - Institute of Water and Energy Sciences
RC – Research Cluster
RCM – Regional Climate Models
ReCON – Regional Collaboration Network
ReHON - Regional Hydrology Observation network
REOF – Rotated Empirical Orthogonal Function
ReSON -Regional Socio- economics Observation Network
RSON - Remote Sensing Observation Network
RSON - Remote Sensing Observation Network
SAC –Scientific Advisory Committee
SEACRIFOG - Supporting EU-African Cooperation on Research Infrastructures for Food Security and Greenhouse Gas Observations
TCBF - Tiger Capacity Building Facility
TCS - Total Carbon Stock
UAC- Université d'Abomey-Calavi
UAM- Université Abdou Moumouni de Niamey
UCAD- Université Cheikh Anta Diop de Dakar
UENR - University of Energy and Natural Resources
UFHB- Université Felix Houphouët Boigny
UL- University of Lome
USPCALERS - Upscaling Site-Specifc Climate-smart Agriculture and Land use practices to Enhance Regional production Systems
UTG - University of the Gambia
WABES - West Africa Biodiversity and Ecosystem Services
WADI – WASCAL Data Portal Infrastructure
WMO - World Meteorological Organization
WP - Water Productivity
WRAP – WASCAL Research Action Plan

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