Institution: University of Sussex

Unit of Assessment: 14 – Geography and Environmental Studies

Title of case study: Building climate resilience in Africa by enhancing anticipatory risk management

Period when the underpinning research was undertaken: 2006 – 2020

Details of staff conducting the underpinning research from the submitting unit:

Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Martin Todd	Professor	2009 – present
Dominic Kniveton	Professor	2001 – present
Pedram Rowhani	Senior Lecturer	2011 – present
Mohammad Shamsudduha	Lecturer	2019 – present

Period when the claimed impact occurred: 2014 – 2020

Is this case study continued from a case study submitted in 2014? N

1. Summary of the impact

Much of sub-Saharan Africa is extremely vulnerable to present and future climate shocks, which jeopardise development gains as it continues its rapid socio-economic transformation. Anticipating and preparing for tomorrow's weather and the emerging climate changes is central to Africa's sustainable and climate-resilient future. Sussex research has changed the way weather and climate forecast information is produced and used. Sussex researchers have pioneered an approach of 'co-production' between researchers, forecast producers and decision-makers. This has resulted in forecasts and information on weather/climate risk that is useful, usable and used in practice: by government agencies, national and international NGOs and populations at risk. This has supported a shift to anticipatory approaches, in both near-term disaster risk management and in planning long-term development investments across the nexus of water, energy and food production. Together, this has enhanced climate resilience in Africa.

2. Underpinning research

Climate Information services in sub-Saharan Africa have always had very limited uptake by assumed users. As a result, climate risk management had remained stubbornly reactive. Sussex research addressed well-recognised barriers to effective anticipatory climate risk management, namely: the salience, credibility and legitimacy of weather/climate information; and the methods and capacities to use this inherently uncertain forecast information in decision-making. Sussex researchers have produced a large body of strongly interdisciplinary research on African climate risk (>130 papers in the last ~15 years). This includes fundamental science on how African climate/environment systems operate, and their predictability over multiple timescales. Research has quantified climate impacts on resources and the interaction with societal processes. On this basis, the researchers have developed new weather/climate forecast and scenario products and novel approaches and tools for 'decision-making under uncertainty', applied in a wide range of risk management contexts. This body of work has emerged substantially through taking a leading role in a series of major international research projects aimed at building climate resilience in Africa (UK Research Councils NERC/ESRC/EPSRC and EU funding exceeding £13M, see [G1-6]). Due to the extent of this research, only a small, representative selection has been cited in section 3.

In these projects, Sussex pioneered methods for interdisciplinary, participatory, and engaged research on 'co-production' in climate risk management (Todd, Kniveton and others, [R1]). Their work brought together different stakeholders, knowledge and experiences to jointly co-produce new climate information, that is better able to support specific decision-making contexts. These advances in co-production are key to this impact of 'mainstreaming' anticipatory risk management, across two decision time horizons:

(i) Near-term disaster risk management. Todd and others [R2] established East Africa as a 'sweet spot' of predictability for extreme rainfall. Notably, this includes sub-seasonal timescales, currently at the frontier of forecasting advances. This opens the door for a new approach of forecasts over continuous lead-times (from days to months) to support evolving preparedness action (what is named 'seamless' forecasts and actions in the research). For example, Rowhani and others, including Oliver et al (Physics, UoA 9), developed new methods to forecast decision-

relevant drought indicators of vegetation condition [R3, G6]. To further improve the legitimacy and uptake of forecasts, Kniveton et al. [R4] developed participatory methods to integrate local knowledge with Meteorological Service forecasts.

(ii) Long-term, climate-resilient development decisions. The projects GroFutures [G4], AMMA-2050 [G2] and UMFULA [G3] have all advanced understanding of climate risk and decision-making under uncertainty in the 'water-energy-food' sectors. To illustrate, Todd, Shamsudduha and others [R5] established that extreme rainfall is critical in recharging groundwater resources. Strong evidence of future intensification of rainfall, even in drying regions, thus supports a greater role for groundwater in climate-resilient water resource development. To improve uptake of climate change risk information, Kniveton and others [R6] developed novel participatory methods for aiding climate-resilient decision-making, including discursive 'adaptation pathway' development.

3. References to the research

R1. a) Taylor O., et al. (inc. Todd, M.C., Kniveton, D.R.) (2019) Co-producing Approaches to Forecast-based Early Action for Drought and Floods in Kenya; b) Visman, E., et al. (inc. Kniveton, D.R.), (2019). AMMA-2050: Combining Scenario Games, Participatory Modelling and Theatre Forums to Co-produce Climate Information for Medium-term Planning. Both in Carter, S., et al., 2019, *Co-production of African weather and climate services*. Second edition. Manual, Cape Town: Future Climate for Africa and Weather and Climate Information Services for Africa https://futureclimateafrica.org/coproduction-manual

R2. Kilavi, M. et al. (inc. Todd, M.C.) (2018) Extreme rainfall and flooding over central Kenya including Nairobi city during the 'long rains' season 2018: Causes, predictability and potential for early warning and actions. *Atmosphere* 2018, 9(12): 472. https://doi.org/10.3390/atmos9120472

R3. Barrett et al. (inc. Rowhani, P.) (2020) Forecasting vegetation condition for drought early warning systems in pastoral communities in Kenya. *Remote Sensing of Environment,* 248: 111886 https://doi.org/10.1016/j.rse.2020.111886

R4. Kniveton, D.R., et al. (2015) Dealing with uncertainty: integrating local and scientific knowledge of the climate and weather. *Disasters*, 39: S35-S53. https://doi.org/10.1111/disa.12108

R5. Cuthbert, M.O., et al. (inc. Todd, M.C. and Shamsudduha, M) (2019) Observed controls on resilience of groundwater to climate variability in sub-Saharan Africa. *Nature,* 572: 230–234. https://doi.org/10.1038/s41586-019-1441-7

R6. Ayeb-Karlsson, et al., (inc. Kniveton, D.R.) (2019) Embracing uncertainty: A discursive approach to understanding pathways for climate adaptation in Senegal. *Regional Environmental Change,* 19: 1585–1596. https://doi.org/10.1007/s10113-019-01495-7

Supporting research grants (NERC unless stated):

G1. *ForPAc.* NE/P000673/1, total £1,254,280 (£1,033,743 to Sussex), 2016-20, PI Todd, Co-Is Kniveton and Rowhani, plus *INFORM* (£100K, 2019-20) PI Todd; **G2**. *AMMA-2050.* NE/M020428/1, total £1,867,472, 2016-19, Co-I Kniveton; **G3**. *UMFULA.* NE/M020258, total £314,288 to Sussex, 2015-19, PI Todd; **G4**. *GroFutures.* NE/M008932/1, £426,381 (£58,779 to Sussex, Co-PI: Todd), 2015-20; **G5**. *StARCK+* (FCDO). GB-1-203574, £250K, 2011-13, Co-I Kniveton; **G6**. *Astrocast* (STFC). ST/R004811/1, £100,462, 2018-19, Co-Is Rowhani, Todd.

4. Details of the impact

Sussex research has changed operational practices and guiding policies for climate resilience in a range of contexts in Africa: local, national and international, for near-term and long-term risk.

4.1. Near-term flood/drought hazard risk management

Moving from reactive to anticipatory disaster risk management is a major challenge. Sussex research has led to recognition across the Disaster Risk Management community that: "*mainstreaming the anticipatory approach… into national systems [is] the key to sustainably*

scaling up", and that co-production is essential for effective mainstreaming [Director, Red Cross Climate Centre, S1]. Specifically, Sussex research projects (ForPAc and INFORM [G1], Astrocast [G6], and StARCK+ [G5]) led to the following changes (i)-(iii) in operational risk management systems across national, regional and international agencies, facilitating this shift to anticipatory action.

(i) Co-produced technical advances in forecasting and risk management systems

In Kenya, research led to new co-produced decision-relevant forecast products for drought and flood hazards, over forecast lead-times of days to months [R2, R3]. These products are now in operational production by mandated forecasting agencies: (a) For the Kenya Meteorological Department (KMD) ForPAc has: *"Supported improvements in existing forecast operations across our forecast portfolio [including] new co-produced forecast products [e.g. the] improved and actionable seasonal/monthly forecasts...used in the [Kenya] drought phase classification system, sustainably formalised into KMD operations"* [Director, KMD, S2]; (b) The Regional Centre for Mapping and Resource Development (RCMRD) for East Africa *"now use the [Sussex] AstroCast algorithms…and software…into our own pipeline [to] produce the novel VCI forecast product, [which is] qualitatively different from anything we've been able to do before and provides our stakeholders with a decision making tool with much greater power"* [[text removed for publication] S3].

These new operational forecasts are now deployed by national risk management agencies, supporting a transformation in their systems towards anticipatory action. The National Drought Management Authority (NDMA) of Kenya has advanced their national drought Early Warning System from being reactive to partially forecast-based: *"Following [ForPAc and Astrocast] research, several novel and skilful forecasts of key drought indicators (Standardized Precipitation Index, SPI; Vegetation Condition Index, VCI; Soil Moisture) have been co-developed and piloted in several counties. As a consequence, the NDMA has developed a new template for its monthly drought bulletins... The template now includes… [these] forecasts"* [CEO, NDMA, S4]. The new forecasts enable NDMA to manage drought risk better*, "in order to reduce the impact, recovery time and costs associated with traditional drought response".* The new forecasts enabled earlier warning with forecasts for Oct-Dec 2020 issued as early as July 2020, *"giving stakeholders ample time to initiate drought preparedness actions"* [S4]. In summary, *"These projects have substantially advanced our drought Early Warning System"* [S4].

Further, for the Kenya Red Cross Society (KRCS, mandated first responders) Sussex projects have *"supported decision-making at KRCS"* leading to *"concrete changes in its practices in disaster risk management and underpinning a paradigm shift towards a more anticipatory approach"* [[text removed for publication] S5]. Specifically, the two KRCS disaster risk management systems have been improved. In the new flagship nationwide Early Action Protocols for flood and drought, the Sussex research was *"used in the development of forecasts and thresholds for triggering early action"* [S5]. This has also *"ensured better alignment of [KRCS] Early Action Protocols with [other] existing systems such that indicators and triggers will be consistent with those of national mandated agencies"* [S5]. Further, KRCS's Multi-hazard Contingency Planning system now adopts *"a likelihood approach [using] multi-model forecasts... available at different lead-times enabling staggered and evolving institutional planning"*, based on *"increased understanding and use of climate forecasts probabilities and uncertainty"* [S5].

The research has had impact beyond Kenya, across the wider East African region. ForPAc science has supported the IGAD Climate Prediction and Applications Centre (ICPAC) – the designated regional centre for climate prediction for the Greater Horn of Africa – to improve the method by which it produces its seasonal forecasts. From 2019, ICPAC now utilise a *"new objective, traceable and reproducible seasonal forecast method"* [S6]. These forecasts are disseminated *"to different stakeholders/sectors over the region for informed decision-making processes"* [S6]. The East African regional Food Security and Nutrition Steering Group issued their first food security warning in September 2020, based on this new robust forecast method, informing risk management stakeholders across the region [S7]. Further, the Sussex participatory tool [R4] has been adopted in a new regional Early Warning System protecting fisherfolk on Lake Victoria, and *"changed the ways in which forecasts of weather-related impacts*

are constructed and tailored to local contexts and demands… making them more relevant and usable" [UK Met Office, S8].

(ii) Capacity building for sustainability

To ensure long-term sustainability of these advances, the projects built national institutional capacity by design. ForPAc/INFORM funded staff embedded in the following agencies (with mandates in Kenya and regionally), and undertook an extensive training programme: Kenya Meteorological Department (KMD); National Drought Management Authority (NDMA); Kenya Red Cross Society (KRCS); IGAD Climate Prediction and Applications Centre (ICPAC). The KMD's Director states: *"ForPAc has improved the capacity of KMD to take advantage of the major advances in global forecasting and the appetite of our national risk management agencies, to respond to this opportunity*" [S2]. For NDMA, the work "*built trust of the decision makers in these forecasts and the capacity of stakeholders in the counties to interpret... forecast... and probabilistic information has greatly improved*" [S4]. Training is being rolled out to all NDMA County Officers to use new forecast-based action approaches [S4]. At the Regional Centre for Mapping and Resource Development (RCMRD), "*the training [by] Sussex has increased the skills of our… team and thus the capacity of the organisation and the subsequent impact on Kenya, and the regions that RCMRD serve. [T]he algorithms are open source, RCMRD can modify and adapt the code… which increases our… capacity to deliver new and improved products to our member countries*" [S3]. Further, the project's co-production approach improved the coherence and alignment across these agencies through "*enhanced partnerships*" [S2], "*strengthened linkages*" [S3] and "*interactions*" [S4], between the forecast producers (KMD and RCMRD) and the risk management agencies (NDMA, KRCS).

(iii) International scale-up

As attested by [text removed for publication] the Kenya Red Cross Society, the Sussex research has provided "*the technical capacity to guide the development of [anticipatory action] in Africa*" [S5]. This is echoed by the Director of the Red Cross Climate Centre, who confirms that the work so far offers "*a template of how to move towards anticipatory risk management within existing national frameworks*" [S1]. It has informed plans and activities by the International Federation of Red Cross Societies (IFRC) to scale-up anticipatory 'Forecast based Finance' (FbF) into national systems: "*[T]he ForPAc project has supported and advanced the technical aspects of Forecast based Finance application, influenced the way FbF is being scaled up by highlighting the importance of mainstreaming, while underpinning capacity and dialogue between national Red Cross societies, risk management agencies and the global FbF movement… ForPAc forecast research advances have influenced our best practice*", and "*evidence from ForPAc research… has fed into [this] key publication for Red Cross-Red Crescent National Societies*" [S1]. ForPAc research has informed the technical design of drought FbF systems for all national Red Cross societies, via the FbF and Early Action for Drought Guidance Notes [S9]. Further, the Regional Centre for Mapping and Resource Development "*will scale the [VCI forecast] products to all RCMRD member states in Africa to support early warning and rangeland monitoring*" [S3]. Finally, the research team's participatory knowledge tool [R4] has been embedded in a co-production training module rolled out across nine African meteorological training institutions to scale-out the research's co-production methods [S10].

4.2. Long-term climate resilient development planning

Sussex research projects (GroFutures [G4], AMMA-2050 [G2] and UMFULA [G3]) have influenced policies and practices towards climate-resilient development, focussing on major development decisions across the Water-Energy-Food nexus and urban planning in contexts across Africa. In each case their co-production of information by scientists and decision-makers [R1, R4, R6] led to a chain of impact effects. New scientific evidence, generated with greater stakeholder inclusion and engagement, helped raise awareness of climate risk, supporting specific climate-resilient planning decisions, whilst further embedding climate resilience in national and sectoral planning.

Sussex research in the GroFutures project, on groundwater recharge under changing climates [R5], has informed sustainable exploitation of groundwater for climate-resilient agriculture and water supply. At the international policy level, the African Ministers' Council On Water (AMCOW)

established a new pan-Africa groundwater initiative (APAGroP) to guide its 55 member states to develop, manage, and utilize groundwater resources, in order to assure water, food and energy security in Africa. GroFutures research "*contributes centrally to this programme [and] provides the most compelling evidence to date of the resilience of groundwater to climate change in Africa*" [[text removed for publication] S11]. In Tanzania, GroFutures "*informed discussion in the Ministry [of Water] about the future of water supply*" [[text removed for publication] S12]. As a result, "*the Ministry is evaluating... Managed Aquifer Recharge*" for climate-resilient water management, taking advantage of "*crucial... heavy rainfall [in] replenishment of groundwater*" for which GroFutures [R5] provided "*the rationale and benchmark*" [S12].

Sussex research in the AMMA-2050 project improved climate-resilient development in Burkina Faso and Senegal. Application of its 'adaptation pathway' approach to co-production [R6] enabled an open exploration of climate-resilient development pathways. In Burkina Faso, this raised awareness of climate risk amongst decision-makers and supported modelling of the outcomes of different land use polices on future flood risk scenarios. This "*reinforced the anticipation and adaptation capacity of Ouagadougou [for] flood prevention, in addition to contributing to the Risk Reduction Plan [which] reinforce the resilience of Ouagadougou to flood events*" [Mayor of Ouagadougou, Burkina Faso, S13]. In Senegal, AMMA-2050 future climate and impact scenarios were used in the Scientific Support Project that forms the basis of the forthcoming National Adaptation Plan [S14].

In Malawi, the Sussex UMFULA project has directly influenced national policy and planning documents, by providing climate risk information and raising the profile of climate resilience. The co-production approach [R1] ensured UMFULA representation on the Malawi National Planning Commission Core Advisory Panel, which resulted in: the National Resilience Plan (2019) "*[having] four pillars… all addressing UMFULA related objectives including investments for resilience, climate information and early warning, water and agriculture resources*" [S15]; the National Planning Commission's Long-Term Development Plan 'National Transformation 2063', having "*enhanced… climate resilience profiles (for both water and food systems)*" [S15]; Malawi's third National Communication to the UN Framework Convention on Climate Change (UNFCCC) on Agriculture Adaptation incorporating risk profiles generated by UMFULA; and the submission of Malawi's Science Technology and Innovation Policy to the President and Cabinet, which "*incorporates [UMFULA evidence] on climate change science and investments*" [S15].

5. Sources to corroborate the impact

S1. Testimonial, Maarten van Aalst, Director of Red Cross Climate Centre.
S2. Testimonial, S. Aura, Director, Kenya Meteorological Department.
S3. Testimonial, [text removed for publication].
S4. Testimonial, J. Mwangi, Drought Information Manager on behalf of James Oduor CEO, Kenya National Drought Management Authority.
S5. Testimonial, [text removed for publication].
S6. ICPAC 2019 Technical note https://medium.com/@icpac/improved-seasonal-forecast-for-eastern-africa-57872645f449.
S7. Food Security and Nutrition Working Group alert https://www.icpac.net/fsnwg/alert-impact-below-normal-oct-dec-2020-rains-food-security-and-nutrition/.
S8. Testimonial, J. Faragher, Senior International Development Manager, UK Met Office.
S9. Forecast-based Financing And Early Action For Drought Guidance Notes For The Red Cross Red Crescent https://www.forecast-based-financing.org/wp-content/uploads/2020/07/Guidance-Notes-A-Report-on-FbA-for-Drought.pdf.
S10. Learning to Co-Produce (L2CP) course: http://walker.ac.uk/about-walker/news-events/learning-to-co-produce-course-goes-live-on-walker-academy/.
S11. Testimonial, [text removed for publication].
S12. Testimonial, [text removed for publication].
S13. Testimonial, A. Beounde, Mayor of Ouagadougou, Burkina Faso.
S14. Scientific Support Project for the Senegal National Adaptation Plan, 2019.
S15. Testimonial, D. Mwkambisi, Malawi University of Science and Technology.