BIANNUAL ACHIEVEMENTS REPORT

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Reporting period: April to September 2018

Dear Colleague

Please find attached template to report on the outcomes and impacts of NERC programme for which you are science co-ordinator for the period from April to September 2018. Please email your completed report to reporting@nerc.ac.uk by 15 October 2018.

Please provide narrative under the following headings:

- *Key achievements (please try to keep within 200 words each)*
- *Overall progress with the programme (100-200 words as a guide)*
- *Any notable issues encountered (if any and remedial actions undertaken, if needed)*
- *Any newsworthy activity planned or known about in the next 6-9 months*

This reporting process is intended to be high-level, light touch and flexible. In a programme consisting of multiple projects, please try to do more than list achievements from individual projects. Consider how achievements integrate together and report on activity at the programme level. Please try to be concise. Ideally, the whole report should not exceed one side.

Between reports, if there are any significant good news stories, delays or issues affecting the programme, please let us know as soon as possible.

Please note, if there are any significant delays or issues affecting delivery of the programme please contact the programme manager immediately and do not wait until the biannual achievement report to notify us.

If you require further help in completing the report, please do not hesitate to contact us reporting@nerc.ac.uk.

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Programme/investment	Sustaining Water Resources for Food, Energy & Ecosystem Services (SWR) / NERC-MoES Newton-Bhabha Fund		
Completed by	Gwyn Rees, Adebayo Adeloye, Ana Mijic & Helen Houghton-Carr	Date	10-Oct-2018

Key achievements

1. The first **SWR cross-programme workshop** was held at ICRISAT, Hyderabad 18-20 September 2018 on the topic of Modelling & Scenario Development with the goal of understanding how the three projects address the SWR theme of "sustaining water resources for food, energy and ecosystem services" through whole systems modelling. The objectives of the workshop were to: (i) Increase awareness of different modelling approaches across SWR programme and better appreciate challenges in whole systems modelling; (ii) Explore use of different/common scenarios for climate, socio-economic and land use change across SWR programme; (iii) Agree best practice approaches to address science-policy interface; (iv) Develop a coordinated process to dissemination of project outputs that seeks to increase impact with different stakeholder groups; and (v) Discuss comparability of project insights across SWR programme and make recommendations for further SWR activity. The workshop was attended by 28 Indian and UK researchers from across the three SWR projects.
2. The **SWR website** was released: http://www.newton-bhabha-swr.org. The website links to the websites of the three SWR projects, and will help raise the profile of the SWR programme. An associated email address SWR-india@nerc.ac.uk will facilitate communication with people interested in finding out more about the programme or the individual projects.
3. **Publications and datasets: CHANSE** team members published a paper in Water Resources Research on the topic of including farmer irrigation behaviour in a socio-hydrological modelling frameworks in June (http://dx.doi.org/10.1029/2018WR023038). This will form an important framework for future modelling publications. A collaborative manuscript on **SusHi-Wat**'s whole systems modelling approach was submitted to Science of the Total Environment (September), while at least four papers dealing with specific aspects of the project have now been published. **SusHi-Wat** has lodged a remote sensing-derived product of monthly maps of snow cover with EIDC. **UPSCAPE** team members published a paper in Advances in Water Resources on multi-scale evolution of the persistence of rainfall and streamflow in August (https://doi.org/10.1016/j.advwatres.2018.08.018) in which the Cauvery basin was a case study.
4. **Dissemination of outputs: CHANSE** team members presented research results at the annual AGU conference (New Orleans, December). **SusHi-Wat** team members presented research results at: the annual EGU conference (Vienna, April), the India-UK Water Centre workshop (Dehradun, May), the Indus Basin Knowledge Forum (Vienna, May-June), the IAHS 8th International Water Resources Conference (Beijing, June), and at Adaptation Futures 2018 (Cape Town, June).

Overall progress

1. **Events:** Collaborative working between Indian and UK partners continued across the three SWR projects, involving activities such as fieldwork, modelling and stakeholder engagement. In April 2018, the third **UPSCAPE** consortium meeting, and in September 2018, the third **CHANSE** consortium meeting, were held, both at IISc, Bangalore. The CHANSE UK team hosted researchers from CHANSE-India at Exeter University (February 2018) and Imperial College (June 2018). A **SusHi-Wat** MSc student from Heriot-Watt University made a 3-month exchange visit (June-September 2018) to IIT-Roorkee and NIT-Hamirpur to work on the field irrigation water demand and scheduling studies.
2. **Fieldwork: SusHi-Wat** successfully conducted field crop experiments (soil moisture and canopy temperature measurements) on Indian mustard and has now moved onto maize. Other **SusHi-Wat** fieldwork focused on macro-invertebrate sampling to improve understanding of the link between ecosystem service delivery and water utilisation, and the collection of data on cultural ecosystem services. **UPSCAPE** field campaigns included geological mapping and hydrochemical/tracer studies which have informed conceptual models of the Cauvery basin and subcatchment hydrogeology, and borehole water level analyses which have been used to develop a yield map for the Cauvery basin. Other **UPSCAPE** fieldwork and modelling (SWAT) examined water use under different cropping patterns as part of a command area optimisation study. **CHANSE** drilled monitoring boreholes and

installed surface and groundwater monitoring equipment in canals and the new boreholes. **CHANSE**'s field data collection programme included pre-monsoon hydro-meteorological and hydro-geological data including water samples, and ecological data.

3. **Modelling:** Validated hydrological models for the Beas-Sutlej basin (SWAT and VIC, **SusHi-Wat**) and the Cauvery basin (GWAVA and VIC, **UPSCAPE**) provide baselines for future hydrological projections based on climate and socio-economic scenarios. The AMBHAS-1D groundwater model was implemented within the GWAVA water resources model in **UPSCAPE** and fully linked with the VIC hydrological model in **CHANSE**. **CHANSE** has developed a spatially distributed socio-hydrological model for the Gandak basin, and strengthened it with the AquaCropOS module. **CHANSE** made progress with the systems modelling framework, ecological model development and link with the climate simulations. **CHANSE** also received an additional grant to implement the modelling framework as an online open source platform. **Sushi-Wat** generated high resolution, accurate weather data for a baseline period (1980-2005) by dynamically downscaling from two coarse-scale CMIP5 GCM simulations and appropriately bias-correced. A whole-system model for use by the Bhakra-Beas Management Board (BBMB) and other relevant stakeholders to better manage water resources was developed and demonstrated on-site in Chandigarh by **SusHi-Wat**. Multi-reservoir, multi-purpose operation tools for reservoirs in the basin have been developed to improve absorption of any climate change shocks.
4. **Stakeholder engagement:** In April 2018, **UPSCAPE** carried out stakeholder engagement events in Bangalore, Karnataka, and in Tiruchirappalli and Chennai, Tamil Nadu. In total, the events engaged 56 stakeholders from 22 organisations representing state governmental departments, national governmental agencies, educational institutes and non-governmental organisations within the Cauvery basin, to construct narratives of the potential socio-economic futures. The facilitated discussions identified seven socio-economic drivers of hydrological change (population, urbanisation, policy, technology, agriculture, industry/energy, and environment), and discussed how these drivers may vary to create 'best-case', 'middle of the road' and 'worst-case' futures for water resources. The results will be used to inform the quantification of water resources demands and their trajectories across the basin over time, otherwise referred to as 'regionally downscaled socio-economic futures'. The socio-economic projections will be combined with climatic projections to understand the future water resources challenges in the Cauvery basin. The **UPSCAPE** flier was reproduced in simple English, Kannada and Tamil to improve communication with local stakeholders.
5. **Food-energy-ecosystem services nexus:** Assessments of water resources for food, energy and ecosystem services have commenced across the three projects, and outputs are being presented as journal and conference papers by Indian and UK partners.

Notable issues (if any)

1. **Data: SusHi-Wat** and **UPSCAPE** report that there are still difficulties in obtaining field data of some of the sites which is hampering the hydrological modelling work.
2. **Communication: UPSCAPE** notes that communication between UK and Indian partners remains difficult with some Indian partners not responding to standard methods of communicating e.g. email, telephone, whatsapp. Most progress is made during face-to-face meetings.
3. **Funding:** Delays and cuts in funding from MoES for the Indian partners has impacted activities and India-UK collaboration across the three SWR projects. NERC has awarded extensions to all three projects - 6 months for **CHANSE**, 9 months for **UPSCAPE**, and 12 months for **SusHi-Wat**. The different end dates may have implications for end of programme events.

Upcoming newsworthy activities

1. **Recent:** Laura Wignall recently started a PhD at Exeter University under the WISE (Water Informatics Science & Engineering) EPSRC DTP, working on research related to **CHANSE**. **SusHi-Wat** PI Adebayo Adeloye was recently appointed as a Visiting Professor in Water Resources Management, China Agricultural University (CAU), Beijing. The citation stressed the significance of his work in **SusHi-Wat** in furthering understanding of the water resources in the Indian Himalayas. In June 2018, Adebayo Adeloye visited CAU to give lectures based on **SusHi-Wat** outputs. **SusHi-Wat** Indian-PI CSP Ojha was appointed as Institute Chair Professor at IIT Roorkee on 1 June 2018, for a period of three years and as Adjunct Professor of Civil and Environmental Engineering, University of Missouri, Columbia, USA from 1 September 2018 for a period of two years. **CHANSE** project leads, Subimal Ghosh (IIT Bombay) and Jagdish Krishnaswamy (ATREE) have been appointed to IPCC AR6 Working Groups as, respectively, Lead Author for Climate Science, and Coordinating Lead Author for Climate Change and Land. There is potential to link **CHANSE** project outputs to the reports' recommendations.
2. **October 2018: Sushi-Wat** PI Adebayo Adeloye will be attending the International Conference on Water Science for Impact at Wageningen University and Research, Netherlands, where he will make a presentation on aspects of **SusHi-Wat** under the theme "Water Management in India". **UPSCAPE** team member Pawan Wable from ICRISAT will make a two-week exchange visit to CEH Wallingford to assist with the incorporation of interventions in basin-scale hydrological models.
3. **November 2018:** Ian Holman from **SusHi-Wat** will run a 1-week GIAN (Global Initiative of Academic Networks) short course at IIT Kharagpur on "Improved climate change adaptation strategies in water resources" (in February 2016, Adebayo Adeloye ran a similar workshop at NIT-Hamirpur). On 20 November, the second **UPSCAPE** UK team meeting will be held at CEH, Wallingford.
4. **December 2018:** Jimmy O'Keefe and Simon Moulds from **CHANSE** will be attending the AGU Fall Meeting in Washington where they will make a presentation on project results.
5. **2019: SusHi-Wat** will run a Farmers Extension Workshop at the Agricultural Research Station Bajuara, Kullu, Himachal Pradesh which will focus on benefits of irrigation scheduling. In February 2019, the fourth **UPSCAPE** consortium meeting will be held at IISc, Bangalore. The **CHANSE** team will meet again in March 2019 in India: planned activities include a Gandak basin visit, a stakeholder engagement workshop in Patna, and the final consortium meeting in Mumbai.