Science and Innovation for Catchment Management

Report of Scientific Workshop May 2019

January 2020

INDIA-UK
Water Centre
भारत-यूके
जल केन्द्र

Science and Innovation for Catchment Management

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Natural Environment Research Council

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Government of India

The India-UK Water Centre promotes cooperation and collaboration between the complementary priorities of NERC-MoES water security research.

भारत-ब्रिटेन जल कें द्र एमओईएस-एनईसीआरसी(यूके) जल सुरक्षा अनुसंधान के पूरक प्राथमिकताओ के बीच सहयोग और सहयोग को बढ़ावा देने के लिए करना है

Front cover image: The Dordogne, France; A. Parsons

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Executive Summary

This report represents an overview of the participation, activities and conclusions at a Scientific Workshop, held at Warwick Conferences at the University of Warwick, UK from 8th to 10th May, 2019. The workshop was convened by the India-UK Water Centre and led by Mr Ant Parsons (ALP Synergy Ltd) and Dr Kapil Gupta (IIT Bombay).

The three-day workshop aimed to explore and build on existing knowledge and research to enhance collaboration and identify pathways to impact (including relevant NERC-MoES Science), identify gaps in research and innovation that are constraining sustainable catchment management, explore innovative approaches to monitoring and management, and consider the potential for SMART Rivers as part of integrated catchment management. The aims of the workshop were met by bringing together early career researchers, seasoned professors and experienced professionals from India and the UK, who covered a wide range of topics across the themes of climate, water quality, water quantity, and land and catchment management.

The following report outlines some common challenges, cross-cutting themes and activities required for improving catchment management, potential solutions to catchment management and shares some of the ideas for new collaborative projects that were developed.

The report is intended for the workshop participants, India-UK Water Centre members and stakeholders.

Figure 1: Group photo at University of Warwick, May 2019

1. Workshop Conveners

The Junior Research Scheme project was convened by the India-UK Water Centre (IUKWC) and led by the principal researcher

Mr Anthony Parsons

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The workshop was held at Warwick Conferences at the University of Warwick, UK on the 8th – 10th May 2019.

2. Workshop Aims

The India-UK Water Centre is based around five key cross-sectoral themes and aims to deliver a portfolio of activities across these themes. This activity focused on the themes:

- Using new scientific knowledge to help stakeholders set objectives for freshwater management;
- Improving freshwater monitoring frameworks and data for research and management; and
- Transforming science into catchment management solutions.

The specific aims of this workshop were to:

- Explore and build on existing knowledge and research to enhance collaboration and identify pathways to impact (including relevant NERC-MoES Science).
- Identify gaps in research and innovation that are constraining sustainable catchment management.
- Explore innovative approaches to monitoring and management, and consider the potential for SMART Rivers as part of integrated catchment management.

A SMART river supports the effective integration of physical, digital and human systems, increases citizen engagement and contributes to catchment resilience.

3. Workshop Participants

This workshop was advertised as an opportunity for relevant early career and experienced researchers, Non-Governmental Organisations and Businesses (SME's and Industry) who are active in Science and Innovation for Catchment Management. This could include activities linked to water quality, water resources, flood risk and resilience, citizen science, water governance or technologies. The workshop was marketed through the IUKWC network, through social media and other channels.

The workshop had more than 80 applications and from these, 30 delegates were invited to attend based on the information they provided and their connection with the theme of the workshop. The selection was done using the established IUKWC policies and procedures. The attendees included 19 delegates from the UK and 19 from India as shown in Table 1 below.

	Name	Institution
		UK
1	Dr David Oliver	University of Stirling
2	Dr Sarah Cook	University of Warwick
3	Dr Rachel Helliwell	James Hutton Institute
4	Mr Richard Dallison	Bangor University
5	Dr Vasiliki Ioannidou	Birmingham City University
6	Dr Andrea Momblanch	Cranfield Water Science Institute – Cranfield University
7	Mr Amit Kumar	University of Nottingham
8	Dr Nathalie Gilbert	Thames 21 (INTCATCH project)
9	Dr Komali Kantamaneni	Solent University
10	Mr Mike Bowes	Centre for Ecology & Hydrology
11	Mr John Bryden	Thames 21 (INTCATCH project)
12	Dr Jimmy O'Keefe	Imperial College, London
13	Dr Mark Scrimshaw	Brunel University, London (INTCATCH project)
14	Dr Geoff Brighty	Environment Sustainability Associates Ltd (INTCATCH project)
15	Miss Paula Nickson	Downstreams CIC Ltd (INTCATCH Project)
16	Mr Anthony Parsons	ALP Synergy Ltd (INTCATCH project; UK Lead)
17	Mrs Lesley Parsons	ALP Synergy Ltd (INTCATCH project; UK Co-Lead)
18	Prof Harry Dixon	UK Centre for Ecology & Hydrology (IUKWC Coordinator, UK)
19	Dr Sunita Sarkar	UK Centre for Ecology & Hydrology (IUKWC Secretariat)
20	Ms Emma Bennett	UK Centre for Ecology & Hydrology (IUKWC Secretariat)
		India
21	Professor Kapil Gupta	IIT Bombay (Indian Lead)
22	Mr Saikat Pal	Rajarhat PRASARI
23	Dr Vinay Nikam	Envirocon Urban Hydro Environment Centre
24	Dr Azhoni Adani	National Institute of Technology, Karnataka
25	Dr Somasekhar Rao Polisetti	Advanced Centre for Integrated Water Resources Management (ACIWRM)
26	Dr Rajeev Singh	IESD, BHU Varanasi
27	Mr Kuldeep Swamkar	IIT Bombay
28	Mrs Ashwini Pai Panandiker	The Energy & Resources Institute (TERI), Goa.
29	Professor Rajendra Singh	Indian Institute of Technology Kharagpur
30	Dr VK Mini	Meteorological Centre, Thiruvananthapuram India Meteorological Dept. MOES
31	Dr Rehana Shaik	International Institute of Information Technology, Hyderabad
32	Dr Ajai Singh	Central University of Jharkhand, Ranchi
33	Mr Nitin Bassi	Institute for Resource Analysis and Policy (IRAP)
34	Dr Pradyna Dhage	Indian Institute of Tropical Meteorology Pune
35	Mr Jaydeo Dharpure	National Institute of Hydrology, Roorkee
36	Mr Amar Tiwari	Indian Institute of Technology, Gandhinagar
37	Miss Sreeparvathy Vijay	Indian Institute of Science
38	Dr Atul K Sahai	Indian Institute of Tropical Meteorology Pune (IUKWC Coordinator, India)
39	Ms Priya Joshi	Indian Institute of Tropical Meteorology Pune (IUKWC Secretariat)

4. Activity Structure

The workshop was organised as a three-day event (8th – 10th May), however the Indian delegates were diverted to land at Vienna airport and subsequently stayed there for 23 hours completely missing the first day of the workshop. The workshop was then condensed into two days for the Indian delegates. We re-arranged the first day of the workshop to take into account this disruption, and to ensure that the UK delegates already present could make use of the opportunity to collaborate.

The workshop was structured so that the sharing of knowledge would expose problems and potential solutions. This insight was then used to underpin co-creation activities where new project ideas were explored. The three days were divided as follows:

Day 1: UK delegates only

Co-creating new research proposals and collaborations on pathways to impact.

Day 2: Indian and UK delegates

- **Welcome for all participants** including an explanation of the workshop purpose, objectives and an introduction to the possibilities of a SMART River.
- **Session 1 – Integrated Catchment Management (5 presentations)**

  Objective: To explore a range of approaches taken for integrated catchment management to inform where there are research gaps.
- **Session 2 – Water Quality & Monitoring (3 presentations)**

  Objective: To share experience of water quality challenges and innovative approaches to monitoring.
- **Sessions 3 - Urban Drainage and Nature-Based Solutions (3 presentations)**

  Objective: To gain an insight into urban drainage and nature-based solutions.
- **Poster Session** – A number of delegates produced posters on their project and were given the opportunity to present this back to the workshop delegates.

Figure 2a: Dr Azhoni Adani presenting to the workshop

- **Session 4 – Challenges of Climate Change on Catchment Hydrology (3 presentations)**

  Objective: To explore the challenge of climate change on catchment hydrology and identify areas for further research.

- **Session 5 – Hydrology and Hydrometry (2 presentations)**

  Objective: To explore innovations in hydrology and hydrometry

Day 3:

- **Session 6 – Catchment case studies (3 presentations)**

  Objectives: To identify learning from applied science in catchment case studies.

- **Session 7 – Co-creating new research proposals and collaborations on pathways to impact.**

  Group work in self organising groups around the priority challenges identified.

- **Session 8 – Training Needs**

  What training is needed by which groups of people (e.g. Doctoral training, early career, research support) to enable greater research collaboration and impact.

The full workshop agenda is shown in Annex A and Information on all the presentations has been provided in Annex B.

5. Activity Conclusions and Outputs

Early career researchers, seasoned professors and experienced professionals enjoyed sharing their experience of science and innovation for catchment management. Common challenges and potential solutions were identified and the seeds were sown for new collaborative projects.

5.1. Key themes arising

Through the delegate's presentations, the workshop covered a wide range of topics across the themes of climate, water quality, water quantity, land and catchment management. This knowledge sharing highlighted a breadth of challenges / problems / gaps in research and innovation that are constraining sustainable catchment management which are summarised as follows:

1. **Catchment Governance and engaging more citizens to play an important role in managing the catchments.**
2. **Data & Information**
   - Understanding catchments including industry, discharges, flow, impacts, groundwater and water quality etc is important.
   - We have lots of river catchment data that is stored in different places, not co-ordinated, not integrated and often not used.
   - The quality and reliability of data, and its accessibility is a real issue in India.
3. **Catchment detachment**
   - Urban and Rural catchments are treated separately, and people aren't connected to their catchments.
4. **Quantifying Pharmaceuticals and Veterinary medicines**
   - New technologies to measure impacts
   - Holistic approach before prescribing medicines

- AMR

5. Climate Change
    - Adaptation is a big challenge in India
    - Changing seasons and weather patterns– Issues for farmers, water availability (drinking water) and water scarcity (Drought)
6. Catchment Scale – Quality
    - Arsenic – Diseases
    - Pollution of the groundwater
    - Polluted water used on farm land that has contamination that wipes out crops.
    - Educating farmers on the use of fertilisers
    - Identify where mitigation measures should be concentrated.
7. Incorporating models into Nature Based Solutions
    - Cost benefit analysis
    - Uncertainty about the figures & data.
8. Land use change
    - Understanding social impacts in catchments.
    - Big Corporates engaging in catchments – to enhance more sustainable results.
    - Rural / Urban migration – Impacts of local interventions, downstream risks / water quality.
9. Water Quality / Quantity
    - Quality / Quantity – Not enough water in the right place at the right time.
    - Movement of water at catchment scale (including energy).

Cross cutting themes and activities were highlighted for their importance in any initiative which is trying to improve catchment management. These included:

- Improving the connectivity between citizens and organisations in catchments.
- Exploring the consequences of changing policies, governance and spend on the water environment.
- Demonstrating demonstrations …. “A Demonstration Hub” may be needed to concentrate best practice
- Communication (mobile phone & apps),
- Simplification of the science – So what? What are the benefits and outcomes?
- **Leaving a legacy from a project or initiative is key**

Participants were given the opportunity to pitch for 1 minute about an idea that they would like to develop and collaborate with others on. Eleven pitches were made:

1. Who owns the SMART river? “Love your river rally” – Integrated data sets for your river.
2. Securing and sharing results from Innovation
3. Rejuvenating the river with flora and fauna
4. Integrated groundwater & surface water management
5. Water Restoration – Restoring the rivers health. Including soil health

6. Citizen Science – Data collection and collaboration
7. Coastal – Nature Based Solutions / Embankments
8. Guidelines on re-using a range of different wastewaters
9. Forecasting stream flows into reservoirs, and operational actions for the reservoir
10. SMART Catchments – Supply & Demand. Urban problems – How do we fix the problems? This links to SMART cities.
11. Monitoring Strategies – Results, citizens and decision support system.

The individual pitches highlighted above were combined into 4 topics which groups of delegates then spent time discussing and developing further. The 4 topics were as follows:

1. Who owns the River? This includes exploring citizens engagement, groundwater and surface water.
2. Monitoring Strategies – Including innovation results and decision support
3. River Restoration – Nature bases solutions, coastal, developing guidelines on quality.
4. Forecasting for operations and smart catchments supply & demand.

These group discussions have set the foundations for new collaborations which are continuing beyond the workshop. Two of the topic discussions have been written up in more detail for sharing and are included in Annex C.

5.2. Training needs identified

A final discussion in the workshop explored the potential training needs of delegates to support implementing science and innovation for catchment management. The following skills and development needs were highlighted:

Innovation

- Practical application of GIS
- Project development
- Bid writing
- Tools e.g. Source apportionment, open source software and webinars

Collaboration

- Practical field work skills
- Guidance / mentoring from experienced partners
- Operational shadowing

Engagement

- Research translation into action
- Visualisation techniques
- Public / stakeholder engagement
- Group problem solving.
- Clear understanding of problems

5.3. Conclusions and next steps

The workshop provided a valuable opportunity for cross discipline collaboration between Indian and UK delegates on science and innovation for catchment management. Experience and knowledge was shared, new collaborations were explored and the seeds of ideas were co-created. The timing of the workshop couldn't have been better in terms of the scale of the challenges facing both India and the UK in terms of water and catchment management. However, the timing didn't coincide with any specific funding opportunities which could nurture the new relationships and support the opportunities identified. Delegates were not deterred by the lack of immediate funding and have pledged to build on the momentum of the workshop, and be ready for opportunities when they arise.

5.4. Participant feedback

At the conclusion of the workshop a feedback form was circulated to participants who were asked to provide comment on:

- the Workshop content;
- the meeting venue and organisation;
- networking opportunities; and
- provide an overall score out of 10 for the workshop.

Twenty eight of the delegates provided feedback and examples of the highs and lows from their viewpoint. The feedback was overwhelmingly positive with many delegates giving the workshop a 10 out of 10 overall (where 10 is excellent). The overall average rating was 9.1 out of 10.

Naturally the delayed arrival of the Indian delegates due to their diversion to Vienna resulted in the agenda being changed, primarily the cancellation of the field visit. The lack of a field visit was one of the only areas of less than positive feedback. Other suggestions for improvement included:

- More presentations of applied research
- More early career researchers attending
- More disciplines involved e.g. social scientists

Positive comments included:

- Each session of the workshop was excellent. I learnt a lot.
- Very diverse and thought provoking
- Making new connections and engaging with research outside of my direct area of research. Very well managed with regard to delayed delegates.
- I really liked interactive sessions we had and the support from all delegates to throw out all ideas freely
- I thought ICE blue did an excellent job of facilitating the sessions. Well-structured discussions led to some really interesting research ideas. Allowed everyone's voice to be heard.
- Great venue and very well organised event, especially given the circumstances. Great food and accommodation too.

'One of the best workshops I have ever attended so far.

Very engaging and interesting at the same time.'

6. Annexes

ANNEX A: Agenda

Day 1 – Wednesday 8th May (UK delegates only) – Agenda re-arranged to take into consideration the transport delays for the Indian delegates.

Date	Agenda item
09.30 – 10.00	Opening of Workshop – Workshop purpose, objectives and overview of the 3 days. Explanation of the changes to the agenda.
10.00 – 13.00	Co – creating new research proposals and collaborations on pathways to impact.

Day 2 – Thursday 9th May

Date	Agenda item
9.30-10.15	**Opening of Workshop (10 min)** Workshop purpose, objectives and overview of the 2 days Ant Parsons (ICE blue) and Kapil Gupta (IIT Bombay) **Welcome and Introduction to the IUKWC** Atul K Sahai (IUKWC Coordinator, IITM) **Introduction of delegates and Insight into Funding opportunities** Harry Dixon (IUKWC Coordinator, CEH) **Introductory Session (30 mins)** Setting the ambition for SMART catchments. (presentation and discussion) – future 3-5 years Ant Parsons (ICE blue)
10.15 – 12.15	**Session 1: Integrated Catchment Management** **Objective:** To explore a range of approaches taken for integrated catchment management to inform where there are research gaps. **Chair:** Dr Geoff Brighty (ICE blue and INTCATCH) & Professor Rajendra Singh (IIT Kharagpur) **Presentation: 15 min talks + 5 min questions (20 min total per presentation)** • Mr John Bryden (UK) – Applying scientific approaches to enable Land managers to deliver catchment management. • Mr Saikat Pal (India) – Comparative analysis of catchments and their management diversification: A case from West Bengal, India. • Dr Vinay Nikam (India) – Challenges in managing Urban catchment: Case study of Thane City • Dr Azhoni Adani (India) – Inter-institutional networks for catchment sustainability: insights from Sutlej river basin management in India. • Dr Somasekhar Rao Polisetti (India) - Catchment management for securing water supplies in the Tungabhadra sub-basin of Krishna basin in Karnataka State of India **Facilitated Discussion (20 min)**

12.15 – 13.15	Lunch
13.15 – 14.30	**Session 2: Water Quality & Monitoring** **Objective:** To share experience of water quality challenges and innovative approaches to monitoring. **Chair:** Professor Kapil Gupta (IIT Bombay) & Miss Paula Nickson **Presentation: 15 min talks + 5 min questions (20 min total per presentation)** • Dr Nathalie Gilbert (UK) – Innovative approaches to water quality monitoring - INTCATCH • Dr Rajeev Singh (India) – Agricultural utilisation of waste water: Potential benefits and threats. • Dr David Oliver (UK) – A stakeholder driven approach to mapping diffuse microbial pollution risk in catchments. **Facilitated Discussion (20 min)**
14.30 – 15.15	**Session 3: Urban drainage and Nature-Based Solutions** **Objective:** To gain an insight into urban drainage and nature-based solutions **Chair:** Mr Mark Scrimshaw (Brunel University London and INTCATCH) **Presentation: 15 min talks + 5 min questions (20 min total per presentation)** • Dr Vasiliki Ioannidou (UK) – Hydraulic and design parameters in full-scale constructed Wetlands and treatment units. • Dr Sarah Cook (UK) – The synergy and pathways between microplastic's and solute transport in natural environments. • Mr Kuldeep Swarnkar (India) – Developing a simple mathematical model for solute transport in urban drainage systems. **Facilitated Discussion (20 min)**
15.30 – 16.30	**Poster Session**
16.30 – 17.50	**Session 4: Challenges of Climate Change on Catchment Hydrology** **Objective:** To explore the challenges of climate change on catchment hydrology and identify areas for further research **Chair:** Professor Rajendra Singh (IIT Kharagpur) & Ant Parsons **Presentations: 15 min talks + 5 min questions (20 min total per presentation)** • Dr Jimmy O'Keefe (UK) – Research overview on work exploring feedbacks between land surface and climate. • Mrs Ashwini Pai Panandiker (India) – Projections of future dependable flow in the light of changing climate: A case study of Uguem River in Goa, India. • Mr Richard Dallison (UK) – Modelling the impact of climate change on the sustainability of water supply for a rural catchment (Afon Dyfi) in mid Wales, UK **Facilitated Discussion (20 min)**

17.50 – 18.50	**Session 5: Hydrology and Hydrometry** **Objective:** To explore innovations in hydrology and hydrometry **Chair:** Professor Kapil Gupta **Presentations: 15 min talks + 5 min questions (20 min total per presentation)** • Professor Rajendra Singh (India) – Development of a large-scale conceptual Hydrological Model for India. • DR VK Mini (India) - A study on two extreme weather events in succession over a southern state of India in recent years. **Facilitated Discussion (20 min)**
20.00	**Networking Dinner**

ANNEX B: Details of all presentations and posters

The following table provides short summaries or abstracts for each of the presentations delivered at the workshop. Copies of the presentations are available to IUKWC members on the IUKWC website www.iukwc.org.

List of presentations given during the workshop

Applying scientific approaches to enable land managers to deliver catchment management. **Mr John Bryden, Thames 21, (UK)**
Exploring the role of land managers in integrated catchment management illustrated through a range of innovative projects. Projects include community modelling, mapping traffic pollution, and developing nature-based solutions.
Comparative analysis of catchments and their management diversification: A case from West Bengal, India **Mr Saikat Pal, Rajarhat PRASARI, (India)**
The action research on different catchment management practices has covered four of the six agroclimatic zones of West Bengal, India. Catchment for the springs in the hills (slope>20%) is treated to recharge the aquifers. The recharge zone for the spring on the 'dip' slope of the mountains is located on the 'escarpment' slope. Here the outlet and the catchment of it, belonging to two different micro-watersheds having different degree and direction of slopes. A valley to valley approach of catchment management is adopted, here. The second set of catchment management practices adopted in the red laterite zones (slopes<7%) following conventional ridge to valley approach of watershed management. Coastal alluvium catchments (no slope) are prone to submergence and high salinity. Contiguous rising of the plot beds and earthen field bunds with the excavated soil from same plot, proceeding from valley to ridge, creates an artificial gradient in the catchment and protects the catchment from submergence and salinity. The zone (7-20% slope), at the Himalayan foot-hill is undergoing combined catchment management approach for the open wells, springs and deep tube-wells. The hydrogeological mapping reveals the recharge area, either on the same slope or on the other slope of the source.

Challenges in managing urban catchment: Case study of Thane city **Dr Vinay Nikam (India)**
Thane city is one of the residential hubs of Mumbai Metropolitan Region on the West coast of India. Thane city is developing in an exponential scale due to relatively lower housing prices. The administrative jurisdiction of Thane Municipal Corporation (TMC) spreads over an area of 12823 Ha. The population of Thane city according to Census survey (2011) is 1.86 million. The Thane city is a catchment area of Thane creek, Ulhas River estuary and 35 lakes within city. Rapid development has increased the pressure on city managers to developed physical, social and environmental infrastructure for managing catchment area. TMC has prepared the vision document and city development plan (CDP) for implementation of various projects for managing catchment. Limited funds and high population growth has been witnessed against the forecasted pollution on which CDP was designed, thus restraining the success of projects at city level. Present paper covers the various efforts made by TMC for managing catchment pollutants at source viz: regulation of effective wastewater treatment and recycling by decoding its Development Control Regulation (DCR), managing and treating solid waste, lining major storm water drains, wetland management.
Inter-institutional networks for catchment sustainability: insights from Sutlej river basin management in India **Dr Azhoni Adani (India)**
Institutions, governmental and non-governmental, play a key role in maintaining and governing environmental sustainability. The interaction amongst institutions operating at different scales and in different sectors impact the way policies and hydrological models are translated into reality. Top down approaches, when segmented and segregated lead to contradictions, barriers, and bottlenecks between the various institutions and policies, leading to implementation barriers. To maintain the sustainability of water resources in a river basin or a political boundary these barriers must be identified contextually and frame enabling mechanisms and institutional structures that provides a compliment to the understanding of hydrological models. In this study, inter-institutional networks analysis across administrative scales and sectors in the state of Himachal Pradesh, India was carried out to identify such bottlenecks for cross-institutional interactions. It provides important insights into the current institutional mechanisms and approaches of maintaining the sustainability of water availability in the case study area and thereby provides useful insights for strategizing improved and coordinated water governance.
Catchment management for securing water supplies in the Tungabhadra sub-basin of Krishna basin in Karnataka State of India **Dr Somasekhar Rao Polisetti (India)**
The paper discusses the development of key result area of catchment management for enhancing the water security in the Tungabhadra sub-basin and the possible activities to be implemented in the river basin plan. The paper also discusses the stakeholder participation and communication aspects.
Innovative approaches to water quality monitoring – INTCATCH **Dr Nathalie Gilbert, Thames 21, (UK)**
Introducing the INTCATCH project and illustrating the citizen engagement and harnessing volunteers in water quality monitoring and management.

Agricultural utilisation of waste water: Potential benefits and threats.

Dr Rajeev Singh, IESD, BHU Varanasi (India)

Unplanned development and urbanization accompanied by industrialization and global population explosion across the world has caused critical crisis of fresh water day by day. Waste water production and its proper treatments have become one of the major environmental concerns worldwide. In many developing countries including India, wastewater is one of the reliable water supply for crop production (cereals and vegetables), specially where freshwater supply is insufficient; high nutrient content in waste water helps reduce input costs; provides a perfect medium, e.g., for aquaculture, and can refill groundwater reserves.

Both opportunities and obstacles of wastewater utilization have been reported for agricultural application of waste water. As the wastewater is a rich source of essential plant's nutrients, in several cases wastewater irrigated crops showed higher vigour and yield; but with inconsistent physiological and biochemical response. Presence of potential toxic metals (PTE) in waste water sometimes restricts the uses for irrigational purposes due to high possibility of risks, of food chain contamination, soil contamination etc. As wastewater irrigation expands, human health risks are critical and one of the major concerns, because of possible exposure to a range of contaminants along with the benefits to food security, nutrition and livelihoods.

A stakeholder driven approach to mapping diffuse microbial pollution risk in catchments

Dr David Oliver, Sterling University, (UK)

Effective management of diffuse microbial water pollution from agriculture requires a fundamental understanding of how spatial patterns of microbial pollutants and hydrological connectivity vary over time at the landscape scale. The aim of this study was to develop a decision-support tool (DST) for assessing E. coli delivery to streams by integrating two existing models: (i) a source model predicting E. coli burden on agricultural land; and (ii) a hydrological risk mapping tool (SCIMAP). Here we report on the modification of the SCIMAP approach to predict E. coli pollution risk to surface waters from diffuse landscape sources and outline:

1. The development of a national-scale dataset of E. coli loading to land;

2. The integration of this new E. coli national-scale burden layer into SCIMAP to enable novel prediction, and mapping, of spatial 'hotspots' of E. coli delivery to the stream network in catchments;

3. The importance of engaging stakeholders and using participatory approaches in the co-design of environmental models and DSTs for managing water quality;

4. Opportunities and challenges for international transferability of our approach.

The resulting DST provides underpinning evidence to help inform spatially-targeted decision-making with respect to managing E. coli risk in agricultural environments.

Hydraulic and design parameters in full-scale constructed wetlands and treatment units.

Dr Vasiliki Ioannidou, Birmingham City University (UK)

The efficiency of pond and constructed wetland (CW) treatment systems is influenced by the internal hydrodynamics and mixing interactions between water and aquatic vegetation. In order to contribute to current knowledge of how emergent real vegetation affects solute mixing, and on what the shape and size effects are on the mixing characteristics, an understanding and quantification of those physical processes and interactions were made. This presentation presents results from tracer tests conducted in six full-scale systems in the UK under different flow regimes, operational depths, shapes and sizes, and in-/outlet configurations. The aim was to quantify the hydraulic performance and mixing characteristics of the treatment units, and to investigate the effect of size and shape on the mixing processes. Relative comparison of outlet configuration, inflow conditions, and internal features between the six different treatment units showed variations in residence times of up to a factor of 3. A key outcome of this study was that the width is a more important dimension for the efficiency of the unit compared to the depth of the treatment unit. Results underlined the importance of investigating hydrodynamics and physics of flow in full-size units to enhance treatment efficiency and predictions of water quality models.

The synergy and pathways between microplastic's and solute transport in natural environments

Dr Sarah Cook, Warwick University, (UK)

An understanding of how microplastics interact in a fluvial system is required to elucidate where they 'end up' within a catchment. Increasing urbanisation within India is exerting immense pressure on city water utilities as such plastics are directly washed into effluent. Current management systems are based on outdated tools that do not accurately describe the pathways of these pollutants in real-life scenarios. As such, there is an urgency to acquire the necessary knowledge if the protection and enhancement of India's natural water quality are to be fully realised. Here we present data on the longitudinal dispersion of microplastics in laboratory-based flumes. We use fluorometric principals to track the movement of both fluorescent dye and fluorescent stained microplastics (polyethylene_ in purpose-built laboratory flumes with existing solute transport technology. Data is also presented from our living field "laboratory" in the waters of Mumbai, India

Developing a simple mathematical model for solute transport in urban drainage systems.

Mr Kuldeep Swarnkar, IIT Bombay (India)

As part of the India-UK Project titled "Pathways and Evolution of Pollutants: Interaction between Physical Controlling Effects and Pollutant Bio-degradation" the aim of this work is to develop a simple mathematical model for solute transport in urban drainage systems. It is proposed to carry out a mathematical simulation to characterize the fate and transport of water-borne solutes in urban water system. This research will explore a catchment-scale 'minimum data approach'. The research is expected to deliver a decision support tool for verifying mathematical description for residence times. This is aimed at benefiting the local stakeholders.

Research overview on work exploring feedbacks between land surface and climate.
Dr Jimmy O'Keefe, Imperial College (UK)

Population growth, urbanisation and environmental change are leading to increased water stress. This impacts many millions of people worldwide, and it is typically the most vulnerable in society who are most affected. Solutions require understanding the feedbacks between humans and their surrounding natural environment; a significant research challenge given the inherent complexity which exists within the system.

This presentation will provide a research overview on our work exploring feedbacks between the human and natural environments, in collaboration with our Indian and UK colleagues. The talk will describe the creation of and outcomes from our modelling tools, developed for socio-hydrological system understanding and catchment management, while also highlighting the extensive field work undertaken in the north Indian region. This has involved collection of both hydrological and water user information through stakeholder interaction and our in-house, low cost, robust sensor development and deployment.

Projections of future dependable flow in the light of changing climate:
Mrs Ashwini Pai Panandiker (India)

Considering that the political and technical measures to adapt to climate change are implemented at a regional/local level; site-specific studies are urgently needed. It is in this context, that this study was undertaken at a watershed level for the Uguem River in South Goa.

The future climate parameters of precipitation and temperature were generated using the regional climate model PRECIS. A 30-year baseline data, climate scenario A1B SRES, and a resolution of 25 X 25 km were used for the projections. The PRECIS output was provided as an input to the hydrological model, QSWAT (version 1.2) and streamflow was simulated. After calibration of QSWAT model, a Nash Sutcliffe Efficiency and R2 of 0.7 were obtained indicating a good fit. Streamflow predictions were done till the year 2050. The streamflow is likely to decrease in the decades of 2040s and 2050s. To comprehend the temporal variation in water availability in the future, dependable flow and peak flow analysis was done. Based on the results, site-specific recommendations have been provided for better management of the water resource.

Modelling the impact of climate change on the sustainability of water supply for a rural catchment (Afon Dyfi) in mid Wales, UK
Mr Richard Dallison, Bangor University (UK)

Key amongst challenges facing UK water supply is climate change, the impacts of which on surface water quantity (seasonality and extreme events) and consumer demand are uncertain. This is particularly true in supply zones reliant on abstraction directly from river channels, potentially affecting the ability of water companies to fulfil demand.

In this study, we use the Soil and Water Assessment Tool hydrological model to investigate the impact of future climate change on the abstraction potential of the Afon Dyfi catchment in mid-Wales. We consider a worst case scenario approach using an ensemble of 12 regionally downscaled climate

models (to account for uncertainty), from UKCP18 projections, based on Representative Concentration Pathway 8.5. To estimate future water demand we extrapolate historic catchment trends between weather factors and total water abstraction to the future period. The impact of climate change on water supply and demand is compared for the periods 2020s-30s, 2040s-50s and 2060s-70s, allowing informed operation and planning decisions for the short, medium and long term. We envisage this approach allowing for robust future planning of water resource allocation and supply provision, both within the studied area as well as at similar locations elsewhere in the UK.

Development of a large-scale conceptual Hydrological Model for India.

Professor Rajendra Singh (India)

Large-scale hydrological modelling is viewed as one of the powerful tools to develop required scenarios for sustainable development and management of water resources. This study aims at developing a large-scale conceptual hydrological model, Satellite-based Hydrological Model (SHM), with the long-term objective of utilising the relevant products, e.g., soil moisture, evapotranspiration, etc., based on the data fetched from the Indian Remote Sensing Satellites. The model simulations at daily time steps are eventually expected to generate various outputs that could be utilised for proper water resources management in the country. SHM has grid cells of 5 km . 5 km resolution and has a modular structure with five modules: Surface Water (SW), Forest (F), Snowmelt (S), Groundwater (GW) and Routing (ROU). A robust hierarchical operational testing scheme has been adopted to test the credibility of the developed model in the Subarnarekha basin, India. The results of the proxy-basin and differential split-sample tests confirm that the model is both geographically and climatically transposable. Further, the uncertainty analysis, using quantile regression technique, represents reasonable predictive ranges, e.g., for a sub-basin calibration and validation 95 per cent prediction uncertainty (PPU) band encloses 63% and 76% of the observations.

A study on two extreme weather events in succession over a southern state of India in recent years.

DR VK Mini (India)

A study has been done on two recent extreme weather events on hydrological aspect over a tropical state of India – Kerala. One is on the Very Severe Cyclonic Storm (VSCS), Ockhi formed during November – December 2017 over southwest Bay of Bengal and Arabian Sea, which caused unprecedented heavy casualties to fishermen community of Kerala and the other is on the devastating flood in Kerala during August 2018. The causative factors in synoptic and sub-synoptic scale for both these events have been analysed and presented. Ockhi originated from a low pressure area which formed over southwest Bay of Bengal (BoB) and adjoining areas of south Sri Lanka & Equatorial Indian Ocean on 28th November and it emerged into comorin area. There was rapid intensification of cyclone during its genesis stage of Ockhi, as it intensified into a CS within 24 hrs from the depression stage. It further intensified into a Severe Cyclonic Storm (SCS) on 1st Dec and Very Severe Cyclonic Storm (VSCS) over southeast (SE) Arabian Sea to the west of Lakshadweep in the afternoon of 01st Dec. After its movement over Arabian sea for next four days, it crossed South Gujarat coast as a well-marked low around early morning of 6th Dec. Kerala experienced exceptionally high rainfall during 8-16 August 2018 in two consecutive spells leading to devastating floods in many parts of the state. The number of casualties in Kerala because of these two extreme rainfall events was too high. The main factors for the occurrence of heavy rainfall over Kerala were strong westerly/south westerly winds over the Arabian Sea along and off Kerala coast, associated with the depression over northwest Bay of Bengal. Vorticity, divergence, low level convergence and directional shear of wind for two days in advance of occurrence of these extreme weather systems are also analysed and studied in this paper.

Assessment of hydro-climatological induced regional evapotranspiration over Krishna river basin.

Dr Rehana Shaik , International Institute of Information Technology Hyderabad, (India)

Evapotranspiration (ET) is the largest water flux next to precipitation representing atmospheric water demand and defining the surface water availability. At regional scales the ET flux is influenced by the regional climate, land use changes under human interventions of the land scape, water withdrawals from the rivers for agricultural practices etc. The conventional forms of ET are Potential Evapotranspiration (PET), Actual Evapotranspiration (AET), Reference Evapotranspiration and pan Evaporation. Among these, AET is the commonly used regional hydrological variable representing the evaporation from land and open water and transpiration from vegetation. Empirical models to estimate AET based on PET and precipitation are based on specific climatological conditions without considering the available water balance over the catchment. The talk will mainly focus on the possibilities of estimating AET accounting for water balances at river basin scales. Further, the study analyses the contributions of PET and AET estimated based on empirical models. The study considered the Krishna River Basin, fifth largest river system in central India, to study the evaporative water demand accounting for the river water balances.

Detection and delineation of water bodies in Hilly regions using CartoDEM SRTM and ASTER GDEM data.

Dr Komali Kantamaneni , Solent University (UK)

Detection and delineation of Water Body Area (WBA), particularly over the inaccessible hilly region is not always possible in view of time, resources and cost issues. An automated procedure for detection and delineation of water bodies in the hilly area was performed using satellite-derived DEMs. CartoDEM, SRTM and ASTER GDEM data with 30, 90 and 30 m resolutions, respectively to generate the Elevation Points Features (EPF) in GIS platform. Total 7194906 EPFs were produced using these three DEMs. Contour and slope maps were also prepared to eliminate the outlier EPFs (non-water bodies) with flattered surface logic. Flattened area on DEMs, connected contour at edges of water bodies and 0° to 0.5° slopping area were considered as WBA in the region (2311 Km2) of Western Ghat (India). The nearest neighbour to cubic convolution conversion of DEMs was found useful for detection of the boundary of water bodies more precisely. These results were validated from Landsat-8 satellite images and topographic maps (Survey of India). About 3.09% from CartoDEM, 2.22% area from ASTER GDEM and 4.38% from SRTM DEM were estimated as WBA. CartoDEM data can be suggested for precise detection of smaller water bodies in the hilly region. Methodology formulated in this study could be used as a rapid assessment tool for detection of water bodies, particularly in the inaccessible region for better water resources management.

Assessment of supply – demand by using Water Evaluation and Planning model for Ur river watershed, Madhya Pradesh, India

Dr Ajai Singh, Central University of Jharkhand, Ranchi (India)

In the present study, an attempt has been made to apply WEAP-MABIA model to prepare link-node based schematic to develop spatially distributed model that are used for the analysis and simulation of agricultural water demands in the Ur river watershed in Tikamgarh district, Madhya Pradesh. The proposed model was setup by subdividing the whole watershed into 8 sub-watersheds based on geomorphologic and topographic watershed characteristics. To estimate domestic water demand, the population data from Census 2011 was used while for livestock, livestock Census 2007 data was used. The Kharif and Rabi crops coverage data was obtained from analysis of high resolution remote sensing (Cartosat satellite) data having resolution of 2.5m which was also verified with the data available in the district agriculture report. In this study, year 2013 is used as base year and then water demands and supply requirement of various catchments were estimated. The result showed that due to shortage of water in deficit irrigation ET actual cannot meet to ET potential, while in fully irrigation scenario the ET actual is almost equal to ET potential. Crop yield of 11 different crops which are mainly grown in different sub-catchments of Ur river watershed has also been analysed. Crop yield was the maximum for full supply irrigation and minimum for the deficit irrigation condition, also crop yield reduces when stress is allowed during late season stage but yield was obtained considerably appreciable if stress applied during initial and mid-season stage.

List of posters that were presented during the workshop

Catchment assessment and planning in India

Mr Nitin Bassi, Institute for Resource Analysis and Policy (RAP), India.

In India, water is largely a state subject and most of the development and management of the basin water resources take place at the administrative boundaries than on the basis of hydrological units. This often leads to conflict between the upper and lower riparian states, sharing the same river basin, over water availability. Thus, there is an immediate need to formulate approaches which can lead to sound and sustainable development and management of river basins and catchments and which can cater to the growing water demand for societal, economic and environmental purposes. This research study demonstrates the importance of hydrological assessment of river basins and catchments through the use of hydrological model as a tool to support river basin development and management of its water resources. Case studies on preparing water balance and generating scenarios on the likely impact of different catchment management interventions and also of the climate variability and change on the water supply and demand for sub-basins of Narmada and Mahanadi Rivers in India have been discussed. Potential of such hydrological modelling based catchment assessment approach in addressing inter-sectoral water allocation and transboundary (inter-state) water conflicts has also been discussed.

High Frequency automated biogeochemical monitoring techniques to determine pollution sources, nutrient dynamics and their impact on river ecology

Dr Mike Bowes, Centre for Ecology & Hydrology (CEH) UK

Generating hourly water quality data using the latest automated monitoring technologies can provide unique insights into river pollution sources and dynamics. The relationships between total reactive phosphorus (TRP) and nitrate concentration signals and flow have been studied in the River Thames, UK. A combination of hysteresis and load apportionment modelling was used to determine changes in nutrient sources through the annual cycle and each individual storm event. TRP concentrations were mainly dominated by inputs from sewage treatment works (STW), with agricultural diffuse inputs only dominating during storms in May, relating to manure application at this time. The nitrate concentration–flow relationship indicated major inputs from groundwater and to a lesser extent STW. Significant diffuse agricultural nitrate inputs were observed during the first major storms of the winter period. A five-year monitoring programme of the Thames, combining physical and chemical observations and hourly chlorophyll concentrations were used to identify flow, temperature, light and nutrient conditions required to produce algal blooms. This study indicated that for nutrient enriched rivers such as the Thames, manipulating residence time (by removing impoundments) and light/temperature (by increasing tree shading) may offer better solutions for controlling excessive phytoplankton biomass.

Assessing the impact of land use / land cover change dynamics on the performance of Kangsabati reservoir

Dr Pradyna Dhage, Indian Institute of Tropical Meteorology Pune, India

The performance of the Kangsabati irrigation project was assessed under historical and future LU/LC change scenarios using Integrated Reservoir Canal Irrigation Model (IRCIM). In order to assess the impact of LU//LC change dynamics, two scenarios were considered: (I) Existing LU/LC (Year 1999) and (II) projected LU/LC (Year 2025). Cellular Automata (CA) - Markov was used for prediction of land use scenario for year 2025 based on past land use/ land cover dynamics and Distributed SCS CN module with Muskingum routing technique was used for prediction of reservoir inflow. Thereafter, the impact of change in LU/LC was assessed on the system performance.

Understanding the spatial differences in terrestrial water storage variations in the Indus, Ganga, and the Brahmaputra river basin.

Mr Jaydeo Dharpure , Indian Institute of Technology, Roorkee, India

The spatio-temporal variability of terrestrial water storage anomalies (TWSA) was analysed using the Gravity Recovery and Climate Experiment (GRACE) data for the Indus, Ganga, and the Brahmaputra (IGB) river basin from January 2003 to December 2016. The non-parametric Mann-Kendall test and Sen's slope methods were used for trend estimation. The data was evaluated via monthly, seasonally and yearly of the study area. The mean annual TWSA trend was decreasing with significant ($p < 0.01$) over the region. The monthly and seasonal variations in TWSA showed a significant decreasing trend in all the river basin. The spatial variations in TWSA indicate significant spatial differences in all seasons. The results also showed that TWSA decreases with a higher rate in the middle part of the IGB basin compared to the western and southern region with statistically significant. The result indicates that the high mass variations over the areas could be largely controlled by the meteorological as well as hydrological variables.

Working at the science-policy interface: Lessons from CREW on emerging issues and innovative approaches to monitoring and management in Scotland.

Dr Rachel Helliwell , James Hutton Institute, (UK)

The presentation will draw on a selection of emerging hot topics identified by stakeholders that are a concern to catchment managers and regulators. Selected topics will range from understanding the potential implications of climate change on private supplies to novel faecal indicator organism monitoring techniques. In addition a summary of key outcomes from the World Water Day event (22nd March 2019), on resilience to drought and low flow conditions in Scotland will be presented.

Evaluating CHMs and GHMs simulations of droughts across eight large river basins.

Mr Amit Kumar, University of Nottingham (UK)

We evaluated simulations of runoff from nine catchment scale hydrological models (CHMs) and eight global scale hydrological models (GHMs) over eight large river basins: Upper Amazon, Lena, Upper Mississippi, Upper Niger, Rhine, Tagus, Yangtze and Yellow. The simulations were conducted within the framework of phase 2a of the Intersectoral Impact Model Intercomparison Project (ISIMIP2a). We evaluated the ability of the CHMs and GHMs to simulate observed monthly runoff and hydrological droughts over 30 years. Observed and simulated hydrological drought events were identified using the Standardised Runoff Index (SRI). Our results show that the GHMs and CHMs performed well in representing observed monthly runoff. However, in the case of drought events, simulations from individual GHMs and CHMs did not perform as well. The number of drought events identified at all intensity levels (i.e. SRI values equal to -1, -1.5, -2, -2.5 and -3) varied significantly for each individual model. While low intensity events were simulated relatively well, all the models, as well as the two ensemble means (GHMs and CHMs) present limited ability to accurately simulate high intensity drought events in all eight basins, in terms of their timing and intensity. By analysing the monthly runoff time-series for several extreme droughts over the historical period, we identify opportunities for improving the models so that extreme droughts may ultimately be better represented by CHMs and GHMs.

Making the most from nature: modelling catchment management measures to reduce treatment costs.

Dr Andrea Momblanch, Cranfield Water Science Institute – Cranfield University (UK)

Nature-based catchment management measures can enhance the water purification capacity of rivers and their associated basins, thereby, providing improved water quality and reducing drinking water treatment costs among other benefits. Catchment and in-stream water quality models are useful tools that allow analysing the evolution of many pollutants and their interactions. They are able to capture upstream-downstream effects and provide results on the effectiveness of the measures. When linked with an ecosystem services approach, these models also help determining the most cost-beneficial measures. The poster shows different studies which combine water quality modelling with ecosystem services assessments to define and test catchment management measures and support decision making in relation to their prioritisation and financing options.

Short to sub -seasonal streamflow forecast for the natural inflow reservoirs.

Mr Amar Tiwari, Indian Institute of Technology, Gandhinagar, India

Reservoir storage forecast is crucial to mitigate the effect of extreme events like floods and droughts. Despite the need for reservoir storage prediction for planning and decision making, a reservoir storage forecast system is lacking in India. We calibrated and evaluated the daily streamflow for 13 river basins in which major reservoirs are located using the Variable Infiltration Capacity (VIC) model. We get a satisfactory coefficient of determination (> 0.5) for calibration and evaluation between observed and VIC simulated streamflow. We used regrided observed forcing at 0.25° from the India meteorological department (IMD). We used precipitation and air temperature forecasts from the Global Ensemble Forecast System (GEFSv2), 16 products from the Extended Range Forecast System (ERFS) and 5 products from Subseasonal Experiment (SubX) model after regriding at 0.25°. We showed that the 1-day, 7, 15 and 32-days cumulative streamflow forecast could be used operationally to provide a streamflow forecast to the reservoirs in India. These model forecast results further improved substantially by bias correction using Quantile-Quantile mapping for precipitation and air temperature with observed data. Forecasted streamflow to the reservoir at short and sub-seasonal lead time can be valuable for water management related decision making and planning in India.

Performance evaluation of Hydrometric networks in India.

Miss Sreeparvathy Vijay, Indian Institute of Science, Bangalore India

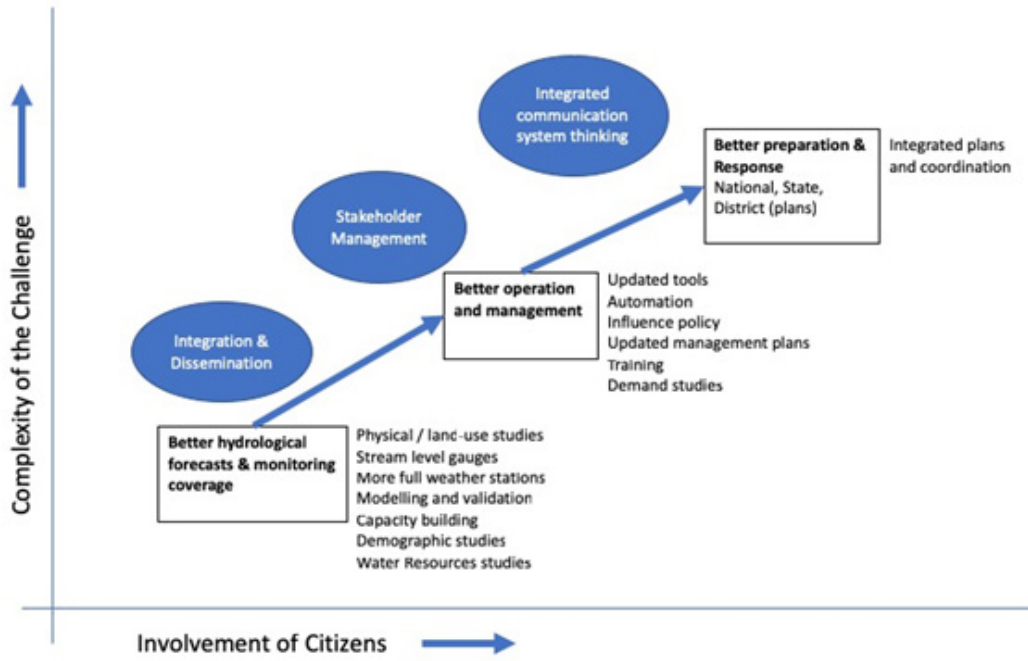
In the past few decades, there is growth in evidence of intensification of global hydrologic/ water cycle due to climate change associated with anthropogenic forcing. In this perspective, an efficient and effective hydrometric network for monitoring the spatio-temporal variation of surface water is highly essential for better catchment management. World meteorological Organization (WMO) recommends periodic reviewal of hydrometric networks to reduce hydrological uncertainty brought by changes in budgetary, data and end user's needs. This is of great significance to Indian context, as there are no periodic reviewal nor prior studies to assess the adequacy of existing hydrometric networks. In this study, the potential of Shannon information entropy approach is made use to assess the adequacy of existing stream gauge networks by identifying stream gauge deficit zones. A regionalization-based approach was also carried out to substantiate whether the existing gauge networks meets the WMO [2008] minimum guidelines for stream gauging networks. Furthermore, prioritization of existing gauges was carried out using the entropy approach. The study concluded that all the stream gauge networks in peninsular India are inadequate for effective monitoring of flows and there is growing need for their expansion.

ANNEX C: Topic Summaries for new Collaborative Projects

The following information captures a summary of two of the proposed new project areas. The detail is limited as these ideas may become project bids.

1.0 Forecasting for operations and smart catchments supply & demand

Building Climate Resilience



2.0 Monitoring Strategies

Problem - Getting the right information to and from the right people in the right way to make important decisions and differences.

- Lack of data – This includes not having access to the correct data, the data quality is not good enough, there isn't enough data on a particular subject and the type of data is not correct.
- We need sufficient data on the different pollutants including, sources, types, impacts, loadings, management, mitigation / interventions.

State of Knowledge – (What we currently understand is happening as a group)

- INTCATCH, Environment Agency & CEH monitoring stations
- Community – NGO's (UK) & India and citizens scientists
- Other innovative sensor research
- Local knowledge and research
- Hyper spectral cameras / earth observations
- Cameras measuring flow
- SMART city intelligence

Solution

- Integrate technology and approaches
- Existing and new data streams including data from people on a perceived problem. Returns / informs decisions that enables action.

Concept

Legacy

- Infrastructure (alert system)
- Key points
  - Who is the community?
  - Empowerment, community driven & management
  - Training – spread the “word of mouth”
  - Connecting communities
  - Innovation pioneers

Back cover image: The Dordogne, France; A. Parsons

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