mountain EVO
environmental virtual observatories

MOUNTAIN EVO INSIGHTS

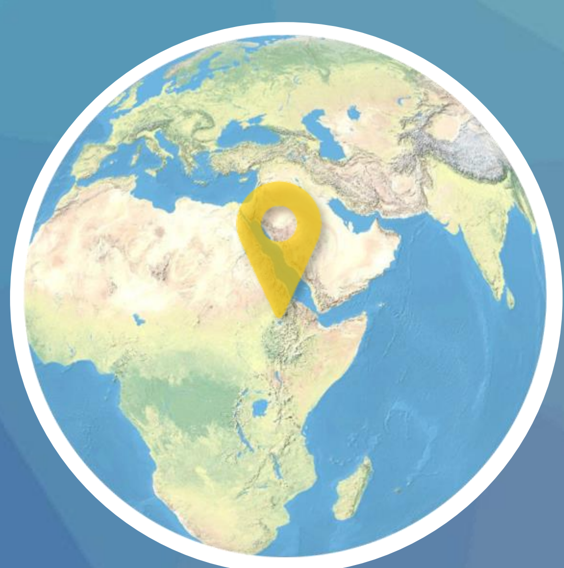
... given by a strongly interdisciplinary team including hydrologists, environmental engineers, human and physical geographers, social scientists, political scientists, software developers and development scholars.

The ***Mountain EVO*** project focuses on using recent conceptual and technological innovations to implement demand-driven and interactive approaches to knowledge generation about ***Ecosystem Services*** in ***four remote and poor mountain regions*** globally.

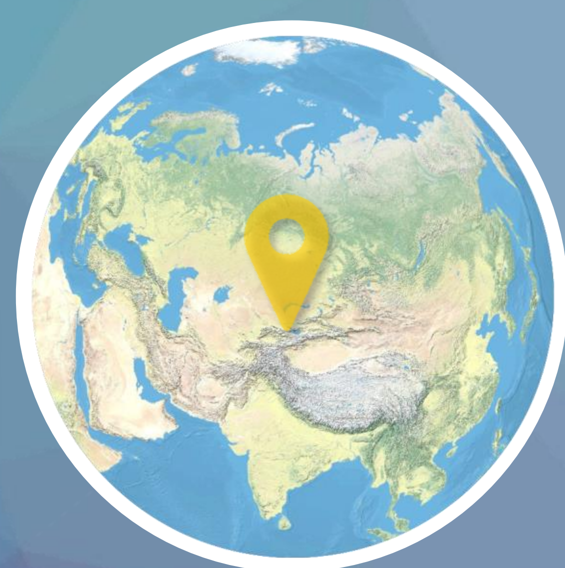
This Insight series has ***eight posters*** summarising key experience and outcomes of the project.

Upper Kaligandaki basin
Mustang, Nepal

Huamantanga
Lima, Peru



Lake Tana region
Amhara, Ethiopia



Central Tien Shan Mountains
Naryn, Kyrgyzstan

MOUNTAIN EVO INSIGHTS

mountain EVO
environmental virtual observatories

Citizen Science: Research for society, with society

Citizen science (CS) is the practice of public participation in research, it:

- brings out a sense of data and project ownership and environmental awareness in communities.
- is not for every project: requires ongoing facilitation and long-term engagement.
- takes various forms: semi-automated sensors, paper-and-pencil, smartphone-enabled observations, collaborative workshops, etc.

What is Citizen Science?

The gathering, processing and distribution of scientific knowledge with and by ordinary people.

A bottom-up practice that takes into account local needs, practices and values.

TRADITIONAL RESEARCH	CITIZEN SCIENCE
INFORMANT	PARTNER
INTERVIEW	DIALOGUE
CONSUL TOOL	CO-DESIGN TOOL
ASSESS SOLUTION	CO-DESIGN SOLUTION
MENTORSHIP	PARTNERSHIP

Figure 1. *Traditional research vs. citizen science*

References: Buytaert, W., Dewulf, A., De Bievre, B., Clark, J., & Hannah, D. M. (2016). Citizen Science for Water Resources Management: Toward Polycentric Monitoring and Governance? Journal of Water Resources Planning and Management, 1816002. http://doi.org/10.1061/(ASCE)WR.1943-5452.0000641 | Buytaert, W. et al., 2014. Citizen science in hydrology and water resources: opportunities for knowledge generation, ecosystem service management, and sustainable development. *Front. Earth Sci*. 2, 1–21. https://doi.org/10.3389/feart.2014.00026

Why we use it?

Citizen Science can:

- enable co-generation of knowledge between scientists and lay people.
- serve policy makers by raising awareness about environmental issue.
- increase transparency and accountability.

What is Participatory Monitoring (PM)?

A structured collection of observations of natural resources by local people.

Growing availability of ICTs makes PM suitable also for development contexts.

Monitoring data can feed in to EVOs to be combined with other data sources.

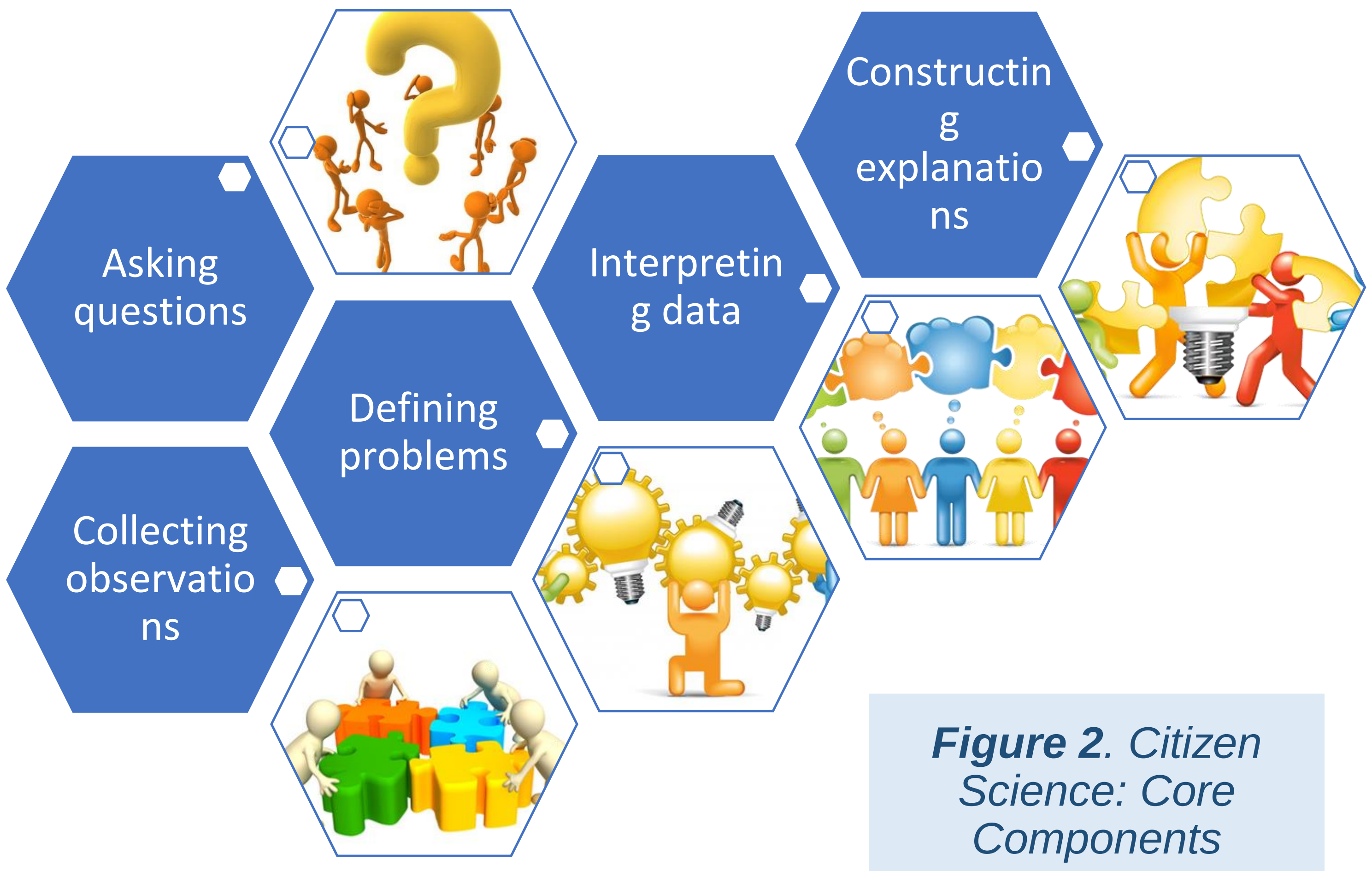


Figure 2*. Citizen Science: Core Components*

Figure 3. *Experimental water reservoir in Huamantanga, Peru*

Can be cited as: Mountain-EVO (2017). Citizen Science: Research for society, with society. Retrieved from http://paramo.cc.ic.ac.uk/espa/

http://paramo.cc.ic.ac.uk/espa/

mountain EVO

MOUNTAIN EVO INSIGHTS

mountain EVO
environmental virtual observatories

Theory of change as a tool for managing and evaluating multi-stakeholder projects

- Ecosystem services projects are *multi-stakeholder* and *embedded* in *coupled social-ecological systems* - hence requiring *participatory management*
- **Theory of change** is a useful tool not only for monitoring and assessment but also for *structuring* stakeholder communication and decision making
- Effective use of theory of change requires *reflexivity* and *flexibility*: two core elements of organisational learning

What is a Theory of Change?

An explanation of how a group of stakeholders expects to reach a commonly understood long-term goal

Why use it?

- A useful tool for strategic planning, monitoring and assessment
- In multi-stakeholder projects: a tool for structured communication throughout the project
- Fosters learning within and across stakeholder groups (i.e. local community members, development practitioners and academia)

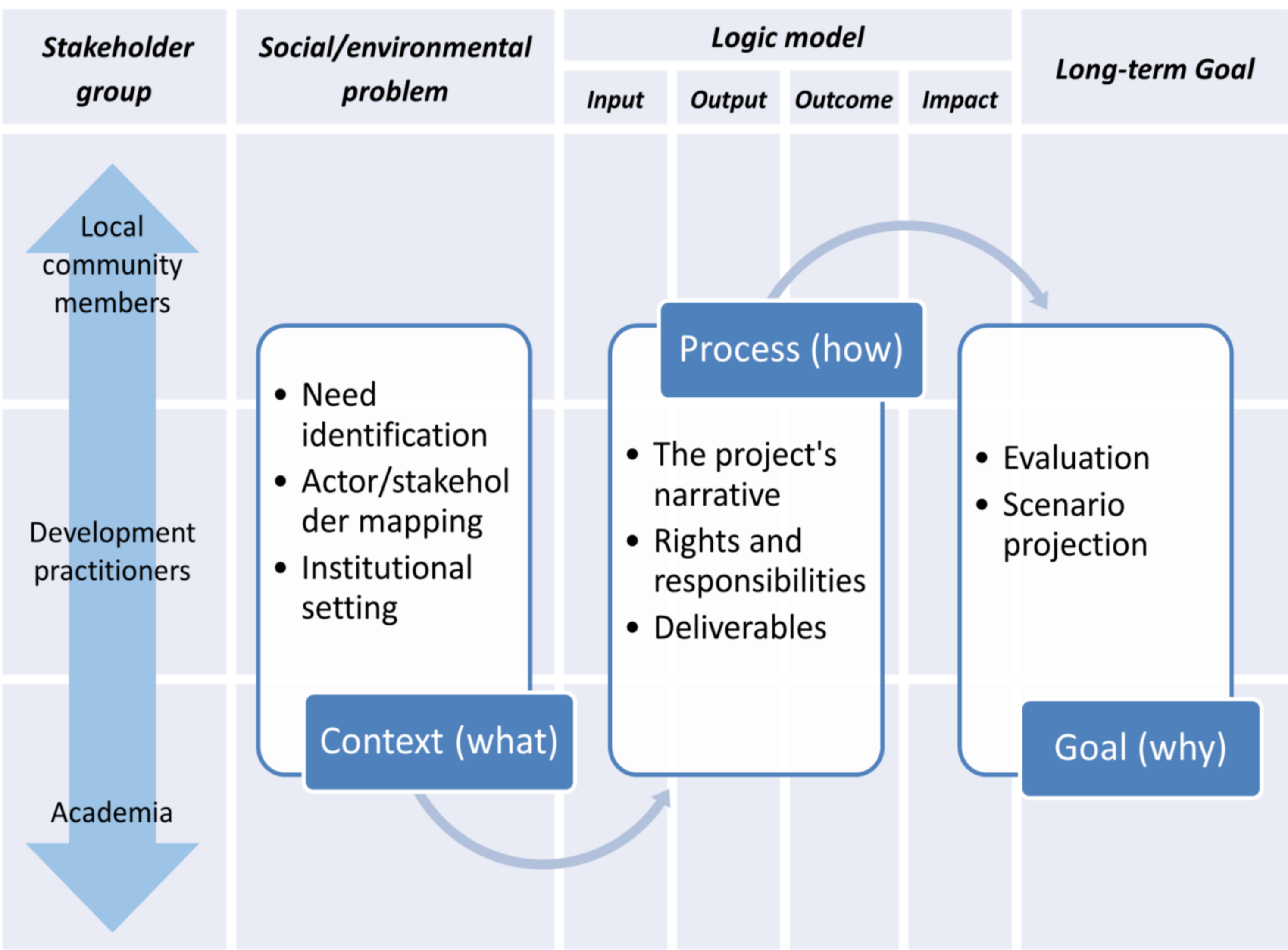


Figure 1*. Theories of change: dynamic and stakeholder specific*

Problematising impact assessment

- Theory of change **encourages a structured approach to project evaluation** by creating a targeted project narrative and setting clear thresholds for implementation
- At the same time, they tend to prioritize the project logic ('metanarrative'), crowding out counter – narratives, endangering the project's participatory credentials

Pros:	**Cons:**
Establishing conceptual clarity	Limiting adaptability
Making implicit assumptions explicit	Oversimplifying social reality
Identifying short and long term objectives for different stakeholders	Underestimating external circumstances
Enabling more meaningful communication and evaluations	Overlooking externalities and spill-overs
	Endangering sustainability prospects
	Time and resource consuming

Figure 2. *Theory of change in use: pros and cons.*

Case study experience: Huamantanga

- Applied retrospectively, theory of change allows us to reconstruct the stakeholders' perspectives on the project's purpose and objectives; enabling descriptive assessment
- The research revealed substantial discrepancies between the perspectives of different stakeholders regarding Mountain-EVO's *purpose* and *goal*
- We find *knowledge creation* to be recognised as a common goal by all three stakeholder groups
- Considering the nature of Mountain-EVO as a *pilot research project* (not purely development project) we recommend the following:
    1. Recognising *process* as *impact* – awareness, understanding, and experimentation are all stages of citizen participation in research
    2. Shifting from Linear Outcomes Logic (OLM) to Dynamic Models – allows for flexibility and adaptation that are the pillars of participatory management

Reference: Cieslik, K., Dewolf, A., Karpouzoglou, T. (forthcoming). Theorizing Change - Mapping Stakeholders' Perspectives on the Ecosystem Services Project in Huamantanga, Peru.

Can be cited as: Mountain-EVO (2017). Theory of change as a tool for managing and evaluating multi-stakeholder projects. Retrieved from http://paramo.cc.ic.ac.uk/espa/

MOUNTAIN EVO INSIGHTS

mountain EVO
environmental virtual observatories

espa ecosystem services for poverty alleviation | Imperial College London | University of Birmingham | Wageningen University & Research | CONDESAN | Society of Hydrologists and Meteorologists | University of Central Asia | Cornell University | Universiteit Antwerpen | Freie Universität Berlin | United Nations Educational, Scientific and Cultural Organization

Building hydrological monitoring **sensor networks** with low-cost technologies

Thanks to the development of **low-cost Information and Communication Technologies (ICTs)**, the barrier and cost of building hydrological monitoring networks has significantly reduced.

This poster visually presents how hydrological sensor networks in rural areas can be **understood and assembled** at different scales, from (1) individual technologies and components, to (2) basic network nodes, to (3) local and regional hydrological sensor networks.

ICT components

Low cost monitoring networks are usually built with ICTs that are inexpensive, energy efficient, have large learning communities, and a variety of types (Figure 1).

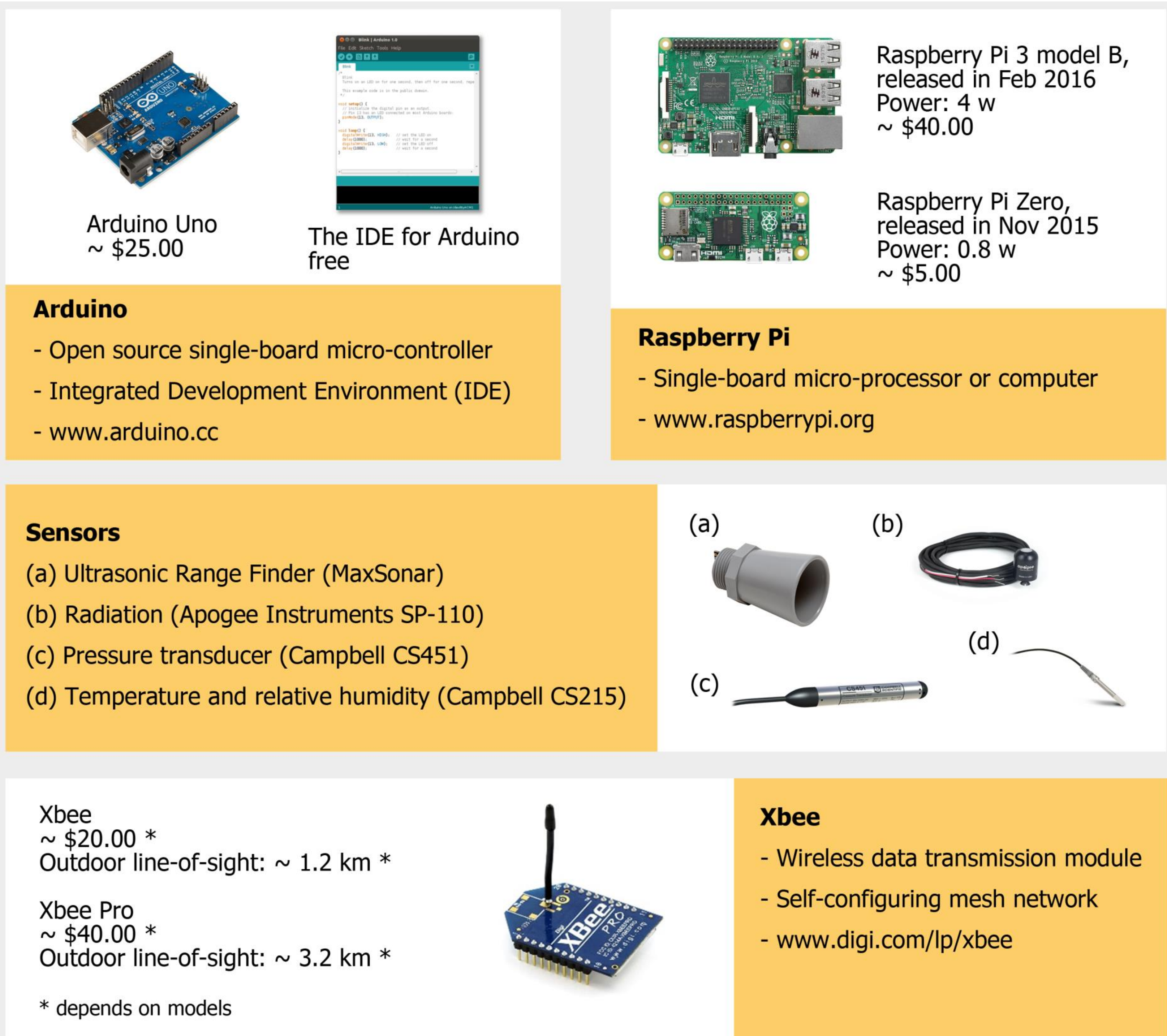


***Figure 1**. Examples of low-cost technologies and components.*

References: Buytaert, W., Dewulf, A., De Bièvre, B., Clark, J., & Hannah, D. M. (2016) Citizen Science for Water Resources Management: Toward Polycentric Monitoring and Governance? J. Water Resour. Plan. Manag. 142, 1816002. http://doi.org/10.1061/(ASCE)WR.1943-5452.0000641 | Karpouzoglou, T., Zulkafli, Z., Grainger, S., Dewulf, A., Buytaert, W., & Hannah, D. M. (2016) Environmental Virtual Observatories (EVOs): prospects for knowledge co-creation and resilience in the Information Age. Curr. Opin. Environ. Sustain. 18, 40–48. http://doi.org/10.1016/j.cosust.2015.07.015 | Buytaert, W. et al., 2014. Citizen science in hydrology and water resources: opportunities for knowledge generation, ecosystem service management, and sustainable development. Front. Earth Sci. 2, 1–21. https://doi.org/10.3389/feart.2014.00026

Basic network nodes

Network nodes are composed of certain ICT components, and each has certain functions and roles in the network (Figure 2).

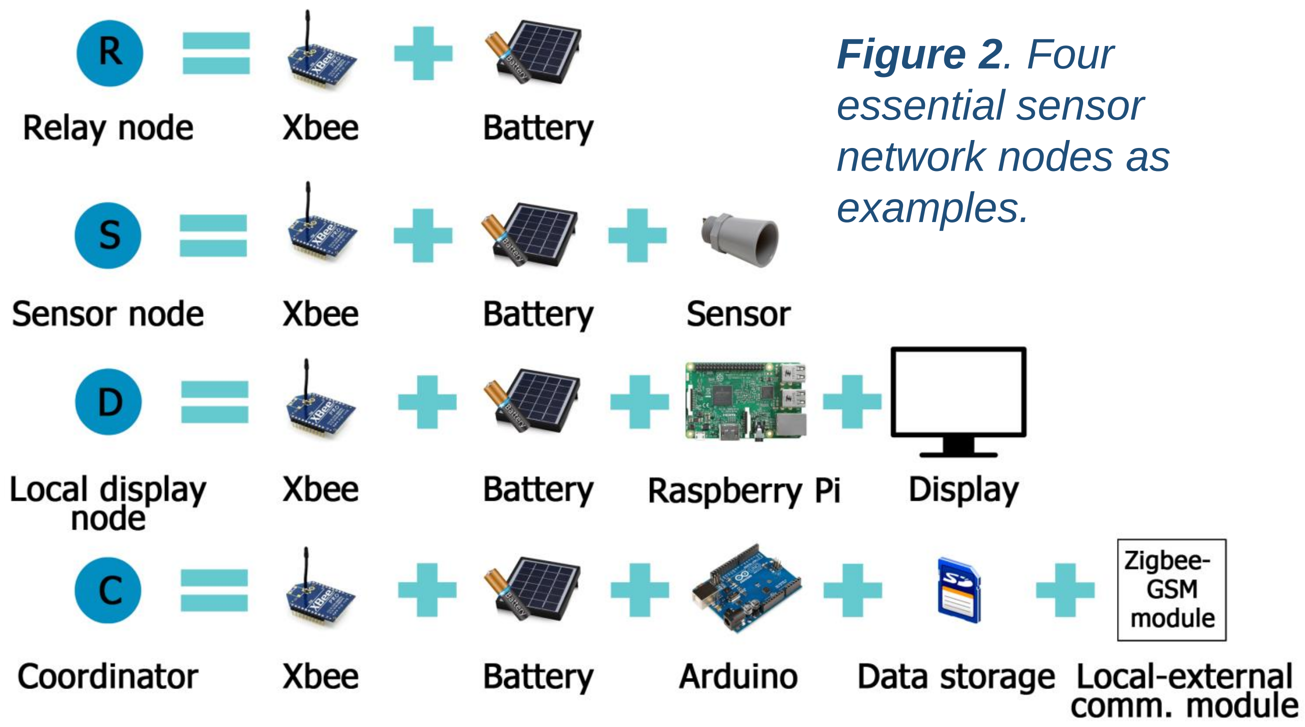


***Figure 2**. Four essential sensor network nodes as examples.*

Sensor network

In simple words, a sensor network is a collection of connected nodes (see Figure 2). Figure 3 demonstrates an example network scheme.

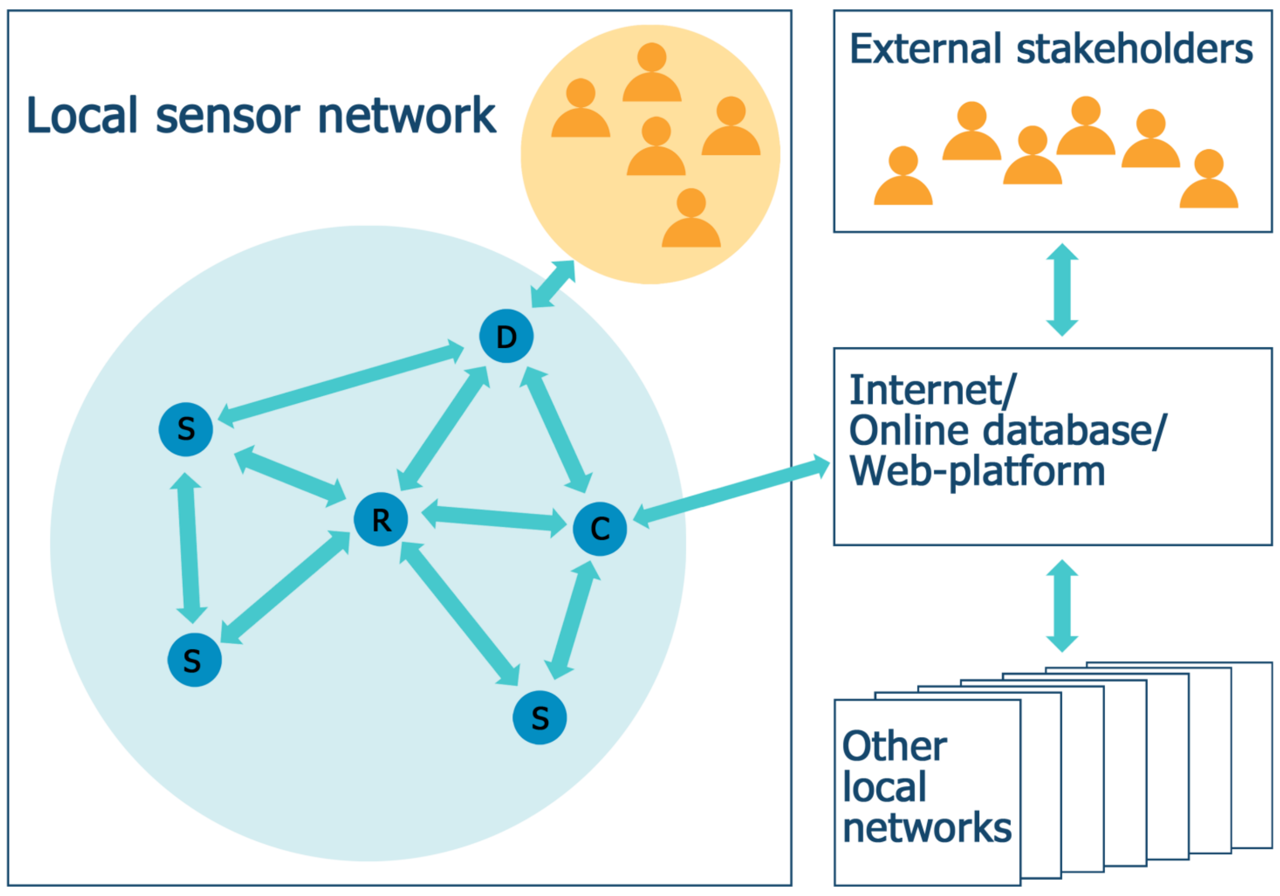


***Figure 3**. An example scheme of hydrological sensor network.*

Take home messages

- Low-cost ICTs provide opportunities to build inexpensive sensor networks to monitor hydrology in remote areas.
- We need to consider the conditions in rural areas, such as limited electricity accessibility, internet coverage, or ICT capacities.
- Stakeholder engagement is crucial to the success of these monitoring networks. e.g.,
  - Co-designing the network and participatory monitoring with local community members
  - Making the collected data locally useful
  - Connecting local and external stakeholders

Can be cited as: Mountain-EVO (2017). Building hydrological monitoring sensor networks with low-cost technologies. Retrieved from http://paramo.cc.ic.ac.uk/espa/

http://paramo.cc.ic.ac.uk/espa/

mountain EVO

MOUNTAIN EVO INSIGHTS

mountain EVO
environmental virtual observatories

espa ecosystem services for poverty alleviation | Imperial College London | University of Birmingham | Wageningen University & Research | CONDESAN | Society of Hydrologists and Meteorologists | Cornell University | Universiteit Antwerpen | Freie Universität Berlin | University of Central Asia | United Nations Educational, Scientific and Cultural Organization

Hydrological data **visualisation** in remote mountain communities

Visualisations can be powerful tools to engage remote communities with hydrological information, potentially useful for day-to-day water management.

Visual products or tools should be driven by user needs and characteristics and ideally co-developed in collaboration with community members (end users). This poster summarises **three options** we co-developed during this project.

Paper-based infographic poster

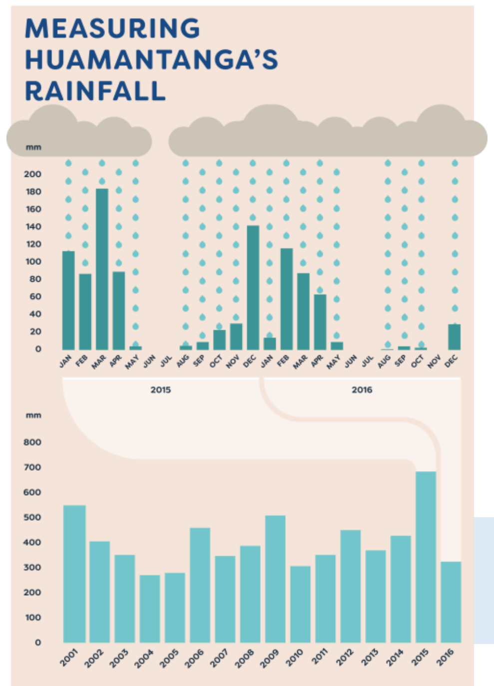


Figure 1. An example infographic poster.

Pros

- Low cost/tech
- Easy to install
- Publically accessible
- Large display

Cons

- Limited information complexity
- Limited user interaction
- Out of date quickly
- Requires specialist design expertise

Figure 2*.*
Above: A co-designed matrix board from the Peruvian case.
Right: A concept illustration for an on-site board.

LED matrix board

Pros

- Publically accessible
- Real time data.
- Weather resistant
- Does not require specialist design expertise

Cons

- Limited information complexity
- Limited user interaction / immersion
- Development, testing and maintenance cost
- Energy consumption, especially when installed outdoors

Monitoring screen in rural information centres

Pros

- Real time / complex / detailed information
- User interaction / immersion

Cons

- High development and maintenance cost and energy consumption
- Requires specialist design expertise

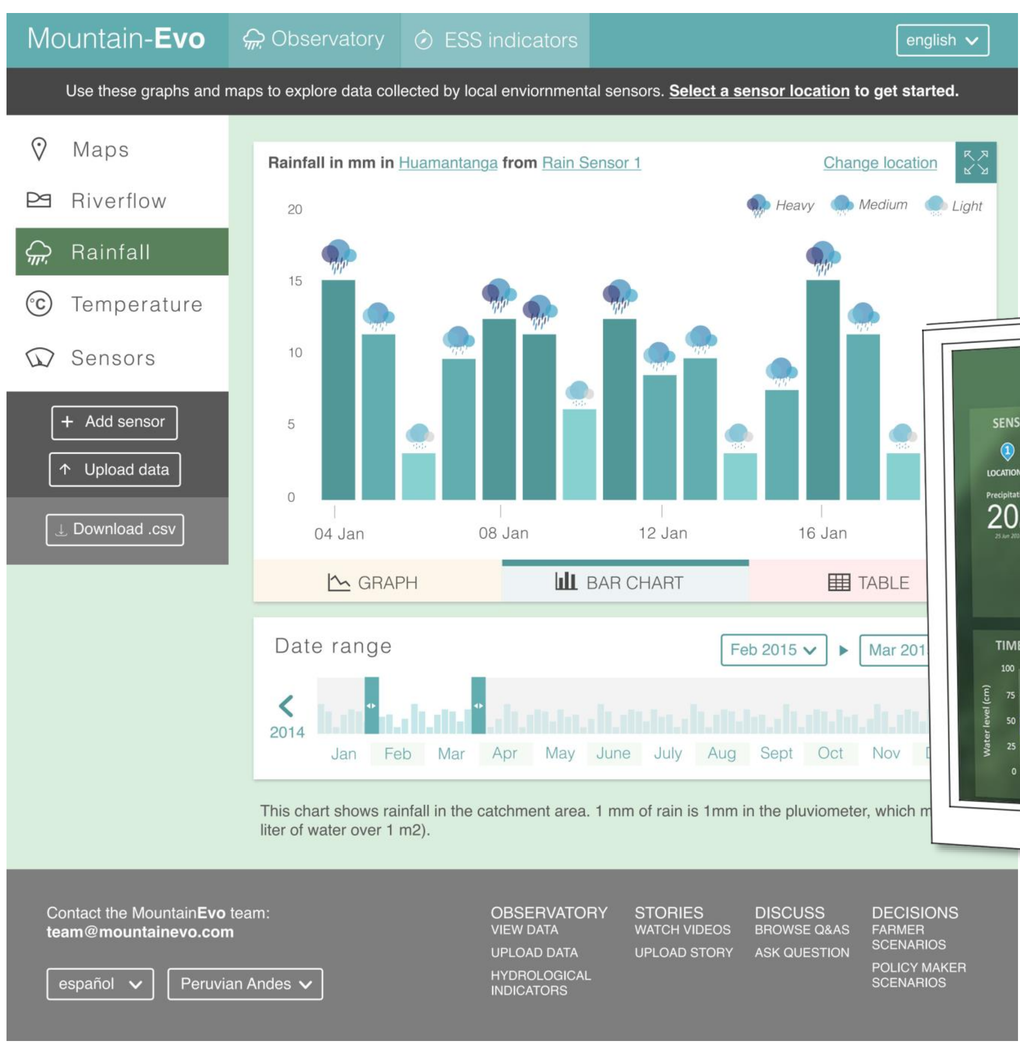
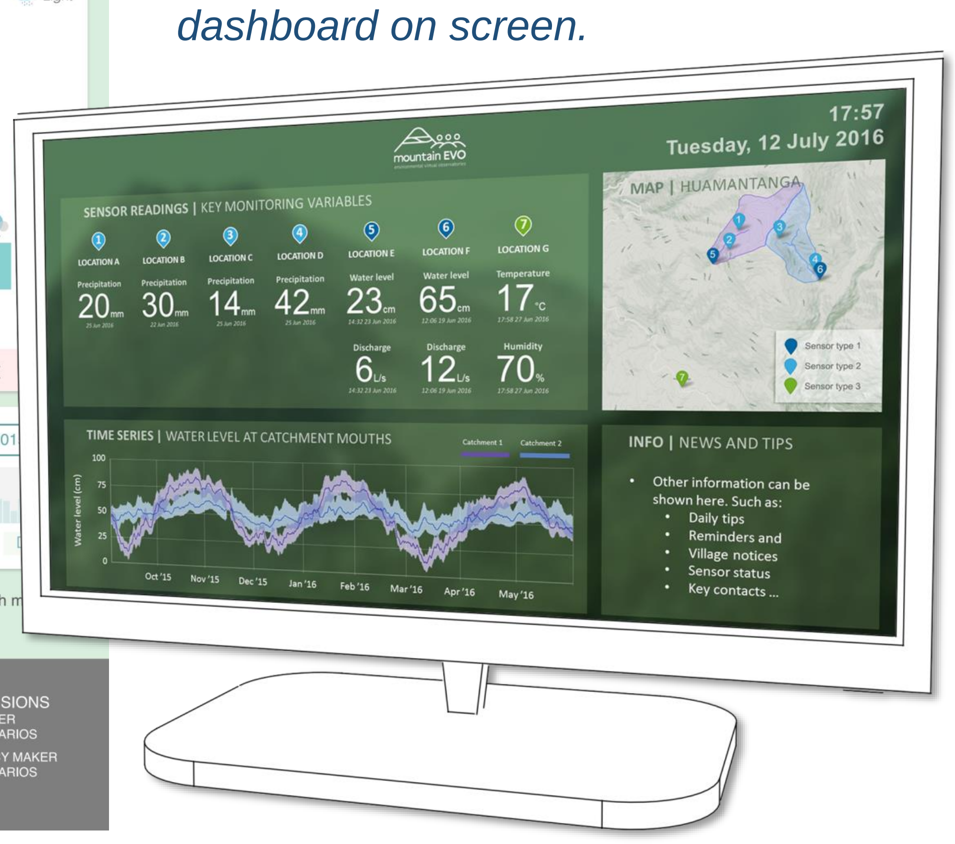


Figure 3*.*
Left: A screenshot of the Mountain EVO web-based visualisation platform prototype.
Below: A prototype of monitoring dashboard on screen.



References: Zulkafli, Z., Perez, K., Vitolo, C., Buytaert, W., Karpouzoglou, T., et al. (2017) User-driven design of decision support systems for polycentric environmental resources management. Environmental Modelling & Software, 88, 58–73. http://doi.org/10.1016/j.envsoft.2016.10.012 | Grainger, S., Mao, F., & Buytaert, W. (2016) Environmental data visualisation for non-scientific contexts: Literature review and design framework. Environ. Model. Softw. 85, 299–318. http://doi.org/10.1016/j.envsoft.2016.09.004 | Buytaert, W. et al., (2014) Citizen science in hydrology and water resources: opportunities for knowledge generation, ecosystem service management, and sustainable development. Front. Earth Sci. 2, 1–21. https://doi.org/10.3389/feart.2014.00026

Can be cited as: Mountain-EVO (2017). Visualisation approaches of hydrological data in remote communities. Retrieved from http://paramo.cc.ic.ac.uk/espa/

http://paramo.cc.ic.ac.uk/espa/

mountain EVO

MOUNTAIN EVO
INSIGHTS

mountain EVO
environmental virtual observatories

Smartphones for Sustainability: Building ‘learning landscapes’ in Kyrgyzstan

New technologies such as smartphones and semi-automatic weather stations may provide a boost to agricultural outputs and livelihoods by enhancing the availability of local data, but only if newly acquired or updated information is made readily accessible to the intended public in meaningful, accessible ways.

Environmental resources form the basis of a significant part of the rural economy in the Tianshan Mountains in Central Asia.

In recent years, much **resource governance** in Kyrgyzstan has been decentralized and has devolved to community ‘Pasture Committees’ (PCs), yet often these PCs are still perceived as non-local agencies and their decisions are not always respected or readily adopted.[1]

As part of a process of **empowering local people** and communities,[2] and in context of the recently established University of Central Asia[3] with the long-term educational opportunities it provides, a development-oriented approach to research is being advanced under the umbrella of UCA’s ‘Learning Landscapes’ Initiative.[4]

Three technological or **digital innovations** were successfully introduced through the Mountain-EVO project in Naryn province, Kyrgyzstan:

Smartphones for participatory data collection (*Cybertracker*)
Increasing availability of data & co-production of knowledge about pasture conditions, natural hazards, etc.

Information boards (incl. digital screens)
Displaying current information, synthesis of data collected by community partners, recent and current weather conditions

Weather stations (semi-automatic)
Tracking climatic conditions, enhancing predictive capacity in support of agricultural decision-making

By providing access to **new digital tools** that can enable more participatory monitoring of resources, the relevance of current locally ‘owned’ data for decision-making was demonstrated.

Although more study is still needed to determine the lasting impact, it is clear that several sectors of mountain agricultural communities in Naryn, Kyrgyzstan are keen to have greater involvement in the monitoring of environmental resources to better inform their **development decisions** in the future.


Information board in Eki-Naryn village, Kyrgyzstan, with recently updated data on local weather, pastures, wildlife, etc.

Resources monitored:

- Pasture conditions
- Indicator plant species
- Wildlife / snow leopard
- Under-utilized plants (mushrooms, herbal plants, etc.)
- Problems with infrastructure (e.g. roads), natural hazards
- Attractive places for tourism (e.g. mountain springs, petroglyphs)

Useful Tips for Practitioners

1. Inclusive processes in monitoring and decision-making can strengthen legitimacy and contribute to lasting outcomes
2. Use of new digital technologies must still be supported by genuine engagement with local communities and institutions
3. Targeted investments of time, finance and/or technologies that encourage local participation may enable the greatest synergies

‘We became more attentive to what surrounds us. To our surprise, we found how much we missed! Springs, medicinal herbs, berries, weed plants on pastures (plants not edible by livestock) – all this information, stored and visualized on the phone, this could be very useful for many different people…’

Local herder, after beginning to use a project smartphone for data collection

References: **1**. Shigaeva, J., et al. (2016). Decentralizing governance of agropastoral systems in Kyrgyzstan: An assessment of recent pasture reforms. *Mountain Research and Development* 36(1):91-101. http://dx.doi.org/10.1659/MRD-JOURNAL-D-15-00023.1 **2**. Tengo, M., et al. (2017). Weaving knowledge systems in IPBES, CBD and beyond – lessons learned for sustainability. *Current Opinion in Environmental Sustainability* 26:17-25. http://doi.org/10.1016/j.cosust.2016.12.005 **3**. See http://ucentralasia.org/. **4**. Schmidt-Vogt, D., et al. (2016). Strengthening Mountain Societies in Central Asia in a Context of Multidimensional Change. *Mountain Research and Development* 36(3):380-383. http://dx.doi.org/10.1659/MRD-JOURNAL-D-16-00101.1

Can be cited as: Mountain-EVO (2017). Smartphones for Sustainability: Building ‘learning landscapes’ in Kyrgyzstan. Retrieved from http://paramo.cc.ic.ac.uk/espa/

Central Tien Shan Mountains
Naryn, Kyrgyzstan

http://paramo.cc.ic.ac.uk/espa/

MOUNTAIN EVO INSIGHTS

Learning to cope with water variability through **participatory environmental monitoring**: Mustang, Nepal

The implementation of environmental **participatory monitoring (PM)**:

- enables communities to understand the use and management of local water resources.
- helps to develop a sense of ownership of environmental information.
- helps to improve scarce water utilization in agriculture and domestic uses.

Questionnaires, semi-structured interviews, and transect walks evidenced strong linkages between irrigation and poverty reduction.

Bridging the existing information gap between formal and informal decision makers/institutions through several combined workshops allowed us to address the problems that were **identified and prioritised by and with the communities**.

We proposed to involve local farmers in **participatory monitoring** (PM) of local water resources by quantifying precipitation and the resulting flow in the stream.

By involving the local youth leader in the entire process, we gained the trust of the communities and were more able to face obstacles related to the isolated location, use of local language and hesitation caused by recurrent visit of researchers in the past.

Figure 1. *Installation of rainfall station and streamflow monitoring station at Lumbhuk stream, Nepal.*

References: Bhusal, J. K., Chapagain, P. S., Regmi, S., Gurung, P., Zulkafli, Z., Karpouzoglou, T., Buytaert, W and Clark, J. (2016). Mountains Under Pressure: Evaluating Ecosystem Services and Livelihoods in the Upper Himalayan Region of Nepal. International Journal of Ecology and Environmental Sciences | Regmi, S., & Gurung, P. (2015). A Report on Detail Situation Analysis of the Research Site 'Dhakarjhong and Phalyak village of Kagbeni VDC' | Regmi, S., Bhusal, J. K., Gurung, P., Zulkafli, Z., Karpouzoglou, T., Tocachi, B., Buytaert, W. (2017). Learning to cope with water variability through participatory monitoring: The case study of Mustang Nepal (submitted)

The communities were engaged and involved through several field visits; staying with local residents, personal and group discussions, resource mapping exercises and collaborative identification of problems like climatic vulnerability and water scarcity and solutions.

PM helps local communities to quantify water volume in the stream and the contribution of precipitation and snow.

Local people has started to discuss about different water management and irrigation practices such as the construction of ponds and canals, improved irrigation, etc.

Initially the water scarce problem was limited within the village, but PM has helped to spread it to wider scale (Local, District and National levels).

Examples of the generated information

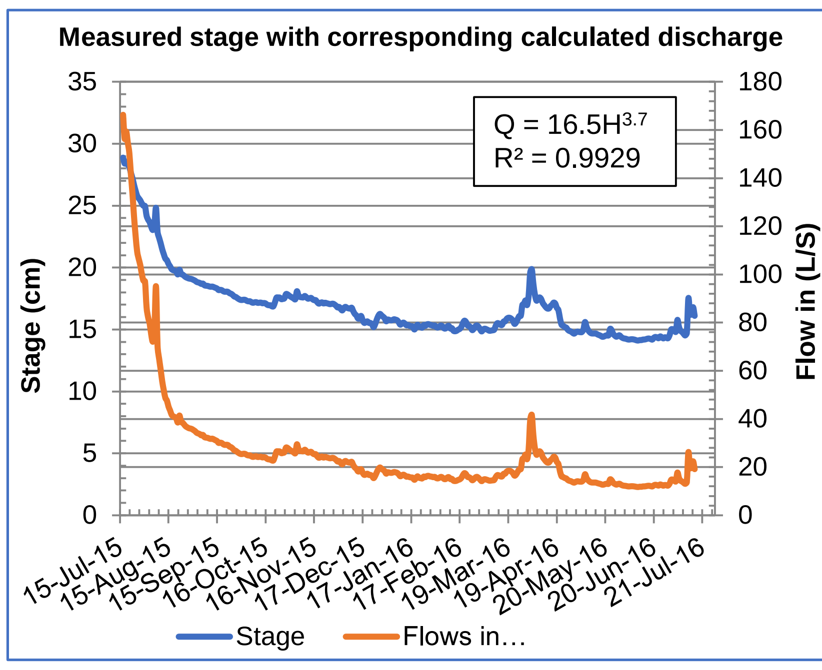


Figure 2. *Monitoring of streamflow based on water levels recorded by automatic sensors and manual observations by local farmers.*

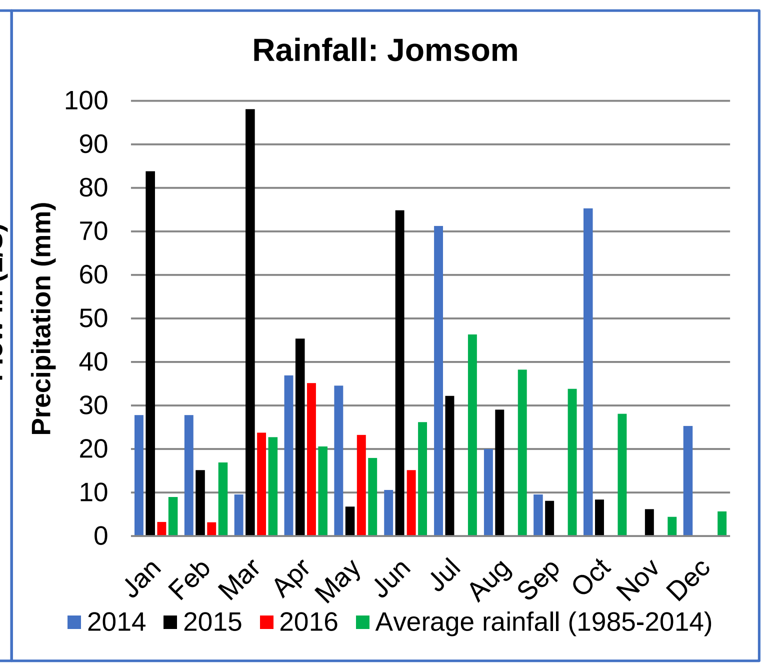


Figure 3. *Precipitation at Jomsom station shows a high temporal variability with potential impact on flow.*

Impacts of this participatory research

- PM develops ownership and increase the confidence in the research activities and in the implementation of the research outputs by communities and government stakeholders.
- Communities have committed to take responsibility of the installed instruments and District Development Committee has ensured management, sustainability and data utilisation.
- Irrigation Office has allocated the budget to build a diversion weir and canals, and has committed to invest in other works in the coming years.

Upper Kaligandaki basin
Mustang, Nepal

Can be cited as: Mountain-EVO (2017). Learning to cope with water variability through participatory environmental monitoring: Mustang, Nepal. Retrieved from http://paramo.cc.ic.ac.uk/espa/

http://paramo.cc.ic.ac.uk/espa/

MOUNTAIN EVO INSIGHTS

mountain EVO
environmental virtual observatories

espa ecosystem services for poverty alleviation | Imperial College London | University of Birmingham | Wageningen University & Research | CONDESAN | Society of Hydrologists and Meteorologists | UCA University of Central Asia | Cornell University | Universiteit Antwerpen | Freie Universität Berlin | United Nations Educational, Scientific and Cultural Organization

Farmers as researchers for sustainability of local livelihoods and the environment

Understanding the experience of **farmers and land users** in **Ecosystem Services (ESS)** as part of participatory-orientated research helps to identify local problems and solutions and to understand how ESS can be managed more sustainably.

Participatory rural appraisal (PRA) for detail situation analysis

1. Household surveys: random groups of active female and male farmers.
2. Key informants: Farmers that know the community and its environment, have access to information and a meaningful ability to absorb it, and are willing and able to communicate their knowledge when interviewed.


a. ESS Mapping
c. ESS base map
b. Field observation
d. Group discussion

3. Focus group discussions: purposive sampling to ensure different points of view; considering active farming representatives, diverse gender and age (see pictures above).

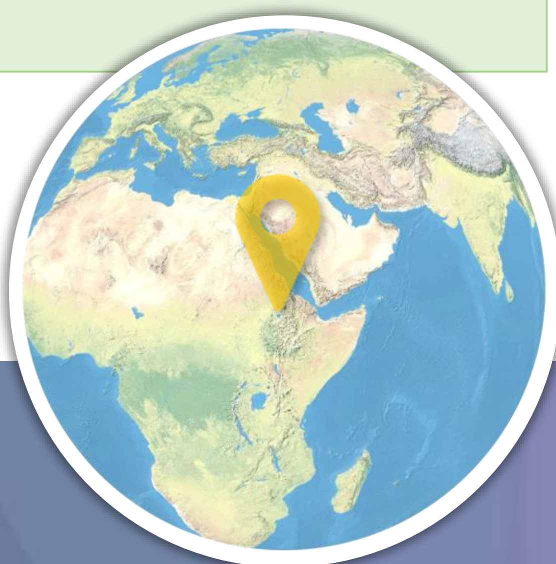
Environmental monitoring by farmers

1. Investigating water harvesting and groundwater accessibility.
2. Conducting experiments to increase awareness on monitoring their own environment and considering farmers' experiences in the evidence generation.
3. Creating a platform for knowledge sharing among farmers.

Impacts of this participatory research

- Continuous knowledge generation and exchange about ESS by the local community, and strengthened citizen science.
- Developing resilience and adaptive capacity to unexpected occurrences against the farming practices such as climate change.
- Livelihood and environmental sustainability.

References: Fentahun T and Gashaw T. (2014) Population Growth and Land Resources Degradation in Bantneka Watershed, Southern Ethiopia. Journal of Biology, Agriculture and Healthcare, 15 (4), 2224 -3208. | YountR. (2006) Populations and Sampling, The Rationale of Sampling Steps in Sampling Types of Sampling Inferential Statistics: A look ahead the case study approach. Working paper, 4th ed. | Ali M, David MK, Ching LL. (2013) Using the Key Informants Interviews (KIIs) Technique: A Social Sciences Study with Malaysian and Pakistani. Man and Society, 24, 131 – 148.



Lake Tana region
Amhara, Ethiopia

Can be cited as: Mountain-EVO (2017). Farmers as researchers for sustainability of local livelihoods and the environment. Retrieved from http://paramo.cc.ic.ac.uk/espa/

http://paramo.cc.ic.ac.uk/espa/

MOUNTAIN EVO INSIGHTS

mountain EVO
environmental virtual observatories

espa ecosystem services for poverty alleviation | Imperial College London | University of Birmingham | Wageningen University & Research | CONDESAN | Society of Hydrologists and Meteorologists | UCA University of Central Asia | Cornell University | Universiteit Antwerpen | Freie Universität Berlin | United Nations Educational, Scientific and Cultural Organization

User-driven design of Environmental Virtual Observatories

- Environmental Virtual Observatories (EVOs) provide increasing opportunities to create knowledge and deliver computer-based decision support for **multiple types of users across scales**.
- However, EVOs need to be tailored to meet diverse **user requirements** and types of actors.
- To realise this aim, we developed a participatory framework for designing EVOs that emphasizes a deeper understanding of the decision making structures and the importance of iterative design with users.

Key Steps of the EVO Design Process

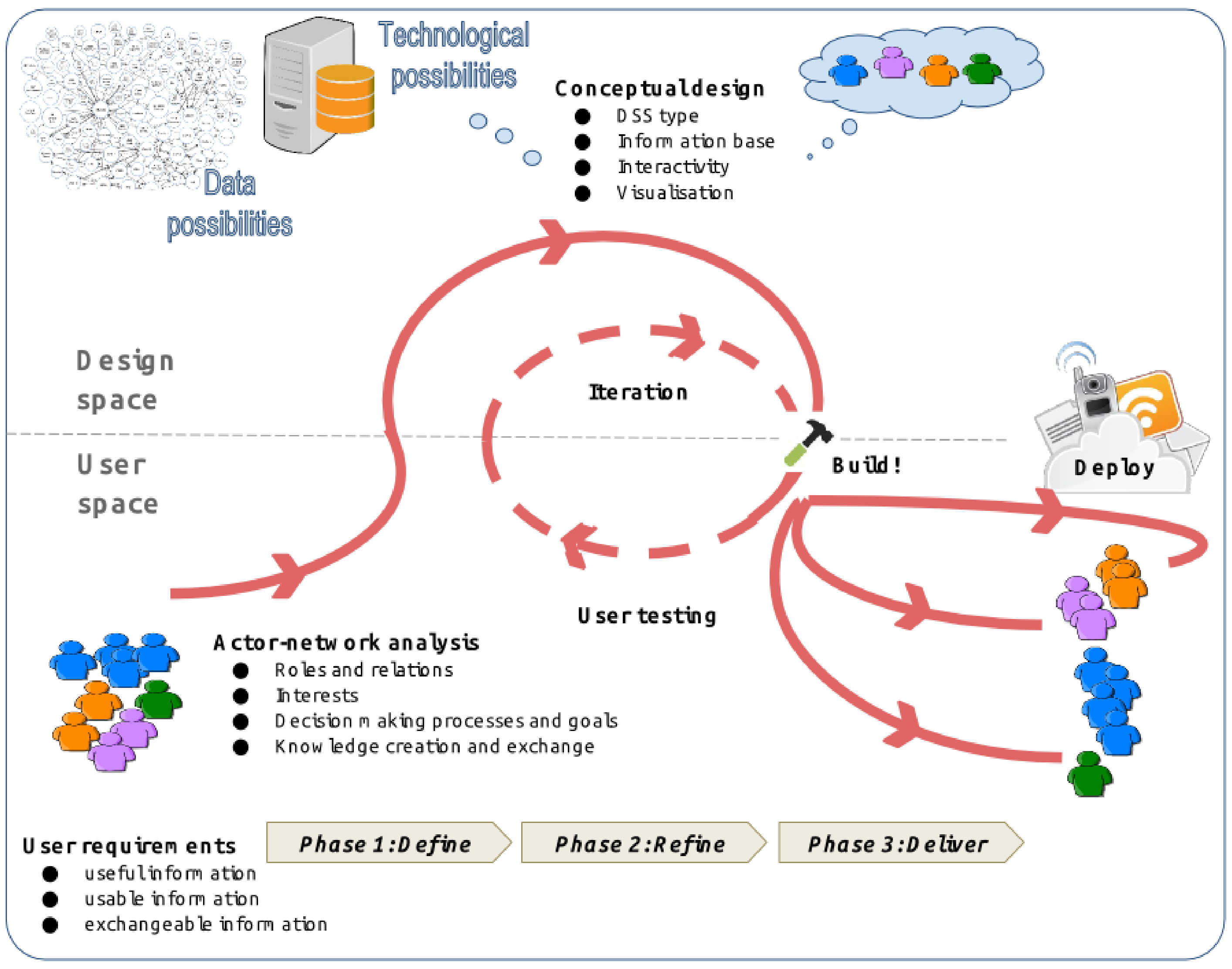


Figure 1. *A sketch of the EVO wireframe provides a quick means for testing design ideas.*

Polycentric Governance

- Participatory EVO design is strongly conscious of the **polycentric** arrangement of governance institutions.
- That is crucial for optimizing **information exchange** across **actors and scales** (i.e. not just one but multiple decision makers operating at different jurisdictional scales).

Figure 2. *A tablet-based prototype is being tested with a farmer in Huamantanga.*

Peru Case Study

- In the context of upstream/downstream water users in Lima, Peru, see reference Zulkafli et al. 2017.
- The case study focuses on EVOs that can respond to the information needs for adapting to water scarcity at the community as well as at the regional and national scale.

Useful Tips For Practitioners

- Participatory design promises **more socially inclusive development of technological tools** for collecting and disseminating environmental information.
- Participation in the design **can be time intensive** while EVOs require strong support and investment by community stakeholders and governing bodies to ultimately succeed in the long term.
- **Want to find out more?**
  Visit the EVO prototype website
  http://mevo.envisim.org/

References: Zulkafli, Z., Perez, K., Vitolo, C., Buytaert, W., Karpouzoglou, T., et al. (2017). User-driven design of decision support systems for polycentric environmental resources management. Environmental Modelling & Software, 88, 58–73. http://doi.org/10.1016/j.envsoft.2016.10.012 | Karpouzoglou, T., Zulkafli, Z., Grainger, S., Dewulf, A., Buytaert, W., & Hannah, D. M. (2016). Environmental Virtual Observatories (EVOs): prospects for knowledge co-creation and resilience in the Information Age. Current Opinion in Environmental Sustainability, 18, 40–48. http://doi.org/10.1016/j.cosust.2015.07.015 | Karpouzoglou, T., Dewulf, A., & Clark, J. (2016). Advancing adaptive governance of social-ecological systems through theoretical multiplicity. Environmental Science & Policy, 57, 1–9. http://doi.org/10.1016/j.envsci.2015.11.011 | Zulkafli, Z., Perez, K., Vitolo, C., Buytaert, W., Karpouzoglou, T., Dewulf, A., De Bièvre, B., Clark, J., Hannah, D. M., Shaheed, S., 2017. User-driven design of decision support systems for polycentric environmental resources management. Environmental Modelling & Software 88, 58–73. http://doi.org/10.1016/j.envsoft.2016.10.012

Huamantanga
Lima, Peru

Can be cited as: Mountain-EVO (2017). User-driven design of Environmental Virtual Observatories . Retrieved from http://paramo.cc.ic.ac.uk/espa/

http://paramo.cc.ic.ac.uk/espa/