HI-AWARE Internal Report

HI-AWARE
Himalayan Adaptation, Water and Resilience Research

CARIAA
Collaborative Adaptation Research Initiative in Africa and Asia

Workshop Proceedings

Water Availability and Access in Mountain Areas of the Teesta Basin

26 November 2015, Gangtok, Sikkim, India

Consortium members

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About HI-AWARE

The Himalayan Adaptation, Water and Resilience (HI-AWARE) Research Consortium conducts research and pilot interventions, capacity building and policy engagement to enhance the climate resilience and adaptive capacity of poor and vulnerable people living in the mountains, hills and flood plains of the Indus, Upper Ganga, Gandaki and Teesta river basins in Pakistan, India, Nepal and Bangladesh.

HI-AWARE aims to influence policy and practice to aid the climate resilience and adaptation of poor and vulnerable populations in the region by generating evidence-based knowledge on geophysical, socioeconomic, gender and governance drivers and conditions leading to climate vulnerability, as well as monitoring and assessing adaptation measures. It focuses on identifying 'critical moments' when communities are most vulnerable to climate risks, 'adaptation turning points' when existing adaptation strategies no longer work, and "adaptation pathways", sequences of policy actions that address both short-term responses to climate change and longer-term planning. It looks at strengthening the expertise of researchers, students and science-practice-policy networks to conduct as well as use research on climate/social vulnerabilities, resilience, and adaptation.

HI-AWARE comprises of five consortium members: The International Centre for Integrated Mountain Development (ICIMOD), the Bangladesh Centre for Advanced Studies (BCAS), Pakistan Agricultural Research Council (PARC), The Energy and Resources Institute (TERI)-India, and Alterra-Wageningen University and Research Centre (Alterra-WUR).

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Water Availability and Access in Mountain Areas of the Teesta Basin

26 November 2015, Gangtok, Sikkim, India

Organised by

Himalayan Adaptation, Water and Resilience (HI-AWARE) Research
Collaborative Adaptation Research Initiative in Africa and Asia (CARIAA)
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Executive Statement

The Energy and Resources Institute (TERI), New Delhi, along with The Mountain Institute (TMI India), Gangtok, Sikkim organised a workshop on Water Availability and Access in Mountain Areas of the Teesta Basin under the Himalayan Adaptation, Water and Resilience (HI-AWARE) Research project on 26 November 2015. The workshop aimed to understand issues regarding water in the Teesta Basin from the perspectives of different stakeholders, identify response actions and their challenges and opportunities for implementation, and create an environment for shared understanding across stakeholders. After the inaugural, the first of the workshop's three sessions began.

A panel discussion on the status of water in the basin area, chaired by S Vijay Kumar, Distinguished Fellow, TERI, and Former Secretary, Ministry of Rural Development, Government of India took place. A group of experts from the field participated in the discussion as co-panellists: Sarika Pradhan, Joint Secretary, Rural Management and Development Department (RMDD), Government of Sikkim; HK Badola, Scientist In-charge, GB Pant Institute of Himalayan Environment and Development; GC Khanal, Joint Secretary, Sikkim State Disaster Management Authority (SSDMA), Department of Land Revenue and Disaster Management, Government of Sikkim; and Keshar Kumar Luitel, Geologist, Department of Mines and Geology, Government of Sikkim.

In the second session, a group activity was carried out by categorising participants into four groups according to their institutional affiliations: local *Panchayats* and State government officials, among others. A causal tree showing status, drivers, impacts and responses was mapped for highlighting the nuances of water availability and accessibility issues. This was followed by a plenary with open discussion across the groups.

Group activity resumed post lunch in session three where participants in their respective groups prioritised one of their identified responses for a network map and provided their own logic for its selection. Each group identified actors involved in the same, along with the type of linkages between them, and the degree of power to influence a given response action. Finally, each group was given the opportunity to recommend change/s in their selection of responses and/or network maps in order to have better impact in terms of the problem's solution. This was followed by a plenary with open discussion taking place across the groups.

Introduction

The stakeholders' consultation workshop on "Water Availability and Access in Mountain Areas of the Teesta Basin" aimed to understand issues regarding water access and availability in the Teesta river basin in Sikkim, keeping in mind the perspectives of different stakeholders in the State. The workshop aimed to identify the response actions needed, and the challenges and opportunities associated with their implementation, besides creating an enabling environment for shared understanding across stakeholders.

The workshop assisted the use of a methodology to facilitate the collection of inputs for Research Component 2 (RC2) on drivers of vulnerabilities and research uptake. The methodology used, and key findings from the workshop contribute to the discussions on governance research under RC2 i.e. 2.2. The workshop engaged local leaders, Panchayat members, members of civil society, the academia, regional experts and government employees from State-level agencies in a brainstorming activity so as to develop a shared understanding on issues related to water availability and access, and challenges and opportunities for policy, research and practices for responding.

Event Highlights

Session 1: Panel discussion

The event was divided into 3 sessions:

Session 1

A panel discussion was conducted on the status of water in the Teesta basin in Sikkim. It was chaired by S Vijay Kumar, Distinguished Fellow at TERI and Former Secretary, Ministry of Rural Development, the Government of India.

The experts on the panel were:

- Sarika Pradhan, Joint Secretary, Rural Management and Development Department, Government of Sikkim;
- HK Badola, Scientist in-charge, GB Pant Institute of Himalayan Environment and Development;
- GC Khanal, Joint Secretary, Sikkim State Disaster Management Authority (SSDMA), Department of Land Revenue and Disaster Management, Government of Sikkim
- Keshar Kumar Luitel, Geologist, Department of Mines and Geology, Government of Sikkim)

Session 2

The second session was a participatory group exercise. The participants were first divided into five groups according to their institutional affiliations: local panchayats and state government officials, among others.

The groups were then assigned the task of mapping a causal tree with states, drivers, impacts and responses for understanding different nuances of existing water availability and accessibility issues.

This was followed by a plenary with an open discussion of the results of the group exercise among the five groups.

Session 3

The post-lunch session was merely a continuation of Session 2. This time, each group had to prioritise one of their identified responses for a network map and explain the logic behind its selection.

Each group identified actors in the network along with the types of linkages between them, and the degree of power each wields to influence the response action.

Finally, each group was given an opportunity to recommended change(s) in their selection of response(s) and/or network map(s) so as to have a better impact on the solution of the given problem. This was followed by a plenary with open discussion among the groups.

Inaugural Session

The chair of the session, S Vijay Kumar, Distinguished Fellow, TERI and former Secretary, Ministry of Rural Development, Government of India, in the beginning of his address talked about respecting the sensitivities of invited stakeholders and stressed on the importance of communication. He said that HI-AWARE is a project in the interface of science, policy and practice. He added that having worked for a long time in hill areas and in rural development activities, he could fully understand the extreme complexities and multi-disciplinary nature of the

project which comprises not only the "biophysical side" i.e. climate-related issues but also the "social side". which is how individuals and communities, institutions and government systems react and adapt to the changes that are taking place in different jurisdictional levels.

Suruchi Bhadwal, Associate Director, Earth Science and Climate Change Division, TERI, lay emphasis on the importance of the workshop as it was creating a base through which to understand processes of change and people's aspirations in Sikkim. She added that the project is in an action research mode and that it will involve the co-creation of knowledge with communities in different localities and find solutions for their problems. She then went ahead to describe the roles of TERI, ICIMOD and TMI, India within HI-AWARE and the scope of research and policy engagement in Sikkim. This was followed by a detailed overview of the project by HI-AWARE's Principal Investigator, Phillipus Wester, Chief Scientist, Water Energy Management, International Centre for Integrated Mountain Development (ICIMOD).

After introducing the partners of the HI-AWARE consortium, Wester talked about the "philosophy" of the project, which is to deliver strong output and have impacts in terms of policy and community practices, and hence the need for such strategic engagement processes. He iterated that HI-AWARE is not just a project but is a consortium with a long-term agenda and will continue beyond the time frame of this specific funding which will end in September, 2018.

He stressed that the partnerships being formed, the network, the expertise being created through the initiative will carry forward into the next 10-20 years. He expressed his happiness about the workshop being conducted by TERI in collaboration with TMI India to have an interaction in Sikkim which introduced key stakeholders to the HI-AWARE project. He said that the project team would also gain a better understanding of the needs of the diverse stakeholders as a result of the workshop

Session 1: Status of Water in Mountain Areas of the Teesta Basin

The first session started with a brief address from the chair, S Vijay Kumar, who informed that the session would look into science-policy linkages.

Sarika Pradhan

Sarika Pradhan then talked about climate change in Sikkim and the Dhara Vikas Yojana initiative. Pradhan said that adaptability is not easy, both as a concept and in practice, and explained how risks to water resources could lead to livelihood vulnerabilities as people in rural areas depend on farming and animal husbandry. She said that over the past few years, the RMDD, under the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) programme, has been trying to do its bit through the Dhara Vikas Initiative. She said that while it is true that the mountains are the water towers of the world, it is also lamentable that most of the research on climate change adaptation is restricted either to the glaciers or to the river basins. The people living in the mid hills, she said, are not getting their water from the glaciers, nor are they getting it from the river basins.

The RMDD is engaged in identifying the sources of springs, understanding water storage, seasonal variations in spring discharge and means by which to increase discharge. The department conducted vulnerability assessments of all the Gram Panchayats in Sikkim according to the findings of which South Sikkim—the area which receives around 150 cm of annual rainfall on average, situated as it is in the rain-shadow area of the Darjeeling hills—is most vulnerable. She talked about the difficulties associated with measuring ground water in mountainous regions, largely due to the terrain. Reducing runoff, she explained, also presents a challenge due to the presence of barren sloping land, deforested land and dried-up lakes. It was in such a situation, that the RMDD went ahead with its springshed development plan where springs were first taken up, followed by areas around the springs being studied. Over a period of around six years, the RMDD has been able to revive 54 springs and five lakes. The RMDD has engaged with think tanks and the scientific community, and has published its work. The department has prepared a village spring atlas for the state of Sikkim which is updated regularly.

The Dhara Vikas Yojana, apart from digging trenches for recharging aquifers, also engages with communities in activities such as the construction of water storage tanks which ensure that discharge water can be stored during the night. Due to such interventions, the farmers of South Sikkim are now earning 20,000-30,000 annually per household. This would have been impossible around six years ago. Apart from the success attained in terms of discharge, storage and scientific engagement, another unique aspect is community maintenance which has been made possible through the training of local opinion leaders as para hydro-geologists in partnership with the Advanced Centre for Water Resources Development and Management (ACWADAM), Arghyam and the World Wildlife Fund (WWF). However, such development programmes can only be taken up if there is forestland on top of a given hill. Hence, currently, there is no scope for communities that live on hilltops to benefit from the Dhara Vikas Yojana's spring recharge programme. Even though the RMDD wants to include more springs in the programme, there is a need for human resources and capital.

HK Badola

The next speaker, HK Badola, talked about "Water, Biodiversity and Adaptation in the Context of the Teesta River Basin". Badola's detailed presentation focused on the natural resources of Sikkim and the risks currently associated with them. He said that Sikkim is drained by over 30 perennial rivers, possesses three percent of the hydropower potential of India, 197 snow fields—which cover an area of 251.24 km2,160 wetlands covering an area of 1,985 km2, six major forest types across the elevation gradient and rich biodiversity—which includes 4,500 species of angiosperms, more than 200 species of trees, more than 150 species of shrubs, 292 species of birds, 42 species of reptiles and 1,000 species of plants of cultural significance. Situated as it is in the Eastern Himalayan Region, Sikkim, Badola, said, is home to faunal flagship species such as the snow leopard, musk deer, Himalayan black bear and the Tibetan gazelle in the high altitude range; the red panda and clouded leopard in the mid altitude range; and the Bengal tiger and Asian elephant in the low altitude range. He said that the Teesta River Basin is a potential biome for new populations or even new species. He highlighted the case of the *Rhododenron maddenii* population exploration; the type's habitat is Choongtam, at an altitude of 1800 metres.

Badola remarked that there is a great threat to biodiversity from hydropower dams which need to be debated upon and studied to understand the scale of the magnitude. He said that many of the smaller wetlands in the region are inappropriately managed and that big wetlands have been encroached upon as a result of infrastructure development and tourism. Badola also talked about springs and rivulets—water channels to the Teesta, and added that monitoring them is crucial for long term ecological sustainability. He went on to say that with increased glacial melt, as a result of global climate change, there will be an increase in the stream-flow of river systems, ultimately leading to desertification, which will be a major problem. Though climate change-induced impacts and the adaptive mechanisms of species are difficult to assess, there has been a drift in the seasonal cycle, an upward altitudinal shift of pests and diseases, and a viability loss of reproductive mechanisms in different species. With respect to the Teesta basin, indicators of climate change include phenology shifts in rhododendrons and an upward altitudinal shift in the case of the Atlas moth. Badola also talked about the shrinking of the Zemu Glacier in Sikkim which has been studied and monitored by the Govind Ballabh Pant Institute of Himalayan Environment and

Development (GBPIHED); the Forest, Wildlife and Environment Management Department of Sikkim; the Department of Science and Technology, Sikkim; and other departments. The shrinking of the glacier is a huge concern for the region.

Badola went on to talk about knowledge gaps relating to livelihood options for marginalised people, traditional knowledge and its linkages with cultural identity, human-wildlife conflicts, landslide and riverine habitat degradation, illegal trade of wildlife and pastureland management—though largely checked in the Kangchenjunga National Park, and the impacts of tourism. He next pointed out research needs including ecological base maps of the Teesta River catchment in Sikkim, normalised difference vegetation index (NDVI) time series analysis, forest species disturbance trends, vulnerability assessment of habitats and species, and monitoring of retreating glaciers and associated biomes. Other research needs discussed included the establishment of long-term weather monitoring stations along the altitude gradient, exploration of trans-boundary cooperation for the implementation of Great Himalayan Trekking Trails and opportunities for trans-boundary eco-tourism, greater focus on gender and social inclusion, and the alignment of conservation to generation of income opportunities.

GC Khanal

GC Khanal delivered a presentation titled "Overview of Earth Formation and Geological/Hydrological Studies of Sikkim Himalayas". He gave an overview of his talk which covered the following: Mountain building processes and the Himalayas, the geological setup of Sikkim, the hydrological status of Sikkim, suggestions and recommendations. He spoke briefly about the break-up of the supercontinent Pangea (225 million years ago), the collision of the Indian and Tibetan tectonic plates, which up until the collision had been separated by the Tethys Sea, resulting in the formation of the Himalayan mountain system—a process that is still ongoing. He also talked about the movement of the Indian plate towards Eurasian plate, and their collision near the Hindu Kush.

Khanal went on to discuss the uplift of the Himalayan Mountains and the Tibetan Plateau (35 million years ago) and added that the collision between the Indian plate and the Eurasian plate is continuing (the movement is somewhere between five-fifteen cm per year). He then showed and explained the geological map of Sikkim, and mentioned that the region has mostly metamorphic rocks—metamorphic rock sequences, and in some parts—the Rangit Valley window area—sedimentary rock formations as well. The geological rock sequence of Sikkim can be summarised within the following formations: Thetyen Sequence, Tsungtang Formation, Darjeeling Gneiss, Daling and the Buxa Gondwana formations. Later, Khanal showed the geological map of Sikkim, showing complex rock formations in certain places, which his team had prepared. The map played an important role in identifying pervious and impervious layers. Next, Khanal briefly discussed fractures and joints: Columnar Joints, Shearing Joints, Brittle Fractures and Tensional Joints, and showed pictorial representations of some of these with figures from the field site in Sikkim. These included an open joint in Granite, an open joint in Mica Schist and close joints, among others. He emphasised on the need to understand them, considering the fact that aquifer leakage can take place through these fracture and joints as well as other openings in rocks. He underlined the need for a detailed geological mapping of the area before any interventions for springs recharge are carried out so as to ensure that the same is proper and result-oriented.

He later spoke about folding and its relation to aquifers, saying that folding occurs when rocks are compressed or deformed and therefore buckle up under stress. The crest of the fold is where the rock layers slope downwards form the anticline and the valley of the fold is where the layers slope toward the lower axis form the syncline. Next, Khanal talked about Faulting and explained what the different types of faults are with figures: Normal Fault (hanging wall block down), Reverse Fault (hanging wall block up), Strike-slip Fault [Left-lateral Fault (Sinistral) and Right-lateral Fault (Dextral)].

He said that hydrological reserves in the Sikkim Himalaya constitute of glacier-fed rivers and lakes; seasonal snow-fed rivers and lakes; and springs of different types (stratum, fault, valley, overflow and artesian). Taking stratum-controlled springs as an example, he underlined the need for having a detailed geological understanding, like while carrying out spring recharge initiatives on tops of hills by studying the rock strata inside. This has been done through the Dhara Vikas Initiative by the RMDD, for which geological understanding is mandated and for which the initiative has the required resources and man-power. If we don't understand rock strata—the pervious and impervious layers, spring recharge interventions on the top of the related hill may cause a landslide downhill, if it is a stratum-control spring. He later talked about other types of springs (fault springs, artesian) and aquifers (confined and unconfined).

When speaking about loss of groundwater sources in Sikkim, Khanal said that some lakes and springs dry up due to natural processes (like earthquakes) or due to anthropogenic activities. He added that due to mountain-building processes, rocks in the region are highly fractured. Depending upon the orientation of such structural elements, water finds access to lower elevations under a thrust fault environment, and the sub-surface accumulation of water is remote. Taking the example of the Sikkim earthquake of 18 September 2011, Khanal talked about how seismic activities cause the drying up of lakes and spring. Next, he talked about a case study in Uttarey, where a lake had dried up after the 2011 earthquake. Reiterating what Sarika Pardhan had said earlier, Khanal pointed out that springs are mainly drying up in the sub-tropical region (500-1500m).

Khanal's presentation concluded with the following recommendations: Springshed development to increase spring discharge, cleaning of spring sources and its proper management necessary, modification of collection tanks, total ban on deforestation around spring sources, encouragement of rain water harvesting techniques, water conservation tanks with enhanced capacity, perennial springs which are not yet tapped to be developed for sustainable water supply, Dhara Vikas initiative for spring recharge by digging pits and trenches in hills to retain surface run-off, creating social awareness at all levels to educate and to bring awareness among people about the adverse impacts of wastage of ground water, and the benefits of conserving water.

Chair of the session, S Vijay Kumar, lauded the speaker for covering different aspects of geology including the basic geology of glacial Himalayas, which is very important. He added that from his understanding of what the previous speakers had said, particularly what Sarika Pradhan (RMDD) had mentioned, programmes for springshed development, including the Dhara Vikas Initiative, seem to be focussed on micro-watershed around the springs themselves, whereas it was made very clear from the presentation by Khanal that we need to look into the structural aspects of aquifers, especially if it is artesian in which case recharge would be taking place at a distance from the spring itself. Kumar added that we need a watershed approach that can be larger than the immediate adjunct of a given spring. According to him, entire watershed need to be treated as a single unit for both soil and water management which is very important for the better management of these resources and for going forward.

Keshar Kumar Luitel

The next speaker, Luitel, delivered a presentation on the "Study of Dried-up Lakes in the Sikkim Himalaya by Geo-physical approach—a Case Study at Uttarey Lake, West Sikkim. The project was sponsored by the Toursim and Civil Aviation Department, Government of Sikkim, to aid the development of the Uttarey Lake area in West Sikkim. An initial geo-hydrological investigation of the lake, using a 2D-electrical resistivity tomography method, was conducted by the Department of Mines and Geology, Sikkim. The lake, Luitel informed, derives its name from the direction of flow, its location and the formation. Located 150 kilometres from Gangtok (elevation: 1952 metres above mean sea level) Uttarey is a natural, bean-shaped lake within a depression formed by falting or glaciations. Its approximate length, width at centre, and surface area are: 280 metres, 140 metres and 40,000 square metres,

respectively. Its catchment area is 1.5 square kilometres, and it has a gentle to moderate slope with medium thick to thin soil cover underlain by competent rock strata. The lake has turned into marshy land as a result of the deposition of silt derived from the catchment area. Luitel highlighted that in 2002 the lake was covered by silt and was almost cultivable. Given this situation, the State Government intervened to restore the area.

Luitel spoke about the geological formation of Uttarey, which falls under a high-grade metamorphic rock sequence belonging to the Chungthang Formation representing steaky gneiss and bended gneiss. The bedding/foliation of the rocks strikes the North East-North West direction and the dip angle is 11-40 degrees. The area is covered with a thick, blanket slope wash material and the bed rock consists of variants of gneissic rocks expected at greater depth (>15 metres). Luitel also spoke about electrical resistivity and mentioned that it is an important geo-physical method to reveal sub-surface information and is used widely to solve various geological problems. It works on the principle of Base Electrical Theory (Ohm's Law), he said, and then explained the technicalities behind the process.

The objectives of the study of the dried-up lakes were to investigate sub-surface conditions, if any; depth of saturation zone, thickness of siltation material, types of material present/information on geological condition, and approximation of depth of the rocks and their physical properties. The instruments, and the result interpretation were also explained.

Towards the end, Luitel talked about the conclusions and recommendations made by the study. A 2D Electrical Resistivity Imaging technique was used to delineate zone weakness, depth of saturation/water bearing zone, siltation overburden material, weathered rock/depth of rock strata, etc. From this 2D-resistivity section, it was revealed that the top 2 metres (on average) of thickness consists of recently deposited silt material. The thickness of siltation may increase a few metres towards the edge boundary/jhora section which feeds the lake during the monsoon. Water bearing zones exist up to a depth of 8 metres (on average) and consist of a saturated silt-clay layer, followed thereafter, at a further depth, by a highly compacted clayey layer of an approximate thickness of four-five metres, except in the middle portion which may be at a greater depth, underlain by highly weathered basement rock after 15 metres in the boundary portion of the lake. These details were inferred during the geo-physical investigation. At this stage of the investigation, it was revealed that no seepage zone was inferred.

It is known that due to capillary action, water rises to a higher level than the existing water level of the lake. Information on the water table was collected from the foundation of a newly constructed building, and was found to be above the existing water level in the lake. This can lead to the withdrawal of sub-surface water with internal erosion of the materials in the peripheral areas at the time of the removal of filled silted material from the lake, leading to damage of existing structures in the vicinity of the lake. Luitel recommended proper rim treatment or sheet pilling (up to a depth of eight-ten metres or minimum water fluctuation level), which was elaborated later, to break the interaction between lake water and the sub-surface water of the upslope area.

Luitel informed that siltation material from the lake can be removed manually or by using light machinery with caution. At the outlet of the lake (to conserve water in the lake), a low-height dam can be constructed with a foundation of at least a 15 metre-depth, or depending upon the compressive strength of the strata/load factor. For this purpose, a sample of excavated material is to be tested at the time of execution from the rock zone.

The speaker then talked about how the study can be replicated across Sikkim. He remarked that the 2D Electrical

Resistivity Tomography technique can also be used for the exploration of sub-surface water/unconfined springs sources, especially in drought-prone areas. Before concluding his presentation, Luitel shared the results of an electrical resistivity survey conducted in Rangpo, East Sikkim, for determining the depth of the water level, which was found to be 21 metres deep for January 2015.

Session 2: Water Access and Availability

In the second session, break-away groups for understanding issue and identifying responses for water access and availability in mountain areas were formed. A causal tree map was developed and a set of questions was put to distinct stakeholder groups. Stakeholders included international agencies—ICIMOD and The German Agency for International Cooperation (GIZ), the Sikkim State Government, the academia (researchers, scientists and experts), local self-governmenance groups (Panchayats) and civil society members.

The problems and responses dealt with figuring out the main problems with water access and availability in Sikkim, the causes of the same and their impacts. It was decided that existing responses to these problems and impacts should be figured out.






The table below presents the analyses that emerged as a result of the group activity:

Group	Issues	Cause	Impact	Response
Government of Sikkim	• Drying up of springs and streams	• Unplanned development • Topography/tectonic activities • Dependency on springs has increased (by up to 80 percent) • Anthropogenic activities are disturbing systems	• Water scarcity	• Proper legislation • Development planning should be supported by proper technical backup • Single window approval • Raising general awareness • Need for technical studies • Plantation of indigenous species • Prevent exotic species from colonising wetland areas • Prevent concretisation of water reserve sources (in springs, streams, ponds or lakes) • The State Government's existing Dhara Vikas Initiative should be provided more support
International agencies	• Drying up of springs/ water sources • Drying up of lakes • Drying up of rivers	• Landslides • Tunnelling in hydropower projects • Erratic and low rainfall during the monsoon • Degradation of springsheds • Road construction in upper catchments • Conventional watershed approach	• Reduced water security for households • Reduction in water supply for communities • Reduction in production and income from winter crops (vegetables) • Increase in hardships for women	• Dhara Vikas Initiative • Village Water Security Plan (VWSP): Through the partnership of GIZ and the RMDD, VWSPs have been initiated in various parts of Sikkim
Civil Society	• Drying up of springs	• Improper selection of species for afforestation programme in spring catchments • Land-use change is one of the major causes, especially mega hydro power projects, construction of roads and buildings in spring catchments • Over population and immigration for employment into Sikkim from other states of Sikkim mainly in the hydropower projects and pharmaceutical companies • Erratic rainfall: Erratic rainfall was one of the major causes for the drying up of water resources, specifically with respect to the temporal spread of rainfall • Government policy: Government policy/scheme was also reported to be one of the causes for the drying up of springs because they encourage cementation in spring discharge sites and spring catchments • Rising temperatures • Contamination of water sources	• Drinking water scarcity, and scarcity of water for irrigation • Decline in agricultural productivity. Agricultural productivity has declined, especially paddy and large cardamom • Increase in hardships for women • Human-wildlife conflict • Water disputes in the villages. Upstream-downstream conflict for water in the villages has been increasing • Rural to urban migration for employment • Health and hygiene problems: As a result of water scarcity, sanitation and hygiene have been compromised • Impact on eco-tourism/the tourism sector. Communities are not able to take tourists to high altitudes because water sources have dried up in such areas • Water crisis in cities and towns. People are facing water crises in Namchi and other smaller towns. Even Gangtok faces a water crisis of its own.	• Plantation of suitable species in spring catchments and spring sites giving more emphasis on indigenous species • Traditional practices for the conservation of springs: Traditional practices of conservation/management of springs/spring catchments like Devithan, Devi Puja should be maintained and revived where they have been discontinued • Preparation of village water security plan: NGOs have also been contributing to the formation of village water security plans in different parts of the state for the conservation of water sources. • Rain water harvesting: Rain water harvesting is being increasingly adopted by local people to increase their access to water, especially in the South and East districts of Sikkim. • Raising awareness about the negative impacts of mega hydro power projects and pharmaceuticals in the state • Purchasing water from nearby water surplus villages

Academia	• Water scarcity	• Causes behind the drying up of springs were identified: • Earthquake, landslides: Landslides can be caused by natural processes or by anthropogenic activities • Change in land use land cover (LULC) which have been caused by developmental and industrial activities • Changing weather patterns • Infrastructure development like tunnelling for hydropower projects, village roads construction under the Pradhan Mantri Gram Sadak Yojana (PMGSY). • The group felt that when these programmes are implemented, it accelerates the drying up of springs. When PMGSY projects are implemented prior to Environmental Impact Assessments (EIA), they might not be properly done • Impact of forest fires needs to be studied. • Glacial retreat	• Decline in drinking water • Decline in water for domestic use • Impact on fisheries • Changing agricultural patterns • Social conflicts for water, and increase in drudgery	• More support to springshed development programme • Soil and water conservation programme • Traditional practice of spring conservation/management like Devithan • Water security plans • Mapping of water resources
Local Government	• Drying up of springs	• Changes in rainfall pattern • Population growth • Concretisation of spring sources • Construction on agricultural lands • Improper solid waste management	• Decline in drinking water availability • Decline in agriculture/ horticulture (large cardamom, paddy, vegetables) • Decline in livestock, diary, poultry and fisheries • Health and sanitation	• Dhara Vikas Initiative • Rain water harvesting • Community tanks and household storage tanks have been constructed • Plantation in spring catchments • Awareness regarding water conservation and water management

Session 3: Operationalising Identified Responses

Session three featured the second group work of the workshop. This session had a network map for a selected response action from Session two. Out of the five groups, four of them selected the Dhara Vikas Yojana while Civil Society stressed on a specific aspect of it i.e. plantation. The following figures provide a summary of the network maps from different groups. They have been redrawn with the software UCINET, and following map measures using graph theory, have been derived for further analysis:

- Map Centrality i.e. how many actors can an agent reach directly
- Betweeness centrality i.e. how likely is the agent to be the most direct route between two actors in a network
- Map density i.e. how well is the network connected
- Map transitivity i.e. how well information/opinions circulate in a network

Key observations made during the group activity were related to variances in the identification of network characteristics and variances in roles. International agencies' networks have a lower density when compared to

Figure 1: **Summary of responses identified**

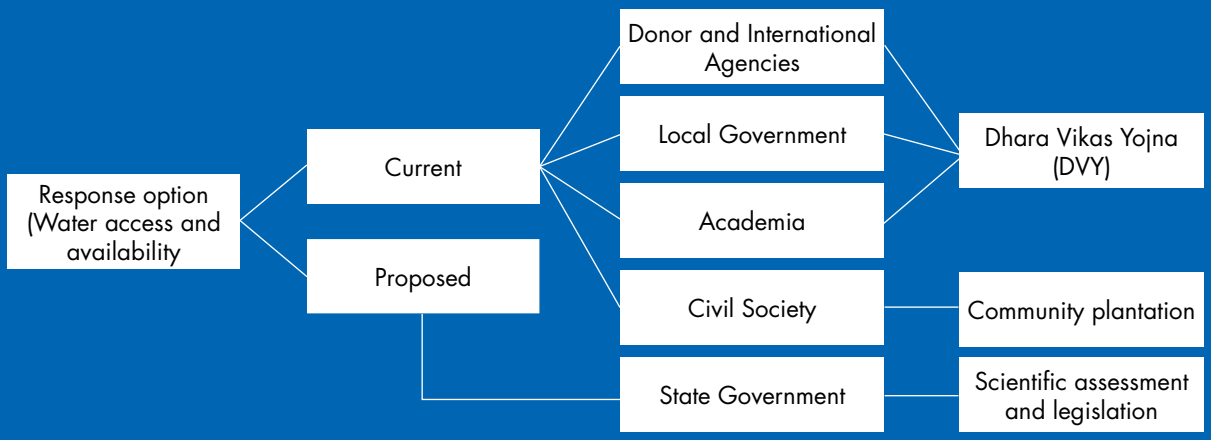


Figure 2: **Network map developed by international agencies**

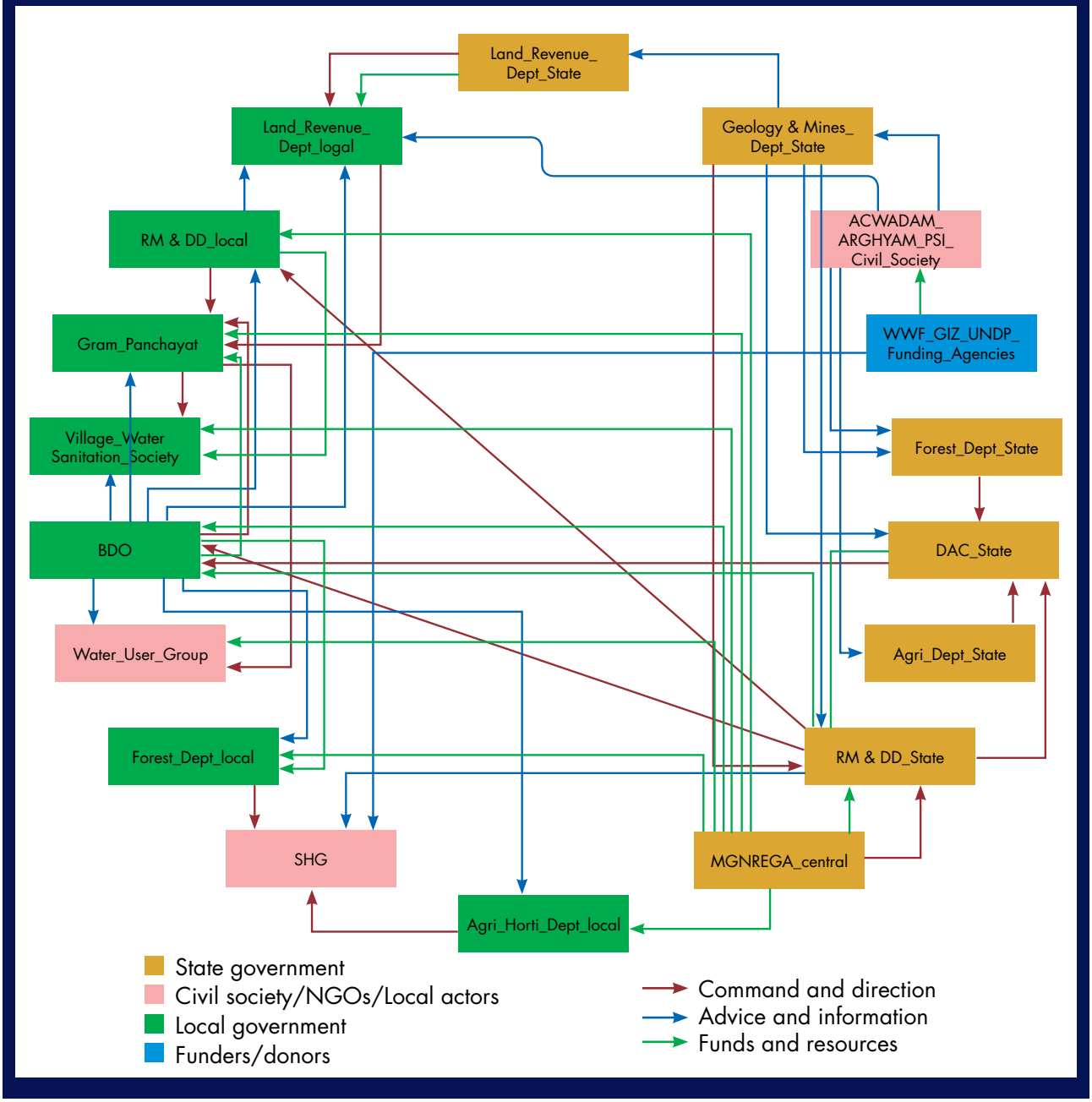


Figure 3: **Develope by local government**

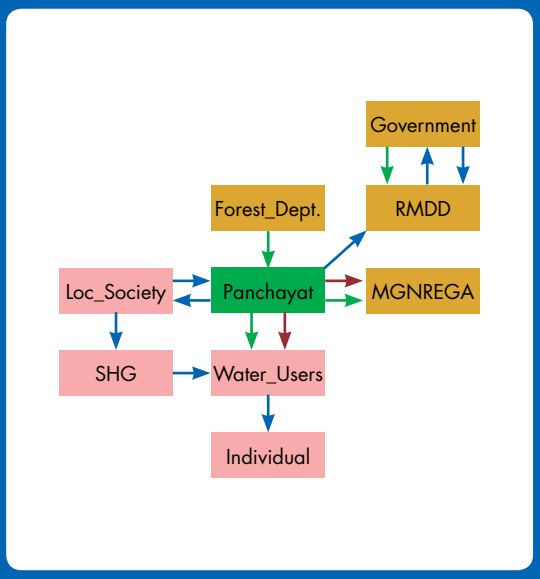


Figure 4: **Develop by civil society**

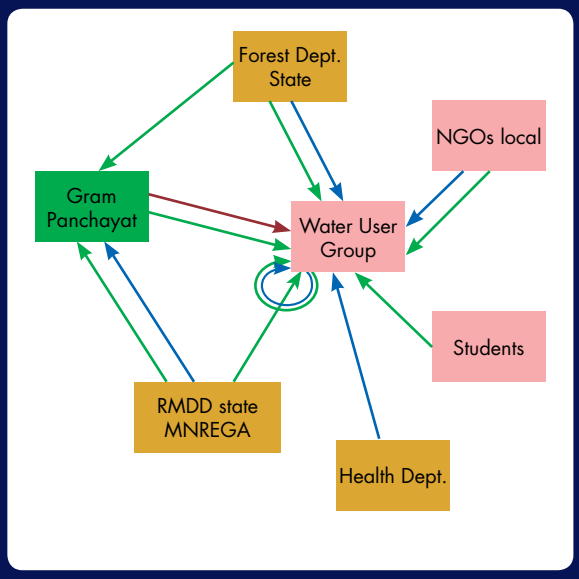
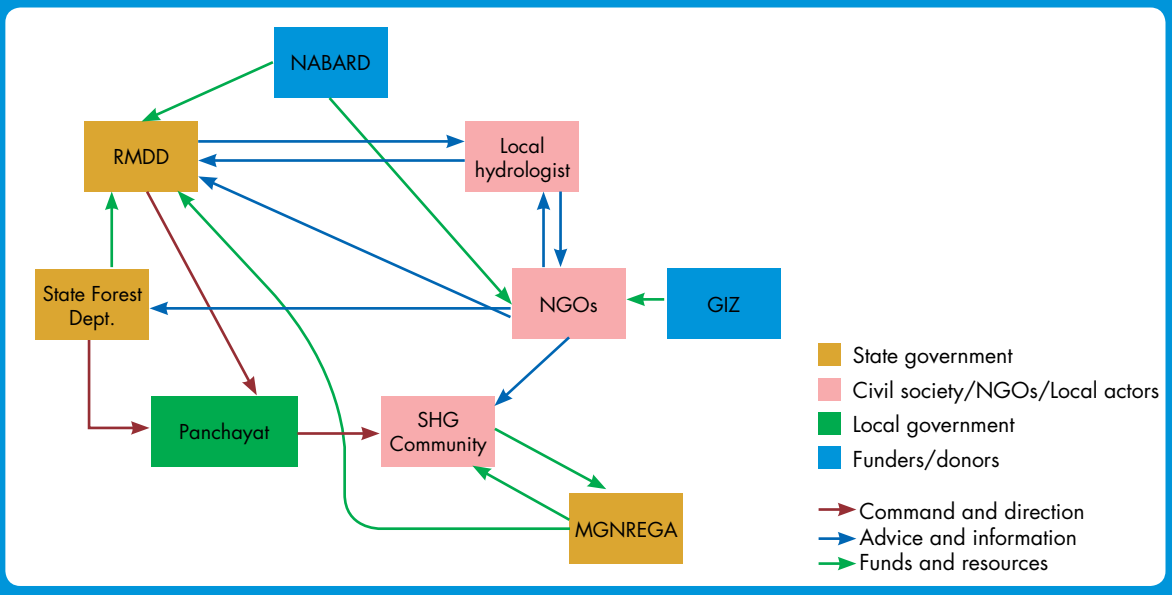


Figure 5: **Develop by the academia**



those of the academia. However, the academia's denser networks have low transitivity when compared to those of international agencies'. This shows that even when a given network is well connected, there are barriers to information and opinion flow due to low transitivity.

International agencies mentioned that the Panchayat is the most influential body. However, the latter's network reflected Block Development Office (BDO) as the most central actor in terms of both direct contact (Centrality) and as a broker (Betweeness) between two actors. The local government identified self-help groups (SHGs) and local communities as powerful, but the same dynamic has not been reflected in the map. SHGs are not major players in the power dynamics as they have medium-level power.

Closing Session

For the benefit of the larger audience especially those participants coming from remote Gram Panchayats Units of East, South and West District of Sikkim, Ghanashyam Sharma summerized in a simple Nepali language on the whole proceeding of the workshop stressing on the Water Availability and Access as the core issue. He started with the first session where status of water in mountain areas of the Teesta basin was discussed. He acknowledged that the participation from the state government department those dealing with water was remarkable which invariably benefited the entire workshop proceedings. He added that the participants were enriched by interesting presentations on geology, hydrology, socio-economics, and biodiversity by G.C. Khanal, Joint Secretary, SSDMA, Department of Land Revenue and Disaster Management, Government of Sikkim, Keshar Kumar Luitel, Geologist, Department of Mines and Geology, Government of Sikkim, and HK Badola, Scientist In-charge, GB Pant Institute of Himalayan Environment and Development, respectively. He further added that the presentation of Springshed Development/Dhara Vikas Initiative in Sikkim by Sarika Pradhan, Joint Secretary, Rural Management and Development Department, Government of Sikkim gave an interesting insight on how springs and the drying lakes are being revived in Sikkim. Similarly, there was a good representation from the Academia consisting of highly renowned academicians, scientists, students and who expressed their view on the issue and also gave very important recommendations.

Further, he emphasized on the active participation of the representatives from the local government (Panchayats) from East, West and South District of Sikkim who openly discussed the issues and gave important recommendations. He then thanked the representatives from civil society/Community Based Organization who participated from different parts of Sikkim, Darjeeling and Kalimpong who participated actively in the Workshop. Similarly, he thanked representatives from donor and funding agencies for their concern on the issues and recommendations in the plenary. He stressed that success of the Dhara Vikas Initiative in the state of Sikkim was possible through the collaborative effort of various agencies. Apart from the convergence with the MGNREGA, some funding agencies like Arghyam, GIZ and NABARD provided funds and other organizations such as ACWADAM, WWF INdia, TMI India, PSI provided technical and scientific expertise and capacity building in better implementation of the Dhara Vikas Initiative in the state, he added.

Ghanashyam Sharma expressed that the design of the workshop was unique in the sense that different stakeholders including local community members, Panchayats, relevant government department officials, R&D institutions, and the donor agencies could come together to discuss the issue of *water access* and *availability* in a common platform.

Annex 1: Agenda of the workshop

Schedule

Registration

Inaugural session

Welcome address: S Vijay Kumar, Distinguished Fellow, TERI and former Secretary, Ministry of Rural Development, Government of India
Welcome address: Suruchi Bhadwal, Associate Director, Earth Science and Climate Change Division, TERI
Overview, HI-AWARE: Phillipus Wester, Chief Scientist, Water Energy Management, ICIMOD

Session 1: Status of water in mountain areas of Upper Ganga Basin

Panel discussion: S Vijay Kumar, TERI
Sarika Pradhan, Joint Secretary, RMDD, Sikkim
HK Badola, GB Pant Institute of Himalayan Environment and Development
GC Khanal, Joint Secretary, SSDMA, Sikkim
Keshar Kumar Luitel, Department of Mines and Geology, Sikkim

Session 2: Water access and availability

Break-away groups for understanding issue and identifying responses for water access and availability in mountain areas

Plenary

Session 3: Operationalising Identified Responses

Break-away groups for discussion on operationalizing identified responses

Plenary

Closing session

Annex 2: Engagement statistics

Participants

Gender			Disaggregated by affiliation					Disaggregated by location		
Male	Female	Total	Researchers	Policy makers – state level	Practitioners	Govt. Officials - Local	Media	International	Other States (besides Sikkim)	Sikkim State/ District /Local
40	9	49	9	12	16	7	5	9	6	34

Figures 1, 2 and 3 demonstrate participants' disaggregation according to gender, affiliation and location.

Figure 1: **Participants— Disaggregated by gender**

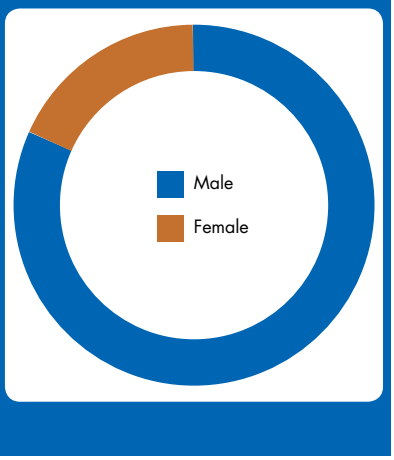


Figure 2: **Participants— Disaggregated by affiliation**

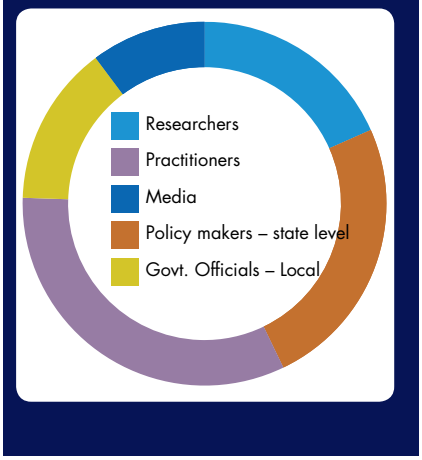
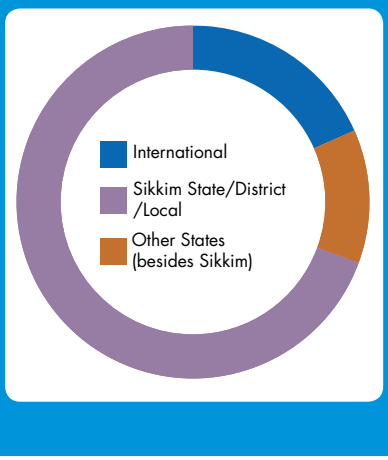


Figure 3: **Participants— Disaggregated by location**



Annex 3: Engagement evaluation

It is evident that the workshop met the satisfaction of the stakeholders in terms of both organisation and expertise of the resource persons.

Figure 4: **Feedback about the event**

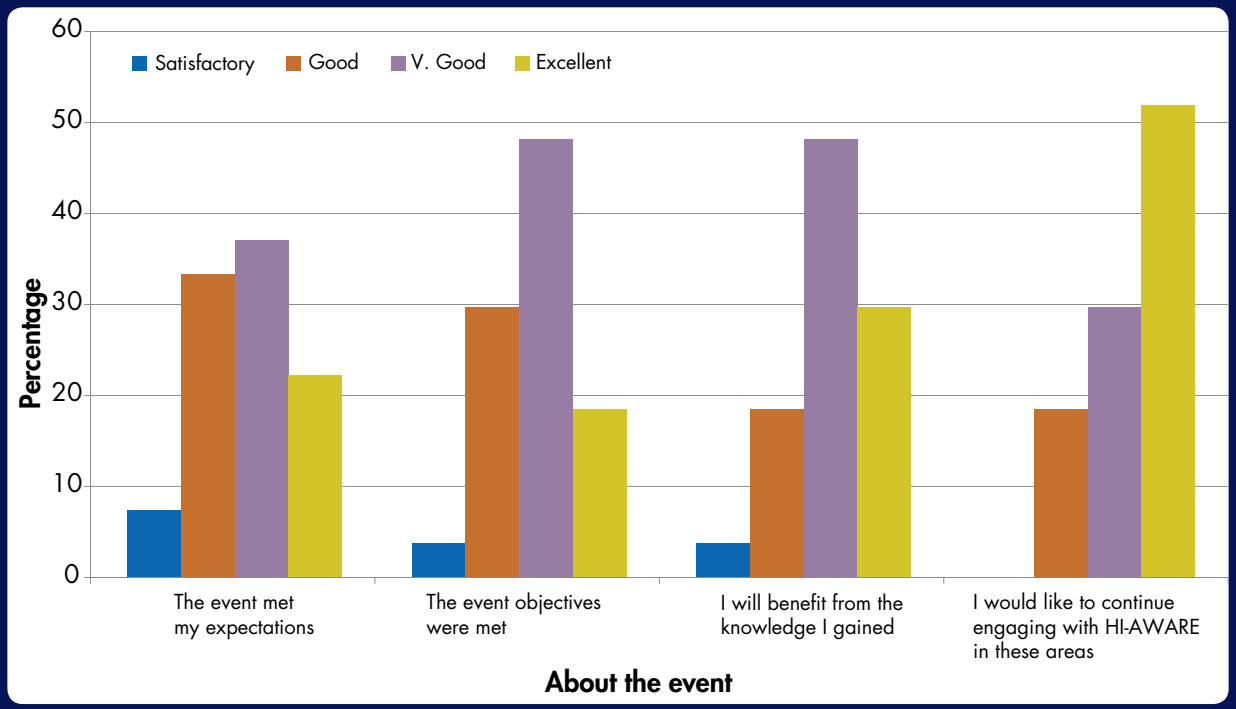
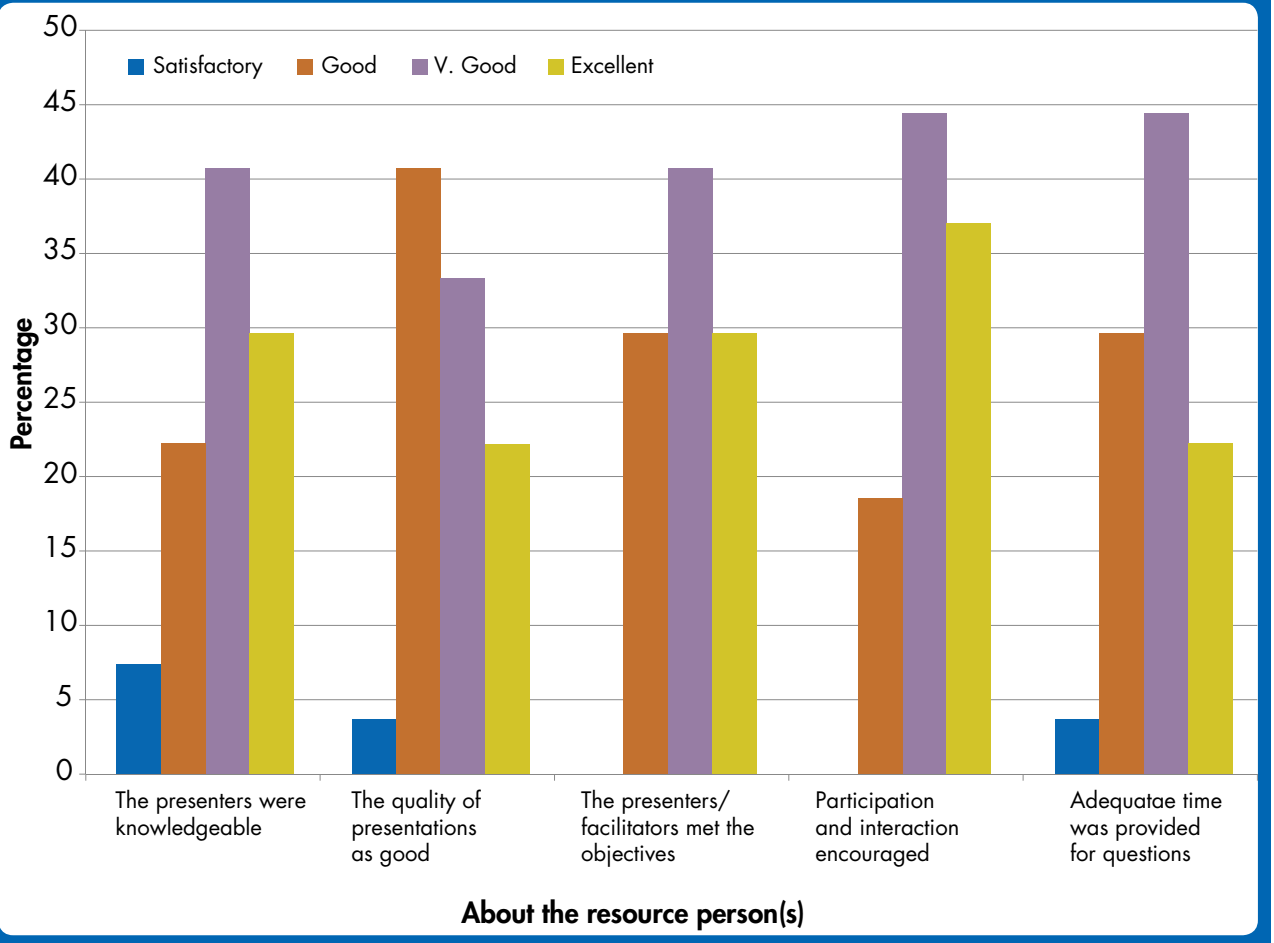


Figure 5: **Feedback about the resource person(s)**



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