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Content

A Knowledge Hub to Address Transboundary Disaster Risk and Water Security Issues in the Koshi River Basin

Kripa Shrestha and Nishikant Gupta

Abstract

The Koshi River Basin is critical for the livelihoods of millions of dependent communities however, is also under increasing stressors. The projected change in climatic variables here has the potential to adversely impact the basin's important services. These impacts are often transboundary in nature. There is an urgent need for the basin countries to identify common challenges and shared solutions for joint targeted actions. The Koshi DRR Knowledge Hub (KDKH) could provide this opportunity.

1. Background

The Koshi River Basin (KRB) is a transboundary river basin shared by three countries – China, India, and Nepal. It contains numerous diverse ecosystems and protected areas, which support a range of species and related ecosystem services for dependent communities (Zhang et al., 2011). The KRB plays an important role in sustaining the lives and livelihoods of millions of people; however, the Koshi River also presents a high frequency of varied natural hazards that annually not only cause widespread damage to infrastructure but also result in considerable loss of human lives in the mountains and in low-lying areas of Nepal and Bihar, India. During the period from 1954 to 2014, Nepal experienced 41 flood events which killed almost 6,500 people. On similar lines, floods in Bihar claimed 9,500 lives between 1979 and 2017 (Government of Bihar, Disaster Management Department, 2019).

Photographed by: Jitendra Bajracharya

Past studies carried out for the KRB project a 4°C likely increase in temperature by the end of the century (Nepal, 2016), and a 5-25% likely increase in monsoon precipitation (Rajbhandari et al., 2016). In addition, the length of the wet and dry spells are expected to increase and decrease respectively (Agarwal et al., 2014). There is a significant temporal and spatial variability projected within the basin for precipitation, actual evapotranspiration, and water availability (Bharati et al., 2016), and the climate change-induced hazards in upstream mountain and hilly areas may lead to severe impacts in both upstream and downstream (low-lying) areas (Rasul & Hussain, 2015). Extreme weather events attributable to climate change and variability and environmental degradation have cascading impacts and are expected to magnify in frequency and intensity over the coming decade. Climate change in the KRB may impact water resources, agriculture, food security, and local livelihoods (Hussain et al., 2016). Women and marginalized communities are most vulnerable as they lack access to information and the capacity to prepare for disasters and deal with their aftermath. Although there have been numerous past and ongoing efforts to improve disaster risk reduction (DRR) in the KRB, related policies and practices need to be further strengthened for a resilient KRB.

2. Importance of transboundary cooperation

The KRB has the potential to contribute to economic growth across boundaries. The scale of damage caused by the disasters highlights the need to enhance the resilience of the basin. There is limited available knowledge on this subject, and information sharing and data generation in the basin presents significant challenges. Therefore, there is an urgent need for transboundary cooperation to address DRR in the KRB. Accordingly, it is critically important to establish a common platform where stakeholders (e.g., policy makers, scientists, practitioners, researchers, academics, media personnel, and private-sector institutions) from neighbouring basin areas can share their experiences, challenges, and success stories to address hazards related to upstream and downstream linkages.

3. Koshi DRR Knowledge Hub – towards a resilient KRB

The Koshi DRR Knowledge Hub (KDKH) has been conceptualized as a platform, led and driven by members to foster transboundary collaboration and promote science, policy, and practice interlinkage. The hub was developed through a consultative process with various stakeholders between 2017 and 2018 to address DRR in the basin as a multifaceted, interdisciplinary, and transboundary issue. The consultative process was led by the Koshi Basin Initiative (KBI) at the International Centre for Integrated Mountain Development (ICIMOD) with support from several partners across the basin who have been collaborating to comprehensively understand the disasters in the basin and enhance its resilience. During the KDKH's inception workshop in December 2018 (organized jointly by the Bihar State Disaster Management Authority (BSDMA), Sichuan University, China and ICIMOD) the hub's common vision, success indicators, working areas, and possible governance structure were discussed. Workshop participants proposed that the KBI at ICIMOD be designated the KDKH's Secretariat. ICIMOD accepted this proposal.

The platform aims to facilitate integration of research, policy, and practice among transboundary stakeholders to develop collaborative activities and projects that will improve decision making related to the management of the KRB. For example, joint projects can lead to better transboundary cooperation. The KDKH will be mobilized through the Transboundary Working Groups (TWGs) to identify areas for cooperation and knowledge sharing between institutions and stakeholders across the basin and contribute to transboundary cooperation.

The KDKH also prioritizes the engagement of graduate students, private-sector institutions, and the media in promoting transboundary cooperation. This approach is critical as young researchers can provide a different perspective, are more future oriented, and can be influenced to focus on transboundary cooperation to enrich the KDKH, keeping the transboundary perspective intact in their research philosophy. Further, Private-sector partners can be the building blocks for on-site investments to enhance the adaptive capacities of local communities. In addition, science-based journalism can play an important role in reducing the spread of misinformation across borders and work towards improving understanding between upstream and downstream communities.

4. Way forward

It is important for the KDKH to gradually grow as a platform for collaborative science- and evidence-based decision making in the long term. Initiating such collaboration is a pressing need, and the KDKH can help to deal with the transboundary impacts of floods, landslides, glacial lake outburst floods (GLOFs), and increasing sedimentation. In addition, promoting the sharing of diverse knowledge and adopting and fostering good practices collectively can serve as a good foundation for cooperation. This can be complemented by data generation and timely sharing of vital information between upstream and downstream agencies for preparedness and coordinated response to minimize the possible impact of climate change and associated disasters (Gupta et al., 2018). Enhancing transboundary cooperation through hubs like the KDKH can also lead to improved mutual understanding between nations and address common transboundary disasters.

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Disclaimer

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Irrigation Water Pricing in Sone Command Area

L. B. Roy

Abstract

The objective of the study was to estimate irrigation water price for wheat and rice crops in Paliganj distributary under the Sone canal System in Bihar. Data regarding canal and tube well water charges were collected from WRD and local farmers through questionnaire and using Residual Value Method, price of irrigation water was calculated. The average irrigation water price on the basis of applied irrigation through canal and tube well lies between Rs. 3.70/m^3 to 4.67/m^3 for rice and Rs 4.17 /m^3 to 5.94 /m^3 for wheat.

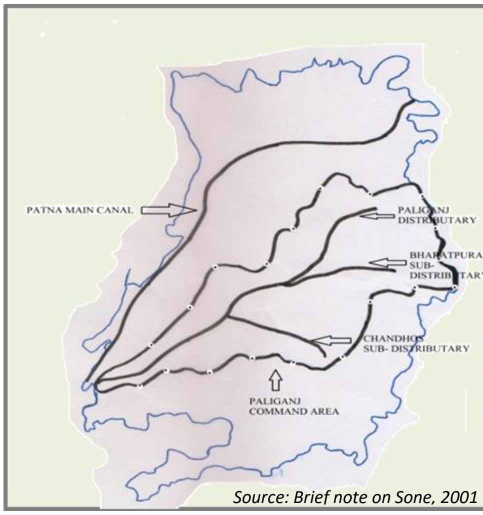
1. Introduction

In India, gross irrigation potential has increased about five folds since 1951 due to phenomenal expansion in irrigation development. However, direct recovery from these irrigation schemes has been very low. The staggering difference between expenditure incurred and revenue recovered, is largely responsible for dismal performance of the irrigation sector. This can also be attributed to the defective pricing structure for irrigation water, which is highly subsidized and is not reflecting its true supply cost. Under-pricing of water has induced excess use of irrigation water leading to environmental problems like waterlogging and salinity in the irrigation commands. Water rates have not been revised in many states. Even now, lower and outdated water rates are continuing and as a result there has been a drop in the revenue from water charges. Irrigation is a crucial input for success of agriculture production and economic development of the country. It is one of the key inputs for food production. With agricultural sector being a major consumer of water, pricing of this input is one of the basic steps and an integral component in the process of rationalizing the totality of the price structure and increasing the efficiency of water use. The pricing has to be such so as to achieve full cost recovery in due course and in the process promote savings, create disincentives for wastages and thereby enable expansion of the service area and assure more reliable delivery.

India is gifted with large and reasonably good land and water resources by nature, but with an alarming increase in population, per capita water use and high living standard availability of water resources is continuously decreasing. The declining per capita availability of water for diverse uses has attracted serious concern for regulating the use of these finite but vital natural resources through rational price structure. Better utilization and management of land and water resources seems to be the only feasible way to increase production on sustainable basis. Worldwide water demand is growing in all parts of the globe.

2. Irrigation water pricing in Bihar

Bihar is one of the prominent states of India, which plays an important role in the Indian economy with the geographical area of 94,163 km^2. Bihar is a landlocked state of India and is covered by forest and mines with huge resources of rivers. It lies between latitudes ranging from 24° 17' 6" N to 27°30.93' N and longitude ranging from 83°19' 17" E to 88° 17' 47" E.



Source: Brief note on Sone, 2001

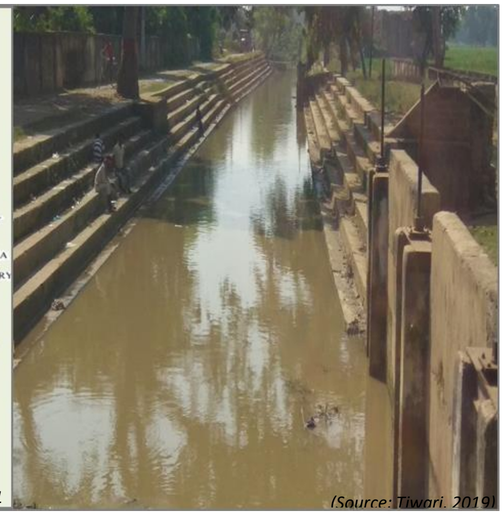

(Source: Tiwari, 2019)

Table 1 Salient Features of Paliganj Distributary (Srivastava, 1994)

1.	Parent channel	Patna Canal
2.	Total length of parent channel	125 km (78 miles)
3.	Discharge of parent channel at offtake of Paliganj distributary	31.5 cumec (1100 cusec)
4.	Offtake point of Paliganj Distributary	75 km (46.2 miles)
5.	Total length of Paliganj canal Network including Chandos and Bharatpurasubdistributaries	40km (25 miles)
6.	Discharge at the head of Paliganj distributary	5.1 cumecs (180 cusecs)
7.	Gross Command area(geographical) under Paliganj Distributary	14,867 ha
8.	Culturable Command area under Paliganj Distributary	12,197 ha
9.	Reported Kharif area (paddy) in rainy season	4960 ha
10.	Reported Average Rabi area (wheat, pulses, oil seeds) in winter season, December- March	2000 ha

Sone command area development authority was created on 1st November, 1973 for all-round development of the command area for the purpose of increasing the utility of irrigation potential and agricultural output i.e. the programme is meant for maximum utilization of available water of the Sone canal system, increasing agriculture production, optimum utilization of underground water with provision of drainage as well, maintenance and regulation of distribution system, restoration of proper crop programme, production management and increasing production and providing marketing facilities. Districts under Sone Command area are Patna, Bhojpur, Buxar, Rohtas, Bhabhua, Gaya, Jehanabad, Aurangabad, Palamu and Garhawa. The salient features of Paliganj distributary and its cropping pattern are as given in Table 1 and 2 respectively.

Table 2 Cropping Pattern in Paliganj Distributary (Brief note on Sone, 2001)

Crop	Rice	Wheat	Maize	Pulses	Oilseeds	Sugarcane	others
% Area	42.1	27.7	9.2	6.9	1.6	3.3	9.2

3. Results and Discussion

As per report of Government of India on flow and lift irrigation water in public system in India (2017), the maximum flow irrigation charge varies from Rs 6297/ha for the state of Maharashtra to the minimum of Rs 61.78/ha in the state of Tamil Nadu. The minimum flow irrigation charge varies from Rs 312.50/ha for Tripura to Rs 2.77/ha for Tamil Nadu. Similarly, the maximum rate of lift irrigation varies from Rs 5405 /ha for Maharashtra to Rs 12.35/ha for Haryana. The minimum rate of lift irrigation varies from Rs 312.50/ha for Tripura to Rs 12.35/ha for Haryana. In States of Arunachal Pradesh, Meghalaya, Mizoram, Nagaland and Lakshadweep, there are no water rates either for flow irrigation or lift irrigation. Thus it is observed that there is wide variation of water charges across the country.
Using Residual Value Method in which difference of gross returns of each crop and costs of production (excluding water) is divided by the amount of water applied (m^3), price of irrigation water was calculated.

The Benefit cost ratio is defined as the ratio of the total present worth of benefit and the total present worth of cost. The costs of cultivation with and without irrigation are estimated. The difference of these two will give the cost of irrigation water. The comparison is usually done using the present works of capitalized benefits and estimated costs. Benefits are capitalized over the life of the system; and normally 50 years life expectancy is used for a diversion irrigation scheme. The present worth of the capitalized benefit or cost is calculated using discounting table and then B/C ratio is calculated using the following formula.

$$B/C\ Ratio = \frac{Total\ Present\ worth\ of\ benefit}{Total\ Present\ worth\ of\ cost} \quad . \quad . \quad . \qquad (1)$$

For each reach ten samples survey were conducted in the field. Based on this the summary of water prices and B/C ratios are as given in Table-3 for three different reaches of Paliganj distributary from which it is observed that for all the three reaches the average B/C ratios for Rice and wheat are 1.36 and 1.21 respectively. It is due to higher yield of rice than that of wheat.

Table 3 Comparison of Irrigation Water Price in the Study Area (Source: Tiwari, 2019)

Reach-1(Head)				
	Irrigation water price on the basis of applied irrigation (Rs/m^3)			**B/C Ratio**
	Max	**Min**	**Average**	
Rice	4.95	2.19	3.70	1.41
Wheat	7.20	2.32	4.18	1.23
Reach-2(Middle)				
	Irrigation water price on the basis of applied irrigation (Rs/m^3)			**B/C Ratio**
Rice	5.55	1.55	3.90	1.35
Wheat	7.00	1.21	4.19	1.21
Reach-3(Tail)				
	Irrigation water price on the basis of applied irrigation (Rs/m$^{3)}$			**B/C Ratio**
Rice	6.44	2.50	4.67	1.33
Wheat	7.00	3.21	5.94	1.20

From Table-3, it is evident that the average irrigation water price was Rs 3.70/m^{3}for rice and Rs 4.18/m^3 for wheat whereas B/C ratio was 1.41 for rice and 1.23 for wheat in Reach -1. For Reach-2, the average irrigation water price was Rs 3.90/m^3 for rice and Rs 4.19/m^3 for wheat, the B/C ratio was1.35 for rice and 1.21 for wheat. For Reach-3, the average irrigation water price was Rs 4.67/m^3 for rice and Rs 5.94/m^3 for wheat. Also, the B/C ratio was 1.33 for rice and 1.20 for wheat. Therefore, it can be concluded that it is more economical to grow rice compared to wheat in the study area. Also, from the Table-3 it is evident that the irrigation water price is maximum in Reach-3 i.e. tail reach for both the crops i.e. rice and wheat. This may be due to the reason that less water reaches the tail end during both the crop seasons. Therefore, tube well irrigation will be needed. The water price is less for rice compared to that for wheat in all the three reaches of the canal. This can be due to high yield of rice than that of wheat.

4. Conclusions

Based on the above results and discussion, it is recommended to have irrigation water price based on volumetric basis, so that it may help in water saving thereby increase in irrigated area. Apart from this, it will improve the process of assessment and collection of water dues

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Drought Monitoring in Southeast Asia, it’s Links to Sustainable Development Goals and Ongoing Initiatives

Rishiraj Dutta

Abstract

Impact of climate change is a major concern of Southeast Asia with the ASEAN region facing extreme weather conditions at frequent intervals and more specifically drought. Efforts are being made to minimize such impacts by strengthening the real-time monitoring capabilities to improve decision-making. Therefore, this paper provides a brief understanding of the ongoing regional initiatives towards drought management and the role of space technology. It also identifies the linkages between drought and SDG’s to address some of the common regional concerns.

1. Background

Climate change have already started showing its impact on water resources from increased temperature and shift in precipitation patterns resulting in prolong droughts and floods. While there has been concerns on the depleting water resources, such conditions are further worsened by changes in precipitation patterns resulting in frequent dry spells. Studies in the recent years have shown that vulnerabilities to important regional water resources are also due to changes in both temperature and precipitation patterns. Therefore, the need of the hour suggests that at local and regional scales, policies needs to be evolved and technical measures needs to be taken to avoid or reduce the negative impacts of climatic change on the natural environment and society. Understanding the possible impacts of climate change on water resources is of utmost importance for ensuring its appropriate management and utilization.

Climate change in Southeast Asia has been recognized as one of the most serious challenges the region is facing today and is expected to impact hydrological processes such as precipitation and evapotranspiration. This, in turn, is already bearing its direct impact on stream flow and groundwater recharge. One of the evolving scenario in the region is the increase in frequency of drought. The El Nino of 2015-2016 have further exacerbated the situation with the region facing once of the most extreme drought situations in its history.

Drought contributes to significant socio-economic costs in the ASEAN region, disproportionately affecting poor and vulnerable communities. The most recent drought in 2015, amplified by a severe El Niño that began a year earlier, cut across large parts of the ASEAN region – triggering extended dry spells, water shortages, prolonged lean seasons, and food shortages that left no ASEAN country untouched. The prolonged drought forced many farmers into substantial debt, while numerous provinces across several South-East Asian countries were declared disaster zones. Drought has significant impacts on many sectors, including fish and aquaculture, forestry, and industry and each country experiences drought in different ways either a single drought situation or multiple drought situations. Around four fifth of economic impact of drought is from agriculture (UNESCAP, Asia Pacific

Disaster Report, 2015). Moreover, farming communities hit by drought also respond is different ways. Some may be able to absorb the shocks by migrating or drawing on their savings while for the poorest farmers, they may resort to erosive coping mechanism such as removing their children from schools, taking high interest loans or even selling off their assets.

2. Importance of space based information for drought monitoring

Space based information specifically satellite data can provide the occurrence, severity and extent of drought in a particular region. Due to its capability to retrieve surface parameters with high spatial and temporal resolutions over larger areas, a comprehensive view of the situation can be obtained for the affected area. Stress associated with vegetation can be easily detected from satellite data using various vegetation indices such as Normalized Difference Vegetation Index (NDVI), Normalized Difference Water Index (NDWI), Enhanced Vegetation Index (EVI) and others. While these information are useful for decision-makers to take effective decisions towards preparedness and response, it however provides farming community with early warning to take appropriate action towards adjusting cropping calendar as well as adopting drought resistant crops and water harvesting methods. Real-time monitoring of drought conditions using satellite data has become important in the recent past to improve the decision-making process of a country. Efforts have already been made to develop drought monitoring tools that can provide real-time information of conditions on the ground. Some of these tools are being explained in the subsequent part of this paper where geospatial data together with observed data are integrated to provide real-time drought conditions in the form of drought indices.

3. Drought and achievement of Sustainable Development Goals (SDGs) in ASEAN

In ASEAN countries, agriculture represents an important share of the national production; except for Singapore and Brunei Darussalam, agriculture represents approximately more than 5% of the gross domestic product (GDP). For Cambodia, Lao PDR, Myanmar and Vietnam agriculture accounts for 17 – 28% of the value-added GDP (WB, 2017). Even though the impacts of drought in the national economies are difficult to quantify, it has been estimated that in years when drought takes place, economic growth decreases by up to 1.7% of GDP (Loayza et al., 2009), and that impacts persists up to one year after the event affecting economic growth with reductions in GDP up to 0.6% (Fomby et al., 2013). These effects are directly related to SDG1 - End Poverty in all forms everywhere - as it challenges providing social protection to the most vulnerable groups, guaranteeing equal rights to economic resources and satisfying basic services, among which water is one of the most important and directly affected by drought episodes (Sena, A., Freitas, C. M. de, Barcellos, C., Ramalho, W. and Corvalan, C., 2016). SDG 8 -Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for al - relates to efforts in promoting local economies and reducing social and economic inequalities that are threatened by droughts since they have larger impacts on the most vulnerable agricultural livelihoods (Sena, A., Freitas, C. M. de, Barcellos, C., Ramalho, W. and Corvalan, C., 2016).

Farmers are the first to endure the effects of drought. This phenomenon jeopardizes food security in countries that already register undernourishment rates above 14% (ESCAP, 2016), and the livelihoods of a population strongly dependent on agriculture. Across the ASEAN region, Lao PDR has the largest share of employed population in agriculture (72%), followed by Cambodia (64%), Myanmar (53%) and Vietnam (42%) (ADB, 2017). Food security and nutrition is directly addressed by SDG2 - End hunger, achieve food security and improved nutrition and promote sustainable agriculture - relating to scarcity and contamination of foods due to scarcity and contamination of water driving food insecurity and malnutrition. Increased crop productivity through increased water availability for smallholder subsistence farmers should be main priorities to address this challenge.

Population in Lao PDR, Cambodia, Myanmar and Vietnam is expected to increase, and this demographic growth imposes pressure on agricultural production. Climate change adds a new dimension to the problem of satisfying the demand for agricultural products. Projections from probabilistic crop models and climate change projections have predicted a reduction of 1.4% in rice production—a staple crop in the region—by 2030 (Lobell et al., 2008). There is high confidence that climate change will impact crops negatively and that variability in crop productivity will increase (IPCC, 2014). Adaptation measures for the agricultural sector are a key factor in reducing these negative effects (IPCC, 2014).

Sena *et al* (2016) provides an analysis on the linkages between other SDG and populations exposed to drought, summarized as follows:

- SDG 3: Ensure healthy lives and promote wellbeing for all at all ages; related to reduced child mortality and disease incidence, and increased life expectancy rely on access to potable water. This goal is directly related to SDG 4 "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" as it allows access to primary and secondary education;
- SDG 5: Achieve gender equality and empower all women and girls; is in many cases challenged when work and local economies depend on women affected by drought or when families get disrupted as women take care of families while men migrate as a response to drought looking for work and income;
- SDG 6: Ensure availability and sustainable management of water and sanitation for all; related to access to water security and quality that depends on water availability, water treatment and hygiene, and services;
- SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all; relates to increased energy inputs from renewable sources, for example, hydro-power. Hydroelectricity generation is the main source of power generation in Cambodia and Myanmar and close to half of total production in Vietnam (ADB, 2017), while other countries have smaller shares the

whole region has plans for increasing hydro-power generation in this decade that will at least double their current output (EIA, 2014, 2015),

- SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation: mostly relates to the effects of prolonged droughts on agricultural value-chains that induce reduced production, consumption and investment capacity;
- SDG 10: Reduce inequality within and among countries; can be affected due to differentiated impacts of drought in time and across landscapes and response capacities;
- SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable; is directly related to access to basic services mainly water quantity and quality,
- SDG 12: Ensure sustainable consumption and production patterns; relates to productive systems that ensure sustainable provision of hydrological services resilient to the impacts of drought;
- SDG 13: Take urgent action to combat climate change and its impacts; relates to drought impacts on degradation and desertification patters that can be enhanced by climate change;
- SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainability manages forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss; related to the effects of desertification on reduced water availability and negative synergies with the frequency and intensity of drought events;
- SDG 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels; related to effects of droughts on social violence enhanced by processes of social migration, urbanization, human and economic losses.

4. Ongoing initiatives of drought at regional level

Although efforts are been made to access tools and information such as the Agricultural Stress Index System, many countries however, do not have institutional capacity to integrate these knowledge products into their operational drought monitoring and early warning system as well as have limited knowledge on data access and interpretation. A further obstacle to effective implementation is a lack of inter-agency cooperation for sharing information or presenting it in ways that could be understood and used.

Therefore, Regional Drought Mechanism of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) (UNESCAP, Regional Drought Mechanism, 2010) was established taking the advantage of data and imagery from the region’s spacefaring countries − such as, China, India, Japan, Thailand and others and shares it with other countries, especially those suffering from frequent and prolong droughts. This service complements World Meteorological Organization (WMO)’s Global Framework for Climate Services by providing more detailed, localized forecasts and monitoring that can be updated during the growing season. The aim is to give a comprehensive real-time drought monitoring and early warning system and linking it to long-term climate scenarios with the seasonal climate outlooks. This would enable countries to use this for monitoring in-season crop stress and issuing timely alerts on the onset of agricultural drought over large areas allowing mid-course corrections and measures for drought mitigation. The mechanism also develops partnerships and works with national governments to clarify and build the institutional network required to ensure the early warning services reach the right people.

4.1. FAO Agriculture Stress Index System (FAO-ASIS)

ASIS (Agriculture Stress Index System) (FAO Agricultural Stress Index System, n.d.) monitors vegetation indices across global crop areas during the growing season and can detect hotspots all over the world where crops maybe affected by drought. ASIS allows countries to fine-tune parameters of the system based on detailed land use maps and national crop statistics. This would allow them to obtain timely and reliable information on the condition of food crops all over the world enabling them for mitigating the impact of agricultural drought.

4.2. Regional Drought & Crop Yield Information System (RDCYIS) for Lower Mekong

Drought is an increasingly frequent phenomenon in the Lower Mekong Region (Cambodia, Lao PDR, Myanmar, Thailand and Vietnam). Whereas seasonal flooding cycles have a number of positive impacts on the region's agriculture and ecosystems, drought events bring primarily negative impacts on ecosystems, agriculture, and socio-economic conditions, of the farming communities. A regional geospatial needs assessment conducted by SERVIR-Mekong during 2014-2015, and subsequent consultations with regional and national institutions highlighted the need for reliable information on past, present, and forecast drought conditions and related crop yields. As a result, the Regional Drought and Crop Yield Information System (SERVIR-Mekong, n.d.) for Lower Mekong was developed with the sole purpose of monitoring and forecasting drought conditions in the five Lower Mekong countries of Cambodia, Lao PDR, Myanmar, Thailand and Vietnam. They system was developed with the aim of improving governance and decision-making in the water and agriculture sectors.

This integrated web-based information system is intended to:

- improve the operational, technological, and institutional capabilities to prepare for and respond to droughts in the Lower Mekong region;
- support local decision-makers in drought monitoring, analysis, and forecasting;
- provide policy makers and growers with current and forecast drought indices to facilitate decision-making within the current growing season; and
- provide ecological and financial forecasting information to inform seasonal cropping decisions. Subsequent functionality may include additional information relevant to decisions at sub-seasonal or multi-year temporal scales.

4.3. Mekong River Commission Drought Management Programme (DMP)

The MRC's Drought Management Programme (DMP) (Mekong River Commission, n.d.) is being implemented with the aim to assist the riparian countries by preparing vulnerable communities for increasingly frequent and severe drought events through monitoring, analysis and implementation of regional drought adaptation and mitigation strategies. The DMP includes developing a greater understanding of the region's drought conditions as well as analysis of drought risk and vulnerability for regional drought projection and mitigation policy. The drought monitoring tools will allow countries towards early detection of drought to identify and understand the key patterns and causes of drought and ultimately improve their long-term agriculture plans as well as proactive and emergency responses to drought events. Through this programme, MRC is taking collaborative actions by embarking on broad views and adaptable strategies to address the multifaceted issues pertaining to drought and its effects on agriculture, water and land use.

4.4. Flood and Drought Management Tools (FDMT) Project

United Nations Environment Programme (UNEP) together with Danish Hydrologic Institute (DHI) is developing the Flood and Drought Management Tool (FDMT, n.d.) that would respond to a need for improved capacity of managers operating in transboundary river basins to recognize and address the implications of changing climatic scenarios and land-use on water resource management. It is currently being piloted in the Chao Phraya Basin in Thailand. The project developed a methodology for basin organisations and local users to allow integration of information on climate variability and change including floods and droughts, into planning across scales: Integrated Water Resources Management (IWRM) planning, Water Safety Planning (WSP) and Transboundary Diagnostic Analyses (TDA) and Strategic Action Plans (SAP). The products generated through this tool enable stakeholders at the transboundary and national basin to local levels, to compile information, from models, indicators and existing planning approaches to develop future planning scenarios that are robust, resilient and pragmatic. The methodology involves tools that enable users to carry out baseline assessments using readily available satellite data, impact assessments through the analysis of the data, planning options and a means for disseminating information to relevant groups or individuals.

5. Conclusions

The ASEAN member states have acknowledged the importance of the Integrated Water Resources Management (IWRM) approach in achieving water security and are currently working on six key water management issues including water supply management; irrigation management; storm water management; flood management; water pollution management; and sanitation management, at the national level. While ASEAN has already made a good progress towards implementing the SDGs, the need to achieve the path of sustainable development would require ASEAN to further engage in joint thinking that goes much deeper to address the underlying causes. Successful delivery of SDGs will require strong systems approach at the regional, national and local levels, across the sectors and involving various stakeholders including public-private stakeholders. While recognizing the urgent need to address issues such as drought, the Chairman of the 9th ASEAN-UN Summit 2017 declaration in his statement "reaffirms its support to the UNESCAP-ASEAN Joint Study on Drought and Poverty Alleviation that aims to address the necessity of deepening understanding of early warning, preparedness and prevention of such disasters that occurs due to climate change and climate variability together with geographic shifts." The study tends to promote risk sensitive policies and interventions based on drought monitoring and assessment both in-season and long-term will thus contribute to a culture of resilience while also exploring the ways in which impacts to poor farmers can be mitigated.

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Navigating the Livelihood Landscape in Tonga

Helena Shojaei and Eloise Biggs

Abstract

Many people in Tonga rely on services from the landscape to support their livelihoods, yet inhabitants remain acutely vulnerable to the impacts of a changing climate. This article presents examples of policy and project interventions which are impacting landscape users through trade-offs in managing natural resources, particularly around water and food security. Our reflections advocate the importance for holistic intervention approaches, designed and implemented to support rural livelihoods, promote landscape sustainability, and build climate resilience.

1. Introduction

The Kingdom of Tonga, a Polynesian archipelago nation of 170 islands spanning 700 km² across the South Pacific, has a relatively small population of approximately 100,000 people (1, 2). Whilst 70% of the population inhabits the island of Tongatapu, the level of urbanisation remains quite low, with estimates suggesting that 88% of the population still reside in rural areas (3). The majority of these rural communities are dependent upon the agriculture and fisheries sectors for their livelihoods (4), and careful management of the natural environment for future generations is therefore vital for ensuring sustainability of local livelihoods, particularly to safeguard water, food and energy security. Current policy and project interventions, such as special management areas (SMAs), are being executed to improve the health of marine and terrestrial environments. Future initiatives are also being considered, such as the government's proposed water bill to improve active management of groundwater resources. These interventions are important to build landscape resilience, particularly in the wake of recent climate events whereby decimating environmental impacts have ensued. For example, Cyclone Ian swept through the northern islands of Vava'u and Ha'apai in 2014, and Cyclone Gita the southern islands of Tongatapu and E'ua in 2018, leaving a large proportion of the population without shelter, power and water, as well as inadequate local food supplies. Here, based on our field observations, we reflect upon why despite the best intentions of management approaches, sometimes project and policy interventions are limited in effective development and implementation at the landscape scale.

2. Managing natural resources

Acknowledging the conflicts that can arise around natural resource management is imperative. In Tonga, landscape users are embedded in a traditional knowledge system that generally promotes the natural environment as an unrestricted resource. Simultaneously, government-imposed approaches are administering interventions that control access to natural supply. In the case of water accessibility, rural communities depend upon rainwater reserves as a supplement to groundwater wells, which are often poorly managed by village water committees due to the on-going costs and required expertise for maintaining infrastructure (5). Under current conditions, communities lack 24-hour water supplies, and groundwater is at increasing risk of saltwater intrusion, chemical contamination, and leakage (6). The government has recently proposed legislation changes to water policies that aim to permanently take control of managing and maintaining groundwater wells for a fee; this has generally not been well-received by rural communities.

Within the marine environment spatial restrictions have been placed on marine resources by the government to try to restore degraded ecosystems through implementing SMAs. Whilst this designation status seeks to empower local communities to act as guardians for enforcing environmental protection, it also restricts fishing, and fishers have reported counter-activities, such as the use of products like dynamite, to enhance catch potential. Unsurprisingly, such practices can have devastating long-term environmental impacts. Overall reductions in marine resource accessibility have lowered the amount of fish in the local diet, and consequently the intake of processed foods and imported meat has increased. It seems that SMAs are protecting local nutritious food supply for the future without accompanying strategies to alleviate short-term impacts and stress on local livelihoods. One potential option being voiced is to investigate diversifying the aquaculture industry from purely commercial activities to supplying local nutritious food, and thereby increasing human capital.

Photographed by: Helena Shojaei

Fig 1 A trial plot of irrigated taro being cultivated by a commercial copra farmer; irrigation infrastructure is unaffordable for the majority of farmers in Tonga (left). Yams are an important staple crop in Tongan diet and a local cash crop (top right). Widespread kava dieback disease affecting crops in the islands of Vava'u (bottom right).

On the land further issues of natural resource management can be exemplified. In the early 1990s reports suggested that many squash farmers did not adhere to government advice regarding planting during the drought years, and as a result were affected by considerable profit losses and food scarcity

(6). More recently, further reports suggest inexperienced and small-scale farmers have planted other water-intensive crops, such as watermelon, during predicted drought periods in an attempt to maximise income. Such decision-making produces significant challenges for a country not equipped with adequate irrigation infrastructure, whereby farmers are forced to hand-water their crops from groundwater supplies; a water trade-off which compromises freshwater reserves used for all household needs. Other higher revenue crops have instigated similar resourcing issues. Rising market prices for kava have attracted an increasing number of farmers to cultivate the export crop, resulting in reduced fallow years, increased deforestation, land-clearing and mono-cropping. Additionally, the proliferation of kava planting has contributed to the rapid spread of kava dieback disease which is currently affecting 50% of the plantations in Vava'u (Fig 1). This poses a significant threat to people's incomes and the possible initiation of a local food security crisis.

3. The climate change challenge

Such issues related to water and food security demonstrate apparent trade-offs between direct economic returns, environmental preservation and sustaining livelihoods. External pressures are also compounding these challenges, particularly those related to climatic conditions. In Tonga, rising temperatures during the wet season are increasing biosecurity risks for the export of commodity crops. Sea level rises of 6mm have already resulted in coastal land erosion which, when coupled with ocean acidification, poses serious threats to fish habitats (7). Furthermore, estimated increases in the intensity of cyclones presents significant risk to both local infrastructure and food supplies (7). Building climate resilience within farming communities is critical, yet some weather predictions and forecasts have been deemed unreliable which has resulted in select farmers choosing to ignore official weather updates and advice, instead relying on more traditional methods of gauging the weather patterns and 'hoping for the best' by focusing on the lunar calendar. Through observations, it seems that weather advice is often only adopted where strong social relationships exist between the farmer and the agency providing the advice, rather than out of respect for authority, unless regulations are being lawfully enforced. We advocate that trust and communication are essential for supporting the sustainability of community livelihoods across Tonga.

4. Communication and collaboration

There is no quick or easy solution to addressing these natural resource challenges for supporting livelihoods and ensuring sustainable multi-functional use of landscapes. However, there are mechanisms which could help build climate resilience for environmental livelihood security more effectively. Improved communication between various stakeholders, such as between government ministries and with community participation, could be realised to co-develop complementary interventions. Several interdisciplinary boards have been initiated and subsequently folded over recent years, largely due to unreliable funding resources. Reliance on short-term one-off grants (often financed from foreign aid) presents continuing obstacles for ongoing collaboration. Yet, if relationships between stakeholders can be strengthened and sustained, perhaps this would present improved focus for investing and targeting interventions to benefit multiple landscape users. Effective collaboration could enhance the productivity of information flows to reinforce the value of climate resilient-building projects and policies across the landscape.

5. Sustainable climate-smart landscapes

Across Tonga there are a variety of stakeholder groups, at various levels, involved in activities that shape how landscapes function and are used. As expected, the primary interests of these stakeholders vary, such as increasing economic returns from agriculture versus ensuring ecosystem sustainability. This is fuelling growing competition for limited natural resources (8) which presents various socio-cultural conflicts and difficulties. Research suggests that adopting a “landscape approach”, which provides a set of guiding governance principles and explicitly acknowledges the diversity of stakeholders (9), can provide the basis from which all interest groups can negotiate climate-sensitive landscape management strategies. A research project currently underway is seeking to use geovisualisation techniques and tools to support interdisciplinary stakeholder interaction, through communicating governance structures, examining trade-offs, negotiating strategies and enhancing understanding of collective problems (Fig 2). This project is aiming to navigate the complexities and challenges of Tongan landscapes to help enhance the capacity of landscape users to mitigate and adapt to present and impending climate threats which are, and will continue to affect water, energy and food security for supporting sustainable livelihoods. Find out more at www.livelihoodsandlandscapes.com.

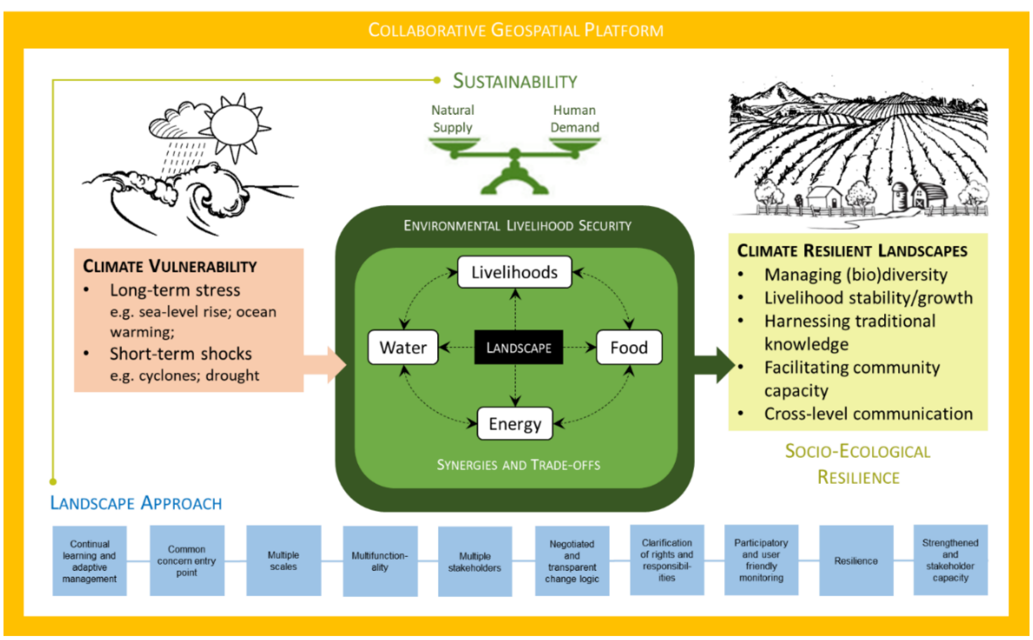

Fig 2 The process being followed to co-develop a collaborative geospatial platform. This tool development is following a landscape approach aiming to enhance environmental livelihood security and help build climate resilience in the South Pacific.

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Technologies for Horticultural Crops for Adaptation to Climate Change

Tanmay Kumar Koley, Ujjwal Kumar and Akram Ahmed

Abstract

Climate change has high impact on the horticultural crops. Variability of temperature and precipitation hinder vegetative growth of horticultural crops. This paper id focused on the technological options for climate resilient horticultural production. It also describes how through selecting appropriate technique during cultivation can avoid production loss due to climate induced factors.

1. Introduction

In the twenty first century, climate change is potential threat to human civilization. The Intergovernmental Panel on Climate Change (IPCC) has projected a temperature increase of 0.5 to 1.2 °C by 2020, 0.88 to 3.16 °C by 2050 and 1.56 to 5.44 °C by 2080, depending on the scenario of future development in the Indian region. Apart from increase in temperature, climate change is projected to cause variations in rainfall, increase the frequency of extreme events such as heat, cold waves, frost days, droughts, floods, etc. As a result, it adversely affects food production. Horticultural crops are most vulnerable to this condition. Since horticultural crops are major pillar of nutritional security, prevention of crop failure in horticultural sector is important aspect.

2. Possible impact of climate change in horticultural crops

Horticultural crops play an important role in ecologically sensitive hilly, coastal, rain fed and dry land area. Climate change has some impact on horticultural crops due to erratic rainfall, general warming and enhanced biotic and abiotic stresses. Various plant processes like vegetative growth, flowering, fruiting and fruit quality are highly vulnerable to climate changes. High temperature in flowering times impairs pollinator movement, dries up pollen and stigma. As a result, poor fruiting will takes place. Similarly in case of fruit crops, fruits will develop more rapidly and mature earlier. High temperature impaired flower bud differentiation and reduced fruit set. In mango, frequent rains occurring during May-June also may delay fruit maturity, reduce fruit quality and adversely impact postharvest life. Beside this, flood, drought, hail storm adversely affect the production of horticultural crops.

3. Technological options for climate resilient horticulture production

3.1 Selection of appropriate crop based on climatic and soil suitability

Selection of appropriate horticultural crops based on land, soil and climatic suitability is important for maximization of overall increase in production of horticultural crops in the country. For sustainable development and realization of high productivity levels, crop planning based on agro ecological considerations and efficient use of inputs has been attempted, only with partial success. The success story of the Konkan region in the Western Ghats in commercialization of mango, cashew, black pepper, etc. demonstrates the possibility of converting once barren hilly tracts into economically viable regions (1). Similarly, there are immense scopes of selecting drought tolerant crops plant in various parts of Bihar. Selection of tolerant varieties to various abiotic and biotic stresses will sustain in changing climate scenario.

3.2 Optimization of land use

Techniques like fruit based multitier cropping systems has proven their effectiveness for improving the land use efficiency through better utilization of land, space and solar radiation. The multitier cropping system comprise of a combination of perennial and annual plant species as different components in the same piece of land arranged in a geometry that facilitates maximum utilization of space in four dimensions (length, width, height and depth) leading to maximum economic productivity of the system (2). Nimbolkar et al (2013) described the general architecture of the fruit based multitier cropping system and existing fruit based multitier cropping systems in various agro-climatic zones of India. Land use systems based on mixed tree crops have clear advantages over annual cropping systems for the maintenance of soil fertility in the humid tropics. Due to climate uncertainty, if one component fails to survive in multitier cropping system, other component supplements income.

Emission of greenhouse gasses is one of the causes of climate change. Multitier cropping system found is beneficial for mitigation of climate change by carbon sequestration (4). Tree components in fruit crop based multitier cropping system can be significant sink of atmospheric carbon due to their fast growth and high biomass production. Fruit tree based cropping system can arguably increase the amount of C stored in the lands devoted to agriculture while still allowing for growing of food crops.

3.3 Green manuring and cover cropping

Growing cover crops and green manure crops can be viewed as a type of crop rotation, where adding nonrevenue generating crop between annual cash crops extends the growing season. Green manures, also referred to as fertility building crops, may be broadly defined as crops grown for the benefit of the soil. The terms cover crop and green manure are frequently used synonymously. Florentín et al (2010) reported the following benefits of green manuring and cover cropping: (1) Add organic matter to the soil, (2) Increase soil biological activity, (3) Improve soil structure, (4) Reduce soil erosion, (5) Increase the supply of nutrients available to plants (particularly by adding nitrogen to the system by fixation), (6) Reduce leaching losses, (7) Suppress weeds, (8) Reduce pest and disease problems, (9) Provide supplementary animal forage, (10) Drying and warming the soil.

3.4 Efficient water management

Due to increasing population and shrinkage of natural resource especially water, Indian population would face severe water scarcity. Water supply for horticultural crops will face more intense competition among the multiple users of water. Furthermore due to climate change, drought is frequent phenomenon to Indian condition. Therefore, increasing water use efficiency for horticultural crops will need attention to mitigate the problem. The strategies for increasing water use efficiency include appropriate integrated land and water management practices like: (1) appropriate scheduling of irrigation, (2) soil–water conservation measures through adequate land preparation for crop establishment, rainwater harvesting and crop residue incorporation, (3) efficient recycling of agricultural wastewater, (4) conservation tillage to increase water infiltration, reduce runoff and improve soil moisture storage, and (5) adequate soil fertility to remove nutrient constraints for maximizing crop production for every drop of water available through either rainfall or irrigation. In addition, novel irrigation technologies such as supplementary irrigation, deficit irrigation, drip irrigation and sprinkler irrigation can improve the water use efficiency of crops.

Drip irrigation practices are becoming popular now-a-days in horticultural crops due to their beneficial effects on water use efficiency and yield which has been successfully demonstrated in different parts of the country (6, 7, 8). Since drip irrigation is a high capital-intensive technique, there are quite a few doubts among the farmers about its net profitability. No doubt, the initial capital investment for drip irrigation system is high. However, the fixed investment is not very high when compared with the benefits realized from the drip method of irrigation. For instance, per hectare cost comes to about Rs. 33,000 for banana, while the same varies only from about Rs. 9,000 to Rs. 16,000 for other crops like coconut, mango, grapes, pomegranate, etc. Though, the initial cost of drip irrigation system is higher, its relative cost is quite low when compared with the average capital cost in the surface system.

3.5 Mulching

Mulching is an effective technique for minimization of evaporative losses. Use of plastic mulches has been successfully demonstrated to increase yield and quality of different horticultural crops (9, 10). Extensive research with coloured mulches has been conducted the experience so far clearly indicate scope of colour mulches under Indian conditions (11). The most serious problems associated with plasticulture relate to removal of used plastics from the field and its environment friendly disposal. Biodegradable plastics are made with starches from plants such as corn, wheat, cassava and potato. They are broken down by microbes. Biodegradable plastics currently on the market are more expensive than traditional plastics, but the lower price of traditional plastics does not reflect their true environmental cost. Application of externally produced organic mulches affects crop growth by influencing weed growth, soil conditions, soil nutrient status, and soil erosion. If weeds are likely to reduce crop yields, organic surface mulches might be able to suppress their growth by hindering and delaying germination (emergence) through shading. On the other hand, mulch may enhance soil conditions for plant growth in general so that also weeds are favoured.

3.6 Protected Cultivation

Protected cultivation of horticultural crops is also another approach for increasing land use along with resource use efficiency. The main purpose of protected cultivation is to create a favourable environment for the sustained growth of crop so as to realize its maximum yield potential even in adverse climatic conditions. Protected cultivation technology offers several advantages to produce vegetables, flowers, hybrid seeds of high quality with minimum risks due to uncertainty of weather and also ensuring efficient and other resources. This becomes relevant to farmers having small land holding who would be benefitted by a technology, which helps them to produce more crops each year from their land, particularly during off season when prices are higher. Thus, protected horticulture has great potential to enhance the income especially of small farmers if appropriate technological interventions are made. Ummyiah et al (2017) described in details about the various Protected Cultivation technologies such as net houses, walk-in-tunnels, greenhouses etc. suitable for temperate regions with suitable crops that can be successfully grown even in low temperature in those structures.

3.7 Grafting

Grafting is a method employed to improve crop production. The first grafted vegetable seedlings used were for Watermelon (*Citrullus lanatus* L.) plants grafted onto *Lagenaria siceraria* L. rootstock to overcome Fusarium wilt. Since then, the use of grafted solanaceous and cucurbitaceous seedlings has spread. The expansion of grafting is likely due to its ability to provide tolerance to biotic stress, such as soil borne pathogens, and to abiotic stresses, such as cold, salinity, drought, and heavy metal toxicity, due to the resistance found in the rootstock. In India under project NICRA, IIHR have identified solanum root stalk which is used for tomato grafting. Grafted plant was found to be tolerant to flood condition. Mauyra et al (2019) described various grafting methods suitable for vegetable crops.

4. Conclusion

Many technologies related to climate resilient horticulture described in this article are available which need to be demonstrated and implemented in farmer’s field for sustainable income. These technologies address at least address one of the Sustainable Development Goals such as fruit based multitier cropping system ensures food and nutritional security as well as sustainable agriculture, green manuring and cover crops reduces land degradation, adoption of efficient water management techniques reduce use of water for agriculture and thus increase environmental water availability and so on. Although some of the techniques such as Protected Agriculture is costlier, long term use of them can be remunerative.

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Case Study 1: Integrated Watershed Management: A Case Study of Som Village in Udaipur District of Rajasthan

Sunita Das

1. Background

Water is an essential element for the sustenance of life. It is chiefly for this reason that the effective management of this precious resource is vital. This case study talks about how the Bhil community in Som village of Udaipur district, Rajasthan managed their limited water resources through watershed development using community participation.

The population of Som village of Jhadol block, Udaipur district is dominated by the Bhil tribes who are one of the largest tribal communities of Rajasthan. The primary livelihood of these communities is agriculture (ET Bureau 2017). At present, mostly small and marginal farmers are practicing subsistence agriculture. During off season they migrate to nearby cities for casual work as labourers. Primarily arid to semi-arid climate prevails in this region with short spells of showers (annual avg. 599 mm) brought by the southwest monsoon (June-September). Rest of the year it receives scanty rainfall resulting in high demand of irrigation for agriculture. Average depth of groundwater here is 15 m from the land surface. Because of low rainfall the farmers have to dig deep bore wells and mine water to sustain agriculture as well as to satisfy their domestic needs. Farmers with large landholding are able to dig bore wells, but marginal farmers can't afford the financial burden. Moreover, most of the families of these communities tend to dwell near their agricultural fields for the ease of management. However, the water sources are available in the main settlement areas which are away from their houses. Hence, in addition of being inherently water scare region, inappropriate management and allocation of water resources are amplifying the water problem in this region. Apart from that, encroachment of forest land and conversion of forest land into agricultural fields have led to land degradation, soil erosion and depletion of the water table in that area. Poor land management and deforestation are affecting the forests and pastures which have high socio-economic and cultural values to the community. The water scarcity issue in the village has increased the drudgery of women and children as they are forced to travel a long distance to fetch water for domestic purposes. Women mostly spend 5-6 hours in a day for fetching water. School dropout rate of girls may also have increased due to water scarcity as they have to help their mother's for fetching water and taking care of their siblings and cattle.

Scarcity, in any form, must be address with the sustainable solutions. Integrated Watershed Management Programme (IWMP) is a worldwide accepted intervention which not only improves the availability of water resources but also helps in upgradation of the socio-economic and ecological status of the concerned region (Department of Land Resource, Govt. of India 2018). The main objective of IWMP is to "restore ecological balance by harnessing, conserving and developing degraded natural resources such as soil, vegetative cover, and water".

2. Objective

With this purview, this study focused on regenerating the degraded watersheds in this rain deficient rural village of Rajasthan using integrated watershed management programme (IWMP). Both the government and non-governmental organization as well as native communities were involved from the planning to decision making process. Priority was given to alleviate the local water scarcity issues using IWMP that will give immediate as well as long term benefits to the community. The broad objective of this study was to restore the watershed (a) by rejuvenating small streams and rivulets construction of water harvesting structures such as check dams and (b) by plantation of income generating species through community precipitation. The study was intended to restore the ecological balance of the watershed as well as upgrade the socio-economic status of the local community.

3. Methodology

In Rajasthan, Watershed Development Programmes are going on since early seventies. Only after 1991 watershed related works are executed by the Watershed Development Department (Department of Watershed Development and Soil Conservation, Govt. of Rajasthan 2019). However, learning through the implementation challenges, now emphasis is given to Participatory Integrated Watershed Management for the sustenance of the programmes. Currently Panchayati Raj Institutions are overlooking the all Watershed Development Works and they are implemented through elected statutory body i.e. Gram Panchayat/ P.R.Is.

Following the existing governance structure Participatory Rural Appraisal (PRA) method was followed during this study. *"Participatory rural appraisal is a methodology of learning rural life and their environment from the rural people. It is based on village experiences where communities effectively manage their natural resource* (Cavestro 2003). The PRA was adopted to ensure the sustainability of the implemented measures.

To understand the needs of the community at first Focus Group Discussion (FGD) was carried out with them. 25 participants were selected and divided into age and sex. Youths (14-18 years), men (> 40 years) and women (> 35 years) were participated in the FGD. The following questions were asked to every participant to understand their needs.

- What are the sources of your drinking water? From how far do you fetch water?
- What are the forest products do you bring from forest? How many times do you visit forest?
- What are the natural resource management measures would you like to be taken up?
- How much land do you need for watershed management?

Local NGO's were also interviewed with same questions to understand their views on the needs. NGO were kept in loop to keep them updated on the ongoing works in that area.

After the FGD, the next step was to form a forest/ watershed protection committee (FWPC). A FWPC of 7 members was formed which was headed by the Gram Pradhan. 3 men, 2 women and 1 youth were selected from the members of Gram Vikash Committee and local Self Help Group (SHG) as other members of the committee. The committee was headed by the *Gram Pradhan* who is also a representative of PRI. He was responsible to ensure links of the FWPC with the PRIs and NGOs.

4. Results and Discussion

During the FGD, it was found that in the past few decades, the livelihood patterns of these tribes have undergone significant changes due to water scarcity. Agricultural practices have reduced in the village and relatively high rate of seasonal migrants are moving out the village to the nearby cities in aspiration of jobs. During PRA planning exercises, the importance of sustainable water management through a watershed approach was explained to the community.

Photographed by: Sunita Das

To meet their needs, in consultation with the villagers, it was planned to restore watershed by rejuvenating a small stream of the Som River that flows through the village, using water harvesting structure like check dams. Along with that a plantation drive was also planned using income generating species both ecological and economic benefit of the residents. A total of 85 hectares of land was identified with the help of the committee for IWMP. In 20 hectares of area two big check dams were built using boulders and nets through *Shram Daan* (voluntary participation) of the community. These check dams were intended to serve for cattle and domestic needs. In the plantation area of 65 hectares around 20 small check dams were also constructed using wooden logs to restore degraded land and increase water holding capacity of soil. The FWPC was responsible of maintenance and sustainability of these check dams. The check dams constructed will create water storage for the local community through rainwater harvesting. It will enhance water availability and accessibility even during the dry months. Irrigation water for agricultural lands can be extracted from these storages. Likewise, Plantation will lead to more groundwater recharge and reduced runoff, improve groundwater quality, and enhance soil moisture and water holding capacity of soil. The communities will also get many spill-over benefits from this initiative. Women and girls will have more time for education and other domestic purposes due to easy access to water. The overall health status of the community may also get better due to access to improved drinking water resources.

5. Conclusion

"Sustainable management of water resources and access to safe water and sanitation are essential for unlocking economic growth and productivity, and providing significant leverage for existing investments in health and education" (Arya 2012).

2 billion people around the world are still affected by water stress even after implementation of Millennium Development Goals and conceptualization of Sustainable Development Goals post-2015 (UNEP n.d.). Hence there are still ample of scope and need of development in improving access to water almost in every corner of the world. When SDG (6- *Clean Water and Sanitation)* is targeting to achieve universal and equitable access to safe and affordable drinking water for all by 2030, the small initiative taken in the Som village in Rajasthan will surely add a significant mark in the world map of access to water. Additionally, keeping climate change in mind it will also help in building resilience of the Bhil community, who are already vulnerable due to limited resources, to adapt against possible adverse condition.

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About the author

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Case Study 2: Water Governance to Enhance Community Resilience of the Tacaná Watersheds

Reviewed by: Aseem Kumar Anshu

1. Introduction

THE TACANÁ WATERSHEDS emanates from Tacaná volcano which is located at the adjoining borders of San Marcos, Guatemala and the State of Chiapas, Mexico. The watershed area constitute mainly of four rivers: the Coatán, Suchiate, Cosalapa and Cahoacán. Coatán and Suchaite watershed originate from the Tacaná volcano, whereas Cosalapa and Cohoacán make up sub-watersheds of Coatán river within Mexico. Geographic location of these watersheds make them of great political as well as strategic importance since Coatán and Suchiate rivers are shared by both the countries i.e. Mexico and Guatemala. A large number of population of both the countries, located downstream are dependent on these rivers. Domestic and agriculture are the major sectors which utilizes the water in Guatemala whereas in Mexico, agriculture, domestic and agribusiness utilizes 54%, 26% and 10% of water respectively. These watersheds are primary source of the water for irrigation in these areas. Agriculture is very diverse across the watershed areas. In the high altitude areas small agricultural farms dominates while corn growers are on the lower watershed areas. In the low and middle part of the catchment sugarcane, African palm, coffee and banana industries are situated. Further downstream, there is a great potential for fishing which makes it primary source of income for the local residents. Despite such great natural wealth, the Tacaná watersheds are vulnerable ecologically as well as politically Anthropogenic activities such as

- deforestation and degradation of the upper watershed by marginalised farmer
- large scale animal farming and unplanned waste water management
- river pollution from the sugarcane, African palm, coffee and banana industries
- degradation of soil quality due to large scale farming in lower and middle parts of the watershed
- water scarcity in dry season affecting agricultural productivity and coffee processing
- unregulated land use pattern resulting in soil erosion leading to increased risk of flood and landslides
- lack of coordination among government institutions, limited laws and regulations, lack of funds, absence of technical support, lack of policies and insufficient stakeholder's participation

2. Pre-intervention

To address these issues local government had already designed a resilience framework in the Tacaná Watershed area. Several community based pilot projects were initiated in response to these vulnerability by taking actions to conserve environment and eventually to escalate the livelihood of the people through Water and Nature Initiative (WANI). The existing framework was mostly concerned with connecting ecosystems, human well-being and resilience from a system perspective and resilience was addressed through *diversity, sustainable infrastructure and technology, self-organisation*, and learning. However, feedback mechanism among private, public and civil society was ignored.

3. New Interventions

As the first step of new interventions a water planning and community management model was developed for Tacaná watershed through WANI with the aim to increase collaboration for water governance. The model was based on community participation, recognition of micro-watersheds as a planning unit, capacity building of community in integrated water resource management, enhance involvement of local political authority and strategic collaboration with government and non-government organizations for environmental management.

Under WANI project, 14 micro-watershed councils in Guatemala and 9 committees in Mexico were constituted which comprised of local government and communities living in Tacaná watershades. The key role of the councils was to coordinate the resources management of shared water and land and critically integrate it with overall community development. The councils were also recognized by the government. Furthermore, the micro-watershed councils were associated with each other which helped them implement effectively and expand their actions to include watershed management at different scale. As part of the model in the midsection of the Suchiate River small coffee producers were included in projects for water conservation in coffee production and organic coffee production was promoted.

Under the micro-watershed approach, multi-level collaboration with the stakeholders was done to ensure implementation of the model. At the local level, capacity development programme were conducted for water managers at the selected planning offices of municipalities in Guatemala (Ixchiguan, Tajumulco, and San Pablo). At regional level collaboration with Community Development Committees were made to ensure the participation of the community in implementation and development parts of the project. At sub-national and national level collaboration was made with 16 government and non-government institutions to facilitate capacity building and training. After successful implementation of micro-watershed model at the local level, National Micro-watershed Commission of Guatemala was established to implement the model across the country.

WANI also empowered "Jóvenes en la Mis- sión"(Youth in Mission, JEM), a youth-led cooperative enterprise who promoted sustainable water use and watershed restoration and at the same time generated livelihood through sustainable farming in Guatemala. WANI and JEM carried out 86 community pilot projects in Mexico and 21 in Guatemala for soil, water and environment conservation. Apart from that, the Living Water Partnership was composed who established payment for ecosystem services, a revenue generating mechanism for an environmental fund, to protect natural resources and restore natural environment. The first payment for ecosystem service was established in the municipality of San Pablo, Guatemala through this partnership in 2008. BY 201 it was ready for implementation as water fund which was planned to be financed through the revenue collected as urban water tax.

4. **Outcome**

The model resulted in the increase in the system resiliency in Tacana watershed after implementation of the interventions. Through strengthening existing water management framework, increasing collaboration with multilevel stakeholders, adoption of bottom-up approach for water governance and ensuring escalation of livelihood along with capacity building addressed the four key goals of the interventions which are *diversity, sustainable infrastructure and technology, self-organisation, and learning*. In a nut shell, interventions such as crop diversification, encouraging afforestation with native species, sustainable organic farming and livestock management, sustainable water management techniques in the agro-industries, formation of micro-watershed councils as unit of water management, participatory approach towards water governance and capacity building at all tier of stakeholders enhanced adaptive capacity of the community and system's resilience towards environment degradation and disasters in the Tacana watershed area.

(Source: The Tacaná Watersheds. Developing Untapped Potential: Strengthening Resilience through Cross-Sectoral Collaboration, Stefano Barchiesi, Rocío Córdoba by IUCN)

About the author

Aseem Kumar Anshu is currently working as Programme Officer (Policy) at Centre for Environment, Energy and Climate Change, Asian Development Research Institute. He has done Bachelor of Engineering and Master of Science in Biotechnology and currently pursuing Ph.D in Biotechnology. He has 5 years of research experience in Environmental Toxicology and Oncology.

Green Skill Development Programme (GSDP) Updates

Under the umbrella of Green Skill Development Programme (GSDP) of Ministry of Environment, Forest and Climate Change, GoI, a new training course entitled **"River Life Management System (RLMS)"** has been conceived to address the increasing pollution of the river Ganga and promote rejuvenation of the holy river. The course is aiming to build the capacity of the communities (those who residing within the 10 Km radius of the bank of the river Ganga) on different aspects of human-river interactions. This course intends to develop green skills among the local communities as well as aware them about the causes and effect of Ganga water pollution, how it is impacting their livelihood and sustenance and how they can be instrumental in Ganga river conservation and rejuvenation.

The Centre for Environment, Energy and Climate Change (CEECC) at Asian Development Research Institute (ADRI), Patna is the lead ENVIS RP to execute RLMS in the pilot phase for the Ganga river stretch from Danapur to Patna. CEECC-ADRI along with the collaboration with other ENVIS RPs/ hubs and research institutions has developed four interdisciplinary course modules under RLMS based on the need and relevance of the selected stretch of river Ganga.

The following training modules will be conducted in different phases under the programme:

1. ETP, STP, & CETP Operation and Maintenance (collaborative partners: BSPCB & GCPC)
2. Biodiversity, Dolphin Conservation & Aquaculture Management (collaborative partners: ZSI, ICAR, & GCPC)
3. Eco-Tourism and River Life Management (collaborative partners: WII, Bihar State Tourism Development Corporation, SCSTS, & GCPC)
4. Forest-based Enterprise and Alternative Livelihood Management (collaborative partners: WII, BNHS, GCPC, & FRI)

Apart from that, every course has a compulsory unit on Cleaner Production and Waste Management in their syllabus. CEECC-ADRI has already successfully conducted first two modules of RLMS, wherein class room lectures were well complemented by the relevant field exposure. Total 27 trainees participated in these two modules, who belongs to the Ganga river stretch and were awarded certificates. Faculties and experts from across India were invited to share their knowledge with the trainees. To impart holistic knowledge of the subject, the trainees of the first course visited the operations and maintenance of Asia's largest tannery common effluent treatment plant (CETP), situated at Calcutta Leathers Tannery Association (CLTA), Kolkata. Apart from that they also visited two industries namely Pepsico, Kolkata and Coca Cola, Patna to gain exposure on the industrial wastewater management procedure. Likewise, in the second module trainees did extensive field visit along the river Ganga to know about river biodiversity and how they are affecting the health of the river Ganga. They also gained knowledge on commercial fish farm with latest Biofloc technology in Samastipur, Bihar which they can use for entrepreneurial ventures in future. In both courses, the trainees were guided and trained by several local and national level scientists and practitioners.

News

Impact of climate change on wind energy industries in India

Photographed by: CleanTechnica

A study by Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) suggests that annual energy production from wind in India has declined by 13% in past forty years. In fact, 63% of the total annual energy production from wind is dependent on the wind of monsoon. The researchers of SEAS also implicate that temperature of Indian Ocean has risen in last few decades due to climate change subjecting to observed changes in annual monsoon pattern due to which wind energy industry suffers a great deal. *(For more details please visit - https://india.mongabay.com/2019/03/study-shows-climate-change-impacts-wind-energy-industry/)*

Hindu Kush Himalayan glaciers shrunk by 27%

Photographed by: thehindu.com

The Himalaya is considered as water tower of Asia as enormous amount of water is locked in thousands of glaciers. Due to climate change, water availability in north India in future seems to be empty. A recent study suggests that thickness of the glaciers in Hindu Kush Himalaya region has melted by 27%. Half of the area of the glaciers today is estimated to be melted away by 2060. As per previous study, the area of glaciers in Hindu Kush Himalayan region was 97000 sq km and was projected to be half melted by 2070. The same team of researchers repeated the study recently by simulating Global Glacier Evolution Model with all the glaciers in the region (96000 glaciers with 97000 sq km area), it was projected to be half depleted by 2060. The study signifies the rapid shrinking of glaciers in the Hindu Kush Himalayan region proclaiming a massive water crisis in north India in coming years. *(For more details please visit - https://www.downtoearth.org.in/news/climate-change/hindu-kush-himalayan-region-contains-27-less-ice-than-estimated-study-63228)*

Water crisis for Madhya Pradesh: Narmada on verge of extinction as six big dams, sand-mining, pollution threaten its survival

Photographed by: The Financial Express

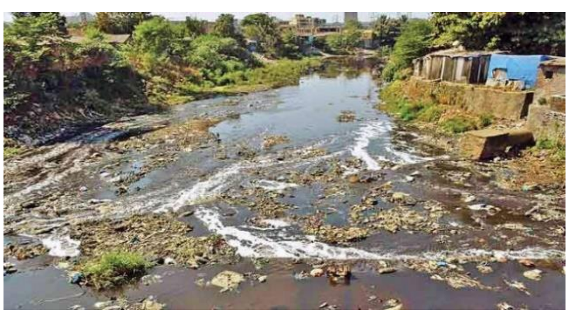
Narmada, being one of the largest rivers in the peninsula, biggest source of water in Madhya Pradesh and Gujarat, it is the fifth largest river in India and the largest in Madhya Pradesh. Narmada has six big dams and several power projects but it faces environmental threats due to illegal sand-mining, pollution, deforestation and river linking project. Water Resource Institute (WRI) has categorized Narmada as one of the six major rivers in the world that faces existential crisis. The tributaries of the Narmada are drying up due to illegal sand mining. It is suggested that shrinking of Narmada basin is also due to huge dependency on the river. The report indicates that more than 28% of dams built on Narmada-Tapti River have almost dried up with less than 10% of their holding capacity. Only 14 reservoirs out of 53 have sufficient water level now. Around 29 cities in the Madhya Pradesh are dependent on the river whereas almost every part of the state gets irrigated from the river. Not only common people but agriculture sector is also getting affected due to shrinking of Narmada. *(For more details please visit - https://www.firstpost.com/india/drying-rivers-of-madhya-pradesh-narmada-on-the-cusp-of-extinction-with-six-big-dams-sand-mining-pollution-threatening-its-survival-6221291.html)*

Ground frost runs to south India

Photographed by: Skymet Weather

Frost is formed when water vapor is condensed by cool air leading to formation of droplets on the ground. As temperature drops between 4-0^{o}C, the water droplets on the ground turns into ice crystals. It is usually confused with snowfall by people. Skymet Weather suggests that frost is commonly seen in winter season in Madhya Pradesh and Rajasthan when minimum temperature falls below 4^{o}C. It also predicts that ground frost can also be observed in Punjab, Haryana, Delhi-NCR, Uttar Pradesh including Madhya Pradesh and Rajasthan. However, it is surprising to come across with the fact that ground frost in recent times has been observed in south India as well. A report indicates that a sheet of ground frost was observed encompassing the hills of Kerala's Munnar, Kannimala, Chenduvara, Sevenvalley, and Nallathanni for many days with temperature as low as -3^{o}C. Ground frost blocks the respiration of plants leading to its decay or loss. The report highlights that several tea plantation owners have suffered losses due to frosting. Indian Meteorological Department predicts ground frosts in the hills of Nilgiris, Coimbatore, and Dindigul district. *(For more details please visit - https://www.downtoearth.org.in/news/climate-change/frost-bites-states-across-india-62723)*

Bad water quality in rivers threatens human health quality in Mumbai



Photographed by: dnaindia.com

Recently, water quality monitoring units in Mumbai have shown the water quality of Mumbai as 'Bad' and between 'Bad to very bad'. A majority of these units monitor rivers such as Tansa, Vaitarna, Bhatsa, Ulhas, Kalu, Patalganga, Surya, Kundalika, Amba, Vashishthi and Savitri which replenish the ground water and reservoirs that fill water supply network of the Mumbai. In 2017-2018, 'bad' category reading monitors rose from 2% to 6% and 'bad to very bad' category reading monitors increased around 3% to over 6%. Bad water quality in Mumbai has raised concerns for water supply bodies, as they have to treat the water multiple times before the supply. *(For more details please visit - https://timesofindia.indiatimes.com/city/mumbai/bad-water-quality-spikes-in-rivers-feeding-citys-dams/articleshow/68339465.cms)*

Event Calendar

Sl. No.	Event	Date
1.	National seminar on addressing the problems of inter-state and inter-district disparity of India (Organized by ADRI)	October 1, 2018
2.	Focus group discussion on control measures clean air action plan of Patna, Gaya and Muzaffarpur	October 24, 2018
3.	Panel Discussion on "Leveraging Public Finance to Mainstream Climate Change" at the International conference on Public Finance: Theory, Practice and Challenges (Organized by ADRI)	December 7 – 8,2018
4.	Signing of MOU between CEECC-ADRI and ISET International	December 10, 2018
5.	Validation workshop on Clean Air Action Plan for Patna	January 29, 2019
6.	Inauguration of River Life Management System: ETP/STP/CETP operation and maintenance	March 25, 2019
7.	Valedictory of River Life Management System: ETP/STP/CETP operation and maintenance	April 26, 2019
8.	Inauguration of River Life Management System: Biodiversity, Dolphin Conservation and Aquaculture Management	June 7, 2019
9.	Awareness drive on "Beat Plastic"	July 15, 2019
10.	Valedictory of River Life Management System: Biodiversity, Dolphin Conservation and Aquaculture Management	July 15, 2019

Event Gallery

Figure 1 Panel discussion on the Leveraging Public Finance to Mainstream Climate Change the International conference on Public Finance: Theory, Practice and Challenges

Figure 2 MOU signing between CEECC- ADRI and ISET International

Figure 3Validation workshop of Clean Air Action Plan for Patna

Figure 4 CEECC-ADRI ENVIS team at ENVIS National Review Meeting, New Delhi

Figure 5 Exposure visit of RLMS (ETP/STP/CETP O & M) at CETP plant of CLC tanners association, Kolkata

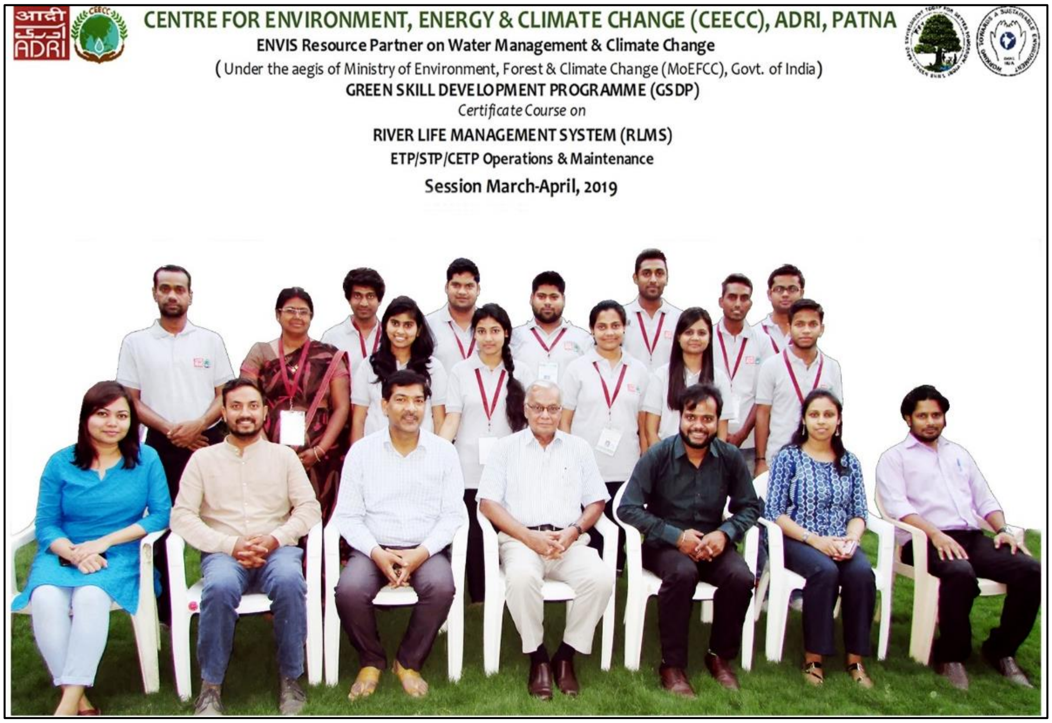
Figure 6 Exposure visit of RLMS (ETP/STP/CETP O & M) at the ETP plant of PepsiCo, Kolkata

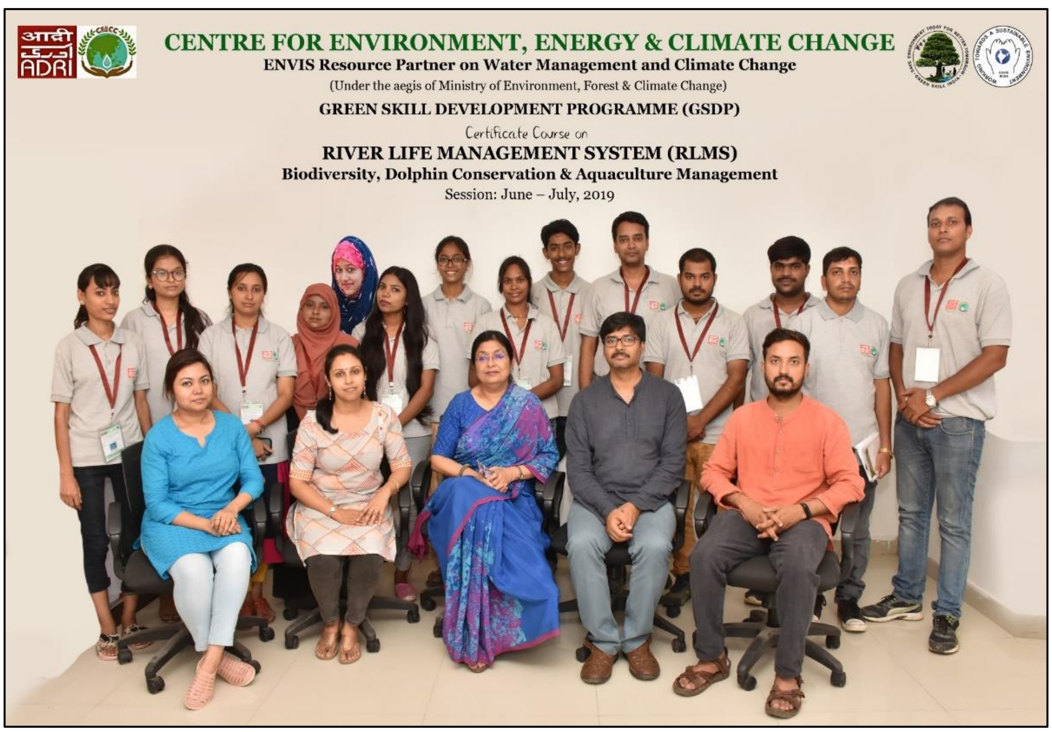
Figure 7 Interaction of GSDP- RLMS (Biodiversity, Dolphin Conservation and Aquaculture Management) with the fisherman community

Figure 8 Session of GSDP- RLMS (Biodiversity, Dolphin Conservation and Aquaculture Management) with Mr. Punam Chandra Rathod from GCPC, Gujarat

Figure 9 GSDP-RLMS (module II) trainees took part in "Beat Plastic" event organised by CEECC-ADRI

Figure 10 GSDP-RLMS (Module II) trainee is handing out cloth bag at the vegetable market


CENTRE FOR ENVIRONMENT, ENERGY & CLIMATE CHANGE (CEECC), ADRI, PATNA
ENVIS Resource Partner on Water Management & Climate Change
(Under the aegis of Ministry of Environment, Forest & Climate Change (MoEFCC), Govt. of India)
GREEN SKILL DEVELOPMENT PROGRAMME (GSDP)
Certificate Course on
RIVER LIFE MANAGEMENT SYSTEM (RLMS)
ETP/STP/CETP Operations & Maintenance
Session March-April, 2019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RIVER LIFE MANAGEMENT SYSTEM (RLMS)
Biodiversity, Dolphin Conservation & Aquaculture Management
Session: June – July, 2019