ABSTRACT

Groundwater resources in the Greater Mekong Subregion; collaborative resource management to increase resilience

Rien A.C. Dam[1] & Ramasamy Jayakumar[2]

with contributions from Adichat Surinkum[3], Paul Pavelic[4], Robyn Johnston[4] and Nienke Ansems[5]

Programme summary data

Countries:	Lao PDR, Thailand, Myanmar, Cambodia, Vietnam
Thematic Focal Area :	**Transboundary water management**
Type of Implementing Entity:	MIE
Implementing Entity:	UNESCO
Executing Entities:	Country agencies, CCOP, IWMI, IGRAC
Amount of Financing Requested:	4.9 million US $
Project Duration:	4 YEARS (48 MONTHS**)**

Abstract: This paper provides an overview of the overall scope, approach and implementation plan for a Greater Mekong Subregion collaboration programme on groundwater resources management to support resilience of vulnerable groups towards climate change. The programme will support regional cooperation focusing on transboundary aquifers in four pilot areas and address the following five major components:

1. Groundwater resource assessment & monitoring: production of a unified groundwater resource inventory and common (GMS) approach to address challenges of climate change and resilience; information-based policy to manage resources and further develop resilience strategies.
2. Priority use & stakeholders: Activities to ensure groundwater users (in different sectors) are involved and aware of resource management issues and have access to information and guidelines that can support more sustainable use across the region; a level playing field across the region.
3. Resource management, information tools & equipment: Resource management concepts and tools, unified information system and information products, varying from strategic (multi)national policy support to practical guidelines for end-users and regulation for different sectoral users (industry, agriculture, domestic water supply).
4. Regional dissemination and coordination: A regionally coherent policy for climate adaptation through sustainable groundwater resource management; equal access to resources for all sectoral users in the region, efficiency gains in common approach and support tools.
5. Capacity building and training: Internal capacity in the Greater Mekong Subregion to develop climate change adaptation policy and practical interventions, to use state-of-the-art tools and work with stakeholders including vulnerable groups.

The programme is advanced with support of UNESCO-Bangkok, CCOP-TS, and experts from IWMI and IGRAC and, when funding from the Adaptation Fund (https://www.adaptation-fund.org/) is approved, will be implemented with support from groundwater agencies in the five participating countries.

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1. Groundwater in the Greater Mekong Subregion

The countries of the Greater Mekong Subregion (GMS – Cambodia, Lao PDR, Thailand, Myanmar and Vietnam) have abundant surface water resources in the multiple large rivers of the region – the Mekong alone discharges around 475 km³ annually, and the Ayeyarwady around 400 km³. Flooding and heavy monsoon rains are common but the region also experiences a (prolonged) dry season. Even though surface water is abundant, spatial (lowlands and plains) and temporal (dry season) shortages are commonly met with supply from groundwater. The GMS countries have a total population of about 240 million people; a considerable part of these are low-income groups and urban/rural communities that rely on easily accessible, reliable, good quality and low-cost groundwater for their domestic and agrarian-based livelihoods. Groundwater use is increasing as drilling and pump costs have become more affordable and will continue to do so in coming years for a variety of reasons that include meeting Sustainable Development Goals, adapting to climate change, and livelihood enhancement.

Groundwater is an important resource in the highlands as well as the lowlands along the Mekong River in Lao PDR, in northeast Thailand, Cambodia, in the Mekong Delta in Vietnam and in Myanmar's Central Plain. Important transboundary aquifers straddle the border areas between Vietnam and Cambodia, between Thailand and Lao PDR, and also between Myanmar and Thailand (Figure 1;

Landon, 2011[1]). Throughout the GMS, complex relationships occur between upstream recharge areas and downstream aquifers. The total potential capacity of groundwater resources is estimated to be about 60 million m³ per day. But groundwater resources of the GMS have not been investigated in detail, and only limited information about groundwater resource volumes, use, sustainability and quality is available. Recent studies (i.e. Erban, 2014[2]; Wagner et al., 2012[3]) illustrate the intensive use and economic significance of groundwater for both the Vietnamese and Cambodian part of the Mekong Delta. This also applies for the drought sensitive northeast of Thailand (the Isan region), adjacent parts of Lao PDR (Pavelic et al., 2014[4]; Vote et al., 2015[5]) and Myanmar's central plain (McCartney et al 2013[6]). Groundwater is also an important resource for crop irrigation, food production (notably in Myanmar, Thailand and Vietnam), for industry (food processing) and for domestic supply for urban and rural communities. Due to economic and population growth pressures on groundwater in the region are increasing fast.

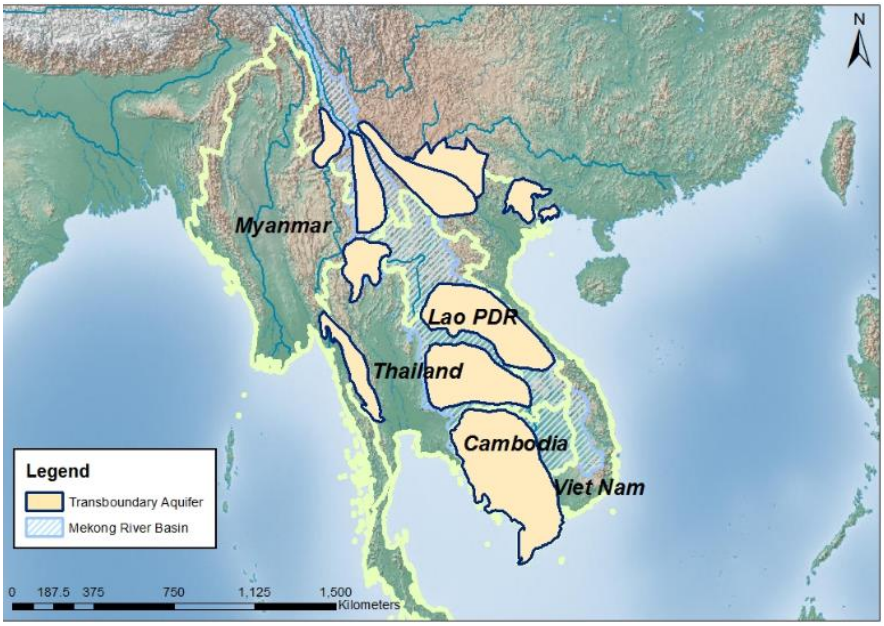

Figure 1: Overview of the main transboundary groundwater aquifers in the Greater Mekong Subregion; source IGRAC.

In the recent past over-extraction of groundwater for the production of high-value crops, such as coffee, has caused a severe drop in groundwater levels in parts of the Vietnamese highlands. Throughout the GMS intensification of irrigation to meet the food demand of growing populations increases groundwater use while recharge diminishes. In some

[1] Landon. M., 2011; Preliminary compilation and review of current information on groundwater monitoring and resources in the Lower Mekong River Basin. USGS report to Mekong River Commission.

[2] Erban, L., S.M. Gorelick and H.A. Zebker, 2014; Groundwater extraction, land subsidence and sea-level rise in Mekong Delta, Environ. Res. Lett. 9.

[3] Frank Wagner, Vuong Bui Tran and Fabrice G. Renaud; Groundwater in the Mekong Delta: Availability, Utilization and Risks, in The Mekong Delta System, Interdisciplinary Analyses of a River Delta, Renaud & Kuenzer (eds.), Springer, 2012)

[4] Pavelic.P., O. Xayviliya and O. Ongkeo., 2014; Pathways for effective groundwater governance in the least-developed-country context of Lao PDR., Water International; DOI 10.1080/02508060.2014.923971

[5] C Vote, J Newby, K Phouyyavong, T Inthavong and Eberbach, P. 2015; Trends and perceptions of rural household groundwater use and the implications for smallholder agriculture in rain-fed Southern Laos. International Journal of Water Resources Development, 02/2015; DOI:10.1080/07900627.2015.1015071

[6] McCartney, M.; Pavelic, P.; Lacombe, G.; Latt, K.; Zan, A.K.; Thein, K.; Douangsavanh, S.; Balasubramanya, S.; Rajah, A.; Myint, A.; Cho, C.; Johnston, R.; Sotoukee, T. 2013. Water resources assessment of the dry zone of Myanmar. [Project report of the Livelihoods and Food Security Trust Fund (LIFT) Dry Zone Program]. Vientiane, Laos: International Water Management Institute (IWMI); Yangon, Myanmar: National Engineering and Planning Services (NEPS). 52p.

areas such as southern Cambodia, parts of Lao PDR and the Mekong and Ayeyarwady deltas, naturally occurring arsenic contamination will be exacerbated by increased groundwater use in a changed climate. Groundwater supports valuable ecosystem services by feeding springs and base flow to rivers, streams and wetlands that are the habitats of fish and aquatic vegetation harvested by riparian communities. Intrinsic linkages between surface water and groundwater exist, but are not always clear but must be taken into account in water allocation planning processes. Further expansion of irrigation, land use changes (deforestation) in the highland areas, increase of domestic and industrial use in expanding cities of the GMS may result in significant depletion of groundwater resources in the future, leading to reduced water availability, higher pumping costs, saltwater intrusion in coastal areas, and loss of ecosystem services. These effects will be exacerbated by the impacts of climate change (further increasing demand and potentially reducing recharge) throughout the GMS. The full impacts of climate change on groundwater availability are likely to be complex and require further investigation.

Even where transboundary cooperation in surface water management (viz. Mekong River and MRC) has progressed, there is no common approach or even modest recognition and cooperation for groundwater resources. The challenges in river management (resource sharing, impacts of river management and hydropower development, climate change, etc.) are equally valid for groundwater resources and their diverse users. The absence of a sizeable community and cooperative network of groundwater experts in the GMS severely hampers addressing these issues, in particular in Myanmar, Lao PDR and in Cambodia, where local capacity in hydrogeology is very limited. Regional cooperation in the ASEAN Economic Community offers an opportunity to tackle these challenges.

2. Knowledge/information gaps

There is limited information on groundwater resources of the GMS, in particular the kind of insight required to deal with pressing issues, such as:

- Extent and/or characteristics of superficial and confined aquifer systems, including resource volumes in aquifers systems in the GMS, existing and/or potential water quality threats.
- Current groundwater volumes being abstracted for various uses; future demand scenario's for irrigation, urban and rural water supply.
- Relationships between recharge in highland (upstream) areas and resource potential in lowland (downstream) areas. This includes several important transboundary systems. Climate change and land use changes will affect these delicate balances.
- Sustainability (in view of increasing abstraction) and vulnerability of riparian groundwater

resources to climate change induced changes in precipitation and changes in river flow regimes (natural or anthropogenic).

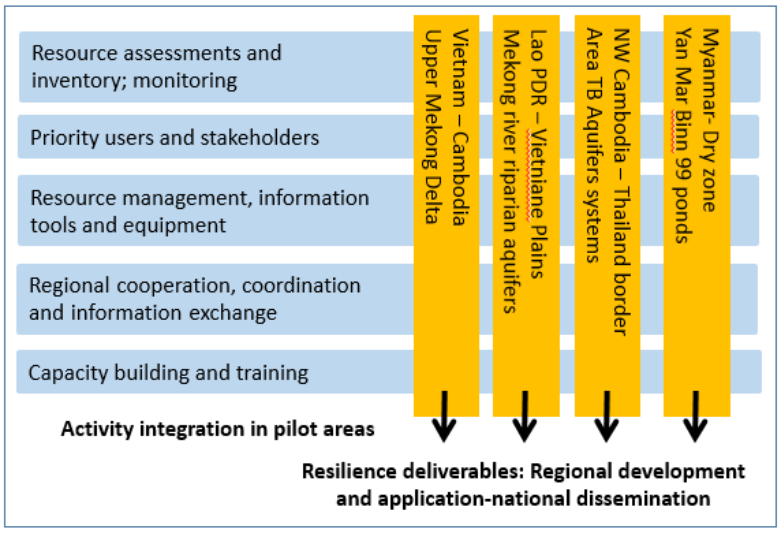

Figure 2: Project implementation in four pilot areas with transboundary aquifers

To understand better the resource potentials and vulnerabilities of groundwater systems of the GMS, detailed hydrogeological and geophysical investigations are required. A crucial groundwater monitoring network is needed to monitor resource status and critical depletion, and for developing and using regional groundwater information systems and groundwater flow models. These regional (transboundary) groundwater models and information tools will help manage resources, viz.:

- Visualize (in maps) regional and transboundary groundwater (recharge and extraction) systems and enable assessment of groundwater recharge rates from flooding and rainfall under the current and future climate conditions.
- Determine groundwater resource potential in shallow and deep aquifer systems (for different users).
- Assess sustainable groundwater extraction rates under various current and future land use conditions
- Assess impacts of the current and likely future climate change conditions on the groundwater resources for transboundary groundwater systems in the Lower Mekong Basin.

3. Project / Programme Objectives

<u>Overall Goal/Objective</u>: share an expanding knowledge and expertise base for sustainable use of groundwater resources for increased climate change resilience in the Greater Mekong Subregion.

Specific objectives are:

- Prepare an updated groundwater resources and shared aquifer inventory for the GMS countries, resource management concepts and tools, and a monitoring network for groundwater systems.
- Dialogues with groundwater users to 1) assess groundwater use scenarios for different sectors (agriculture, industry, rural & urban domestic water supply) and 2) develop and provide appropriate information to attain sustainable use.
- Understand (vulnerability of) groundwater recharge processes and determine/formulate recommendations for protection and long-term sustainable management.
- Capacity building for GW experts from the GMS countries (making use of expertise in Thailand and Vietnam) and initiating regional water cooperation (diplomacy).

4. Project / Programme Components and Financing

Table presenting the relationships among project components, outcomes, outputs and countries in which activities would be executed, and the corresponding indicative budgets.)

Project Components	Expected Outcomes (mid to long-term results – impacts)	Expected Outputs (immediate results)
1. Groundwater resource assessment & monitoring	Unified groundwater resource inventory and common (GMS) approach to address challenges of climate change and resilience; information-based policy to manage resources and further develop resilience strategies	Updated groundwater resources and shared aquifer inventory; a monitoring network for groundwater systems; understanding of complex transboundary GW systems, GW vulnerability assessment
2. Priority use & stakeholders	Groundwater users (in different sectors) are involved and aware of resource management issues and have access to information and guidelines that can support more sustainable use across the region; level playing field across the region.	Dialogues with groundwater users to 1) assess groundwater use scenarios for different sectors (agriculture, industry, rural & urban domestic water supply) and 2) develop and provide appropriate information and guidelines to attain sustainable use.
3. Resource management, information tools & equipment	Resource management concepts and tools, unified information system and information products, varying from strategic (multi)national policy support to practical guidelines for end-users and regulation for different sectoral users (industry, agriculture, domestic water supply)	Adequate and collaborative resource management methods and tools are available, enabling information sharing and mutual support across the GMS region; more sustainable resource use, protection of low-income and vulnerable user groups.
4. Regional dissemination and coordination	A regionally coherent policy for climate adaptation through sustainable GW resource management; level playing field for all	A regional network is established that exchanges information and collaborates in addressing further challenges (advanced

	sectoral users in the region, efficiency gains in common approach and support tools	studies, resolving transboundary conflicts); from information to policy to practice.
5. Capacity building and training	Internal capacity in the GMS region to develop CCA policy and practical interventions, use state-of-the-art tools and work with stakeholders including vulnerable groups	A groundwater community-of-practice has been equipped with the knowledge and skills to ensure technical & policy capabilities. Expert groups can tackle acute problems, GMS cooperation.

5. Project rationale and justification

Climate resilience & added value of regional approach, GMS transboundary collaboration

By introducing and stimulating robust methods for resource assessment and collaborative principles for sustainable groundwater use, valuable water resources are saved for strategic and emergency purposes, thereby enhancing resilience in water supply and food production. Climate resilience is based on the full suite of options, viz. limited surface water and groundwater, and overall use efficiency is stimulated.The regional approach creates significant efficiency gains in development of resource management concepts, tools and supporting systems and in developing the required regional human resources capacity.By developing regional regulatory guidelines for appropriate groundwater use, unsustainable practices are prevented/stopped equally across the region (also creating a level playing field), instead of pushing communities to compete with each other.

Innovative solutions to climate change adaptation; a regional approach and cost-effectiveness

The development of groundwater management information (systems) for the region will provide ample opportunities to introduce innovative (ICT supported) data collection, information sharing and training. Direly needed groundwater resources monitoring (in collaboration with well owners) provides excellent opportunities for data collection through crowdsourcing also strengthening stakeholder involvement

The programme connects to national priorities for climate change adaptation i.e. groundwater conservation and sustainable use as included in respective national Climate Change adaptation policy documents. The programme partners are already now working on related studies in the region; this earlier and ongoing work will pave the way for this new and challenging regional project.

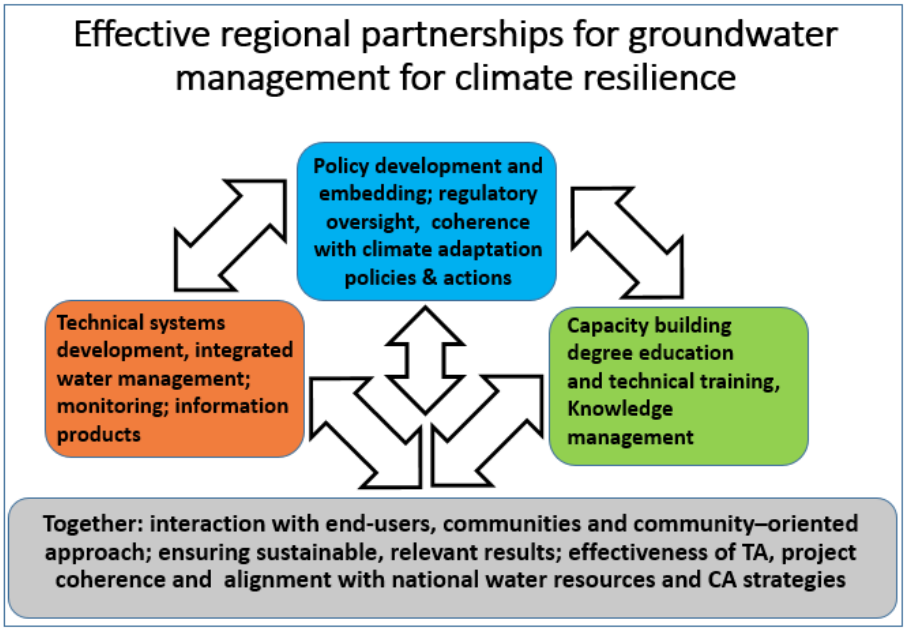

Figure 3: The project emphasizes four concepts in the overall approach; 1) groundwater management should be supported by policy embedding, recognizing the need for climate adaptation (blue box), there should be supporting technical systems and tools to enable information-based policy making (red box) 3) project work should include capacity building and training (green box) and finally 4) all groundwater management work should address priorities and needs from stakeholders and groundwater users. There should be closer cooperation with the groundwater end-users groups to ensure results on the ground.

Learning and knowledge management to capture and disseminate lessons learned

Learning, knowledge development and sharing of expertise is one of the key elements of the program; the more advanced groups (Thailand, Vietnam) will contribute to this process by helping their less advanced colleagues in Lao PDR, Myanmar and Cambodia. In comparison with isolated single-country interventions this is much more cost effective. The bulk of the technical support work can be done by regional experts.

Vulnerable groups and sustainability, sharing regional data and experience

Project preparation will include dedicated discussion session on how to design the interaction process with stakeholders in such a way that vulnerable groups and women are prioritised. By focusing on groundwater conservation/sustainable use access to water supply for households and smallholders will improve. The advancement of the program is such, that progressively regional collaboration will take place without external support; CCOP has 60 years of experience with keeping regional cooperative networks alive in this way.

Positive environmental and social impacts, a balanced inter-vention with sustainable results

The program will mitigate environmental impacts: of droughts on agriculture and food production, and on rural and urban domestic water supply constraints, and social impacts: on access to low-cost domestic water supply and on rural communities' access to irrigation water for self-reliance in food production. The funding requested is allocated in a balanced way to 1) technical studies and deepening of the knowledge base, 2) dissemination and interaction with stakeholders and 3) human resources development and creation of a regional GMS community of experts.

The project has only positive environmental and social impacts: it will stimulate sustainable use of valuable natural resources and increase awareness on vulnerability; it will support approaches to ensure equitable access to water for food production and domestic use. It will enable conservation of scarce water resources for low-income groups. By following a regional approach also an international level playing field is supported.

Capacity building to form a GMS community of experts and address societal needs

Sustainability of the intervention lies partly in the capacity building component. With a strong focus on human resources development a new generation of dedicated groundwater experts will engage with pertinent challenges of the coming decades. They can do this in a concerted manner, with common tools and data. Sustainability is also enhanced by closely linking groundwater resource studies to societal needs (in various sectors like food production, domestic water supply, industry, ecology/environment).

6. Implementation arrangements

Beneficiaries and stakeholders - NIE's (National implementing/executing entities)

1. Government of Cambodia, Ministry of Water Resources and Meteorology - Ministry of Mines and Energy and partner agencies.
2. Government of Lao PDR, Ministry of Natural Resources and Environment (MoNRE), Lao PDR is in the process of endorsing the Water Resources Law and the National Water Resources Strategy and Action Plan 2015-2020. This includes a National Groundwater Action Plan. These are the very first government policies on groundwater. Local expertise is virtually absent, but capacity building forms part of the Action Plan. The Natural Resources and Environment Institute (NREI) has an executive role in groundwater management.

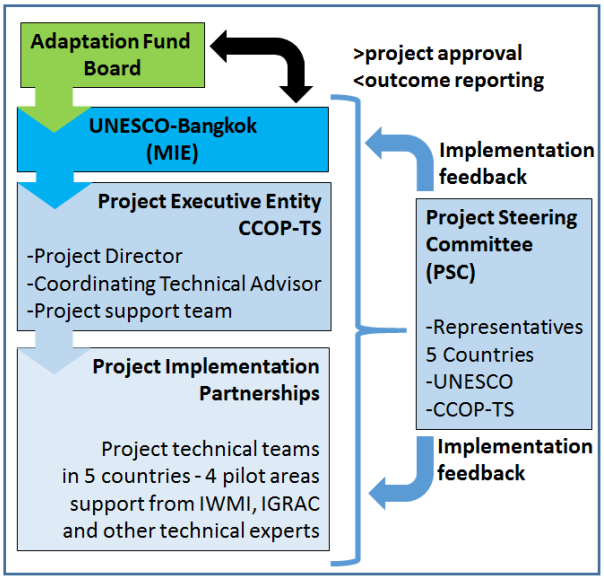

Figure 4: Implementation arrangements

3. Government of Thailand, Ministry of Natural Resources and Environment; Within the Ministry the Department of Groundwater Resources is tasked with the development and sustainable management of groundwater resources in the country and has responsibilities in planning, assessment, resource conservation, and regulations at

national and regional levels.

4. Myanmar, Ministry of Agriculture and Irrigation;
5. Government of Vietnam, Ministry of Natural Resources and Environment- MoNRE as the coordinating ministry for water resources management, is implementing, on a national scale, river basin water resources management plans that include groundwater. Important studies are conducted on crucial aquifers in Mekong Delta. NAWAPI, the National Center for Water Resources Planning and Investigation has an executive role.
6. Universities and research institutions in the GMS contributing to capacity building on groundwater; Thailand and Vietnam have considerable groundwater expertise, but capacity is weak in Lao PDR, Myanmar and Cambodia. Hence, there are opportunities for regional collaboration and support.

The collaboration will be supported by:

UNESCO: will be able to provide all technical backstopping, facilitation with member states and application process with Adaptation Fund Centre

Coordinating Committee for Geosciences Programmes (in East and Southeast Asia): CCOP has a considerable track record in coordinating groundwater programmes in SE Asia. It will provide technical expertise and will support local coordination and implementation along with the National partners.

International Water Management Institute: IWMI has been at the forefront of research aimed at exploring opportunities for greater groundwater development for poverty alleviation improving groundwater governance across SE Asia. IWMI would be one of the implementing partners. IWMI has had long and fruitful relationships with most of the national partners.

International Groundwater Resources Assessment Centre: IGRAC is UNESCO's and WMO's groundwater centre that facilitates and promotes international sharing of information and knowledge required for sustainable development, management and governance of groundwater. IGRAC has extensive experience with transboundary aquifers assessments and management, design of groundwater monitoring networks and information management systems

The project proposal preparation process and workshop are intended to assess the need/possibility to engage additional technical assistance partners (MRC, other), national partners for implementation on a local level, and essential stakeholder organisations.

Step-by-step implementation strategy

1. Organise an executive project team consisting of national experts from the GMS countries, and experts from the supporting Technical Assistance partners (CCOP, IGRAC, IWMI) As MIE, UNESCO will also convene a project Steering Committee.
2. Develop a common view and understanding of the role improved groundwater management can play in strengthening climate resilience in multiple sectors; identify additional opportunities through transboundary collaboration; sharing information, expertise and collaborative policies for climate resilience
3. Resource assessment: common methodology to be adopted and approach to data collection/sharing; agree on protocols for sharing available data on transboundary aquifers
4. Compile various maps available from countries/organisations and further demarcate the recharge and extraction zones and consider transboundary issues.
5. Identify data gaps and need for new data collection; collaborative monitoring approach, initiate base-level monitoring
6. Agree on common approach for a groundwater resources management information system, its basic functions and operations (data entry, data integration, analysis), training of expert users and dissemination of the system to end-users in the five countries.
7. Consult stakeholders and identify the specific sectors with interest in groundwater.
8. Raise stakeholder and public awareness on groundwater vulnerability through development of tailored information for sectoral users and multi-media awareness for urban and rural populations.
9. Build capacity of the local groundwater management professionals, planners and policy makers in the pertinent national government organisations.

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