Regional Diagnostic Report
Asia & the Pacific Region
Groundwater Governance - A Global Framework for Action (2011-2014) is a joint project supported by the Global Environment Facility (GEF) and implemented by the Food and Agriculture Organisation of the United Nations (FAO), jointly with UNESCO's International Hydrological Programme (UNESCO-IHP), the International Association of Hydrologists (IAH) and the World Bank.

The project is designed to raise awareness of the importance of groundwater resources for many regions of the world, and identify and promote best practices in groundwater governance as a way to achieve the sustainable management of groundwater resources.

The first phase of the project consists of a review of the global situation of groundwater governance and aims to develop of a Global Groundwater Diagnostic that integrates regional and country experiences with prospects for the future. This first phase builds on a series of case studies, thematic papers and five regional consultations.

Twelve thematic papers have thus been prepared to synthesize the current knowledge and experience concerning key economic, policy, institutional, environmental and technical aspects of groundwater management, and address emerging issues and innovative approaches. The 12 thematic papers are listed below and are available on the project website along with a Synthesis Report on Groundwater Governance that compiles the results of the case studies and the thematic papers.

The second phase of the project will develop the main project outcome, a Global Framework for Action consisting of a set of policy and institutional guidelines, recommendations and best practices designed to improve groundwater management at country/local level, and groundwater governance at local, national and transboundary levels.

Thematic Papers

No.1 - Trends in groundwater pollution; trends in loss of groundwater quality and related aquifers services
No.2 - Conjunctive use and management of groundwater and surface water
No.3 - Urban-rural tensions; opportunities for co-management
No.4 - Management of recharge / discharge processes and aquifer equilibrium states
No.5 - Groundwater policy and governance
No.6 - Legal framework for sustainable groundwater governance
No.7 - Trends in local groundwater management institutions / user partnerships
No.8 - Social adoption of groundwater pumping technology and the development of groundwater cultures: governance at the point of abstraction
No.9 - Macro-economic trends that influence demand for groundwater and related aquifer services
No.10 - Governance of the subsurface and groundwater frontier
No.11 - Political economy of groundwater governance
No.12 - Groundwater and climate change adaptation

www.groundwatergovernance.org
Groundwater Governance Regional Diagnosis

Asia and the Pacific region

Groundwater Governance: A Global Framework for Action

August 2013

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Institute for Global Environmental Strategies (IGES)
1. Background

The Groundwater Governance Regional Diagnosis for Asia and the Pacific Region is prepared for an international project entitled “Groundwater Governance: Global Framework for Action” under the auspices of the FAO, UNESCO and IAH, in partnership with the World Bank. The Groundwater Governance Project (the “Project” hereafter) aims to raise global awareness of the need for improved groundwater governance in a bid to reverse negative trends in groundwater resource use, thus contributing to global water security.

Groundwater plays a key role in the socio-economic development of the Asia-Pacific region. However, unplanned and inadequate governance of this resource has resulted in overexploitation and quality degradation in many places, which threatens both lives and livelihoods of local populations and also denies the future potential of this resource. To reverse this negative trend improved groundwater governance is urgently needed as this would secure this groundwater resource and contribute to greater water security throughout the region. Considering the strategic importance of improved groundwater governance for future water security in the region, this short report sets out to provide an overview of the challenges and opportunities currently facing groundwater governance, and identify what actions must be taken to improve groundwater governance. This report draws on the information and knowledge accumulated through the Project, including the Regional Consultation for Asia and the Pacific Region organised in December 2012, Shijiazhung, China.

2. Current Status of Groundwater Governance in the Region

1) Definition of Groundwater Governance

No universal definition exists to describe exactly what ‘water governance’ means (WWAP 2003), and this is also true for ‘groundwater governance’ for Asian and the Pacific region. This report therefore adopts the same working definition of groundwater governance in the Thematic Paper 6 of the Project, i.e., “the process by which groundwater resource is managed through the application of responsibility, participation, information availability, transparency, custom, and rule of law. It is the art of coordinating administrative actions and decision making between and among different jurisdictional levels—one of which may be global” (Mechlem 2012).

Regardless, any definition of groundwater governance must account for diverse factors, such as diversity in terms of geography and climate, population dynamics, level of economic development, distribution of benefits among populations, customs and cultures, and politics and governmental structures. Modalities of groundwater governance could be dictated by a combination of factors, such as the state of water resources, the needs of multiple user groups as regards groundwater resource access, policy, legislation, institutional provisions, as well as those from other sectors, such as energy policy and land use planning. A wide range of management practices, institutional setups and legal and regulatory arrangements to manage groundwater issues currently exist throughout the region; however, the current structure of groundwater governance faces a huge challenge due to the anarchic state of open access in most of the countries in the region—regardless of whether such access is formal or informal. There is an almost complete lack of any formal groundwater governance mechanism throughout the entire Asia-Pacific region, especially in south Asia and the plains in northern China, resulting in widespread unrestricted open access (Shah 2007).

On the other hand, examples of good governance could also be visualised based upon the urgent need to address common but widespread problems, such as depletion of groundwater, land subsidence, contamination and sea water intrusion. In consideration of our understanding of the region as a whole, this report suggests factors for good governance of groundwater resources, as revealed through the regional consultation processes shown in the following box.
2) Drivers for Groundwater Development and the State of Groundwater

The critical driver of groundwater development in the Asia-Pacific region is the rising demand for water due to expanding populations, rapid economic development, and resultant transformations in living standards, which all translate as an increase in groundwater abstraction in the region, as depicted in the following table. A causal link between local GDP and groundwater abstraction in selected cities as exhibited in figure 1 is further evidence of this trend. From these is can be seen that groundwater aided urban growth as a major or supplemental water source.

Table 1. Extent of current and original groundwater abstraction in selected countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>Early stage</th>
<th>Recent</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year</td>
<td>Tube wells/pumps (millions)</td>
<td>Year</td>
</tr>
<tr>
<td>India</td>
<td>1960</td>
<td>&lt;1</td>
<td>2006</td>
</tr>
<tr>
<td>Pakistan</td>
<td>1960</td>
<td>0.01</td>
<td>2006</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>1986</td>
<td>0.134</td>
<td>2002</td>
</tr>
<tr>
<td>Nepal</td>
<td>1970</td>
<td>Almost zero</td>
<td>2005</td>
</tr>
<tr>
<td>China</td>
<td>1965</td>
<td>0.2</td>
<td>2003</td>
</tr>
<tr>
<td>Thailand</td>
<td>1979</td>
<td>Less than 0.5</td>
<td>1998</td>
</tr>
<tr>
<td>Cambodia</td>
<td>NA</td>
<td>2010</td>
<td>0.75</td>
</tr>
</tbody>
</table>

# Pumps are used for abstracting surface or groundwater, so the number is intended to show increased access to pumps only.

Box 1. Factors of good groundwater governance identified through regional consultation process

Many ‘must-include’ elements were elicited during the regional consultation meeting that cannot be omitted from any groundwater governance framework—scientific evaluation, monitoring and assessment, water planning, management and protection of water quality and water quantity, pricing and regulation, development of local initiatives, pollution control, disaster planning and management, capacity building, and public education and engagement. Key steps to improve current governance (to establish networks of stakeholders at multiple scales, their engagement, to establish legal frameworks and their directions, to improve enforcement of policies and regulations, and to take incremental steps towards better governance) are also noted. What remains to be clarified is how such priorities and steps could be executed in a cohesive and coordinated manner.

Figure 1. Groundwater abstraction and regional GDP in selected cities (IGES 2007)
Groundwater irrigation in Asia is by far the largest abstractor of groundwater in the world, with India leading, and Pakistan and China within the top five biggest abstractors (Giordano 2009). The scale of groundwater irrigation in India is massive; it already exceeds 60% of the total irrigated area. In fact, the Green Revolution is often attributed to Asian groundwater irrigation. Groundwater is considered an affordable, convenient, and reliable source by millions of small holder farmers across Asia. As the acreage of land holdings of such farmers is essentially medium to marginal, the only option available for raising yields is to scale up the extent of groundwater irrigation. Other specific factors also ensure groundwater remains the firm favourite source for irrigation (Mukherji, et al. 2009)—a lack of or poor quality surface water, unreliable surface irrigation systems, increasing rainfall variability and incidence of dry spells, lack of proper water storage, introduction of water-intensive high yield varieties, technological advances in pumping technology, and availability of incentives (installation subsidies, flat energy rates). The government of Nepal, after realising the potential of groundwater to improve livelihoods and the economy, also stepped forward to promote government through attractive incentives, although it has yet to fully exploit its available groundwater resources.

High affordability, universal access and high quality also make groundwater a suitable candidate for direct household use, including drinking water, with or without (minimal) treatment. While irrigation dominates groundwater use in the region and contributes to food security, the traditional role of groundwater as a basic habitation need is equally important—around 2 billion of the rural/urban population obtain drinking water from groundwater, which accounts for around 32% of total drinking water supply (Morris, et al. 2003). Such dependence on groundwater is evident throughout South Asia and China, where irrigation dominates groundwater uptake. Large numbers of people living in rural areas, small towns, and cities are dependent on groundwater for domestic use; over 85% of rural drinking water supply in India comes from groundwater, while in cities like Delhi groundwater supplies about half of the water consumed (WB 2010). Major cities and municipalities in the region are fully or partially rely on groundwater as part of the water supply network, where it is also used by small-scale rural or town water supply systems. In the case of Jakarta only 30% of water is supplied from surface sources; the remainder is harvested from groundwater (Delinom 2011). Many geographically isolated small island developing states (SIDS) in the Pacific Ocean as well as states such as the Maldives in the Indian Ocean are particularly dependent on groundwater, as it is often the only locally available natural freshwater source (Villholth 2013). Due to a lack of alternative sources of a safe and reliable water supply, the availability of groundwater to the inhabitants of SIDS depends on its actual usage as well as climatic, hydrogeological, and physiographic factors (White and Falkland 2010). Moreover, where piped water supply is absent or nonfunctional, private digging of tube wells, dug wells or bore holes has enabled self-supply for individuals in villages, towns, and cities alike.

Industrial groundwater is usually excluded from discussions of groundwater management partly due to its insignificance as compared with agriculture. However, industrial sector is a major user of groundwater in urban areas (Figure 2).

![Figure 2. Groundwater Use in Selected Cities (IGES 2007)](image-url)
One observed trend connected with development of groundwater in the region is that new demand from various users has been met with little regard for actual availability or well yield. Demand for water thus progressed silently, unabated and in an unplanned manner in the midst of general ignorance over the consequences. Land use change including urbanization is also a factor affect the state of groundwater in most case by impeding natural recharge to aquifers.

The increasing prevalence of groundwater issues is further compounded by climate change, a new stressor (Shrestha and Kataoka 2008). Groundwater is conventionally considered to be more durable against the impacts of climate change than surface water—which suffers floods and droughts—and therefore the importance of groundwater as a more reliable water source is growing. However, if groundwater is used without good governance, overexploitation and careless use can only result losing out on the full benefits of this precious resource. Further, predicted changes in long-range precipitation patterns in the region will only exacerbate issues related to groundwater storage, which may require strategic planning in order to maximise the benefits of groundwater due to climate change.

3) Groundwater under threat
Groundwater has played a vital role in supporting the phenomenal socio-economic changes that have taken place over the region, in terms of individual livelihoods, agricultural and industrial production; however, all such benefits came at a price of resource depletion and quality degradation, and this is true for virtually the whole region. Groundwater tables are depleting rapidly in many high-use areas, which has resulted in issues of land subsidence, especially in cities such as Bangkok, Jakarta, Manila, Tianjin.

Similarly, groundwater is contaminated from point- and non-point sources, which increases health risks due to geogenic arsenic (Ganges River in Bangladesh, Red River in Vietnam and Mekong River in Vietnam) and fluoride (volcanic formations in Pacific region and hard rock areas of southern Peninsular India, Sri Lanka and central and western China) (Villholth 2013). Sea water intrusion into coastal plains has become evident especially in coastal cities, which is accelerated by land subsidence as well as sea level rise.

There are lots of issues to address in the Pacific Island Countries (PICs) (Box. 1) of which solutions need special consideration on specific geographical, hydrological and social-cultural condition of the PICs.  

**Box. 2  Groundwater Governance – Needs in Pacific Island Countries (PICs)**

Groundwater is available in almost of the Pacific island countries, but dependency on the resource differs from country to country, ranging from 10-90% of total water supply in each country. Groundwater is used mainly for domestic use in PICs. The major problems of groundwater in PICs include overexploitation, salinsation and contamination by households and cultivation fields. Salinasation is not only caused by salt water intrusion that is accelerated by sea level rise but also by overexploitation of the resource. Salinasation and depletion of freshwater lens is very critical for some small island countries since they depend on them. How to increase resilience of water supply especially during drought and post-disaster period is also a big challenge.

There are many challenges of governance need to address including weak legal framework and institutional arrangements, insufficient technical and administrative capacity of local officials, lack of data. Land ownership or a right to access land for water resources is one critical governance issue. To address these challenges on governance, technical and policy leadership support and capacity development programme need to be provided from international community. Information sharing using specific and common indicators will help PICs to promote cooperative-learning process and contribute to promote groundwater governance. A regional network framing through the information change is useful for the region to help policy development in the region.

(Sinclair 2011, Hebblethwaite 2012)
4) State of Groundwater Governance
In sum, groundwater governance – in particular in terms of legal and institutional setting is not sufficient
enough to cope with management of this very complicated resource. To deal with the issues of water and
future water crises, many countries in the region use legal and institutional measures to promote integrated
management of water resource. Groundwater is included in the concept of the large framework of
integrated management but legislations and institutions related to groundwater are still weak and
fragmented. Even there are established groundwater legislations, implementation and enforcement is not
enough to reverse negative consequence of groundwater development.

Legal Setting and Groundwater Rights
A legal framework is the key to good groundwater governance since it forms the bedrock of policy
development and implementation (Mechlem 2012). To date laws have mainly focused on surface water
since as this is more visible and also serves as a major water source for many countries. Within the region,
the countries that relay on groundwater or had faced serious groundwater issues instigated laws to mitigate
or avoid the related problems, such as overexploitation and pollution. Laws and regulations related to
sectors such as mining and hot springs also touch on groundwater management. Within a few decades,
comprehensive laws were established in the region that embraced the principles of water resource
management including groundwater. However, there are not many countries that have national level
groundwater plan or strategies. The following table shows laws and regulations at national level in selected
countries that this report referred to.

Table 2 shows major national legislation related to groundwater in selected countries in the region

<table>
<thead>
<tr>
<th>Country</th>
<th>Comprehensive Water Laws</th>
<th>Groundwater Specific/Related</th>
<th>Groundwater Quality Related</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Water Act 2007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bhutan</td>
<td>Water Act, 2011</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cambodia</td>
<td>Law on Water Resource Management, 2007</td>
<td>Laws on Environmental Protection and Natural Resource Management, 1996; Sub-Degree on Water Pollution Control, 1999</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>Water Law, 2002</td>
<td></td>
<td>Law on Prevention and Control of Water Pollution</td>
</tr>
<tr>
<td>Japan</td>
<td>--</td>
<td>Industrial Water Law, 1956; Law Concerning the Regulation on Pumping of Groundwater Use in Buildings (Building Water Law), 1962 #</td>
<td>Basic Environment Law, 1993; Water Pollution Control Law, 1970</td>
</tr>
<tr>
<td>Korea, RP</td>
<td></td>
<td>Groundwater Act, 1994 #</td>
<td></td>
</tr>
<tr>
<td>Lao PDR</td>
<td>Water and Water Resource Law</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>Law No. 7/2004 on Water Resources</td>
<td>Government Regulation No. 20/2006</td>
<td></td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>Water Code, 2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taiwan</td>
<td></td>
<td>Groundwater Control Law, 2002 Soil and Water Conservation Law, 1994</td>
<td>Basic Environment Act, 2002; Water Pollution Control Act, 1974 Soil and Groundwater Pollution Remediation Act, 2000</td>
</tr>
</tbody>
</table>

# Other laws related to groundwater for different uses such as drinking, hot spring, mining also exist

(Burchi 2013, IGES 2007, Ministry of the Environment, Japan and IGES 2012)
In general, groundwater related legislation is focused more on the quantitative rather than qualitative aspects, and such quality issues are often governed under the environmental governance regime. In the course of strengthening the water quality control scheme, water quality standards for groundwater have been established in many countries in the region, but detailed rules and monitoring of groundwater quality is implemented on an ad-hoc basis when problems occur, which can be partly traced to financial and technical constraints. Contamination from non-point sources can develop into critical issues (Burchi, 2012), but only a few countries have actually addressed them.

As most groundwater use in the region is decentralised, groundwater governance arrangements are better handled at provincial and district levels (Foster et all, 2010). In countries such as China, Japan and India, legislation at the subnational level is also set up to regulate groundwater use and mitigate pollution, and is tailored to local conditions and use of groundwater resources. For India, where hydrogeological conditions and groundwater use vary greatly, a model bill for regulating groundwater was issued by the national government (Ministry of Water Resources) and local government passed groundwater acts on their own initiative in respect of groundwater resources and usage patterns. Such local acts include the Water, Land and Trees Act, 2002 in Andhra Pradesh, and the Preservation of Sub Soil Water Act, 2009 in Punjab. In Japan, more than 300 local entities set up groundwater-related regulations for both quality and quantity. In addition, some local governments where groundwater has strategic importance in their water supply, there are policies and strategies on groundwater development and management; and they also include guideline of groundwater use under emergency situation in their emergency plan. In Australia the 2004 National Water Initiative provides a comprehensive framework for the sustainable water governance including restoration of over-allocated basins to ‘environmentally sustainable levels’, establishment of separate tradable water rights and development of comprehensive surface water and groundwater plans in consultation with stakeholders. The Australian States and Territories are required to put in place nationally consistent measures (i.e. laws, plans, rules) that will allow the NWI’s outcomes to be achieved.

In addition to statutory laws and regulations, there are customary rules of water use at community level. In the practice of groundwater abstraction on the ground, such customary rules or practices is more important than national or sub-national “formal” arrangements (Shah, 2007), but such rules do not necessarily result in rational use of groundwater.

**Property Rights and Groundwater Ownership**

It is often pointed out that the current anarchic use of groundwater is due to the lack of clearly defined usage rights such as statutes, and that groundwater is customarily used as a private domain. In many countries in the region (Bhutan, China, India (Andhra Pradesh, Panjab), Kyrgyzstan, Nepal, Philippines, Taiwan, Thailand1, and Vietnam), groundwater is regarded as a common or state property and regulatory power is held by public authorities. On the other hand, in countries such as Japan, Sri Lanka, and certain small island states in the Pacific, groundwater rights are attached to land ownership and therefore groundwater is regarded as a private domain. However, property rights issues can interfere with proactive public sector sustainability measures such as water pricing and water rights trading. For Australia, land and water ownerships were separated upon the introduction of the water trading system.

**Measures to control groundwater**

Groundwater legislation contains various measures to control groundwater abstraction and quality control. The major components commonly found in groundwater-related laws are as follows (based on Burchi 2012 and IGES 2007):

- Establishment or identification of implementation bodies (Thailand),
- Drilling permits and/or license (Australia, China, Cambodia, Japan, Kyrgyzstan, Philippines, Taiwan, Thailand)
- Zoning of aquifers or areas requiring stringent control measures (Australia, China, India (Andhra Pradesh), Indonesia (Bangdung), Japan, Thailand)
- Registration of abstraction (Australia, China, Japan, Thailand)
- Bans or regulation of groundwater abstraction in designated area (Australia, China, Kyrgyzstan, Japan,

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1 There are no laws to define property rights or ownership of groundwater, but groundwater is considered and dealt as a public goods.
Thailand)  
- Charges and taxes for groundwater abstraction (Australia, China, Indonesia, Thailand, Viet Nam).  
- Regulations on land use or activities with groundwater polluting potential (Cambodia, Kyrgyzstan, Japan)

Measures described in the laws and regulations vary according to the local setting and problem countries and areas are facing because most of existing regulations were introduced to cope with the problems each country or area faced with. Direct regulations are not always effective for several reasons including large number of small users and poor institutional capacity of implementation.

**National and local level institutional set-up**

Institutional arrangements are also important for effective groundwater governance. However, although the related water institutions have undergone water sector reform, groundwater tends to be treated inclusively rather than exclusively of integrated water management and is sometimes neglected in the reform process.

Many countries in this region have undergone organisational changes due to reforms in the water sector. In many of the countries, national water boards and water resource planning committees consist of ministers often headed by heads of state (e.g., prime ministers), and such decision making bodies are responsible for the overall direction of water resource management, including groundwater. Water resources management is governed by dedicated ministries in China and India, under which responsible sections or institutes for groundwater have been established. Countries such as Laos, Thailand, and Vietnam, on the other hand, have consolidated water resource management departments responsible for both quality and quantity, which used to be handled by separate ministries, under natural resource and environmental management, though public water supply services still operate under other line ministries. In the case of Thailand and Vietnam, the groundwater department under the ministry of natural resource and environment has primary responsibility in governing groundwater and coordinating with other related departments as necessary. Conversely, in the Philippines 16 authorities related to groundwater management exist, which has led to overlapping and fragmented responsibilities. (Tabios, 2012). Malaysia does not have a specific groundwater institute, and different line ministries are in charge of groundwater management. (Suratman 2012).

The role of local government is crucial in ensuring effective groundwater governance, but such roles vary in terms of level of involvement in groundwater management due to differences in administrative systems between countries and also the actual capacity of local governments. In rural areas, on the other hand, the community often plays a central role. Water user groups or groups of farmers play a critical role in the community groundwater management projects practiced in India and other areas and some cases show its effectiveness (Box 3).

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**Box. 3 Community participation case in Andhra-Pradesh**

Community participation is a key feature in the success of groundwater management, especially in the context of groundwater use by small users. Andhra Pradesh Farmer-Managed Groundwater System Project (APFAMGS), a community-managed groundwater in Andra Pradesh, India is a case in point. This scheme involves raising the capacity of farmers so that they can manage their own systems, and includes education in hydrogeology and groundwater monitoring. The governing principles of participatory management include equal rights, long-term commitment, community management (embracing all users) and reliable baseline data. Financial incentive scheme has not been introducing under the project. Convincing farmers that reduction of water use can bring future benefit is one of the most difficult part of community participatory project in general. By providing options of gaining more crop, APFAMGS succeeded to reduce groundwater use as an “organic” result of the “profit-oriented decisions”.

(World Bank 2010, Rao 2011)

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**Development of Scientific Base of Groundwater**

Groundwater system is complex such as different the hydraulic response time to stressors by aquifer type, and therefore proper understanding is necessary for sound and adaptive policy making. In most cases, however, hydrogeological survey is not enough and this makes groundwater remain to be the unseen
resource. Quality and abstraction data is not well monitored or compiled. Governments conduct groundwater monitoring when confronting with groundwater problem, but it is often stopped after the problem is mitigated. One encouraged example in the region can be found in China, where regional hydrogeological surveys were conducted in main plains and basins and national groundwater quality investigation was started in 2005. In addition, investigation of Karst groundwater resources was conducted in 8 provinces including Yunnan, Guizhou, Guangxi, aiming to ease water shortage by providing groundwater within yield. Thailand has developed groundwater hydrogeological map and groundwater database that include information on well data, static water level, and water quality.

**Groundwater development by private sector**

Groundwater development by private sector to “sell water” is common in the region such as water tanker and bottled water. Water tanker companies now plays an important role to provide water for people who cannot access water supply. In Hyderabad, local water bodies are encroached and polluted due to urbanisation; and water supply by public sector is not enough. Under this situation, water tanker companies increased its supply to the people there. It is estimated about 500,000L/day is sold based on the data of 2011 (Prakash 2012). Tanker companies basically do not care about resource depletion and this cause severe groundwater depletion. In addition, such groundwater abstraction creates rural-urban groundwater conflict. The similar cases are reported in Nepal. In most case, groundwater is abstracted free of charge. Current groundwater governance in the region does not cope with such private abstraction.

3. **Gaps in Groundwater Governance**

Groundwater governance has thus seen some changes over time, as described in the previous section. Legislation related to groundwater and institutional arrangements has been developed and articulated; water rights issues have been gradually clarified; and community involvement has been promoted. However, there are still many policy hurdles to overcome before effective implementation can be said to exist. Such hurdles include policy gaps (clarity of objectives, responsibilities, conflicting interests, implementation), accountability gaps (monitoring and evaluation, public participation), capacity gaps (trained experts, general expertise, coordination), information gaps (transparency in decision making, implementation, public awareness, collection and sharing, communication), and funding gaps (allocation/distribution, support from outside, impact of FDI). The table below summarises such gaps as identified in the Regional Consultation Meeting held in December, 2012. Some more governance gaps in the context of South Asia are also illustrated in Box. 4

<table>
<thead>
<tr>
<th>Policy gaps</th>
<th>Lack of rules or regulations on groundwater use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Duplication or inconsistency of related laws</td>
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<tr>
<td></td>
<td>Weak enforcement of rules and regulations</td>
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<tr>
<td></td>
<td>Lack of institutional arrangements for enforcement or weak governmental supervision</td>
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<tr>
<td></td>
<td>Overlapping responsibilities of water institutions</td>
</tr>
<tr>
<td></td>
<td>Lack of groundwater plan or exclusion of groundwater from national water master plan</td>
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<tr>
<td></td>
<td>Lack of long term vision or plan, including adaptive aspects</td>
</tr>
<tr>
<td></td>
<td>Weak integration of quality and quantity management</td>
</tr>
<tr>
<td></td>
<td>Weak linkage of land-water legislation (esp. in diffuse pollution)</td>
</tr>
<tr>
<td></td>
<td>Lack of or weak legislation over shared resources</td>
</tr>
<tr>
<td></td>
<td>Weak scheme to address rural-urban relationship (e.g. tanker issues)</td>
</tr>
<tr>
<td></td>
<td>Lack of political will</td>
</tr>
<tr>
<td></td>
<td>Vagueness in groundwater entitlements, groundwater use rights</td>
</tr>
<tr>
<td></td>
<td>No consideration of economic value of groundwater</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accountability gaps</th>
<th>Lack of monitoring of pumps and/or abstraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lack of monitoring/registration of shallow or small wells</td>
</tr>
<tr>
<td></td>
<td>Lack of groundwater vulnerability assessment</td>
</tr>
<tr>
<td></td>
<td>Low public awareness, which hinders introduction or enforcement of regulations and fees</td>
</tr>
<tr>
<td></td>
<td>Insufficient groundwater quality information</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capacity gaps</th>
<th>Lack of sufficient technical staff to control groundwater use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dependency on international consultants rather than local staff</td>
</tr>
<tr>
<td></td>
<td>Complexity in performing conjunctive use</td>
</tr>
<tr>
<td>Information Gaps</td>
<td></td>
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<tr>
<td>-------------------------------------</td>
<td>-------------------------------------------------------------------</td>
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<tr>
<td>· Hydrogeological information and groundwater availability or yield information is not available.</td>
<td></td>
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<tr>
<td>· Lack of clear yields for regulations</td>
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<tr>
<td>· Outdated water databases</td>
<td></td>
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<tr>
<td>· Lack of timely information for decision makers</td>
<td></td>
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<tr>
<td>· Perception gaps between decision-makers and users</td>
<td></td>
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<tr>
<td>· Lack of groundwater visualisation (e.g., groundwater maps)</td>
<td></td>
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<tr>
<td>· Need for hydrogeological surveys to support groundwater governance</td>
<td></td>
</tr>
<tr>
<td>· Lack of public awareness and prevalence of “Out of sight, out of mind” syndrome</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Funding gaps</th>
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<tr>
<td>· Insufficient government budget to implement policies</td>
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<tr>
<td>· High treatment costs of storm water, resulting in barrier of conjunctive use</td>
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<table>
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<th>Other</th>
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<tr>
<td>· Inefficient irrigation systems</td>
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### Box.4 Institutional environment for Groundwater Governance in South Asia

- Large number of users with small land holdings that are overwhelmingly dependent on groundwater
- Governmental interventions favors supply-side intervention with little concern about overexploitation of aquifers
- Water quality issues not well addressed during discussions
- Laws are not enforced
- Withdrawal rights attached with land ownership, withdrawal rights not regulated, and over-abstraction becomes a phenomenon
- Introducing regulations to water use rights and subsidies are often faced with protest having political implications
- Cost for monitoring compliance is simply high due to large number of scattered water users; if possible, incentive for compliance is low in the part of users
- Informal groundwater markets without any relation with regulatory authority; induce further free abstraction and hasten resource depletion
- Provision of energy (subsidy) in the form of electricity could be the only connection between government and water users


In the regional consultations, the importance of overcoming such policy gaps was emphasised, while some legal and institutional reform has taken place in many countries in the region, which shows that the region needs to closely study institutional arrangements to enable more effective groundwater governance. Gaps of perception between policy makers and water users are also pointed out that may hinder promotion of community management.

Further, information gaps were also highlighted at the meeting, and such gaps are related to insufficient monitoring, for which more technical and financial support should be provided. Although it is challenging to develop scientific basis such as aquifer system, monitoring and modeling techniques are already available to use. Addressing the technical capacity of local staff in preference to dependence on external experts also needs to be studied. In addition, how to integrate future social and economic changes can be integrated in the scientific assessment would be a challenge. The following points are areas current groundwater governance significantly lagged behind.

Conjunctive use and IWRM

The so-called “Asia-monsoon region”—in which many countries in Asia are located—is relatively rich in terms of water, and surface water is the main source of water. Here groundwater is regarded as a supplemental source of water although it also often plays a critical role, and therefore the incentive to conserve groundwater is rather low. Recently, the importance of groundwater as a substitute for surface water is growing as a result of water shortages caused by population growth and climate change impacts. It is therefore necessary to promote integrated management of surface water and groundwater. However, the current groundwater governance framework fails to respond to such integration needs, thus the technical,
financial and institutional aspects need to be considered, in terms of operationalising integrated management.

To promote conjunctive use, knowledge on surface water and groundwater interaction, but such knowledge is not yet well explored to apply in policy and management practices. Managed aquifer recharging is a key starting point to strengthen the linkage in promoting surface water and groundwater management. Also, as pointed out in the regional consultations, a scenario approach with clear targets, such as quality and groundwater level, would help promote coordinated efforts among relevant stakeholders (Hiroki 2012). Rational conjunctive use should be promoted to strengthen social resilience against droughts and also during post-disaster periods.

**Transboundary Aquifer**

Transboundary aquifer issues have not been addressed seriously in the region, since there are no significant conflicts emerged like surface water. However, transboundary aquifer governance gives a chance for relevant countries to promote information collection and sharing among them.

**Missing linkage with water-energy-food**

The water-energy-land nexus is an emerging policy issue. Land use change, including changes in vegetation, soil coverage, and state of run-off and retention capacity of the surface weakens the environmental function of groundwater. Further, land use change may also affect groundwater quality. However, current legislation and institutional arrangements fail to sufficiently address such missing linkage. For example, more than 60% of existing thermal power plants capacities exists in water scarce or water stressed region (Mitra and Bhattacharya, 2012) that shows high groundwater development rate. However, the future energy scenarios of the country fail to consider future water crises despite the fact that energy production involves large volumes of water. It is thus necessary to identify critical linkage points and include nexus issues in future strategies for each sector. It is a critical challenge for groundwater governance for the region to integrate such concerns.

4. Lessons Learnt and Opportunities to Address the Gaps

Many hurdles that thwart improvements in groundwater governance exist throughout the region, but many positive developments can also be found as explained below.

**Filling accountability and information gaps – strengthening the linkage between science and policy**

The inability to control groundwater problems and lack of understanding of planned development is partly caused by a lack of functional and dynamic awareness of groundwater systems, their suitability for use, and vulnerabilities stemming from misuse. Lack of sufficient scientific knowledge is thus one of the big gaps that need to be bridged in order to promote groundwater governance. New technologies are used for filling such gaps, such as satellite-based monitoring of groundwater depletion in India (Rodell, Velicogna and Famiglietti 2009) and use of telemetry to monitor and regulate groundwater in Tochigi, Japan (Jinno and Sato 2011). Barind Integrated Area Development Project (BIADP) in 1985 and the later formation of Barind Multi-purpose Development Authority (BMDA) exhibited a mix of science-based approaches, such as in improving water efficiency (use of electronic water coupon charges), minimising losses (underground piping), minimum well spacing, and enhanced participation (Faisal, Parveen and Kabir 2005).

In China, water management focuses on reducing non-productive evapotranspiration (ET) and discharge to groundwater while leaving overall water consumption (ET) unchanged. Setting limits to groundwater use (e.g., via pre-paid cards for pumps) in combination with training, capacity and agricultural reforms can lead to an increase in farm incomes, while saving water and reducing pollution. Card systems for managing irrigation water use are accepted when it can be shown that they raise farm income. Such scientific based demand management is accountable for water users and may make implementation easier. (Jin 2012).

Managed aquifer recharging (India Groundwater Recharge Master Plan) and conjunctive use are promising options in regions with seasonal variations in precipitation, although actual feasibility depends on local
conditions. As mentioned before, managed aquifer recharge can become a way to connect surface water and groundwater regime.

![Figure 3. Role of MAR in IWRM](image)

(Prepared by author based on the figure showed in the report of WG5 of the Regional Consultation Meeting)

**Provision of incentives and disincentives (An Incentive-led Approach)**

**Direct charge to groundwater use**

In Bangkok, groundwater user charges were successfully implemented and have contributed to mitigation of groundwater overexploitation. The groundwater preservation charge, which is imposed in addition to the groundwater user charge on groundwater users in critical groundwater use zones, became a critical factor in discouraging groundwater use (Figure 4). By adding the preservation charge, users had to pay about double and also more than for water provided by the municipal water supply scheme. The income raised via the preservation charge supports governmental monitoring of groundwater and therefore contributes to increased financial stability of monitoring.

![Figure 4. Change in groundwater abstraction, supply volume by Municipal Water Authority (MWA) and the Groundwater Charge (IGES 2007)](image)
Discouraging groundwater use by addressing electricity charge

In the West Bengal in eastern India, a telemetric metering system (Universal Time of the Day (TOD)) to meter electricity use by agricultural tubewells was introduced together with equipment to read the monitored result remotely. By the system electricity can be charged by different time and electricity charge can be charged based on monitored results. The system was considered to increase resource efficiency. However, small farmers who need to by water from tube well owners or private tankers were subject to increased water price as a result of the project.

Gujarat located in western India used to encourage groundwater irrigation with electricity subsidies. However, this policy resulted in bankrupt of electricity utility, and groundwater was depleted by excessive irrigation use. The government of Gujarat introduced groundwater charge, but it failed because of high transaction cost. The Jyotigram (“lighted village”) scheme was introduced the government of Gujarat launched in 2003 to rationalise electricity cost and mitigate overexploitation of groundwater resources. By separating power supply for domestic uses and irrigation uses, it has become possible to limit power supply for 8 hours but on pre-announced basis and with full voltage. With stable electricity supply, farmers in the state can produce more and save water with planned schedule. In addition, the project enable 24 hour supply (3 phases) to domestic sector, which increase people’s welfare. (Mukherji and Shah 2005)

Payment of Ecosystem Services promoted under partnership of stakeholders

In Kumamoto, Japan (Box 5), payments via ecosystem services are one of the key elements in promotion of groundwater governance, as they provide financial stability for groundwater management. By combining the groundwater recharging scheme and water demand control initiative led by Kumamoto City Government, groundwater conservation is better promoted in the area. Factors that promote the groundwater conservation initiatives implemented include the high administrative capacity of local governments and high awareness of local populations of the value of groundwater and implications of socio-economic activities, and partnerships among local stakeholders, especially local governments, farmers’ groups, local NGOs and private companies.

**BOX 5. Payment for Ecosystem Services - Water Offset in Kumamoto, Japan**

Kumamoto, located in Kyushu Island of Japan, benefits from a rich groundwater resource as a source for domestic, agricultural and industrial use. However, the groundwater level has dropped in recent years due to increased water demand and also decreased recharging capacity due to land use change such as conversion of agricultural land to urban use (industry and housing) and also conversion of paddy field to “idle-field” in response to Japan’s rice production reduction policy and low rice price.

To end the continued depletion of groundwater, Kumamoto City Government revised the “Groundwater Preservation Ordinance” such that it defined groundwater as a resource to be conserved as a common property of the population and introduced a variety of schemes for groundwater conservation. One example of this is the provision of a “cooperating fee” to farmers who contribute to groundwater recharge by flooding idle fields and crop fields between cultivation periods. This recharging initiative is replicated by a private company of which factory located in the groundwater recharging area under the slogan of “to fully return the groundwater we used” based on an initiative proposed by a local environmental NGO. This initiative was also entered into by other local companies.

Another initiative taken in Kumamoto is the water-offsetting program, which was initiated by a farmers group and Kumamoto City Government. It is designed to enhance groundwater recharging through the support of rice farming. Local companies and universities purchase “eco-rice” from partner farms, which is slightly higher in price than conventional rice, and grown with less pesticides and fertilisers. Through such purchases of eco-rice, populations indirectly contribute to the recharging of groundwater, which resulted in an estimated water-offset contribution of 10,000 tons of groundwater recharge in 2009.

(Ministry of the Environment, Japan
In the past cases of natural disasters and drought events, groundwater was served as water source readily available to use. For this reason, it is recommendable to enhance “preparedness” such by identifying safe groundwater and exploring flexible governance arrangements for emergency situation. In Japan, national government prepared a draft guideline for groundwater use during post-earthquake period, and local governments also developed emergency plan in which possible water sources in initial stage of emergency and rehabilitation plan are identified. In addition to develop and maintain emergency wells by themselves, local governments promote registration of existing wells maintained by individual household users and business entities who agree to use the well for emergency use. Recently, there are some cases to conclude memorandum between local governments and hospitals about emergency use of the hospital owned wells that has treatment equipment and also earthquake resistant structure. To ensure health of people, registered individual-owned well water is to be used only for toilet flushing, cleaning and washing since many of them are taken water from shallow aquifer and therefore water quality is not ensured for potable use. The lists of registered wells are shared with local people such through the Internet.

**Progressive Development of Groundwater Governance**

Groundwater governance must be adaptive in full consideration of changes in local social, economic and hydrology. Most countries that have more articulated and nested groundwater governance structure developed its governance arrangements to cope with “problems” they are facing – such as land subsidence, critical water shortage, and contamination. The case of Thailand illustrated in box. 6 shows progressive development of groundwater governance with a responsible institute in which groundwater governance objective also changed according to social needs.

**Box 6. Groundwater Governance in Thailand**

The history of groundwater management in Thailand starts in 1970s when the country started to suffer land subsidence in Bangkok caused by excessive groundwater abstraction. Increasing water demand of municipal water supply triggered large scale groundwater development in the mid-1950s, and then industrial sector started abstraction for their production.

To mitigate excessive abstraction the Thai government stipulated the Groundwater Act in 1977, strengthened regulations step by step in consideration of the state of social development. Major measures introduced by the national government includes the followings: penalties and fines for non-compliance of the Act; designation of “critical zones” need intensive measures; ban of well drilling in “critical zones”; groundwater abstraction licensing; groundwater user charge; groundwater preservation charge imposed in addition to groundwater user charge; inspection of well-metering by private users; phase-out of groundwater use by municipal water supply and development of alternative water source. Groundwater monitoring has been also strengthened although there are constraints of budget. Among those measures, groundwater user charge and preservation charge were very effective to reduce abstraction (Figure 4). Because of step-by-step but intensive approach, land subsidence is mitigated and groundwater management objective seems to be turning into sustainable groundwater management where the resource should be protected from overexploitation and pollution while getting maximum benefits from it.

The Department of Groundwater Resource (DGR) (a part of the Department of Mineral Resources in the past) is the responsible institute of groundwater management from early stage of groundwater management to the present. The Groundwater Act entitled DGR to execute their administrative power to control groundwater abstraction and this clarity of responsibility of DGR is a factor of success of groundwater management in Thailand. Currently, DGR tries to decentralised their responsibility to smallest administrative unit, which is expected to strengthen local groundwater management.

The case of Thailand shows the effectiveness “step-by-step” arrangements and the importance of a responsible institution with consecutive commitments for strengthening groundwater governance. A retrospective review presented by DGR includes the messages to the region as follows.

- Monitoring is “a long term job” that needs commitment from the political leaders. Complicated monitoring instrument for monitoring is not necessary from the beginning.
- Capacity development of technical staff is important.

(IGES 2007; Lorphensri 2013)
Transparency and Accountability – Making groundwater visible with stakeholder participation

Gaining understandings on groundwater of key stakeholders including users are very much in need to improve groundwater governance. Since groundwater is not visible resources, people cannot notice its disruption easily. The Community participation in Andhra Pradesh in India (Box. 3) shows that participation of users in monitoring and assessment of groundwater facilitated their knowledge on groundwater, which became a driver for cooperation. With participation of users, transparency and accountability of groundwater governance are promoted and water users would make rational decision if groundwater users are given proper and trustworthy knowledge and information with appropriate technical support.

It is also useful to develop index to assess the status of groundwater governance (groundwater governance index) that helps visualization of the state of groundwater and its governance. An example is “groundwater sustainability infrastructure index (GSII)” (Pandy et al., 2011). GSII consists of 5 components (Environment, Society, Economy, Mutual Trust, and Institution) under which 3 to 4 indicators are identified to evaluate. For example, environmental component consists of indicators such as monitoring of groundwater level, groundwater extraction, groundwater quality, and land subsidence; and institutional component includes such as existence of groundwater management authority, legal framework and control mechanisms, and institutional capacity. Each indicator is assessed and ranked with qualitative expert judgment. By involvement of stakeholders including experts, policy makers, regulators and users, the index could be one way to assess groundwater governance and good communication tool among stakeholders. The index is tested for Kathmandu case in the research. An attempt to articulate GSII and develop groundwater index will be studied by Asian Institute of Technology (AIT) and Institute for Global Environmental Strategies (IGES) in collaboration with their partner organisations under ADB and UNESCO-IHE Knowledge Partnership Project “Comparative Research of Groundwater Management in the Coastal Areas in Southeast Asia”.

Figure 5. Conceptual Framework of Groundwater Sustainability Infrastructure Index (GSII) (Pandy et al. 2011)

The lessons described in this paper are a part of good lessons available in the region. Technical advancement support scientific knowledge development for policy making and groundwater governance is progressed by addressing water shortage, environmental impacts and other needs of society on groundwater. Groundwater governance lessons can be roughly divided into two types – governance developed based on urban groundwater issues and the one developed at community base to address groundwater issues at rural level. Direct regulations with incentives/dis-incentives succeeded to some extent in former type of governance and main player is a national or sub-national government and relatively large users in city. On the other hand, in rural context direct regulations did not work because regulatory target is too many and decentralised. In latter case, community plays a central role with support of experts and indirect measures (e.g. change of water supply patterns and charge) worked more than direct regulations. As such, there are no “fixed forms” of governance suitable for the region. Governance arrangement must be adaptive.
Governance arrangement is supposed to work effectively at “groundwater bodies” that is “clearly-defined” and “scientifically-sound boundaries” of resources management (Foster et al. 2010). Most lessons shows groundwater is managed in a parts of aquifer system that forms of “groundwater bodies”. In urban context such in Thailand, it is necessary to coordinate with other sectors such as surface water development and municipal water supply to pursue effective countermeasures – in such case groundwater governance should interact with other governance regime. Ideally, groundwater governance should not be considered only within “groundwater bodies” but it should be need to consider relationship with other sectors. Also groundwater governance arrangements need to consider vertical relationship – between national, sub-national, and community. Gap of arrangement in vertical relationship may hinder sound implementation at groundwater bodies. The following figure shows horizontal and vertical relationships that groundwater governance need to consider. The scope of consideration may change according to characteristic of problems to be solved and social and economic conditions of groundwater bodies.

![Groundwater governance: Interaction with different levels and sectors](image)

**Figure 6. Groundwater governance: Interaction with different levels and sectors**

**Conclusion**

The Asia-Pacific region is very diverse and so is the national policy priority. However, it must be commonly understood that the development of the region cannot be attained without conserving natural capitals that all our activities rely on. Groundwater, one of the key elements of natural capitals should be developed and utilised without losing its sustainability. However, increasing water demands have been giving more pressure on groundwater resources and creating problems such as groundwater depletion, land subsidence, and contamination; and it is an urgent task to reverse the negative trend for sustainable future of the region. The regional consultation process identified that there is a high aspiration among experts and policy makers for the improvement of groundwater governance as a basis to change the current looming trend of the resource use.

Current groundwater governance and the lessons in the region shows us that groundwater governance in progress in the region by adapting changes such in hydrogeological conditions, water demand, social and economic needs. There are great advancements of groundwater governance such in China and Thailand. However, in general, groundwater governance of the region is still very weak to achieve the objective and more financial and human resources are in need to improve it.

There are lots of challenges identified through regional consultations. The following points are priority areas need actions emphasized more than others.

- Scientific base development for policy making though strengthened groundwater quantity and quality monitoring, modeling and data sharing mechanism – supported by research communities and
international organisations;

- Creation of enabling environment to ensure implementation and enforcement of laws and regulations in consideration of resources available, such through national policy development, streamlining current legal and organisational arrangements, capacity development of government officials, and adequate budget allocation, and alignment of groundwater ownership/entitlement issues. Incremental approach is very much necessary;

- Promotion of water user involvement in planning, implementation and review of groundwater governance, especially at the lowest feasible level of implementation, which need proper incentives (not necessarily direct financial incentives) and rules of participation;

- Inclusion of water saving (demand management), conjunctive use and managed aquifer recharge (MAR) in the scope of groundwater governance to ensure sustainability of the resource. This integration efforts may be more applicable at project basis and it should be extended to wider application;

- Facilitation of policy coordination with relevant sectors especially at national level, in particular with policies for surface water management, land-use planning, agriculture, and energy. The nexus issues are very critical for effective groundwater governance.

National governments should play a leading role for the priority actions. In practice, in addition to water users and local practitioner, awareness raising and capacity development at sub-national level is very important to consider soundness and sustainability of local groundwater governance. What is important is to find a pathway for improved groundwater governance considering local physical, economic and social conditions and priority. It is necessary to identify which organisation should play a leading and responsible role. International and regional organisations and science communities need to take a role to advocate implementation of the priority actions with financial and technical supports. Current project of FAO, UNESCO and other partner organisations of the Project can serve as the basis for promoting actions of the priority areas.

Since global and regional agenda and goals are one of the useful tools to put national actions forward as we saw in the progress of water supply sector in relation to Millennium Development Goals, it is very important to incorporate groundwater governance aspects in the future global and regional agenda, in particular in the context of sustainable development. Transboundary aquifer management is the work that international organisations should promoted and facilitated. Transboundary issues are politically sensitive, but we may need to start dialogues for ensuring effective management of not only groundwater of water resources. In addition, the following three actions are also recommended as next steps forward at international and regional communities.

1) Turning challenges into opportunities – redefining strategic importance of groundwater in the context of social resilience

The profile of groundwater is low in many parts of the region, particularly in the countries or areas where people mainly depend on surface water; and groundwater governance does not exist or very weak to cope with misuse. However, groundwater use has become highlighted recently in the context of climate change adaptation and emergency planning and is gaining policy attentions, and therefore it is a good time to redefine strategic importance of groundwater in the context of social resilience and also in Integrated Water Resource Management (IWRM); and raise awareness of decision makers on groundwater governance. The Groundwater Governance Project can provide good opportunities to publicise groundwater and social resilience linkage and facilitate the understanding of decision makers and international community. To highlight groundwater, it is necessary to emphasise the benefits of good groundwater governance will bring to the society.

2) Develop communication tools among stakeholders – for visualization of groundwater

Groundwater governance should be multi-layered (e.g. national-sub-regional-community) and also needs cross-sectoral arrangements. To facilitate communication among different stakeholders at different level
and in different sectors, it is necessary to develop tools or mechanisms of consultation. Groundwater mapping is one of them. Tools such as the groundwater sustainability infrastructure index that can facilitate understandings and develop common basis for further communication should be elaborated and practiced. By setting common methodology and indicators, such tools can be compatible and facilitate regional communications for further actions. Stakeholder participation in developing such tools would be beneficial in terms of knowledge sharing.

3) Networks for synergizing knowledge

Rich information and knowledge including lessons of groundwater governance in different settings and available technologies exists in the region. Although efforts to share such information and knowledge have been made, it is not always enough to encourage behavioral change of policy makers and water users. To facilitate information and knowledge sharing in the region for groundwater governance improvement, it is necessary to strengthen knowledge sharing functions of existing networks and develop a platform to synergize knowledge sharing operated by different networks. Rather than creating a new mechanism, it is recommended that a meta-network (network of networks) in the region should be developed with participation of key networks and organisations identified in the Project. Knowledge networks can leverage resources putting into projects implemented in the region.
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