WBI Case Studies on Integrated Water Resources Management (IWRM)

China: Water Management in the Tarim Basin

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The XUAR Region

1. There are severe water shortages in the north-western China[1]. The Xinjiang Uygur Autonomous Region (XUAR) is located about 3,000 km northwest of Beijing and is bordered by Mongolia, Afghanistan, Pakistan, Tajikistan, Kyrgystan, Kazakhstan and India. Internally it borders with Xizang (Tibet), Qinghai, and Gansu. XUAR is China's largest province, about 4 times the size of France. It occupies one-sixth of the country's land area, but is sparsely populated (9 persons/km^2)[1].

The Setting: Tarim River Basin

2. Located in the southern part of XUAR, the Tarim River Basin, with an area of one million km^2 is one of the most water short areas in the country. Except for the high mountain regions that surround it, the basin is relatively flat desert with less than 50 mm of annual precipitation, although precipitation in the mountainous areas surrounding the basin could reach 1000 mm[2]. The Tarim River, which extends 1,300km after the confluence from its three main tributaries (Aksu, Yergiang and Hotan), has no sea outlet—it ends up in a terminal lake, Taitema (Chart-1).

3. Water resources come mainly from seasonal snowfall and glacier melting, which feed the Tarim River through its tributaries. The total annual precipitation in the basin averages about 60 billion m^3, nearly all of which is evaporated either in irrigated agricultural areas, natural vegetation areas along rivers, human habitation areas, or from water surfaces and high groundwater table areas. The flows into the Tarim main river runoff total only 4 billion M^3[2]. The lower reaches of the Tarim River historically supported a "green corridor" of trees and vegetation that have been gradually receding as upstream consumptive water uses increased and water reaching downstream areas decreased. Because of the lack of flows to the lower reaches of the River, about 300 km of river channel and the terminal Taitema Lake had dried up for 30 years.

4. Approximately 5 million people live in the Tarim Basin, the majority of which are dependent upon agriculture[2] for their livelihood, covering an area of about 1.4 million ha.

[1] On a per capita basis, the annual runoff in China represents about 2,300 m^3, which is a quarter of the world's average [9].
[2] Such as wheat, cotton, corn, horticulture, and sheep/cattle.

Population centers are located along the rivers in the areas where irrigated agriculture has been developed these areas are referred to as "oases". The areas between the oases are unpopulated [3].

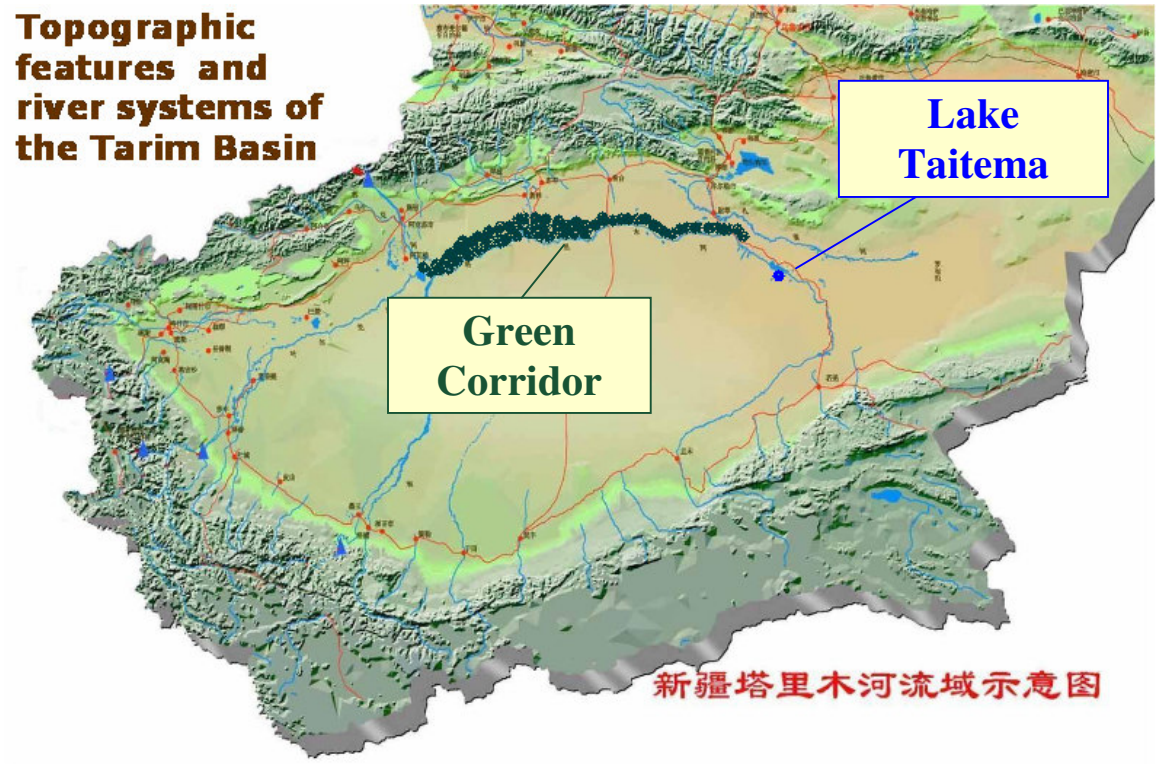

Chart 1

5. In the past, the general approach to water resources management had been to maximize water use and retention within and around the areas of human habitation in the sub-basins, and to minimize the downstream flows. Although there were minimum downstream delivery requirements from each sub-basin to the Tarim River main stream, the fact that there were no strong control and regulatory bodies, and annual flows vary—all made it difficult to enforce downstream requirements, which were based on averages. Poor water conservation practices, plus expansion of irrigation and other development in the upstream areas, gradually reduced flows to the lower basin. This caused severe problems in the basin—encroachment of desert, degradation of the Green Corridor, and drying up of the Taitema Lake and 300 km of the lower river.

6. To address the above serious problems, and given the importance of the river (which is known locally as “mother river”) to the whole regional social economy, the Chinese government launched major investment programs (US$1.3 billion in 5 years from the central government) to reduce and control water diversions in the upper basin, to allow more flows into the Green Corridor to revive the eco-system, and at the same time to sustain economic development in the basin. Development of the Tarim basin was part of the central government’s overall regional strategy for the poverty-struck western regions of the China.

Tarim Basin Development Intervention

7. The most important development in the basin happened in the last 15 years, during which two World Bank projects (Tarim Basin I and II) were implemented with major investment and reform in integrated water resource management at the basin level. However, the two projects had quite different objectives and approaches, both represent an evolutionary process towards sustainable nature resources development.

8. ***Tarim Basin– Phase I.*** From 1991-1997, the Bank financed US$125 million under Tarim-I project. The first Phase had objectives to expand the irrigated area for agriculture production, promote livestock development, improve agricultural services, improve water resources management and restore ecosystems in the Tarim Basin[4]. *Note: basin institutional development was not an objective.*

9. These objectives were achieved through irrigation and drainage improvement on 200,000 ha; hydropower development; improved agricultural and livestock services; and monitoring of environmental quality in the basin. For example, investment in irrigation increased the efficiency of water delivery and saved about 940 million m^3 of water annually. The water saved gave the local counties the opportunity to expand irrigated areas by 73,000 ha and to provide additional land for cultivation by small farmers and thereby increasing their incomes[5]. Indeed, both agricultural and livestock production, and farmer income were increased (by some 65-70%), but at a cost to further devastating the downstream ecosystem, as with expansion of water uses and increased evaporation, even less water flowed into the downstream Green Corridor. The basin already enjoyed a high overall basin water use efficiency. Lining canals and repairing water leaks resulted in little incremental benefits to the basin as a whole [10].

10. From a basin development viewpoint, the objectives of Phase-I were achieved by increasing production and improving water use efficiencies to save water. It laid the foundation for Phase-II basin-wide water management. It also attempted to address basin water management by establishing a Tarim River Committee (TRC) and a Tarim river management bureau (TRMB) (details in sections below)[10]. However, from a basin management viewpoint, Phase-I was only a preparation step as it established a Tarim river entity, which could be expanded in phase-II into a full fledged river basin body. TRMB under Tarim-I did little except building its office and recruitment of staff, in additional to some research studies and the set up of ecological monitoring stations to obtain first hand data. The institutional set ups could not fully fulfill the functions of a river basin body for water management nor for water allocation [6] due to factors that will be discussed in the later sections. It was felt that a different approach must be sought to address the basin-wide water management issues and the Green Corridor degradation. For this, an effective institutional mechanism must be in place.

11. ***Tarim Basin- Phase-II.*** Based on the success and lessons from Tarim-I, the Tarim II Project (1998-2004 with US$150m) was designed to bring into focus the issue of "basin-wide sustainable water resources management" [3]. Interventions of Phase-II were thus aimed to create the right conditions for "controlled development", combined with the establishment and effective enforcement of water allocation and controlled water

withdrawals in the upper catchment in order to increase water availability and quality in the lower basin and provide environmental flows to restore the dried river channels, wetlands and the terminal Taitema lake,.

12. Therefore the objectives of Phase-II were framed differently from Phase-I and were to (a) increase the incomes of poor farmers through irrigated agriculture development, (b) set up institutional mechanisms for the sustainable development, management and use of the basin's water and land resources, and (c) partially restore and preserve the "green corridor" in the lower reaches of the Tarim river.

13. As such, the institutional development, which was not part of the development objectives of Phase-I, was now a central part of Phase-II.

14. Phase-II continued interventions to increase water delivery efficiencies, increase crop yields and to reduce farmers' production costs. Implementation of measures in water conservancy accounted for 70% of the investment—ranging from development and improvement of reservoirs and water division weirs, head control structures for water withdrawals and releases, to improving in irrigation and drainage canals, dikes, ponds and establishment of groundwater well fields for conjunctive use of water with surface water. Although Phase-II had an objective (a) similar to that in Phase-I, the approach used was different. Unlike in Phase-I, where water savings resulting from improved irrigation efficiencies were used for expansion into new areas, Phase-II focused on improving yields and not expanding into new areas, and on saving water for the river systems (the Institutional Development section below presents how this was achieved)[3]. It defined non-beneficial evapo-transpiration (ET), mostly in low-lying areas with high water tables and non-ecological beneficial water surfaces. It was estimated[10] that of the 60 billion M^3 of precipitation, 5 billion M^3 was for consumptive use, 10 bil. M^3 for beneficial ET and 45 billion M^3 for non-beneficial ET. The overall goal of water management in the basin was to maximize consumptive use and beneficial ET and minimize non-beneficial ET. To maintain the existing level of beneficial ET, any increases in consumptive use would need to be off set by corresponding decreases in non-beneficial ET[4].

15. The Tarim Basin II project effectively achieved its objectives as follows:

i) Increased farm incomes through increased agricultural productivity of water usage, modernization of cropping systems, reduced farm input costs, and diversified agriculture to higher-value products. In the project area, the number of people in poverty was reduced by nearly 70% [7].

[3] Tarim-II also included land reclamation, improvement of low yield lands, agricultural support services, etc. Agricultural support brought in new technologies and applications, set up post-harvest processing, training centers, databases, collected information, trained staff and farmers, carried out scientific studies and research, purchased equipment, and launched campaign on water control and savings, crop disease control, better seeds. Under the upper watershed component, the project implemented reforestation, grassland restoration, sand stabilization, wind break plantation, soil erosion control, etc.

[4] Nonbeneficial Et could be reduced in several ways: (i) line canals as seepage resulted in significant amounts of non-B ET. (ii) replace existing reservoirs with well fields through conjunctive use; (iii) lower high groundwater tables in areas of high capillary flux by building well fields and drain and by canal lining and on-farm improvement. (iv) improve operation by irrigation only when needed to reduce the amount of water applied to the fields.

ii) Partially restored the Green Corridor in the lower reaches of the Tarim river by reducing the quantity of water used in upstream withdrawals, allocating a water quota to the riverine environment. From 2000-05, seven water deliveries were specifically made to the lower river reaches, totaling nearly 2 billion cm^3 [8]. The lake Taitema, a dust bowl for 30 years with no water flowing to it, has reached a water surface area of 200 km^2 [7]. The increased river flows to the Green Corridor and the reinstatement of the lake have revitalized trees, shrubs and grasslands along the river sides[5], providing food, shelter and water for wildlife and people[9].

iii) Increased forest cover by over 30%, and grassland by 15%; damages from wind and sand storms losses (socio-economic) were reduced by half, resulting also in better natural environment[8].

iv) Development of a truly participatory and inclusive river basin institutional mechanism for water management through the establishment of farmer water user associations and irrigation district committees.

Evolution of Tarim Basin Water Resources Commission

16. The Tarim basin water resources commission (TBWRC) took over 13 years to evolve and to this date, the Commission considers itself still at an infancy stage. It evolved through two major stages.

17. *Preparatory stage*: Under Phase-I, the Xinjiang provincial government in 1992 set up the *Tarim River Committee* (TRC) and *Tarim River Management Bureau* (TRMB), which is responsible for managing water only in the main stream of the Tarim river. The functions of the TRC were to formulate policy directions for water management, coordinate multi-agency plans and actions, and regulate water use. The functions of the TRMB were to (a) operate and manage hydraulic structures, (b) study and investigate water management options, and (c) monitor and control water allocation to sub-basins.

18. The TRMB exercised its first two functions (a) and (b) but was ineffective in performing the above function (c). For several years, the TRC and TRMB were ineffective to address water allocation and management issues of the whole basin, especially the tributaries in the upper part of the river basin. Looking back, several factors were responsible for the ineffectiveness. (i) basin development took priority over ecosystem preservation. Environmental flows were a brand new concept then in most leaders' mind. TRC was not taken seriously by the leaders, reflected in three meetings of TRC in five years. Even the meetings did not have a specific agenda apart from general reporting of progress and issues. (ii) TRC has no clear link with TRMB. Neither had any legal stands to exercise the function of water allocation[6]. (iii) TRMB was responsible only for the mainstream of the Tarim river and but no control over the main tributaries flow into the mainstream. It was set up in parallel to the Provincial Water Resources Bureau (WRB)[6]. WRB was a crucial player in water management as it was mandated by

[5] The lower river reaches have seen a return of 25 species of native birds, amphibians, reptiles and eleven species of fish. Wildlife such as red deer has also returned.

[6] Which managed the Tarim basin water prior to TBM-B and is still responsible for water resources in the XUAR.

law to manage water resources of the entire region (Chart-2). There was unavoidable confusion, overlapping turf tights and a lack of proper authority for basin water management. (iv) TRMB had no power nor funds and was left hopeless in managing water resources of the Tarim river.

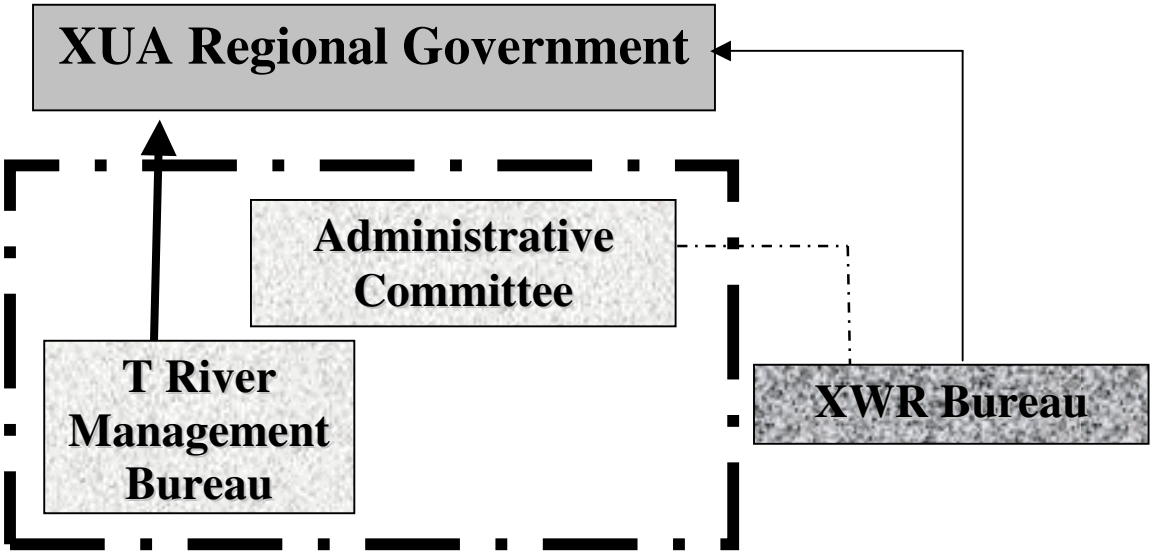

Chart 2

19. There was an urgent need for a change in the overall water management framework in the Tarim Basin! But how ?

20. *Full development stage:* Under Tarim-II, institutional development at river basin level through the establishment of a true basin management entity became a central part of Tarim development intervention. The intention was to use strong institutional and legal measures to achieve sustainable water resources management and to preserve and restore the eco-systems of the basin. In 1997, the Xinjiang People's Congress passed "*Regulations for Tarim Basin Water Resources Management*" to establish the Tarim Basin Water Resources Commission (TBWRC) as the sole authority for water management in the entire basin. The "*Regulations*" set out the principles for sustainable water and land use, development and management in the basin. They set out the institutional framework of TBWRC, define its responsibilities, power, organizational structure and mode of operations. The previous Tarim river committee (TRC) was revived and expanded to include also the Bureaus of Finance and of Planning. Together with TRMB, which was changed to TBMB, the institutional framework was transformed into a basin commission (TBWRC).

21. TBWRC has the following functions: policy making, coordination, regulation, monitoring, enforcement of water allocations, oversight prefecture performance, data collection and management, project design and construction, financing through supervision of government grants, water permit, operating agreements for control of hydraulic structures and control of key basin projects.

22. The Board of Commissioners consists of a Standing Committee, an Executive Committee with an Executive Office. Together with the Bureau (Chart-3), it has about 200 staff[2][6][7]:

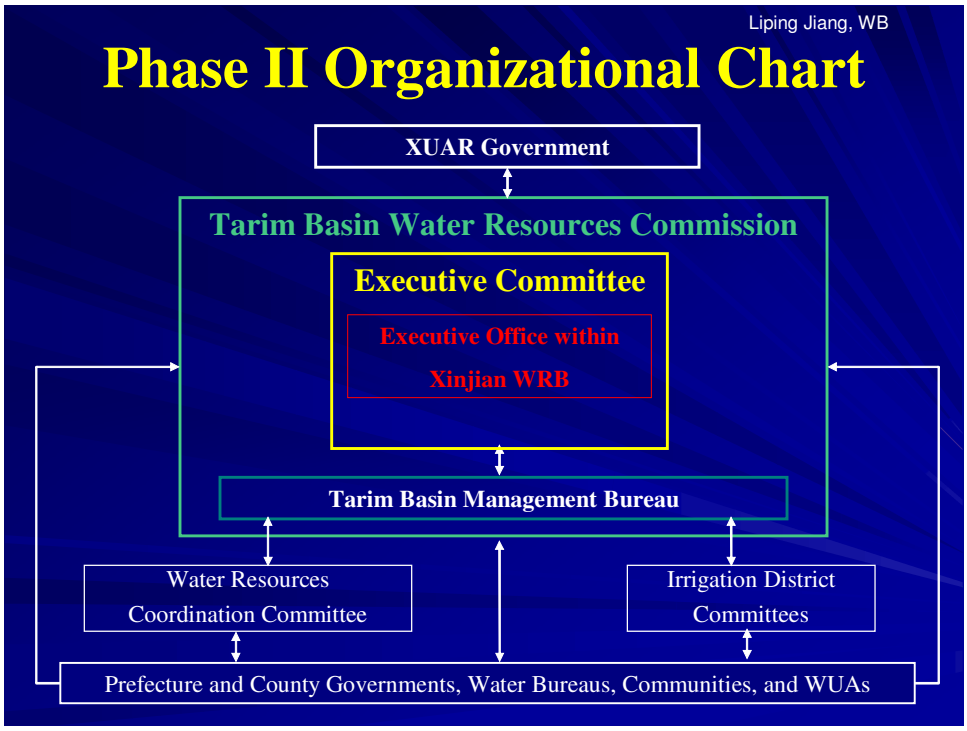

Chart 3

- The *Standing Committee* is high-level policy and strategy decision-making body, headed by the first Vice Governor of the Province. The deputy is headed by vice governor responsible for Agriculture. Its members include heads of all provincial water-related agencies (Water, Environment, Land, Finance, and Planning), administrative heads of the five prefectures in the basin, and the head of the TBMB. They work in equal partnership, and meet at least once a year as required by the "*Regulations*" that established the TBWRC. The Committee's function includes policy setting, decision making, review and approval of plans/projects, and review budgets and reports of TBMB. The SC often meets at the beginning of the year.

- The *Executive Committee* has delegated power from the Standing Committee, when the latter is not in session. It is headed by the vice Governor responsible for water and agriculture, and has members from the relevant line departments only. It makes policy and urgent decisions in between meetings of the Standing Committee.

- The *Executive Office* is a working office of the Standing Committee and of the Executive Committee, and is headed by the Director General of the provincial Water Resources Bureau (WRB). It acts as an administrative secretariat of the SC/EC.

- The *Management Bureau* is a technical secretariat of the SS. It is headed by a Deputy Director General of the provincial WRB, and is thus administratively accountable to the WRB (though the head of the Bureau is at the same grade level as the head of the WRB). It carries out technical programs as directed by the Commission as it is directly accountable to the Commission (not to the WRB!).

23. The "*Regulations*" define the mandate of TBWRC water policy setting, review and approve water resources development plans, exercise regulatory functions and control of water use and related natural resources in the Tarim Basin. Specifically, the Commission formulates annual quotas for water use and withdrawals from the Tarim River, monitors and enforces the quota implementation. The main objective of the TBWRC is to manage the basin's water resources in a sustainable manner, and to ensure the rational and equitable development and use and the preservation of the water resources, including water for the environment.

24. The functions of the TBMB became: (i) implement the water allocation quotas per the decision of the Standing Committee and the signed agreements with all water users in the basin; (ii) monitor water withdrawals at key locations[7], (iii) report to the Standing Committee the implementation of the annual quotas, and (iv) other technical studies relating to water resources of the basin. TBMB can set up field offices as needed and approved by the Executive Committee.

25. These institutional arrangements were tested and have been workable for the past 8 years. Since 2000, the Standing Commission has met each year to establish water quotas for each sub-basin and the Green Corridor and to make policy decisions. The above institutional structure was made permanent in March 2005, when the revised "*Regulations for Tarim Basin Water Resources Management*" were passed by provincial People's Congress [7].

Combining Top Down with Bottom-Up Water Management

26. The Tarim institutional framework was intended to ensure management of water resources with a comprehensive river basin approach and with lower level stakeholder participation. Basin management was thus set up and carried out utilizing both a top down and bottom-up approach: The top down measures includes the basin-wide TBWRC with responsibilities for the planning, development and management of the Tarim Basin's land and water resources. At this level, water management by the Commission is related to (i) establishing policies, laws, organizations, and regulations; (ii) defining the availability of water and determining broad water allocations to different sectors and administrative entities within the river basin; (iii) setting water quality standards; and (iv) fostering cross-sectoral coordination.

27. The bottom-up level institutions are the farmer owned and controlled Water User Associations (*WUAs)*[8] for water delivery at the low end of the distribution network.

[7] Many intake points were closed off, keeping open at key locations only where automatic monitoring devices were installed for monitoring, with field investigations by the lower level units of the TBM-B.

[8] The Tarim-II project set up 200 WUAs and 1 WSC, with 15 WUA during a pilot period. Afterwards, 5,000 more WUAs were set up by the regional government.

WUAs purchase water in bulk from the water service provider and have the power to charge individual farmers for water deliveries and maintain own bank accounts. This has been reinforced by implementation of policies on "volumetric water charging", "measuring water to individual farms", and "farmer participation in irrigation management", all of which fostered the concepts of economic value of water, and gave incentives to farmers to save water, paving ways for eventual elimination of subsidies in water pricing. The co-ordination and participation between the two levels is done through the establishment of a water resources coordination committee and two Irrigation Committees (at county level). These committees also provide formalized to input decision making processes from bottom-level stakeholders/farmers to the basin level Commission.

Unique Features of the Tarim Basin Experience

- Establishment of a river basin entity is fully backed up by legislation, which is the first legislation in a river basin context and which allocate water quotas to environment – all of the above has no precedent in China.
- TBWRC is a true basin entity for water management (although several river basins in the country have got basin commissions—e.g. the Yangtze, Pearl, Hai—they have no legal back up nor authority in water allocation and nor participatory representation of all basin stakeholders). TBWRC combines top-down and bottom up approaches - with the basin commission at the top, and WUAs at grass-root levels.
- Introducing evapo-transpiration (ET) management as indicators for true water saving – which is the first application in developing countries. Remote sensing was used to collect ET data both on surface and groundwater so that their conjunctive uses were introduced.

Lessons from the Tarim Basin

1. There must be a driving force behind a major institutional change, such as the establishment of a river basin body.
2. Basin institutional mechanisms must be backed up by legislation.
3. For water allocation to be effective, three elements should be in place:
    - Backed up by legislation – in the case of Tarim: the Regulations were issued in 1997 and modified in 2005 to be consistent with the new national water law.
    - An effective institutional set up for implementing /enforcing it - – in the case of Tarim: the TBWRC was set up, with top leadership, strong political commitment and support, which created an enabling environment for establishing right policies and institutional framework.
    - Good information/data system to provide scientific basis, and technical tools to perform meaningful analysis for decision makers, and for monitoring purposes – in the case of Tarim: Overall basin master plans were developed to guide the basin water development and management. 3S (DSF, Remote Sensing, MIS) were introduced to develop water balance models to assist water allocation decisions, and monitoring its implementation.

4. Rules without enforcement is no use – The Quota System is enforced by reward/punishment – in the first 2 years, people did not take the quotas seriously. But after the reward and punishment took place, they became serious about sticking to their allocated quotas. Rules are also enforced through actively monitoring the extractions, both on a monthly and on annual basis. A 10-day quota system is being developed now by TBMB.
5. Institutional set up must match the local conditions - the initial disconnection between WRB and TRMB was not an effective working set up. River basin management needs a well coordinated and integral approach across a number of government departments, political and administrative boundaries, and stakeholder. WRB was moved from outside to the inside the "box" (Chart-2), to oversight the TBMB. This eased coordination. However, the heads of WRB and TBMB are at the same administrative levels. Although the head of TBMB administratively reports to WRB, he is accountable to the Standing Committee.
6. The establishment of WUAs was a fundamental part of basin management as it provided a focal point for communication by the farmers of their responsibilities in efficiently managing water for irrigation.

Concluding Remarks

- The Tarim case is considered as among the best practices in IWRM for an intra-provincial river basin. It provides a successful example of integrated water resources planning, allocation and management fully achieved within an intra-provincial institutional set up and through an integrated "top-down" and "bottom-up" approach.
- It shows that an effective river basin institutional framework takes time to develop and evolve. Tarim took nearly 15 years to establish and reach a point of effective management. However, it is still considered to be at a young stage and will continue to evolve over time. Tarim case provides valuable guidance for those in developing or enhancing river basin institutions for water management. But each river basin and each country has its unique conditions. Lessons from others can only provide food for thoughts.
- Knowledge building is an important element in the initial stage of basin management! In the Tarim case, many well organized and targeted training and studies visits (both overseas and within country) provided food for thought and simulated the reform process throughout the project implementation. Expert panels were organized at national levels to provide semi-annual visits to the project area to input ideas.

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