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Country Policy Support Programme (CPSP)

What is CPSP?

The objective of the Country Policy Support Programme (CPSP) is to contribute to develop effective options for water resources development and management to achieve an acceptable food security level and sustainable rural development. The study aims at assessing and integrating water needs for three sectors viz. food, people, and nature for the present and for the year 2025 with a goal to evolve policy interventions. The CPSP Phase-I was launched by ICID in the year 2002 with a funding support from the Government of The Netherlands.

Which are the Participating Countries?

CPSP in its 1st phase (2002 to 2005) has carried out a detailed assessment in two countries viz. China and India, to a lesser scale in Egypt, Mexico and Pakistan. The programme is executed by ICID's respective National Committees of these five countries viz. CNCID (China), INCID (India), ENCID (Egypt), MXCID (Mexico), and PANCID (Pakistan) in coordination with the Central Office, New Delhi.

Which are the Contributing/ Participating Organisations?

Contributing organisations

- International Water Management Institute (IWMI),
- International Food Policy Research Institute (IFPRI),
- Food and Agriculture Organization (FAO),
- International Programme for Technology and Research in Irrigation and Drainage (IPTRID), and
- The World Bank

Participating Organisations

- Global Water Partnership (GWP)
- International Federation of Agricultural Producers (IFAP)
- United Nations Environment Programme (UNEP)
- The World Conservation Union (IUCN)
- World Water Council (WWC)
- World Wildlife Fund for Nature (WWF)
- World Health Organization (WHO)

What are the Contents and Approach?

- ❖ Compilation and updating of available knowledge base (KB) for three sectors i.e. water for food, people and nature,
- ❖ Water assessments in representative river basins of participating countries,
- ❖ Up-gradation and integration of IWMI's PODIUM and IFPRI's IMPACT (WATERSIM) models for use in China and India.
- ❖ Broad-based multi-stakeholder consultations at the respective basin and national level,
- ❖ Consultations with concerned Governments of China and India.
- ❖ Broad-based initial consultations in Egypt, Mexico and Pakistan.
- ❖ Preparing comprehensive reports based on basin/national level consultations, and
- ❖ Briefing meetings with funding agencies such as World Bank, ADB and others.

What are the Outcomes of CPSP Studies?

- Improved "knowledge base" on major aspects of integrated water resources development and management (IWRDM) for appropriate policy support,
- An improved understanding of the water resources development and management issues in China and India,
- A land use based "Basin-wide Holistic Integrated Water resource Assessment" model- the **BHIWA** model,
- Improved/ upgraded country specific PODIUM (**PODIUMSim**) for its application at basin/ national level in India and China,
- A report on application of WATERSIM for India, and
- National Consultation Reports for China and India and preliminary reports in respect of Egypt, Mexico and Pakistan.
- A draft proposal for Phase-II study

Country Policy Support Programme (CPSP) study, India

Land and Water Resources of India

Geographical area	329 Million Hectares (Mha)
Arable area	180.6 Mha
Net sown area	142 Mha
Net irrigated area	57 Mha
Ultimate irrigation potential	148 Mha
Number of river basins	24
Total average annual precipitation	4000 Billion Cubic Meter (BCM)
Average annual renewable water resources	1953 BCM
Potentially utilisable water resources	1086 BCM (690 BCM from surface water and 396 BCM from ground water)
Population in 2001 " 2005	1027 Million 1333 Million
Present water withdrawals (1999) Projected withdrawals (2025)	629 BCM 843 BCM
Annual food grain production (2000) Estimated requirement of food grain (2025)	208 Million tons 350 Million tons

Basin assessment studies

In India, four sample basins viz. Brahmani, Sabarmati, Tapi and Pennar have been selected for carrying out detailed water assessment using Basin-wide Holistic Integrated Water Assessment (BHIWA) model. The assessments pertaining to Sabarmati and Brahmani basins have been completed while for other basins it is in progress.

Key policy issues emerged from the assessment and consultations

BHIWA model developed for assessment of water resources at the basin level and two sample river basins namely - Sabarmati and Brahmani basins are briefly described in the report. The sample basin results were extrapolated to other basins of India. Policy interventions emerging from the studies in the context of integrated and sustainable water use have been evaluated in the report.

A summary of the key policy issues emerging from the detailed assessments and consultations held at basin/national level is as follows:

- To account for direct evapo-transpiration from rainfall and soil moisture, it is essential that *precipitation (or rainfall*), which forms the primary source of all waters on land, *rather than the terrestrial surface and ground water runoff* is to be recognised as the primary and real resource for water assessments.
- There is also the need for accounting of *additional water availability due to return flows*; and accounting of water *withdrawals* and *consumptive use* by sectors, separately and collectively towards an integrated and sustainable water management.
- The consumptive use, which results in the *depletion of resource*, needs to be managed through increases in efficiencies across all sectoral uses, and by curtailing specially its "*non-beneficial*" component of evapo-transpiration both from lands under natural use and from lands under agricultural use.
- While local harvesting of rain can to some extent be promoted, its usefulness in water short basins, where the existing reservoirs hardly fill up, is very limited as it impacts *negatively* on the filling of existing storages on the main river and its tributaries.
- Integration of land and water uses is necessary. In irrigation projects, where all lands cannot be irrigated in all seasons due to water availability and other constraints, rain-fed agriculture needs to be integrated in the cropping patterns.
- Integrating of land, water and livelihoods is necessary. In many low rainfall and water short areas, with considerable rural population. This rural population has to obtain much of the income from the land. Irrigation may be a viable option for increasing their income

levels, and for alleviating poverty. Similarly, tribal population settled in forests, which, according to the emerging policy initiative, would obtain some land rights for cultivating small patches in the forests. These lands may have low productivity. Water use, through watershed management or irrigation may provide them with some additional income, and alleviate poverty.

- Inter-basin transfer of surface waters from adjacent river basin or basins is an obvious option to meet the *additional needs of water deficit basins* such as Sabarmati and to *restore the groundwater regime and provide for environmental flows in the downstream*.
- Inter-basin transfers, in the water short basins with considerable rural population, appear necessary to increase the economic carrying capacity of the basin, through increased income from the small landholdings.
- The high groundwater use, which has developed in many water-short basins, needs to be curtailed as artificial recharge from imported water may be technically and economically unviable, besides threatening water quality and reducing dry season river flows.
- For water short basins, a better soil and water management through introduction of sprinkler and micro irrigations etc. would no doubt be of some help in demand management. But likely growth of irrigation and D&I demands in future dictate much *larger imports* from outside basins in future. As mentioned earlier, this is also needed to restore the dry season flow in the vulnerable reaches and improve freshwater environment especially in the lower reaches of the rivers like Sabarmati.
- The increasing hazards of pollution of surface and ground waters, through higher proportion of return flows, needs to be countered both by adequate treatment of the wastewater being discharged into natural waters, and by encouraging reuse of wastewaters without discharging these in water bodies.
- The use of good quality stored water, for dilution of wastewaters, appears a costly solution, which ties up the precious water resource. Adequate treatment of wastewaters, recycling and reuse appear to be the more efficient options. But even then, in a few industrialised zones having large potential for accidental pollution hazards, some stored water can be kept reserved for dilution, as an emergency measures.
- In some water-rich basins, the groundwater use are not developing beyond that required for meeting domestic demands of the rural

areas. The growing use of surface water for irrigation is likely to increase the returns to the groundwater, and the consequent regime changes in groundwater can lead to waterlogging. A balanced, conjunctive use of both the sources is essential for avoiding such hazards. Policies, which encourage the farmers to use the ground- waters, in preference to the cheaper public canal water, need to be put in place in such situations.

- Adjusting the cropping patterns to the availability of water, through a shift from post monsoon irrigation to monsoon irrigation, can reduce the consumptive use of water.
- The high priority given to the drinking water has to be elaborated by defining the core and non-core demands, and by allocating the better quality and more reliable sources to meet the core demand.
- The development of urban water supply needs to be done along with the development of sewerage and sewage treatment. A mandatory provision, which does not allow the public funding of only the supply part, would be of help.
- Recycling of water within the domestic use would reduce the demand on good quality raw water, and this needs to be encouraged in water short areas. Similarly, as stated, reuse of domestic wastes in irrigation would improve the quality of river waters.
- A periodic review of supply norms, in regard to domestic water, is necessary. In the long run, the disparity between urban and rural users needs to be diminished, by providing piped household connection and flush toilets, in the rural areas.
- Environmental water requirements need to include both the requirements (mostly consumptive) of the terrestrial eco-systems, as also the flow requirement (EFR) of the aquatic ecosystems. While environmental flow requirements (EFR) need to be recognised as valued requirements, acceptable methods (which consider the water regimes required by the different species, as also the tradeoffs, as preferred by the society, between the environmental and other uses), need to be developed.
- Navigational use is many times compatible with the environmental flow requirements. However, where the navigational flow requirements in some months are more than EFR, the trade-offs between navigation and other uses would have to be considered, and the basin water management may have to be adjusted to meet the accepted navigational requirements.

Assessment of Sabarmati river basin, India

Sabarmati river basin

The river basin has a total drainage area of 21,565 Km^2 (in Gujarat state 17,441 Km^2 and in Rajasthan state 4,124 Km^2) and is a water deficit basin having intensive agriculture, industrial development and larger population density. The current population of the basin is 11.74 Million (51% in urban area) and estimated to increase to 19.86 Million by 2025. Average annual rainfall is 750 mm with annual renewable water resources as 3,810 Mm^3. The per capita water availability is the lowest (324 cubic meter) among the river basins of India. Gross cropped area is 1.5 Mha. Presently, surface irrigated area is 0.43 Mha and about 0.7 Mha are irrigated through groundwater. Currently, about 1580 Mm^3 is imported from the adjacent Mahi river and it is planned to import upto 2138 Mm^3 from Narmada river to meet the current gap in demand and future demands.

Scenarios studied

Apart from Business as Usual (B as U) scenario, following alternative future (2025) scenarios were examined:

- Irrigation expansion, but no Import of water from Narmada basin (worst case scenario);
- The current proposals of Gujarat Govt. for water infrastructure development including the pumping of Narmada waters in the upper reservoirs, and increase in amounts of in-basin use, imports and exports
- Lesser import and export of water;
- Irrigation expansion and agricultural seasonal shift;
- Reduction of groundwater use and in the pumping Narmada waters into the reservoirs; (as compared to the future plan of Gujarat)
- Reduction of groundwater use by lesser irrigation expansion and better management; and
- Limited agriculture shift and water exports.

Key findings of basin assessment

- Non-beneficial ET in the nature and agriculture sectors is of the same order as the annual river flow.
- Reduction of non-beneficial ET through appropriate soil and water management can be a potential strategy.
- Import of Narmada water is necessary to sustain the present withdrawals and to meet also the future needs, including that for improvement of low flows to maintain river ecology.
- Quantum of the groundwater use at present is unsustainable. While the situation would improve slightly in future due to possible large addition on account of imports from Narmada, composition of return flow indicates much higher risk of groundwater pollution. This problem calls for large-scale artificial recharge to groundwater, or alternatively for a considerable reduction in groundwater and the total use.

Policy Related Issues and Recommendations

- To account for direct evapo-transpiration from rainfall and soil moisture it is essential that *precipitation (or rainfall*), which forms the primary source of all waters on land, *rather than the terrestrial surface and ground water runoff* is to be recognised as the primary and real resource for water assessments.
- There is also the need for accounting of *additional water availability due to return flows*; and accounting of water *withdrawals* and *consumptive use* by sectors, separately and collectively towards an integrated and sustainable water management.
- The consumptive use, which results in the *depletion of resource*, needs to be managed through increases in efficiencies across all sectoral uses, and by curtailing specially its "*non-beneficial*" component. .
- While local harvesting of rain can to some extent be promoted, its usefulness in water short basins like Sabarmati, where the existing reservoirs hardly fill up, is very limited as it impacts *negatively* on the filling of existing storages on the main river and its tributaries
- Inter-basin transfer of surface waters from adjacent river basin or basins is an obvious option to meet the *additional needs of water deficit basins* such as Sabarmati and to *restore the groundwater regime and provide for environmental flows in the downstream*.

- Interbasin transfers, in the water short basins with considerable rural population, appear necessary to increase the economic carrying capacity of the basin, through increased income from the small landholdings.
- The high groundwater use needs to be curtailed as artificial recharge from imported water may be technically and economically unviable, besides threatening water quality and reducing dry season river flows.
- Better soil and water management through introduction of sprinkler and micro irrigations etc. would no doubt be of some help in demand management. But likely growth of irrigation and D&I demands in future dictate much *larger imports* from outside basins in future. As mentioned earlier, this is also needed to restore the dry season flow in the vulnerable reaches and improve freshwater environment especially in the lower reaches of the rivers like Sabarmati.
- The increasing hazards of pollution of surface and ground waters, through higher proportion of return flows, needs to be countered both by adequate treatment of the wastewater being discharged into natural waters, and by encouraging reuse of wastewaters without discharging these in water bodies.
- Adjusting the cropping patterns to the availability of water, through a shift from post monsoon irrigation to monsoon irrigation, can reduce the consumptive use of water.
- The high priority given to the drinking water has to be elaborated by defining the core and non-core demands, and by allocating the better quality and more reliable sources to meet the core demand.
- Environmental water requirements need to include both the requirements (mostly consumptive) of the terrestrial eco-systems, as also the flow requirement (EFR) of the aquatic ecosystems. While environmental flow requirements (EFR) need to be recognised as valued requirements, acceptable methods (which consider the water regimes required by the different species, as also the tradeoffs, as preferred by the society, between the environmental and other uses), need to be developed.

Assessment of Brahmani river basin, India

Brahmani river basin

Brahmani river is one of the east flowing rivers of India. The basin has a total drainage area of about 39,268 km^2 of which 22,516 km^2 lies in Orissa State, 15,405 km^2 in Jharkhand and rest 1,347 km^2 in Chhattisgarh State. The river has two main tributaries, namely the Sankh and Koel. The basin has a sub-humid tropical climate, with an average rainfall of 1305 mm most of which is concentrated in southwest monsoon season June to October. Rain-fed agriculture is predominant except in lower deltaic parts where irrigation plays a major role. Compared to national average, the basin has a higher proportion of both land under forests and culturable wastelands. In contrast to Sabarmati, the basin is almost double in size, with a much less population (about 8.5 million total habitants in 2001) and even lesser percentage of urban to total population and much less land under irrigation. Irrigated area in recent years has averaged only about 1.23 million ha against a total cropped area of 1.57 million ha.

The per capita water availability in the basin in 2001 was about 2,590 cubic meters per year considering the past estimates of annual renewable water resources of the basin at 21,920 million cubic meters per year, and the population of the basin at 8.5 million. The per capita water availability is much higher than the Falkenmark's water stress threshold of 1000 cubic metres per person.

The basin is abundant in mineral resources such as iron ore, coal and limestone. The Rourkela Steel Plants built in 1960 is one of the large steel plants with substantial ancillary industries in the Angul-Talcher area. There are two large thermal plants established by National Thermal Power Corporation and National Aluminium Company, besides coal-based fertilizer plants set up by the Fertilizer Corporation of India. Industrial activity in Jharkhand is also picking up substantially.

The basin is rich in forests occupying as much as 37% of the basin total area. Near the Brahmani-Baitarani delta are located mangrove ecosystems including the famous Bhitarkanika National Park and a Wild Life Sanctuary. About 215 sq.km of the mangroves in this region has been listed as RAMSAR SITE in November 2002. The basin has a considerable potential for development of inland fisheries in reservoir, ponds, tanks and canals.

The occurrence of floods, particularly in the deltaic region is a common feature and on an average a population of about 0.6 million and crop production of over 50,000 ha is affected annually. A large multi-purpose dam Rengali project completed in year 1985 has provided some relief to lower flood plains in this regard but its canal systems are not yet fully ready. Pollution of surface water of Brahmani and some of its tributaries below Rengali on account of discharge of industrial effluents continues to be a cause of concern despite some recent measures of the Orissa State Pollution Control Board made to improve the situation.

Water Assessments

The initial basin level consultations were held based on preliminary studies, primarily to help identify issues concerning water use for food, people and environmental sectors. The model was applied to derive responses to past, present and four future alternative scenarios using long term average rainfall. Apart from Business as Usual (B as U) Scenario (F-I), other future scenarios examined include:

* Large expansion of agriculture and irrigation (F-II) to harness much of its water and land potential.
* More industrialisation, considering the present base and its future growth (F-III)
* Lesser agriculture and industrial expansion with increased allocation of water to nature sector needs and navigation (F-IV).

In all the three cases, better water management through increasing of irrigation system efficiencies, recycling and reuse is assumed.

The aggregated results of the study and discussions of the results at the basin level are presented in the report.

To summarise, the total water input (rainfall and imports) to the basin is 51,586 million cubic meters. The major water outflow from the basin comprises consumptive use (69%) and river flows (31%). The total consumptive use (ET) at present (2000) situation is 34,138 million cubic meters comprising about 64% by nature sector (forests, pastures and barren lands), 35% by agriculture sector (rain-fed and irrigated agriculture) and 1% by people sector (domestic and industrial). The non-beneficial ET is about 28% of the total consumptive use.

Major Findings

1. Nature sector is by far the largest consumer of water.
2. Contribution of groundwater to base flow is increasing, indicating risk of waterlogging
3. Future withdrawal requirements would need full use of Rengali Dam storage as well as creation of additional storage in the basin.
4. Considerable land would remain rain-fed, and productivity increase may require watershed management of upper regions.
5. The basin would not have overall water shortage even in the projected scenario of increased agricultural and industrial water use.
6. To depict impacts of water use on water availability status both in quantitative as well as qualitative terms, four simple indicators were selected, two to depict the pressure of withdrawals and the other two to depict potential hazard to water quality, in the surface and groundwater systems. The water situation indicators in the Brahmani river basin in different scenarios studied are presented in the report for present conditions. Based on the classifications suggested for the indicators, the Brahmani river basin presently lies in the category of basins having little or no stress on account of surface water withdrawals and it is very moderately stressed in groundwater withdrawal. It is in the category of low or no threat in respect of surface water quality and it is in the category of moderate threat in respect of groundwater quality.

Policy Related Issues

Some important policy related choices emerging from the Brahmani river basin assessments are:

- Shift in the concept of “water resources” : In order to consider impacts of nature sector use, terrestrial as well needs of aquatic eco-systems, impacts of rainfall harvesting, artificial recharge, and above all, for integration across the three sectors precipitation is to be considered as the primary renewable water resource
- Need for accounting return flows as additional water available for use

- Need for accounting water use by sectors, and their integration
- Need for recognising EFR and mainstreaming such requirements in to basin water management. Multi-purpose reservoirs like Rengali generating hydropower can indeed play a great role in maintaining or even improving low season river flows. However, the effects of any changes in the hydrologic regime, including improvement of flows, on the aquatic ecology needs to be studied and understood. There is a need for, an integrated management of land and water resources and integrating rural livelihoods.
- Need for a more balanced use of surface and ground water and provision of adequate drainage and relief from floods
- Improving water distribution and on-farm efficiencies through participation of beneficiaries, improved designs and O&M of structures, agriculture practices, waste water treatment technologies, etc
- Need for adopting a participatory approach, in regard to the choice of a strategy for flood control.
- Need for exploring the possibilities of 'Inland Navigation' in and near the delta, and the need for integrating the water needs for navigation (which may be compatible with EFR and hydropower), and of the consumptive uses.

Country Policy Support Programme (CPSP) study, China

Land and Water Resources

Total geographical area	960 Mha
Major river basins	9
Mean annual precipitation	6,188.9 Billion Cubic Meters (BCM)
Annual renewable water resources	2,812 BCM
Potential utilizable water resources	873 BCM (751 BCM surface water and 122 BCM groundwater)
Present water utilization (2001) Projected requirement in 2025	557 BCM 1,138 BCM
Existing storage capacity of reservoir	458 BCM
Total arable land	139 Mha
Present irrigated area (2001) Projected increase by 2025	54.4 Mha 60.3 Mha
Present population (2001) Projected population in 2025	1,276 Million 1,600 Million
Annual per capita availability at present (2001) Projected in 2025	2,204 cubic meter 1,875 cubic meter
Food grain production (2002) Estimated demand in 2025	400 Million tons 640 Million tons

Basin assessment studies

Water assessment studies of two sample river basins viz. Qiantang River located at south east coast and Jiaodong Peninsula located at east coast were selected for the study.

Key policy issues emerged from the assessment and consultations

- From the perspective of the economic and social development, it would be necessary to change perception of water resource availability by promoting and improving water resources management.
- Developing harmonious coexistence between man and nature for sustainable development.
- Change in the perception that water is inexhaustible to the recognition that freshwater resources are limited.

- Paying special attention to the prevention of human damage to water while preventing water damage to mankind.
- Shifting focus on water development, utilization and management to water allocation, conservation and protection while developing, utilizing and managing water resources.
- Emphasizing water works management through strengthening non-structural measures and scientific management of water works.
- Matching water supply according to demand.
- Developing pressurized irrigation systems and promoting efficient water use.
- Realizing water as a natural gift, structural measures should be taken up for its optimum utilisation.
- Proper Management and monitoring of water quantity and quality in all uses.
- Promoting re-use of poor quality water.
- Integrating water allocation, distribution and management.

The strategy for sustainable use of country's water resources focuses on developing water resources and expanding the capacity of water supply; increasing water use efficiency and saving water; protecting water resources and improving water environment. Measures for sustainable use of water resources include – optimal allocation, effective protection and utilization, appropriate development, scientific management and increased financial input.

The detailed hydrologic modelling and analysis of the two basins for various scenarios provided a greater insight into the understanding of the water resources of the basins. The holistic view of the assessments taken through the modelling gives a sound and much broader basis to describe the state of water availability and the likely water use under different sectors under various future scenarios at the basin / sub-basin level; source-wise - surface and groundwater separately and interaction between the two. Modelling has been used to develop a set of indicators, which help in understanding the current water scene for other basins of China. Similarly, the modelling has allowed the testing of various possible land and water use scenarios, in regard to their hydrologic implications, and allows assessment and integration of the individual water use sectors. Following is a summary of important points that have emerged, and may need to be studied further for suitable modifications in the Water Law of China adopted in 2002.

2.5 Summary of Findings

2.5.1 Change in the perception of water resources

Improvement of water management has become a common concern of all people in China. From the perspective of the economic and social development, it would be necessary to change perception of water resource availability by promoting water resources management at a better level. The following important aspects need to be considered for better water management.

- Developing harmonious coexistence between man and nature for sustainable development;
- Change in the perception that water is inexhaustible to the recognition that freshwater resources are limited;
- Paying special attention to the prevention of human damage to water while preventing water damage to mankind;
- Shifting focus on water development, utilization and management to water allocation, conservation and protection while developing, utilizing and managing water resources;
- Emphasizing water works management through strengthening non-structural measures and scientific management of water works;
- Matching water supply according to demand;
- Developing pressurized irrigation systems and promoting efficient water use.
- Realizing water as a natural gift, structural measures should be taken up for its optimum utilisation.
- Proper Management and monitoring of water quantity and quality in all uses.
- Promoting re-use of poor quality water.
- Integrating water allocation, distribution and management.

2.5.2 Areas of Sustainable Use of Water Resources

Developing water resources and expanding the capacity of water supply

- Optimizing regional and sectoral allocation of water resources

- Strengthening evaluation of water resources development and utilization
- Constructing number of water resources development and utilization projects
- Promoting the comprehensive use and multi-purpose development of water resources
- Developing alternative water resources

Increasing the water use efficiency and saving water

- Strengthening water conservation and management
- Formulating national and local, middle and long term plan for water supply and demand
- Extending water saving in irrigation with enhanced vigour
- Promoting water saving practice in industry
- Promoting water saving in municipal use
- Publicizing vigorously water saving practices through news media like radios, television and newspapers, mobilizing the public participation.

Protecting water resources and improving water environment

- Drawing up overall plans for the protection of water resources and water environment in all the river basins
- Strengthening the water environment monitoring
- Strengthening water environment protection in urban and rural areas
- Strengthening scientific research for the protection of water resources and improvement of water environment, popularising new technologies of water environment control through experiments and demonstrations.
- Publicizing the importance of water resources protection and water environment improvement, mobilizing the public support and participation.

2.5.3 Measures for Sustainable Use of Water Resources

Optimal allocation

- Formulate water resources planning, specify water resources macro control index.
- Formulate water allocation schemes and indices as well as reliable measures for Provinces, river basins and the whole country;

- Coordinate water use for nature, food and people sectors based on total allocated water amount,
- Implement water-drawing permit; formulate contingency water supply plan during dry seasons and prioritise water uses,
- Development of contingency policies and measures to guarantee water use safety;
- Optimise inter-river basin and inter-region water allocation on the basis of scientific research and analysis;
- Formulate water rights and rotation systems suitable for the country's situation and market economy.

Effective Protection

- Formulate water resources protection program of major rivers,
- Divide water function areas, specify amount of waste and total discharge of various pollutants in the river system so as to realize total amount of control for waste discharge;
- Establish an economic compensation system for water resources protection and eco-system rehabilitation
- Formulate GDP statistics index for pollution control
- Specify water source protection zones for providing safe drinking water for urban and rural population over 200,000;
- Readjust industrial structure to encourage clean production so as to control pollution at the source;
- Implement wastewater discharge permit.

Effective utilization

- Formulate national policies on water saving,
- Designate micro water use quota for different areas, different sectors and different products specifying water use index of 10,000 Yuan GDP of various sectors, and water-saving evaluation index,
- Develop and utilize water-saving technology and equipment,
- Increase waste treatment and reuse of industrial water.
- Develop water-saving in industry,
- Establish water saving societies in cities to improve water use efficiency

Appropriate development

- Develop new sources appropriately to improve distribution and water supply safely for conserving water.
- Solve drinking water problem to poor people and guarantee water supply for economic and social development.
- Construct storage projects to make full use of local water resources;

- Develop inter-river basin and inter-regional water transfer projects after overall planning and scientific research;
- Rationally utilize groundwater resources in areas with potential;
- Increase utilization of rain and floodwater, speed up wastewater treatment and reuse of industrial and domestic water, seawater desalination and direct use, and other unconventional water utilization.

Scientific management

- Revise “Water Law” and formulate “River Basin Law”, “Water-Saving Law” to establish and improve the legal system for water resources management.
- Promote the water management system with integrated urban and rural water management;
- Establish an integrated, authoritative and efficient water resources management system for major rivers and develop sound water project operation mechanism to realize effective combination of river basin management and regional management;
- Coordinate the use of surface water and groundwater, as well as the use of local water resources and water transferred from other areas to achieve effective and efficient uses;
- Establish water resources real-time monitoring system, distribution system and management information system.

Increased financial input

- Divide the rights and responsibilities between the central and local government and among the government, market, beneficiaries; and investors of water projects.
- Implement active fiscal policies to increase government input in water resources development and utilization.
- Establish a rational water pricing mechanism and make full use of the market system to raise funds for water projects;
- Mobilize the public to participate in water development through policies and measures.

Assessment of Qiantang River, China

Qiantang River basin

The Qiantang river basin has total drainage area of 55,558 km^2. For the present study drainage area of 35,500 km^2 in the upstream of Hangzhou Gate has been considered. The river system, climate, land use, water resource and its development, water demand at present and projected water requirement of the Qiantang basin in the year 2025 have been briefly discussed in the report.

The per capita water availability in the basin in 2000 was 3,621 cubic meter per year considering the estimated renewable water resources of the basin at 38.64 km^3 per year and the population of the basin at 10.67 million. The water availability is likely to be 3,389 cubic meter per year in the year 2025 with the projected population of 11.40 million by 2025.

Scenarios studies

Apart from Business as usual Scenario (F-I), other scenarios studied include:

- With no expansion of water infrastructure and better water management (F-II);
- With increased water infrastructure (including small import), and irrigation expansion

  (F-III);
- With increased water infrastructure, no irrigation expansion, more industries, and export of water (F-IV);
- With increased water infrastructure, no irrigation expansion, more industries, and better water management (F-V).

The aggregate results of the Qiantang river basin assessment and related discussions are given in this report.

The total water input (rainfall and imports) to the Qiantang basin is 58,014 million cubic meters. The major output consists of consumptive use, river flows and exports. The total consumptive use (ET) at present situation is 25,322 million cubic meters comprising about 67% by nature sector (forest, pasture and barren lands), 29% by agriculture sector (rain-fed and irrigated agriculture) and 4% by people sector (domestic and industrial).

Four types of indicators have been suggested to depict status of water in regards to quantity as well as quality. Two indicators depict the level of withdrawals as a fraction of total water available in surface and groundwater system while other two indicators depict potential hazard to water quality in surface and groundwater system. The water situation indicators in the Qiantang river basin in different scenarios studied are presented in the report.

The major findings of the assessment are:

1. Nature sector consumes major part of the primary resource (rain water)
2. Consumptive use under nature sector is expected to increase significantly in the future due to the expansion of forest area. This in turn would tend to reduce river flow. Part of this decrease can however be restored through better soil and water management initiatives.
3. Due to abundant surface water resources almost entire irrigated agriculture including fisheries is presently dependent on surface water resources.
4. Groundwater use is presently restricted to domestic and industrial sectors. There exists a great potential for groundwater development in this basin.
5. Surface water withdrawal constitutes only a small fraction of available supplies and its further use for irrigation seems to be constrained by availability of cultivable land.

Major Findings of the Assessment

- Qiantang river basin is rich in water resources. However, there is a variation in the water availability in different regions of the basin. In some regions there is a shortage of water. Therefore, the construction of reservoir for storage purposes and water saving measures to reduce water losses should be taken up to better utilize the basin water resources and reduce the water shortage;
- As there is no groundwater use in irrigation in this basin so far, conjunctive use of surface water and groundwater should be adopted for both agricultural and D & I uses. But as much of the shallow groundwater in this river basin is return water, this is also the reason why there is not much groundwater use at present.
- Meanwhile, to guarantee the stability of river bed for flood control, the total withdrawal from rivers should be within 12 per cent of the total river runoff.

- Possibilities to explore the potentials of the current projects should be exploited to increase water supply;
- Recycling of industrial water should be encouraged to minimize the fresh water supply to industries;
- Inter-basin water transfer projects need to be formulated to transfer water from rich areas to water short areas, such as Yongkang and Yiwu etc.
- Some reservoirs need to be rehabilitated to increase their regulation capacity to increase water supply;
- Water-saving technology in paddy grown areas should be strengthened in the basin as rice is the major staple crop and consumes highest water;
- Qiantang river basin is water rich and located in developed area of southeast China. Structural and non-structural flood control measures should be taken up to safeguard the people's life and property;
- Nature sector consumes major part of the primary resource (rain water);
- Consumptive use under nature sector is expected to increase significantly in the future due to the expansion of forest area. This in turn would tend to reduce river flows. Part of this decrease can however be restored through better soil and water management initiatives.

Assessment of Jiaodong Peninsula, China

Jiaodong Peninsula

The Jiaodong Peninsula Basin has a total drainage area of 19,182 km^2. The river system, climate, land use, water resource and its development, water demand at present and projected water requirement in the year 2025 have been discussed in ithe report. The per capita annual water availability in the basin in the year 2000 was 492 cubic meters considering the estimated renewable water resources of the basin as 4,394 million cubic meters per year and 8.93 million as the population of the basin. This water availability is likely to be 454 cubic meters per year per capita in the year 2025 with the projected population of 9.67 million by 2025.

Scenarios studies

Apart from Business as Usual Scenario (Future-I), other scenarios examined include:

- Without expansion of forest (Future-II)
- Better system management and reduced groundwater use (Future-III)
- Better system management and reduced groundwater use and adoption of drip irrigation (Future-IV)
- With soil and land management, import of more water and reduced groundwater use (Future-V)

The total water input comprises rainfall and import of water. The rainfall amount in the basin is 13,748 million cubic meters. At present there is no import and hence total water input is 13,748 million cubic meters. It was projected that an import of 147 million cubic meters in B as U, Future-II, III, IV scenarios and about 295 million cubic meters in Future-V scenario may be required. The major output consists of consumptive use and river flows. There is no export of water in any scenario.

The total consumptive use (ET) at present (2000) situation is 11,821 million cubic meters comprising about 52% by nature sector (forest, pasture and barren lands), 46% by agriculture sector (rain fed and irrigated agriculture) and 2% by people sector (D&I).

The major findings of the assessment are:

- Nature sector consumes major part of the primary water resource (rain water)
- Nature sector consumption for the past (1980), present (2000) and future (B as U) condition is estimated respectively as 5459, 6114 and 6601 million cubic meters. The increasing consumption in the nature sector (hence marked decrease in river flow in Future B as U scenario) is mainly on account of the land use shift between barren and forest land.
- Groundwater flow to rivers has decreased from 570 million cubic meters per year in the past to 230 million cubic meters at present. In future B as U scenario too, contribution from groundwater is likely to decline. For sustainable use, the groundwater withdrawal shall need to be reduced especially in Yantai area.
- To meet the additional future water needs, and to limit likely reduction in river flows, it will be necessary to import some water from outside the area, apart from improved management of soil and water resources.

Table 2. Land Use of Jiaodong Peninsula Basin

Land use	**Area (km^2)**		
	Yantai	**Weihai**	**Total**
Forest	4,373	1,560	5,933
Available cultivated area	4,439	1,722	6,161
Gross cropped area	6,552	2,993	9,595
Farm land irrigated area	2,815	1,198	4,013
Fruit irrigated area	687	228	915
Total Land Area	**13,746**	**5,436**	**19,182**

Table 3. Water Resources of Jiaodong Peninsula Basin (10^6 m^3)

Municipality	Surface water	Ground-water	Double accounted amount	Total water resource
Yantai	2,580	895	610	2,865
Weihai	1,430	399	300	1,529
Total	**4,010**	**1,294**	**910**	**4,394**

Table 5. Water Demands at Present (2000) and Projected Demand for 2025

Sector	2000		2025	
	(10^6 m^3)	(%)	(10^6 m^3)	(%)
Irrigation	1,803	70	1,747	54
Industry	228	9	534	16
Domestic	378	15	615	19
Ecology	171	6	349	11
Total demand	2,580	100	3,245	100

Major Findings

1. The model output shows that the outflow to sea and recharge to groundwater decreased from the past (1980) to the present (2000). The yearly outflow to sea was 2,683 million cubic meters in the past and 2,082 million cubic meters in the present condition. The yearly total recharge to groundwater was 1,261 million cubic meters in the past, and 1,028 million cubic meters in the present. These results matched the observed values obtained by the local agency, thus giving a fairly good validation to the model.
2. The type of land parcels have a large impact on the consumptive use, thus influencing the total hydrological cycle, especially the area shift between barren land and forestland. Corresponding to 20, 30 and 40 percent forest coverage in the past, present and

Future I scenarios, the consumptive use from the nature sector would be 5,459, 6,114 and 6,601 million cubic meters respectively, comprising beneficial consumption as 45, 63 and 75 percent of the total consumption, respectively. Total ET in the nature sector has increased by 12 percent over the past condition. If the forest coverage continues to expand at the same rate, total ET in the nature sector would increase by 8 percent in the future (2025). Therefore, maintaining the prevailing forestland and moderately developing the forest area in the future would be a sensible choice for sustainable water resources development.

3. The base flow from groundwater to river is decreasing from 570 million cubic meters per year in the past to 230 million cubic meters per year at present; indicating decreasing groundwater storage, and signifying the crisis of groundwater depletion. For Future I scenario with business as usual, the flow from groundwater continues to reduce.

4. The actual irrigated area at present is 68 percent of the irrigable area, and the actual water withdrawal computed by the model is 919 million cubic meters. With the expansion of irrigated area for future scenarios, the irrigable area would be 1.16 times the present condition. The model shows that the water requirement for agriculture under planned development condition (Future I) is 1,307 million cubic meters, increasing to 42 percent of water withdrawal. While the proportion of surface water irrigation to total irrigation is maintained at 30 percent, out of the total water requirement for agriculture and D&I 1,074 million cubic meters will be met from surface water and 1,440 million cubic meters from groundwater. The capacity of surface water supply for future scenario (2025) will reach to 1,611 million cubic meters, fully meeting the demand of surface water withdrawal, but the groundwater withdrawal would far exceed the total recharge.

5. In order to sustain the groundwater balance, the groundwater withdrawal should be reduced, especially for Yantai. While the proportion of surface water irrigation to total irrigation increases from 30 to 50 percent and with better water and soil management is adopted, the groundwater withdrawal decreases to 1,081 million cubic meters and 1,057 million cubic meters for Future III and IV scenarios, respectively. With further reduced groundwater use, the groundwater withdrawal for Future V scenario would be 901 million cubic meters.

6. For Future I scenario with business as usual, the river outflow reaches the lowest of all scenarios, affecting the environmental water requirement to maintain the basic water demand of the river. By adopting different measures, the river outflow from Future I to V scenarios is improved gradually. Compared to Future IV scenario, with more water import and better soil and water management, the outflow to sea could be improved and approaches the available level - with only 4 percent lower than that of present condition.
7. The model output shows that Jiaodong Peninsular basin is likely to face a serious water shortage in the future. The groundwater withdrawal will be highly stressed than in the past condition. In order to mitigate the adverse consequences of groundwater withdrawal, the groundwater should be moderately exploited. With the utilization of surface water, the return flows to input ratio would inevitably increase in the future, indicating more pollution risk for surface water resources, especially in the downstream water bodies. Therefore, related measures must be adopted to reduce the pollution as soon as possible along with the change in water use pattern.
8. With the increase of industrial and domestic water use, the agriculture would confront with the crisis of water shortage. Enlarging the strategy of water-saving measures would enhance remarkably the efficiency of irrigation water use, and decrease the water withdrawal for irrigation. Water is also need to be imported from outside the basin to meet the domestic and industrial demands in order to reduce the confrontation between agriculture and D&I water use.
9. There would be a serious water shortage in the future, should the consumption by industries further expanded compare to the planned level. It is therefore highly essential to implement the optimal allocation and combined regulation of multi-water resources, increase the water use and re-use efficiency.