USCID

Third International Conference on Irrigation and Drainage

ICID's initiative on Country Policy Support Programme

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Secretary General, ICID

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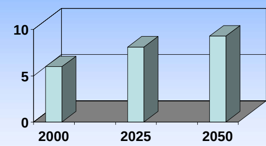
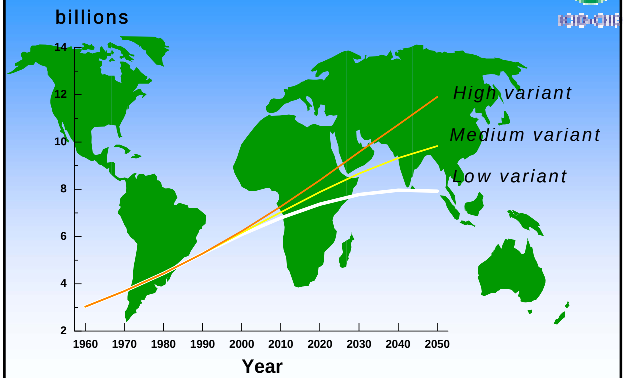
World Population in billion

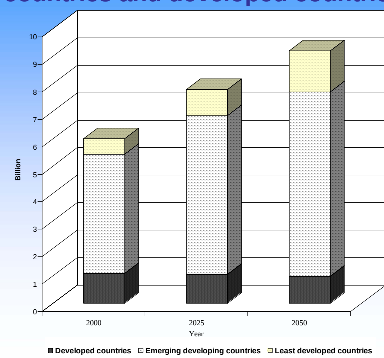
(Source - UN)



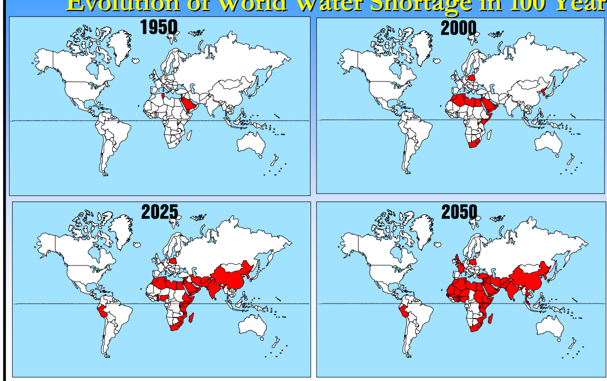
Global Population 1960 - 2050



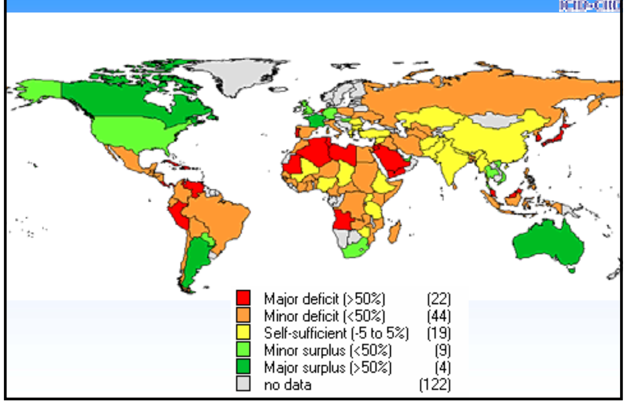
World population and growth in least developed countries, emerging developing countries and developed countries



Evolution of World Water Shortage in 100 Years

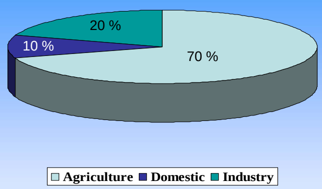


Food Surplus and Deficit around 2000



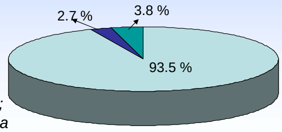
Sectoral Share of world Water

Water Withdrawal



Still 800 million are Hungry; we need to More contribution for Food from agriculture

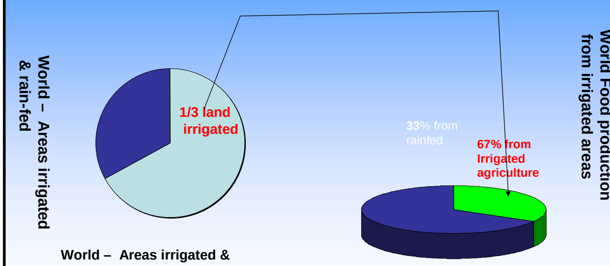
1.4 billion lack safe water.
2.4 billion lack sanitation.
7 million/year die of water-borne diseases, (2.2 million < 5 yrs);
80% of lack of Sanitation is in Asia; 13 % in Africa; 5 % in Latin America & Caribbean; these are Action areas



Water Consumption

Contribution of water to secure food

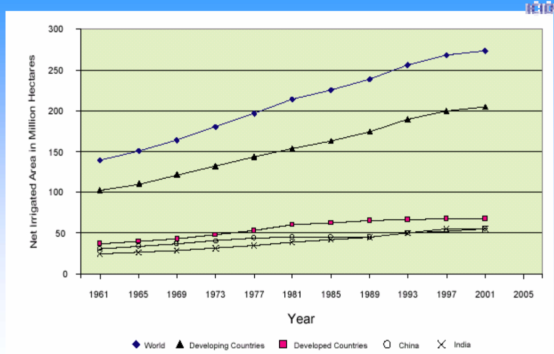
Over 2/3 of agricultural production is from 1/3 of irrigated area



World – Areas irrigated & rain-fed

More irrigable areas only from Asia and Africa(developing countries)

Net Irrigated Area of the World



World Irrigated Area by Region, 2001

Region	Irrigated Area (Million ha)	Share of World Total* (Per cent)	Share of Cropland That is Irrigated (Per cent)
Asia +	183.51	70	37
Americas	40.75	16	11
Europe	23.46	9	8
Africa +	11.93	5	6
Oceania	2.66	1	5
Total (104 ICID countries)	262.31	100	18.54
World	271.68	100	18.14

\+ **Scope for addition of irrigation area.**

Policy Dialogue Model (PODIUM), IWMI

Global Base Projections

Year	1995	2025	Percent Change
Net Irrigated Cereal Area (Mha)	260	340	31 in 2025 (55 in 2050)
Irrigation Diversions (BCM)	2374	2775	17 in 2025 (30 in 2050)

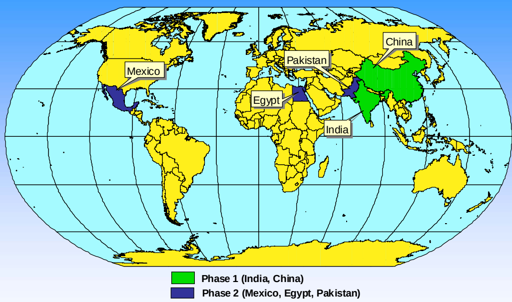
FAO anticipates a net expansion on irrigated land of some 45 million ha in 93 developing countries; that agricultural water demand will increase by some 14% from 200 to 2030 as per a later Report. Improving overall agricultural productivity assumes significance for food security.

A historic background which initiated ICID's Country Policies Support Programme (CPSP)

- **World Water Vision for food and rural development was prepared by ICID in 2000 and presented at WWF2.**

  Three sectors addressed were: food , people, nature.
- **Anomalies between WFFRD and Overview vision**
- **ICID's strategy from vision to action and CPSP.**
- **CPSP to synergise international expertise for policy support**
- **To commence with 'select' countries with a large scale of irrigated agriculture for food security. Chosen country set include: China, India, Egypt, Mexico, Pakistan. (43 % people and 51% irrigated)**

CPSP Participating Countries



How CPSP expectations are achieved?

•Through scientific assessment of water needs for three sectors, viz. food, people and nature – for the present and for the year 2025.

(Two sample basins in China and India were chosen in an attempt to project country level scenes in Phase I, so far; interesting results)

•Take the studies further to more basins in Egypt, Mexico and Pakistan

Overall Objectives of ICID's CPSP Studies

- Country Policies can be revisited to show sensitiveness to sharing aspects;
- International Organisations concerned with water sharing might find in ICID-CPSP model, an added tool to enhance the 'knowledge Base' and help solving conflicting interests of environmental sustainability and food security
- Aim is to evolve a rapid scenario analysis for the "Water Sector Strategy" by integrating land and water uses at basin level – given their dynamic nature

THE POLICY ISSUES

Water for Food

- **Shift in the concept of "Water Resources".**
- **Accounting water use by the sector, and integration.**
- **Proper accounting of return flows, indicator of hazard (PQW).**
- **Consumptive use (evapotranspiration) management.**
- **Watershed Management and water harvesting.**
- **Integrating surface water and groundwater use in irrigation.**
- **Integrated management of land and water resources.**

Water for People

- **Dimensions of priority, water allocation by uses, treatment of waste water at source and reuse for irrigation.**

Water for Nature

- **Terrestrial (CU) / Aquatic needs (NCU)- Quantification / No dilution of waste water. Zero effluent for industries.**

Water Resource Assessment - Scope

- Basin/Regional/Country/Global scale
- Whether integrated and holistic
- Assessment and integration of sectoral demands of water including EFRs
- Impact of land and water use and climate changes on resources
- Development and analysis of scenarios to evaluate effects of water policies
- Linkages with socio-economic and environmental aspects

BHIWA Model

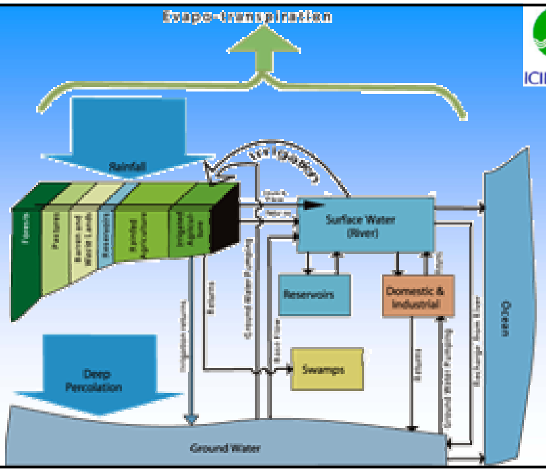
- Simple concept
- Deals with the entire land phase of the hydrologic cycle:
  - Precipitation
  - Evapo-transpiration
  - Outflow to sea
  - Withdrawals
  - Returns

BHIWA Model

- Allows
  - Changes in land use
  - Water infrastructure development
  - Irrigation expansion
  - Changes in domestic and industrial withdrawals and consumption
  - Changes in water use efficiencies

BHIWA Model

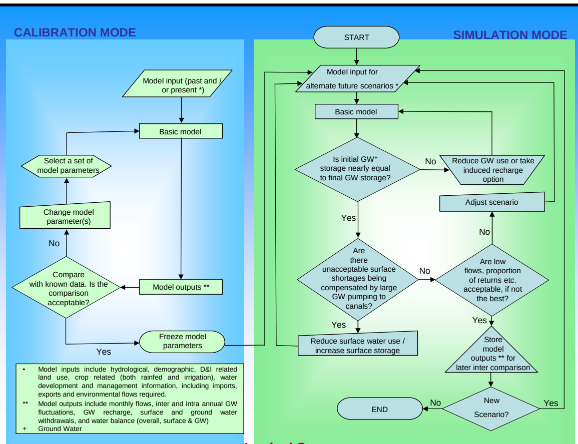
- Allows
  - Surface water balance
  - Groundwater balance
  - Surface water – groundwater interaction
  - Storage and withdrawals
  - Changing environmental flow requirements
  - Gradual changes in rainfall and evapo-transpiration (climatic changes)



ICID's BHIWA Model

Acknowledge that basically

- River Basin is a better way to address the Challenges and Decision Making
- Precipitation as the main source (and not the river flow or aquifer recharge)
- capturing both land and water uses of River Basin is important; ET management is the best way to appreciate the issues/tradeoffs
- potential development strategy through policy intervention, either for improving river flows for ecology and Scenario Development help the cause



Logical Sequence

THE RATIONALE

- The need for depicting the entire land phase, stems from basic hydrologic premise (our view) that precipitation (and not river flow/ aquifer recharge) constitutes the primary resource.
- The evapo-transpiration management can increase the flows in rivers/ aquifers and hence will be a potential development strategy to be encouraged.
- This could be through policy intervention, either for improving river flows or the traditional resource base.

Modules in the Model

- The natural module
- The module depicting hydrologic impacts due to anthropogenic influences.
- Modules for withdrawals, consumptive uses and returns for irrigation and D&I sectors.
- Module for accounting evapo-transpiration by "use sectors".
- Modules for separate and combined balances for river waters, ground waters and total sub-basin / basin.

Capabilities

- Quantification and integration of sectoral needs
- Water Balances for Surface and Ground Water systems and for the overall basin
- Interaction between surface and Ground water system
- Effects of land use changes on supplies
- Impact of sectoral policies
- Maintenance of prescribed Environmental flows (EFR)

Limitations

- Not a distributed hydrologic model
- Not to be construed as a rigorous basin planning tool
- Need for additional modules to evaluate socio-economic impacts ; IWMI together with IFPRI have proposed to bring in global trade aspects on food production but modeling results are awaited
- Simple analysis of possible impact of climate change is feasible but more works are required

Information required for building scenarios

- Engineering possibilities for in basin development, and inter basin imports and exports, efficiency improvements etc.
- Population and demand projections.
- Land development potentials.
- Ecological and environmental considerations regarding land use changes, low flow regimes and water quality.

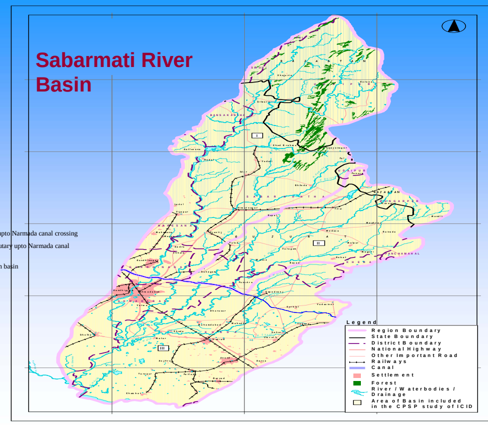
Information required for building scenarios

- Agronomic possibilities in diversification, productivity improvements, changes in varieties etc.
- Possibilities and desirability's of industrial development.
- Possibilities and desirability of rain water harvesting, watershed management and insitu water conservation

India

Sabarmati River Basin Study

Sabarmati River Basin



SB1 : Main stem upto Narmada canal crossing
SB2 : Watrak tributary upto Narmada canal crossing
SB3 : Downstream basin

Figure 2. Sabarmati River Basin

Sabarmati River Basin

- Catchment Area – About 21,600 km^2
- Population (1995) – 11.4 m. 52% urban
- Ave. annual rainfall – 750 mm
- Renewable water resources – 48.5 million m^3 per year including groundwater
- Per capita water availability – 413 m^3 per year (lowest among Indian river basins)
- Capable farming with very high skills of entrepreneurship in this basin!

Sabarmati River Basin

- Water deficient
- Intensive agriculture
- Industrial development
- Large population density
- Inter basin transfer exists already

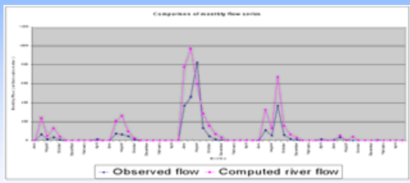
Sabarmati River Basin

- Current Gross Cropped Area – About 1.5 million ha
- Current Gross Irrigated Area – About 0.8 million ha, with predominance of groundwater irrigation
- Inter-basin water transfer – Currently about 1,580 million m^3 from the adjacent Mahi River &
- a plan to import up to 2,138 million m^3 of Narmada river waters is under implementation
- Major Industries – Textile, Chemical, Dairy, Thermal power

Calibration of the model

- Rigorous calibration was not attempted since model is aimed to provide an understanding of relative impacts on basin hydrology.
- Validation of model was done by comparing the following:
  - Annual and monthly river flows
  - Natural recharge to groundwater as a percent of rainfall.
  - Groundwater fluctuations
  - Withdrawals from surface and ground waters

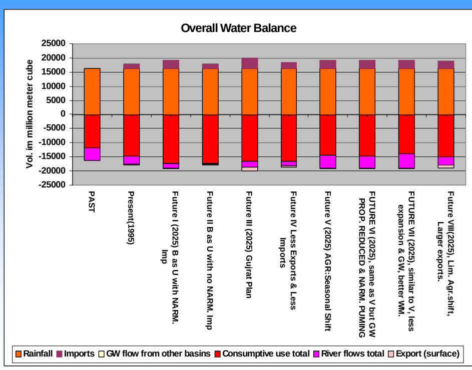
Calibration of the model



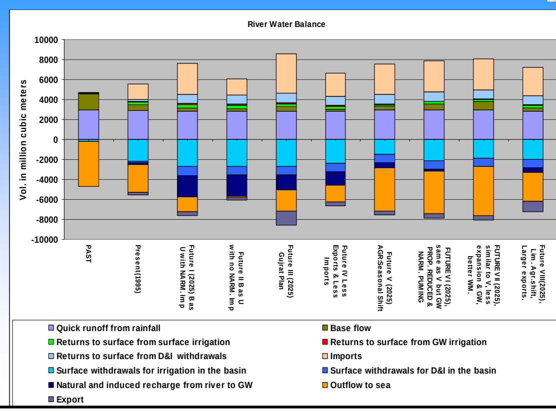
Scenarios studied

Sr. No.	Name	Year	Abbreviation	Explanatory Notes
1	**Past**	1960	-	**No water development**
2	**Present**	1995	-	**Considerable storage, groundwater and surface irrigation, and imports**
3	**Future I**	2025	B AS U	**Irrigation expansion with similar composition Additional Narmada Import**
4	**Future II**	2025	B AS U, no Narmata import	**Same as Future I, without Narmada Import**
5	**Future III**	2025	Gujarat Plan	**Larger imports and exports, pumping imported water in upper reservoirs**
6	**Future IV**	2025	Less Imports and Exports	-
7	**Future V**	2025	Seasonal shift	**Irrigation expansion mostly in wet season**
8	**Future VI**	2025	-	**Similar to Future V but groundwater irrigation reduced. Reduced pumping to reservoirs**
9	**Future VII**	2025	-	**Groundwater irrigation further reduced. Less irrigation expansion. Improved water management and more drip irrigation**
10	**Future**	2025	-	**Smaller Seasonal Shift and improvements in water**

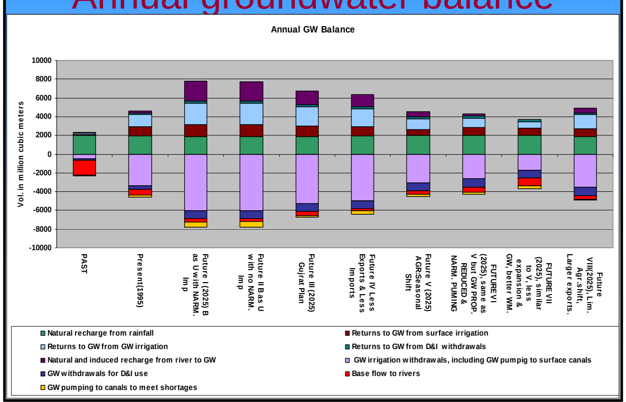
Overall annual water



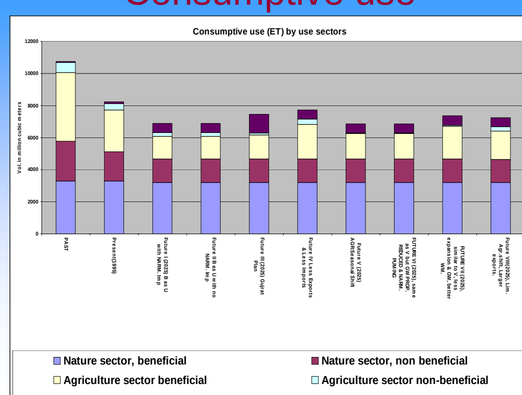
Annual river water balance



Annual groundwater balance



Consumptive use

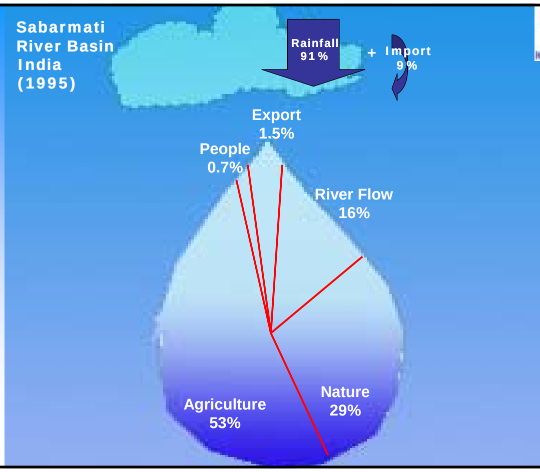


Main Findings

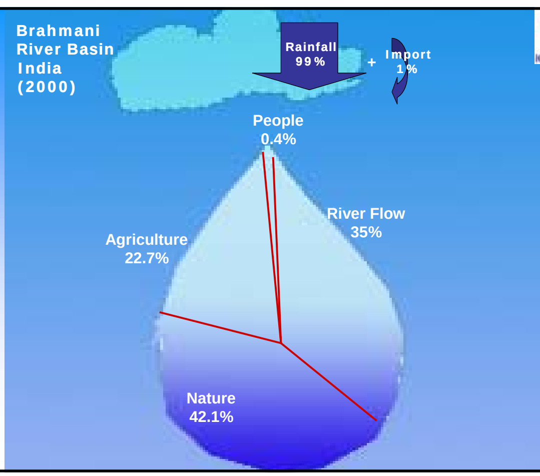
- Non-beneficial ET in the nature and agriculture sectors exceeds quantum of annual river flow
- Reduction of non-beneficial ET through rain harvesting, soil and agriculture management is a potential strategy for improved water management

Main Findings

- Import of Narmada water is necessary to sustain the present withdrawals and meet future needs, including that for improvement of low flows
- Present ground water use is unsustainable
- While the situation would improve slightly in future due to large additional Narmada imports, composition of return flow indicates much higher risk of ground water pollution



Location of Brahmani River Basin



Upscaling ?

- Some attempts to extrapolate for other basins in the country to obtain a Macro scenario
- Essential attempt is restricted to obtain a general understanding of the implication on water stress, basin wise, especially in future, with growing and competing demands

Selection of Water Stress Indicators – Relevance ?

- Large **ground water use** as in India, rise the need for indicators for both surface and G.W resources
- WSI proposed by Alcamo based on **withdrawals** out of which a substantial part may return. Multiple re-uses possibility ? How should we address it better?
- Can an absolute and overriding priority for **environmental water** requirement (Smakhtin's) work in many water deficit basins?

Suggested Indicators

Four indicators proposed for describing state of water resources

Indicator 1: Withdrawals/total input to surface water

Indicator 2: Returns/total input to surface water

Indicator 3: Withdrawals/total recharge to ground water

Indicator 4: Returns/total recharge to ground water

Indicators 1&3- depict quantitative stress due to withdrawals ;Indicators 2&4- depict hazard to water quality

India Case Study -- Indicators

- Surface water resources

S. No	Basin	Total input 109m^3	Total returns 109m^3	Total with-drawal 109m^3	Withdrawal/ Input (I1)	Returns/ Input (I2)
1	**Indus**	185	3	42	**0.23**	**0.02**
2	**Ganga**	525	19	146	**0.28**	**0.04**
3	**Brahmaputra**	633	1	12	**0.02**	**0**
4	**Subarnarekha**	12	--	4	**0.33**	**0**
5	**Mahanadi**	50	1	13	**0.26**	**0.02**
6	**Godavari**	126	3	21	**0.17**	**0.02**
7	**Krishna**	99	3	26	**0.26**	**0.03**
8	**Pennar**	7	1	7	**1**	**0.14**
9	**Cauvery**	28	2	19	**0.68**	**0.07**
10	**Tapi**	18	1	4	**0.22**	**0.06**
11	**Narmada**	51	1	7	**0.14**	**0.02**
12	**Mahi**	13	0	2	**0.15**	**0**
13	**Sabarmati**	7	0.7	2	**0.4**	**0.09**
14	**Brahmani**	17	0.6	2	**0.14**	**0.04**

India Case Study – Indicators…

- For Ground water resources

S. No	Basin	Total input 109m^3	Total return 109m^3	Total withdrawal 109m^3	Withdrawal input to (ratio)	Return to input (ratio)
1	**Indus**	48	33	29	**0.6**	**0.69**
2	**Ganga**	251	115	118	**0.47**	**0.46**
3	**Brahmaputra**	33	7	2	**0.06**	**0.21**
4	**Subarnarekha**	4	3	2	**0.5**	**0.75**
5	**Mahanadi**	23	9	6	**0.26**	**0.39**
6	**Godavari**	49	15	12	**0.24**	**0.31**
7	**Krishna**	37	17	10	**0.27**	**0.46**
8	**Pennar**	9	5	2	**0.22**	**0.56**
9	**Cauvery**	22	13	8	**0.36**	**0.59**
10	**Tapi**	9	3	3	**0.33**	**0.33**
11	**Narmada**	15	4	4	**0.27**	**0.27**
12	**Mahi**	9	2	2	**0.22**	**0.22**
13	**Sabarmati**	5	2	4	**0.87**	**0.54**
14	**Brahmani**	6	1.5	1	**0.11**	**0.3**

Basin grouping by selected indicators

	Class description	Value of indicator	Basin	
a)	Surface withdrawals	very high stress	Indicator 1>0.8	Pennar
b)		high stress	0.4 < Indicator 1<0.8	Cauvery
c)		Moderate stress	0.2 < Indicator 1<0.4	Indus, Ganga, Subarnarekha, Mahanadi, Tapi, Sabarmati
d)	Surface water quality	low stress	Indicator 1<0.2	Brahmaputra, Godavari, Brahmani
e)		low stress	Indicator 2 < 0.05	All basins, in good
f)		moderate stress	0.05 < Indicator 2 < 0.1	Cauvery, Tapi, Sabarmati, Pennar
g)	Groundwater withdrawals	very highly stressed through withdrawals	Indicator 3>0.7	Sabarmati
h)		highly stressed through withdrawals	0.4<Indicator3<0.7	Indus, Ganga, Subarnarekha
i)		moderately stressed	0.2<Indicator3<0.4	Mahanadi, Godavari, Krishna, Pennar, Cauvery, Tapi, Narmada, Mahi
j)	Groundwater quality	under very high threat	Indicator 4>0.8	None
k)		under high threat	0.4<Indicator 4<0.8	Indus, Ganga, Subarnarekha, Krishna, Pennar, Cauvery, Sabarmati
		under moderate threat	0.2<Indicator 4<0.4	Brahmaputra, Mahanadi, Godavari, Tapi, Narmada, Mahi, Brahmani

Findings of Extrapolation

- Inferences drawn from Sabarmati assessments are of much relevance to Pennar, Cauvery, Indus, Ganga, Subarnarekha, Mahanadi and Tapi in regard to surface water
- Ground water problems of Indus, Ganga, Subarnarekha, Krishna, Pennar and Cauvery have similarity with Sabarmati
- Problems of Brahmani resulting out of the high flows and low use of ground water have similar implications for Brahmaputra and Godavari

Assessment for Qiantang basin - findings

- Nature sector consumes major part of the primary resource (rain water).
- Consumptive use under nature sector is expected to increase significantly in future due to the expansion of forest area. This in turn would tend to reduce reduce river flow. Part of this decrease can however be restored through better soil and water management.
- Due to abundant surface water resources almost entire irrigated agriculture including fisheries is presently dependent on surface water resources.
- Groundwater use is presently restricted to D & I sector. There exists a huge potential for groundwater development in this basin.
- Surface withdrawals constitute a small fraction of available supplies and seems to be constrained by availability of cultivable land.

7. Extrapolation of Qiantang assessment to other similar basins

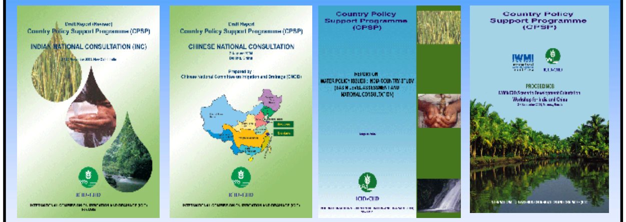
Basin Classification/grouping by water situation indicators

Class description	Indicator value	Basin
Low stress through surface withdrawal	Indicator 1<0.2	Yangtze, Zhujiang,Southeast, Southwest,Qiantang
Surface water quality, low stress	Indicator 2 <0.05	Yangtze,Zhujiang, Southwest, Southeast, Inland, Qiantang
Groundwater low stressed through withdrawal	Indicator 3 <0.2	Yangtze,Zhujiang,Southeast, Southwest, Inland, Qiantang
Groundwater quality under low threat	Indicator 4 <0.2	Yangtze,Zhujiang,Southeast, Southwest,Inland

In the end

- More studies are required to prescribe a certain specific demand for aquatic and other eco-system demands – work will continue.
- ICID's WG(Envt.) could address this aspect in a holistic manner; inputs are being made available
- Phase II studies are being mooted
  - to study the other 3 countries (Egypt, Pakistan & Mexico)
  - To add an East African Basin like Pangani in Tanzania or another from Ethiopia
  - More consultations in dialogue mode;
  - A fair appreciation of Environmental flow to be factored in studies
  - IWMI,IUCN and WWF and other international organisations will be invited to partner
- Please visit ICID web site for full details and reports: www.icid,org

ICID CPSP Publications



CPSP Model - Main Data Requirements

- Hydrological - Monthly data on Rainfall, Reference Evapotranspiration, Runoff data at locations near subbasin outlets, Groundwater information on recharge, fluctuation etc.
- Land Use - Areas of forests, grasslands, barren and fallow lands, reservoirs and agricultural lands.
- Crops Statistics - Gross and net areas under agriculture and irrigated agriculture. Cropwise compositions of both. Cropping calendars. Source wise composition of irrigated area.
- Agronomic Data - Soil moisture capacities, K factors (crop coefficients).
- Information about withdrawals and returns for irrigation use and D&I use.
- Demographic information including growth rates.
- Water Development related - Surface storage changes, Imports and exports; Data about environmental flow requirements (EFR)

CPSP Model - Main parameters

- Hydrological - Soil Moisture Capacities for all land parcels. Proportion of excess flow to surface. Index for soil moisture balance. Recession coefficients of linear GW reservoir.
- Water Use related - Irrigation System Efficiencies for surface and GW. Distribution of return flows to swamp evaporation, surface and GW

CPSP Model - Information for building alternate future scenario

- Engineering possibilities for in basin development, and inter basin imports and exports, efficiency improvements etc.
- Population and demand projections.
- Land development potentials.
- Ecological and environmental considerations regarding land use changes, low flow regimes and water quality.
- Agronomic possibilities in diversification, productivity improvements, changes in verities etc.
- Possibilities and desirability's of industrial development.
- Possibilities and desirability of rain water harvesting, watershed management and insitu water conservation