Indus Basin Model Revised (IBMR) is a basin-wide mathematical programming model, written in General Algebraic Modelling System (GAMS) language to assist in analyzing policies related to agriculture and irrigation development projects in the Indus River Basin.
INDUS BASIN FAMILY OF MODELS

- Farm Level Model (FLM) – 1974-75
- Indus Basin Standard Model (IBM) – 1981-82
  - 53 Irrigated Regions (Polygons)
  - 8000 Constraints
  - FORTRAN Language
- Indus Basin Model Revised (IBMR) – 1985-86
  - 9 Agro Climatic Zones (ACZs)
  - 45 Canal Commands
  - >2500 Constraints
  - GAMS Language
- Indus Basin Model Revised – III (IBM-III) - 1992
  - 12 ACZs
  - 45 Canal Commands
  - 2000 Constraints
  - GAMS Language
CONCEPTUAL LAYOUT OF IBMR

- **Mapping**: Canal Command – Sub Areas – ACZ
- **Production Functions**:
  - Supply – Demand Relationship
  - Linkage between ACZs via Surface Water Network Model
  - Demand – Supplies at Nodes.
  - Water Allocation to Maximize Crop Production Function.
  - **The Objective Function** – Maximize Consumer’s plus Producer’s surpluses, net of production costs plus the value of Exports less the costs of Imports.

<table>
<thead>
<tr>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land, Labour, Water</td>
<td>Crop Yield</td>
</tr>
<tr>
<td>Fertilizer, etc.</td>
<td>By-Product Yield</td>
</tr>
</tbody>
</table>

Crop Yield
By-Product Yield
STRUCTURE OF IBMR

1. ACZs
   - NWFP: NWFP
   - PUNJAB: PMW, PSW, PRW, PCW
   - SIND & BALOCHISTAN: SCWN, SCWS, SRWN, SRWS

2. CANAL Commands: 45

3. Sub Areas: 64

4. S.W. Network: Nodes 37

5. S.W. Network Arcs 27
   (for link canals)

6. Major Crops: 15

7. Livestock: Cow, Bullock, Buffaloes

8. Crop Production Technologies:

9. Draft Power Used: Bullock, Semi Mechanized
   Timing: Standard, L Planting, E Planting, Q Harvesting
   Water Stress Level: Standard, L Stress, H Stress, January Stress
Surface Water Network

[Diagram of surface water network with various labels and symbols indicating water bodies and structures.]

Legend:
- River Diversion Structure
- Irrigation Canal
- Supply Line Canal
- Link
- Ballari - Sulaiman I
- Ballari - Sulaiman II
- Barampat I - DSC - Dholpur
- Sardar Sarovar
- Khalisa - Khalisa
- Indus - Ganges
- Arabian Sea

Schematic Diagram: Indus Basin Irrigation System
INPUT DATA OF IBMR

- AGRONOMIC DATA
- LIVESTOCK DATA
- AGRO-ECONOMIC DATA
- HYDROLOGIC DATA
- IRRIGATION SYSTEM NETWORK DATA
- RESOURCES INVENTORY
- MISC. INPUTS
OUTPUT OF IBMR

- **Water:** River and tributary flows at rim stations and barrages, canal diversions, river losses and gains, water balance at water course head and root zone.

- **Cropping Patterns:** Crop and zone wise acreage by production technology, fresh & saline ground water areas.

- **Production:** Crop and livestock commodity wise production by zone and fresh & saline ground water areas.
Income and Costs:
- Gross Production Value (GPV)
- Farm Income
- Family Labour Cost
- Hired Labour Cost
- Fertilizer Cost
- Seed Cost
- Misc. Cost
- Private Tubewell Operation Cost
- Private Tubewell Investment Cost
- Tractor Operation Cost
- Tractor Investment Cost
- Animal Cost
- Protein Cost
Shadow Prices: On all fixed resources i.e. tubewells, tractors, etc.

Labour: Month and season wise Labour utilization by ACZ and Province.

Ground Water Balance: Month and season wise total ground water recharge and extraction by ACZ and province.
COMPARISON OF ACTUAL AND SIMULATED CROP AREA FOR INDUS BASIN 2000-2001 (000 ACRES)
COMPARISON OF ACTUAL AND SIMULATED CROPPING INTENSITY (%)

The bar chart compares actual and simulated cropping intensity for different periods:
- **Rabi**
- **Kharif**
- **Annual**

- **Actual** and **Simulated** bars are shown for each period.
# Statistical Analysis of Simulated Cropping Pattern

<table>
<thead>
<tr>
<th></th>
<th>NWFP</th>
<th>PUNJAB</th>
<th>SIND</th>
<th>PAKISTAN</th>
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<tbody>
<tr>
<td>Correlation Coefficient</td>
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<tr>
<td>Intercept</td>
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<tr>
<td>R-Squared</td>
<td>.852</td>
<td>.963</td>
<td>.857</td>
<td>.961</td>
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WATER BALANCE AT ROOT ZONE
SIND & BALUCHISTAN

![Water Balance Graph]

- **RABI-Supply**
- **RABI-Req.**
- **KCHARIF-Supply**
- **KCHARIF-Req.**
- **ANNUAL-Supply**
- **ANNUAL-Req.**

Legend:
- Water Req.
- Canal Water
- Rain
- Sub-Irrigation
- Private-T/W
- Govt.-T/W
GROUNDWATER BALANCE
(ACRE FT. PER ACRE OF CCA)

- Ground Water Inflow
- Ground Water Outflow

Fresh
Saline
Average
APPLICATION OF IBMR

WAPDA

- Water Sector Investment Planning Study (1989)
- The Indus Basin Case Study of Complex River Basin Management in a changing global climate conducted by University of Colorado, USA
- The Ranking Study of new Irrigation Projects as a result of Water Apportionment Accord (1991)
- Salinity Management Alternatives, studies under IIMI, Pakistan (1995-1998)
- Evaluation of Irrigation Benefits from Bhasha-Diamer Dam Project (2002)
APPLICATION OF IBMR (CONTINUED)

WORLD BANK

- On-Farm Water Management (1981)
- Left Bank Outfall Drain Stage-I Project (1981)
- SCRAP Transition Pilot Project (1985)
- Agriculture Impact Assessment Study of Kalabagh Dam Project (1985)
- Raised Mangla Dam Project (1991)
LIMITATIONS OF THE EXISTING IBMR

- The model has incorporated 15 specific crops only.
- The model assumes stress for wheat only. Stress for other crops need to be included.
- Aquifer behavior is taken into account, but based on a predefined depth to the water table.
- The model does not simulate the irrigated area outside the Indus Basin.
- The model does not simulate flood protection benefits.
- Drainage component is not included directly.
CAPABILITIES THE EXISTING IBMR

- Future projection of agriculture production under different resource availability.
- Optimum distribution of available water resources between the canal commands particularly within the provinces.
- Identification of resource limitations on desired crop production.
- Evaluation of water resources projects particularly at the national level.
CAPABILITIES THE EXISTING IBMR (CONTINUED)

- Groundwater balance calculations allowing for tubewell development.
- Its zonal and network models can be used for the zonal projects.
- It can be used to study the impact of one or more projects on the overall Indus Basin System.
Lateral sub surface drainage flows between the Physical boundaries of 9 ACZ.

Impact of drainage surplus (deep percolation) on the production activity.

Soil and Water balances and their environmental Impact.

Water saving and Drainage reducing activities.
PROPOSED MODIFICATIONS IN CONTEXT OF NDP (CONTINUED)

- Effect of soil salinity on crop yields.
- Effect of High Water Table on crop yields.
- Use of Surface drainage infrastructure to control flood (indirect benefit from drainage investment).
- Elasticity of demand for each of the crop in each ACZ.
ESTABLISHMENT OF WATER RESOURCE DATABASE

Activities Involved

- Data Collection
- Data Entry
- Arrangement of Computer Hardware/Software
- Database Design and Development
- System Development and GUI Design
- Testing
- Implementation
DATASETS FOR WATER RESOURCE DATABASE

- Climatic Data
- River Discharges
- Diversions at Barrages and Headworks
- Inflows/Outflows of Main Reservoirs
- Surface Drain Data
- Hydrogeology
- Agriculture
- Water Supply to Urban Areas
- Water Quality
- Soil Salinity
# ESTABLISHMENT OF WATER RESOURCE DATABASE

## PROGRESS OF WORK FOR ESTABLISHMENT OF WATER RESOURCES DATABASE

(upto May, 2003)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>ACTIVITIES</th>
<th>Year % PROGRESS</th>
<th>INCEPTION PHASE</th>
<th>EXECUTION PHASE</th>
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<td>Data Entry</td>
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<tr>
<td>7</td>
<td>Implementation</td>
<td>-</td>
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</table>

**Legend**

- Planner Activity
- Progress Achieved
# Progress of Work for Modification of IBMR

**Upto May, 2003**

<table>
<thead>
<tr>
<th>S.No</th>
<th>Activities</th>
<th>Year % Progress</th>
<th>Inception Phase</th>
<th>Execution Phase</th>
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<td>3</td>
<td>Flow b/w ACZs</td>
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<td>M</td>
<td>A</td>
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<td>4</td>
<td>Removing fixed crop price</td>
<td>70</td>
<td>M</td>
<td>A</td>
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</table>

**Legend**
- Planned Progress
- Achieved Progress