RIVERTWIN PROJECT

Concept of integrated model for Chirchik-Ahangaran-Keles sub-basin

Inception report WP-6

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Content

Introduction

Concept of integrated model includes:

- Analysis of Chirchik-Ahangaran-Keles sub-basin (CAKSB) as natural-anthropogenic system (NAS),
- Proposals on planning and schematization CAKSB units singling out
- Proposals on models building and their uniting in common integrated complex
- Requirements to models' information provision – database and GIS.

1. Sub-basin management as natural-anthropogenic system

1.1 CAKSB is considered as an object of management – NAS.

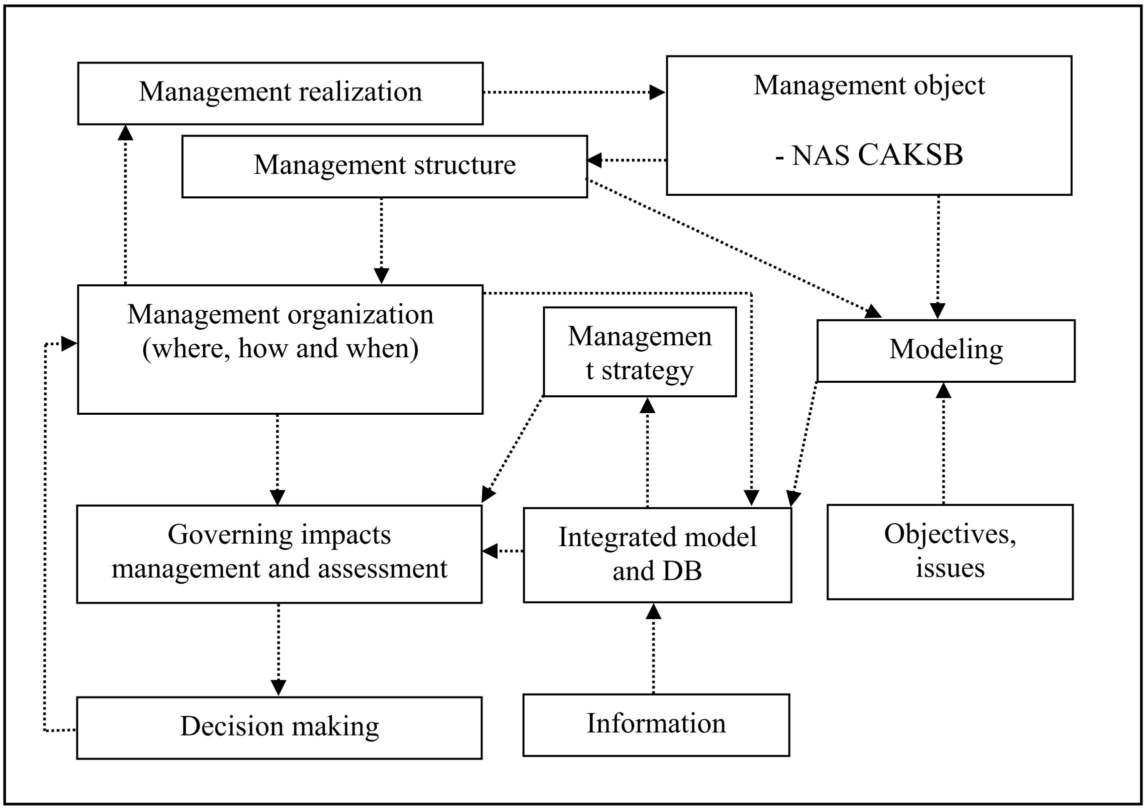


Fig. 1 Scheme of NAS management

1.2. NAS CAKSB consists of following sub-systems:

- Water resources formation,
- water resources distribution,
- water resources use,
- water consumption,
- water resources protection,
- social-economic development.

1.3. Sub-system of water resources formation CAKSB includes natural landscapes with components: climate, soil, water sources (surface and ground), vegetation including under study, protected and controlled and anthropogenic landscapes in flow formation zone.

1.4. Sub-system of water resources distribution CAKSB includes:

- River network,
- Irrigation network (water conveying),
- System "Vodokanal" – conveying water from surface and ground sources for water supply,
- Objects of management – river flow regulation (water reservoirs as accumulators and regulators), distribution (hydraulic structures) and water supply (water intakes, inlets).

1.5. Sub-system of water resources use CAKSB includes:

- Power engineering – existing state, structure development, power requirements, power generation, efficiency.
- Recreation – in coordination with water objects, their regime, protection and effect from population rehabilitation, tourism development and commercial activity.

1.6. Sub-system of water consumption CAKSB includes:

1.6.1. Water consumers:

- Urban and rural settlements' municipal consumption,
- Industry,
- Thermal power engineering,
- Irrigation,
- Pond fish-culture,
- Other consumers – pastures watering, rural water supply.

1.6.2. Agricultural production:

- Agricultural production on irrigated and rain-fed lands within irrigated and non-irrigated zone,
- Cattle-breeding and poultry farming,
- Fish-culture (ponds),
- Agricultural product processing.

1.6.3. Return flow formation system, its re-use and disposal including:

- Collector-drainage water (CDW),
- Industrial wastes,
- Municipal wastes from large settlements,
- Agricultural wastes from farms and small settlements.

1.7. Sub-system of water resources CAKSB includes:

- Ecologic requirements to water objects,
- Ecologic requirements to flow formation zone (FFZ),
- Restrictions of return water release (quantity and quality),
- Requirements to protected zones,
- Criteria and indicators of ecologic sustainability.

1.8. Sub-system of social-economic development CAKSB determines main conditions, boundaries, scale, priorities, indicators, NAC dynamics and includes:

- NAS development scenarios with production dynamics over branches and rayons,
- Investment potential and distribution in future,
- System of compromises, criteria, indicators of NAS functioning and sustainable development in connection with nature and man,
- Factors limiting and stimulating NAS further development, their trends for perspective.

2. Planning units singling out

2.1 From multitude of information objects, each from which can be described from information user's point of view (within project framework), it is possible to single out:

- Local objects,
- Linear objects.
- Distributed objects..

2.1.1. Local objects include:

- Water sources – conditional points of surface (along the rivers) and ground (separate springs and wells) water resources formation,
- Water supply objects – points of water consumption for drinking and municipal needs,
- Industrial objects – points of water diversion for industry,
- Power generation stations – hydropower plants (HPP), thermal power plants (TPP),
- Outlets on rivers and canals (for irrigation, rural water supply, fish-breeding,
- Tpoints of return water inflow to surface and ground water – CDW, industrial, agricultural and municipal wastes,
- Points of water resources management – water works**,**
- Water network points –points of confluence and separation,
- Points of ecologic and hydrologic monitoring and control – gauging stations, observation wells, points of ecologic risk study.

Their detail elaboration for CAKSB is presented in section 2.2.

2.1.2. Linear objects include:

- Separate rivers and their reaches, including over type of interaction with ground water (percolation, wedging out), water losses and pollution, sites of ecologic risk and protection.
- Canals and their sites - irrigation, HPP water conveyor, tale-race,
- pipelines – water supply objects of "Vodokanal",
- collectors and their sites, disposed CDW, industrial, agricultural and municipal wastes.

Their detail elaboration for CAKSB is presented in section 2.2.

2.1.3. Distributed objects – contours of:

- flow formation zone (FFZ) – landscapes with their characteristics: relief, climate, water sources, vegetation (forests, pastures), agricultural production elements (rain-fed lands), cattle-breeding, ecologic characteristics (protected zones, zones of erosion, etc.),
- ground water deposits – contours of their formation**, use** and contamination (distributed agricultural and local industrial)),

- irrigation systems uniting river, irrigation and collector-drainage network and irrigated zones in common complex of water distribution and disposal,
- irrigated zones – water consumption and agricultural; production,
- CDW formation zone in coordination with irrigated area borders and irrigation system;
- Reclamation zones – territories with specific reclamation conditions in coordination with irrigated zones,
- Aquatic ecosystems – water reservoirs, lakes,
- Protected areas, reserves in coordination with FFZ borders,
- Recreation zone in coordination with FFZ borders,
- Zones of ecologic risk – danger ecologic situation in coordination with FFZ borders,
- Climatic zones in coordination with FFZ borders.

Their detail elaboration for CAKSB is presented in section 2.2.

2.1.4. Present schematization is a base for modeling and information units building, coding and mathematical description. Objects' coordination determines information flows' calculation schemes used during integrated model development. – see NAS principal scheme.

2.1.5. Points of objects study according to RIVERTWIN work schedule

Object type	**Object name**	**Modeling, DB, interface**	**Data collection and analysis**
Local	Surface water sources	1.15, 1.9, 1.5, 1.12	2.7, 2.4
	Ground water sources	1.16, 1.10, 1.5, 1.12	2.8, 2.4
	Water supply objects	1.15, 1.19, 1.3, 1.12	2.3, 2.7, 2.4, 2.6
	Industrial objects	1.15, 1.19, 1.3, 1.12	2.3, 2.7, 2.4, 2.6
	Hydropower stations	1.17, 1.9, 1.12	1.17, 2.14
	Thermal power stations	1.17, 1.19, 1.3, 1.12	2.14
	Outlets to irrigated area	1.15, 1.18, 1.7, 1.9, 1.12	2.7
	Points of return water formation	1.15, 1.18, 1.7, 1.9, 1.12	2.7, 2.4, 2.5, 2.6
	Points of water resources management	1.15, 1.9, 1.12	2.7, 2.10
	Points of water network	1.15, 1.9, 1.12	2.7
	Points of monitoring and control	1.15, 1.16, 1.20, 1.5, 1.9, 1.12	2.7, 2.4, 2.6
Linear	River, canal, pipeline, collector, their sites	1.15, 1.9, 1.5, 1.12, 1.20	2.7, 2.4, 2.6
Distributed	Flow formation zone	1.20, 1.12, 1.5	2.4, 2.6, 2.11
	Ground water deposits	1.16, 1.10, 1.12	2.8
	Irrigation system	1.15, 1.9, 1.12	2.7, 2.10
	Irrigated area	1.18, 1.7, 1.10, 1.12	2.5, 2.6, 2.4, 2.6
	CDW formation zone	1.16, 1.5, 1.12	2.7, 2.4, 2.6
	Reclamation zones	1.18, 1.7, 1.12	2.6.1
	Aquatic ecosystems	1.15, 1.9, 1.20, 1.5, 1.12	2.7, 2.4, 2.6, 2.13
	Zones of ecologic risk, protected	1.20, 1.5, 1.12	2.4, 2.6

	areas, recreation area		
	Climatic zones	1.15, 1.18, 1.11, 1.12	2.9

CAKSB objects description is given below.

2.2. CAKSB singled out zones

2.2.1. Climatic zones are determined according to item 2.9 of RIVERTWIN work schedule.

2.2.2. CAKSB irrigation systems:
- “Bozsu”,
- “Parkent-Karasu”,
- “Ahangaran”,
- “Keles massif”.

First two irrigation systems are fully located within Chirchik-Ahangaran irrigation systems (IS) (Republic of Uzbekistan).

IS “Ahangaran” is a part of “Ahangaran-Dalverzin” irrigation system except Dalverzin canal’s command area irrigated from Syr-Darya.

IS “Keles massif” is Kazakh territory irrigated from Chirchik right bank canals – BigKeles canal (BCC), Eski-Honim, Zakh, BTC and STC.

Tashkent main canal is considered as linear object.

Irrigation systems are characterized by water use and management parameters in accordance with item 2.7, 2.10.

2.2.3. Following irrigated zones are singled out within irrigation systems:

Irrigation network “Bozsu”:
- Kibrai,
- Tshkent,
- Zangiata,
- Yangiyul,
- Chinaz.

Irrigation system “Parken-Karasu”:
- Bostanlik,
- Parkent,
- Verkhne-Chirchik,
- Sredne-Chirchik,
- Nizhne-Chirchik,
- Akkurgan.

Irrigation system “Ahangaran”:
- Ahangaran,
- Pskent,
- Buka,
- Bekabad.

Bekabad irrigation zone encompasses part of Bekabad rayon of Tashkent oblast and irrigated from Tashkent canal.

Irrigated zones are characterized in flow regulation, water use and saving according to item 2.7, 2.10, 2.12, 2.15, in agricultural land use – by item 2.5, in agro-economics - item 2.6, in soil properties – item 2.6.1, in ecologic situation - item 2.4, 2.6 of RIVERTWIN work schedule.

2.2.4. Two flow formation zones are singled out adjacent to irrigation zones of the same name:

- Bostanlik,
- Ahangaran.

Irrigated zones are studied according to item 2.4, 2.11, 2.15 of RIVERTWIN work schedule in part of forest cover, erosion and flood impact on flow formation .

2.2.5.Singled out water objects and affiliated aquatic ecosystems:

- Existing reservoirs – Charvak, Khodzhikent, Gazalkent, Ahangaran, Tuyabuguz (Tashkent),
- Pskem reservoir (perspective object),
- Ponds - Chinaz fish reserves.

From flow regulation point of view, given objects are described according to item 2.7, ecology – item 2.4, 2.6, extreme phenomena (flood) – item 2.11, fish-breeding - item 2.13 of RIVERTWIN work schedule.

2.2.6. As to ground water, two deposits are singled out: Chirchik and Ahangaran described according item 2.8 of RIVERTWIN work schedule.

2.2.7. Territories with similar soil-reclamation conditions are classified in accordance with item 2.6.1 of RIVERTWIN work schedule.

2.2.8. Zones of ecologic risk are described according to item 2.4, 2.6 of RIVERTWIN work

All distributed objects over types and groups are introduced in appropriate GIS layers.

2.3. CAKSB linear objects

2.3.1. River balancing sites

- Chirchik (from alignment to alignment): Charvak hydropower station –Khodjent hydropower station, Khodzhikent hydropower station – Gazalkent hydropower station, Gazalkent hydropower station – Gazalkent CA, Gazalkent CA - Verhnechirchik CA, Verhnechirchik CA – g/p Chinaz,
- Pskem river from Pskem hydropower alignment to the mouth,
- Ahangaran (from alignment to alignment): g/s Irtash – Ahangaran reservoir, Ahangaran reservoir – Shahrihin CA, Shahrihin CA – Tuyabuguz reservoir, Tuyabuguz reservoir – Khan CA, Khan CA - Akkurgan CA, Akkurgan CA – g/p Soldatskoe,
- Keles riverfrom g/p Yangi-Bazar to mouth,
- Syr-Darya river from g/p Nadezhdensry to g/p Kokbulak.

2.3.2. Canals:

- Irrigation system "Bozsu" – Eski-Honim, Zah, BTC, NTC (up to border with Kazakhstan), Bozsu, Salar, Kalkauz.
- Irrigation system "Parkent-Krasu" - BKMK (up to border with Kazakhstan), VDC (up to alignment downstream escape "Flat gate"), Parkent, Handam, Left bank, Karasu, Tashcanal (up to Ahangaran river), Tuyabuguz left bank canal (Ung Kirgok), Morgunenkov (right bank), RK-5..7 (water intakes from Karasu left bank), RK-8,9 (water intakes from Khan dam, RK-10 (water intake from Akkurgan water work).
- Irrigation system "Ahangaran" –Tanagi Buka (water intake from Sharihin water work), Tashcanal (Ahangaran right bank), Tuyabuguz left bank canal (Chap Kirgok), Morgunenkov (left bank).
- Irrigation system "Keles massif" - Keles (BKMC), Khonim, Zah, BTC, STC.

River and irrigation network as well as "Vodokanal" system are described according to items 2.7, 2.10 of RIVERTWIN work schedule.

Rivers and main canals of sub-basin are divided depending on anthropogenic load:

  - Watercourses not subject to anthropogenic impact –rivers inside reserves, upstream settlements and recreation zones (Nauvalisai, Pskem, Koksu, Chatkal, Aкbulak, Aктash, Karakiasai, Kyzylsu),
- Chircik, Ahangaran and Ugam upstream – watercourses with negligible contamination (pure water),
- Chirchik, Ahangaran midstream, Salar, Karasu canals' sites upstream Tashkent – watercourses with moderate contamination,
- Chirchik site downstream Yangiul, Ahangaran downstream, Salar and Karasu canals' downstream Tashkent - watercourses with srong contamination.
- Main linear objects are put in GIS thematic layers.

2.4. CAKSB local objects

2.4.1. Surface water sources over gauging stations and aggregation over sites:

- Inflow to Charvak reservoir along the rivers: Pskem (g/p Mullala), Chatkal (g/p upstream Hudaisai river mouth), Nauvalisai (g/p Sidzhak), Кoкsu (g/p Burchmulla), Yangikurgan (g/p Yangikurgan), Chimgansai (g/pChimgan).
- Side inflow to Chirchikalong the rivers: a) before Gazalkent dam – Ugam (g/p Khodzhikent), Kyzylsu, Karankulsai (g/p Karankul), Aulesai, Chimbailiksai, Galvasai (g/p Galvasai), Karakiasai, b) Gazalkent dam – Aktashsai, Aksagatasai, Shurabsai, Nabaksai, Azatbashsai.
- Chirchik – g/p Charvak hydropower station, Khodzhikent, Gazalkent hydropower station, Gazalkent, Verhnechirchik water work.
- Ahangaran – g/p Irtash, Ahangaran and Tuyabuguz (Tashkent) reservoir, Shahria.
- Side inflow to Ahangaran: g/p Irtash – Ahangaran reservoir, Ahangaran reservoir downstream.
- Keles (g/p Yangibazar)
- Syr-Darya river: g/p Nadezhdensky, Chinaz-Syr-Darya, Koкbulak;
- Side inflow to Syr-Darya: escape on right bank Ahangaran (g/p Soldatskoe), Chirchik (g/p Chinaz), Keles (mouth).

Surface sources and river flow regime (over gauging stations) are described according to items 2.7, 2.4 of RIVERTWIN work schedule.

2.4.2. Water works, large water intakes:

- Chirchik river – Gazalkent, Verhnechirchik,
- Ahangaran river – Khan,Sharhin, Akkurgan,
- Karasu left bank – diversions to Khandam, Tashcanal, RK-5..7, Khan dam (outlets to RK-8, RK-9, Morgunenkov),
- Bozsu canal – diversions to Khonim, Zah, Salar, VTC, STC (Kalkauz).

To irrigated zone water is delivered on canal network and directly from rivers and reservoirs through outlets described according to items 2.7 of RIVERTWIN work schedule.

2.4.3. Outlets from canals:

- Flat gate (from VDC to Chirchik river),
- From Tshcanal to Tuyabuguz reservoir,
- Salar escape (from Salar canal to Chirchik river),
- Karasu left bank escape (release to Ahangaran river),
- Escapes RK-5…10 (from canals RK-5…10 to Chirchik river).

2.4.4. Return flow from irrigated areas is accounted as aggregated releases over collectors:

- To Chirchik river,
- To canals Karasu left bank and Bozsu,
- To Ahangaran river,
- To Syr-Darya river (from Bekabad, Buka, Akkurgan, Nizhnechirchik, Chinaz irrigated zone).

Releases from canals are characterized by their capacity and regime according to item 2.7 and on water quality - item 2.4, 2.6 of RIVERTWIN work schedule.

2.4.5. Hydropower stations:

- Chirchik cascade - Charvak, Khodzhikent, Gazalkent,
- Bozsu cascade.

2.4.6. Thermal power stations

Novoangren, Staroangren, Tashkent.

Regimes and power requirements to hydro and thermal stations are described according to items 1.17, 1.19, 2.14 of RIVERTWIN work schedule.

2.4.7. Water consumption objects are presented as follow:

- Points of pipeline system "Vodokanal" taking water to Tashkent, Chirchik, Yangiul, Angren, Almalik and Ahangaran cities and other settlements from canals, sai and groundwater.
- Objects disposing municipal wastes.

2.4.8. Industrial objects are presented as main water consumers and polluters**:**

- Tashkent and Yangiul,

- Almalik mining complex,
- Chirchik chemical complex,
- Chirchik electric-mechanical complex (collector Yumalak),
- Angren coal mine,
- Mining objects in upper Chirchik-Ahangaran basin.

Water consumption industrial complexes will be described according to items 2.7, 2.3, 2.4, 2.6 of RIVERTWIN work schedule.

Local objects are put in GIS thematic layers.

3. Set of models' structure

3.1. While CAKSB set of models developing experience of prospective models development has been taken into account – planning zone modeling in coordination with restrictions and requirements including ecologic ones (ASBMM).

IWRM methods introduction and adaptation to CAKSB conditions and peculiarities, adaptation of regional database part (information provision) and use of GAMS optimization solvers.

On the other hand, CAKSB detailed modeling (as pilot object) allows disseminate approaches to ecologic situation assessment and forecast for both separate ecosystems and entire basin.

It is necessary to coordinate CAKSB with Syr-Darya basin on management regime and ecologic restrictions because sub-basin impact on water supply to downstream (Chardara reservoir) is significant and can impact negatively or positively on water availability, losses and river flow quality.

3.2. CAKSB NAS (fig.2) functioning and development is described by following blocks and models:

- Hydrologic model (HM) including surface water block (SWB) and hydropower block (HEB),
- Hydrogeologic model (HGM),
- Irrigated zone models (IZM),
- Ecologic models (EM) including flow formation block (FFB),
- Social-economic model (SEM) including power block (EB).

Given set of models is connected with DB and GIS (see requirements to DB and GIS) through interface in single integrated model.

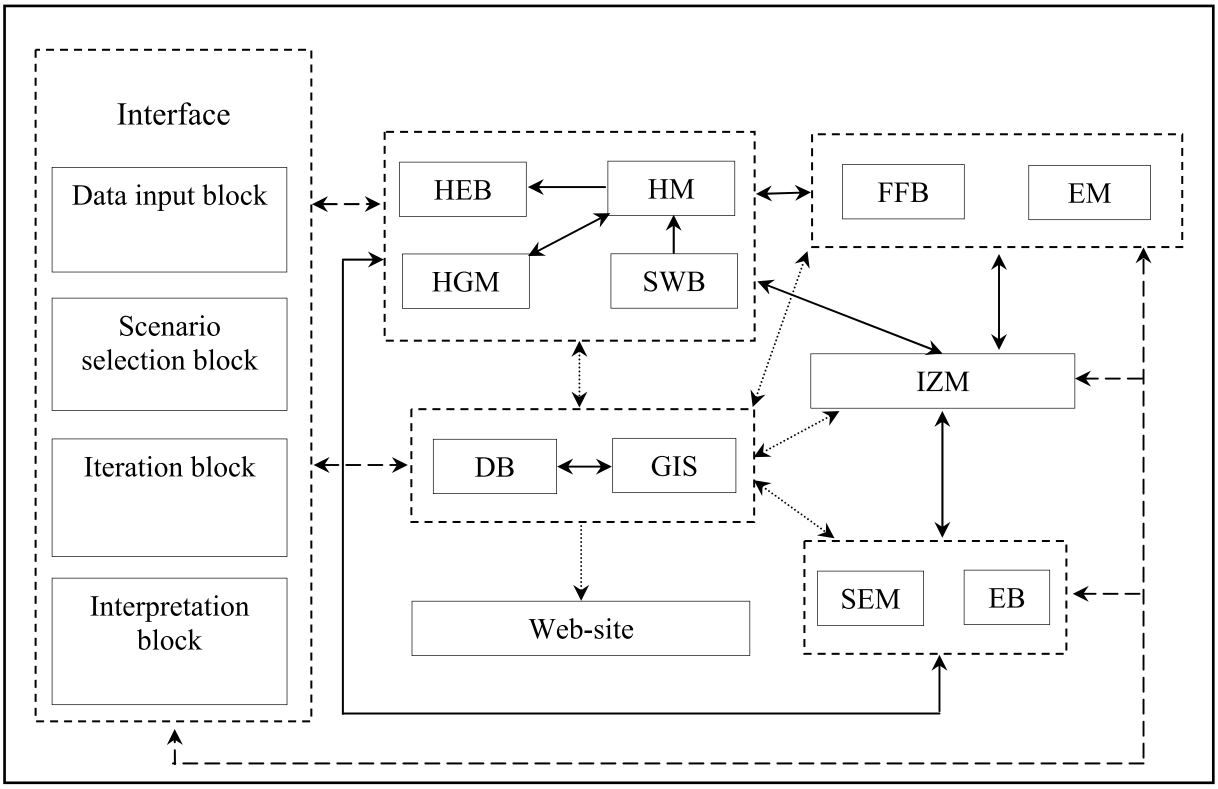


Fig. 2. Block-scheme of CAKSB integrated model

3.3. Main interface components connecting separate models and blocks are as follows:

- Initial data processing and translation from DB,
- Scenario selection,
- Data sharing between models,
- Iteration and model launching (computation),
- Designed data processing (output from models) and results interpretation.

3.4. Block of interface primary data processing is directly linked with DB, GIS separate blocks, each model and its blocks.

3.5. Block of designed data processing and results interpretation is linked with each model and its blocks, GIS, DB (archive) and data visualization program through Internet.

3.6. Links between models, their DB blocks and interface

Item	Model, block	Linkage with other models, blocks
1.15	HM, SWM, HEB	HGM, IZM, EM, FFB, SEM, РБ, surface water, climate, power DB blocks, scenario selection block, block of data input, iteration and interface results interpretation.
1.16	HGM	HM, IZM, PM, SEM, DB ground water block, scenario selection block, block of data input, iteration and interface results interpretation.
1.18	IZM	HM, HGM, SEM, PM, agrarian production block, climate, scenario selection block, block of data input, iteration and interface results interpretation..
1.20, 1.12	PM, FFB	IZM, HM, HGM, SEM, ecologic block scenario selection block, block of data input, iteration and interface results interpretation.
1.19	SEM, EB	IZM, HM, HGM, PM, social-economic and power block, scenario selection block, block of data input, iteration and interface results interpretation.

3.7. Hydrologic model (HM) describes existing processes, peculiarities, trends of surface water formation and distribution among users and consumers in coordination with ground water, flow regulation criteria with regard to ecologic requirements and restrictions on border of release to Syr-Darya river.

HM runs in simulation and optimization mode different scenarios, power plant functioning, water requirements and available resources with regard to river and reservoirs' balance and regime.

HM (main computation block) is linked with HEB (calculation of energy generation compared with requirements), ecologic model (river and reservoir water quality, FFZ characteristics), IZM (irrigation requirement and return flow), block of flow regulation scenario selection (power, irrigation-power), restrictions (ecologic, technical), block of results interpretation. Modeling system-GAMS.

Within HM development long-term natural flow time series are studied and their recurrence with regard to climatic changes and restrictions linking CAKSB with Syr-Darya basin.

Analysis of unproductive water losses, when management is done without Chirchik and Ahangaran and entire Syr-Darya basin interconnection. Model is oriented at alternative computations allowing to develop for practical use (Chirchik-Ahangaran irrigation system, BWO "Syrdarya") regulation and effective water use rules within sub-basin taking into account all water users' interests and ecologic restrictions on allowable impact on ecosystems.

Modeled system presents main rivers' trunks (Chirchik, Ahangaran and their tributaries) divide into balancing sites with reservoirs, hydropower plants, water sources, irrigated zones, water consumption grids (settlements, industrial centers, power stations), waste water formation interconnected along canals, collectors and outlets.

Method of modeled water management system presentation – method of graph, according to which water related network is divided into objects, sites of computation and alignments (according to established planning units) simulated in algorithm by network of arch-grids. For each grid water and salt conservation equations are solved (salt is considered as conservative admixture).

HM input information:

- Data from DB block of surface water (inventory and information sources are presented in sections 4.6, 4.14, and partially - 4.13),
- Data from IZM, HGM and PM, SEM power block, block of scenario selection and surface water block (section 3.12.1),
- Data from DB internal base – morphology, losses function, structures' capacity, reservoirs' biometry (level-area-volume).

Output information HM:

- Data translation into IZM, HGM, PM, power block, SEM (section 3.12.1),
- Data translation into block of results interpretation – water discharge and salinity over main gauging stations, irrigation systems (scenario forecast), reservoirs' operation regime (inflows, releases, water level, water volume, losses),water-salt balance over river sites, main canals, irrigation systems transboundary overflow (Kazakhstan, Syr-Darya).

HM includes following blocks:

- Hydropower block (HEB) –devoted to hydropower calculations on Chirchik-Bozsu cascade.
- Surface water block (SWB) –devoted to surface runoff hydrograph modeling depending on accepted scenarios of climate and flow formation zone changes (forest coverage).

HEB input information:

- Data from power sub-block of surface water DB (section 4.6, partially – 4.13)
- Data from HM, SEM power block and block of scenario selection (section 3.12.1),
- Data from internal DB –Power plant's technical parameters.

HEB output information:

- Data translation to SEM power block (section 3.12.1),
- Data translation to block of results interpretation – power plant operation mode, energy generation, assessment energy deficit, income and costs (forecast over scenarios).

SWB input information:

- Data from SWB and climate block DB (section 4.6, 4.11, 4.14 and partially – 4.13)
- Data from FFB, block of scenario selection (section 3.12.1).

SWB output information:

- Data translation to HM (section 3.12.1).

3.8. During HGM development basic factors are found directly affecting ground water regime (natural, irrigation industrial), regularities of ground water regime formation, ground flow seasonal variability and its links with surface flow.

HGM supposes availability of surface and ground water interconnection in separate places of sub-basin and certain direction of ground water regime under its prediction, in particular, assessment of ground water discharge and balance for separate typical zones () having ecologic peculiarities and pollution risk). Model base is existing structure of ground water sources and consumers.

Sub-basin is characterized by good natural drainability, shallow fresh ground water table, developed irrigation and collector-drainage network. Ground water long-tem and seasonal fluctuations dynamics with some correlation with surface water regime and dependence from locality elevation. On separate sites – study of conjunctive surface and ground water use efficiency.

HGM input information:

- Data from ground water block (section 4.8)
- Data from HM, SEM, PM (section 3.12.1, 3.12.2),
- Data from internal DB – ground water sources and deposits' structure.

HGM output information:

- Data translation to HM, IZM, SEM and PM (section 3.12.1, 3.12.2),
- Data translation to block of results interpretation – ground water consumption dynamics (forecast).

HGM and HM coordination work includes:

- Natural river water availability zoning within "dry-wet year" boundaries, traditional hydrologic evaluation of water availability, natural water availability study and modeling, natural water availability recurrence and synchronization over years and seasons.
- Establishing links between channel natural flow at the entry to valley and "transformed by economic activity",
- Establishing links between river and aquifers (losses for percolation, ground water wedging out),
- Use of above links for sub-basin ground water resources assessment.

3.9. Irrigated zone model (IZM). "Irrigation zone" is taken as basic unit for modeling including all infrastructure elements – population, water and land resources, power resources, agricultural and industrial production, irrigation and collector-drainage systems and environment.

IZM supposes existing situation modeling and forecast within separate planning contours and entire sub-basin in irrigated agriculture, rain-fed lands use, agricultural farming and affiliated production (climate as a factor of agricultural production), agro-economics, etc.

State as a chief manager governs irrigated zones development through mechanisms of financial and water resources distribution. Irrigated zone impact on the state is reflected in volume of agricultural production, rural population social-economic conditions and volume of natural and disturbed runoff. It is worth to note, that zone agricultural production doesn't fully cover "consumption basket", which includes additional import. Besides, zone net profit is only a part of national product taken from this territory (industry and services). In spite of above restrictions, study of IZ totality is very important for both optimal investments distribution in agriculture and hydrologic and ecologic conditions change assessment.

3.9.1. Irrigation zone elements. *Irrigated zone* is geographic unit within hydrographic basin with common inflow and landscape. Irrigated zone is obligatorily located within one administrative rayon but one rayon can be divided into several irrigated zones.

Zone total income is determined as a part of full income of the territory and expressed in economic and financial prices.

Technologic resource is considered only within agricultural activity and determined through cost of irrigated area integrated development (irrigation and collector-drainage systems).

Water resource is determined as totality of all natural and artificial water sources located within territory under consideration. Water resources formed within IZ are called local ones, from transboundary sources – transboundary resources, return waters – collector-drainage outflow. All IZ area is divide into two components:

- *Developed area* – territory used for agricultural production having technologic resource forming main income and return flow.
- *Undeveloped area* – territory not having technologic resources and not participating in return flow formation.

IZ is considered as distributed object consuming some water resources with their further internal spatial and temporal re-distribution and quality changes.

IZ management is performed through investments and costs directed to its elements maintenance, reconstruction and development and through volume of tranboundary and local water resources. IZ consists of developed and undeveloped territories. Developed territory in turn consists of irrigation contours with own physical-chemical indicators, reflecting soil fertility and ecologic state as well as set of technical-economic parameters depending on grown crops, irrigation and collector-drainage systems. Undeveloped area consists of natural ecosystems.

Water resources volume and quality change directly affects volume of agricultural production through crop water availability and indirectly – through soil reclamation state. That's why, both components (volume and quality) are subject to modeling. IZ elements change corresponds to irrigation and collector-drainage network ageing and soil fertility development dynamics.

IZ internal structure is presented by regular set of sown contours for developed territory and natural ecosystems' contours for undeveloped one. In turn, each element is characterized by own set of variables and functions reflecting its spatial, technologic and biologic properties.

Following set of objects is accepted to describe IZ functioning.

Sown contour – part of surface used for crop cultivation with similar soils, irrigation and collector-drainage systems. Sown contour can have several entry points to irrigation system using local and transboundary water resources. Sown contour is characterized by surface, agricultural crops and irrigation and collector-drainage systems' parameters.

Irrigation system – system providing timely water supply of necessary volume to irrigated zone. It is characterized by command area, maximum capacity and O&M cost, reconstruction and development functions depending on investments.

Collector-drainage system – system supporting required salt balance and ground water level on IZ territory and removing excessive water to the rivers, depressions or back to irrigation system for re-use. Drainage system has following parameters: drainage modulus, main assets, O&M cost, reconstruction and development functions depending on time and investments.

Agricultural crop – cultivated crop with following parameters: total area, specific productivity and product unit cost including added value from secondary processing. Besides, each crop has five functions: evapotranspiration, specific water and finance volume, stress functions reflecting yield reduction due to water scarcity and actual agricultural production level.

Undeveloped area contour – part of IZ surface providing natural hydrologic flow formation under various climatic conditions. It is characterized by surface runoff volume and intensity.

3.9.2 Project is based on principle of descending design of complex hierarchic objects and system analysis. IZ formalization is presented as a oriented graph **G**(J,I), where J={0,1, . . .,j}

– multitude of peaks corresponding developed and undeveloped territories, I ={ 0,1, . . .,i} – multitude of arches reflecting flows of water and technical-economic resources.

Dynamics of each peak is described by finite automate with four vectors: [Y(t), X(t), Z(t), $Z(t-1)]_j$, which should be understood as territory with index "j" instate $Z_j(t-1)$ in time moment "t". It responses to input signal $X_j(t)$ by output signal Y_j (t) and turns into new state $Z_j(t)$. Input signal $X_{k,j}(t)$ has two-component structure $\{W,C\}_{k,j}$ and can be formed both within IZ $\in\{J\}$), and at its border ($k\notin\{J\}$). Latter describes conjunction of adjacent IZs or target IZ management by the state, where: W(t) – water resources vector, C(t) – investment and cost vector. Output signal Y_j (t) has four-component structure $\{V, W, \aleph, P\}_{k,j}$, wehre: V(t) – vector of agricultural production volume, W(t) – vector of return flow, $\aleph(t)$ – scalar of net income from agricultural production, P(t) – vector of water use efficiency. State of peak Z(t) is described by set of functions reflecting density of corresponding parameter distribution over area by functions of unclear relations.

Thus, state of peak Z(t) is determined by distribution function value for current time moment and peak Z(t) trajectory is these function changes with time. IZ assembling is started with GIS-singling out developed and undeveloped areas with further data collection and analysis on demographic, social, economic, technologic and hydrologic indicators. These data reflect region development dynamics. Numerical modeling gives region development under various social-economic scenarios. Field inspection is carried out to check modeling results.

3.9.3. IZM input information:

- Data from SWB, agricultural and climatic blocks from DB (section 4.9, 4.11, partially – 4.13),
- Data from HM, HGM, EM, SEM, block of scenario selection (section 3.12.1, 3.12.2),
- Data from internal DB –technical parameters of irrigation and drainage network.

3.9.4. IZM output information:

- Data translation to HM, EM (section 3.12.1, 3.12.2),
- Data translation to block of results interpretation – degree of irrigation water demand satisfaction, water losses, water supply, water consumption and water removal, agricultural production structure and volume, water-salt balance (forecast over scenarios).

3.10. Social-economic model (SEM) – is oriented at presentation of total indicators for entire sub-basin and over each IZ, large power plants, industry and water supply, assessment of water availability and water sector development, first of all, in irrigated agriculture.

3.10.1 Main requirements to SEM:

- Dynamics of demographic growth,
- Dynamics of production by different sectors,
- GNP dynamics over sectors and for entire sub-basin,
- Food stuff demand,
- Investment distribution over IZ and economic sectors.

SEM summarizes and describes within sub-basin (based on set of scenarios, measures, management rules, restrictions, macro-indicators and criteria) development of irrigated farming, rain-fed farming, cattle-breeding, poultry farming, industry and power engineering, municipal sector, fish breeding and forestry, rural water supply and recreation.

SEM unites water sources (surface, ground, return), power resources, water and energy consumers and users based on current and prospective balance.

Model permits to evaluate (through interconnection with other models) scenarios of social-economic development and ecologic stabilization as well as destabilizing factors consequences and risks (population number, climate, etc.) for sub-basin economy.

3.10.2 Special SEM attention is paid to following blocks:

- Capital investments,
- Export-import.

Block of "capital investments and financial resources":

- Dynamics of state investments and international financial organizations donations to water saving ,irrigation development, water sector and environment;
- possibility to attract additional capital investments:
- water sector own resources formed on base of water and pollution fees collection;
- municipal and irrigated agriculture resources (formed depending on IZ income);
- income of affiliated sectors.

Block "export-import" and processing:

- Cotton, agricultural row materials and secondary products;
- food staff.

3.10.3. SEM – economic-mathematical model in GAMS system having output to ASBMM and interconnected with all sub-basin models.

Iteration with HM – depending on decisions made in HM, GNP, sectors' production volume, damage compensation costs will change. From SEM to HM (power block) predicted prices for electricity, requirements to generation (hydro and thermal power stations) and back – volume of generated energy.

Main information from ecologic model – pure water availability.

Iteration with IZM . From IZM to SEM:

- food and export goods production,
- non-agricultural sectors water provision(industry, municipalities, fish-breeding, recreation).
- Irrigated and non-irrigated lands availability.
- Average water consumption and yield indicators.

From IZM to IZM:

- capital investments and financial resources distribution between IZ,
- Predicted prices on main crops and secondary production,
- Prediction of real purchasing price for crop cultivation production.

3.10.4. SEM input information:

- Data from SEM block, block of agrarian production and climatic block (section 4.10, 4.9, 4.11 and partially – 4.13),
- Data from IZM, EM, HM and HGM, SEM power block and block of scenario selection (section 3.12.1, 3.12.2).

Main input data

- population, its structure, urban and rural population, employment degree including over sectors, economic current and predicted growth rate;
- GNP dynamics over sectors (especially agriculture);
- general production structure including over sectors in terms of money;
- special stress on agriculture (irrigated and non-irrigated farming, fish-breeding – in physical volume and money terms);

• sub-basin needs in food, degree of satisfaction including at expense of own resources and import;
• GNP distribution over sectors and zones;
• balance of power needs and their satisfaction;
• affiliated sectors volume and income.

3.10.5. SEM output information:

- Data translation to IZM, HGM (section 3.12.1, 3.12.2),
- Data translation to block of results interpretation – population dynamics, production structure change, total water resources: available and required, water availability dynamics (irrigation, water supply, thermal power engineering, fish-breeding), satisfaction of energy and food demand, GNP, employment changes and recreation development.

SEM main outputs:

- Main social-economic indicators (population and GNP growth rate, GNP per capita, irrigated lands and irrigated lands per capita, etc.).
- Capital investments and financial resources distribution among IZ and administrative rayons;
- Food satisfaction degree;
- Water consumption in water supply and sanitary;
- Employment change;
- Needed agricultural production import;
- Possible agricultural production and energy export.

3.10.6 Power block (PB) within SEM permits to calculate range of indicators and sub-basin power balance in coordination with information coming from HM hydropower block about energy generation.

PB input information:

- Data from DB SEB power sub-block (section 4.10),
- Data from HM hydropower block and block of scenario selection (section 3.12.1, 3.12.2),

PB output information:

- Data translation to SEM,HM, HM hydropower block (section 3.12.1, 3.12.2),
- Data translation to block of results interpretation – power balance (required and prospective energy generation depending on selected scenarios of power engineering development).

3.11. During ecologic model (EM) development special attention was paid to ecosystems' formation and development decisive factors assessment because all factors can't be taken into account. Special attention was paid to ecologically vulnerable areas with assessment of allowable impacts and their changes forecast. Ecologic indicators dynamics is checked in time and space based on control lists and maps (based on GIS technologies). Under equal ecologic effect evaluation of alternative scenarios is determined by efficiency of other models' output parameters, mainly – social-economic and hydrologic.

Main goal of ecologic model is trace possible consequences of ecosystems change (rivers, reservoirs, landscapes) during sub-basin development, applied meaning – recommendations development on ecosystems' impact management. Apart from large objects, ecologic model traces small rivers' ecosystems more sensitive to ecologic changes compared with large ones.

Together with HGM, it is possible to track negative trends in ground water pollution in water supply places (in revealed zones of ecologic risk); together with GM – perspective of man and nature water provision, watercourses' optimal functioning support. For example, through HM it's possible to manage reservoirs' flowage and water exchange (that is most important for dry years), provide minimum ecologic river flows, observe reservoirs' ecologically safe level and emptying intensity; together with SEM - economic assessment of negative consequences of anthropogenic impact on ecosystems.

Ecologic model is strengthened by foreign partners' developments on water quality (J. Ganulis), biologic productivity and fish-breeding (M.Schneider), erosion (F.Lange).

EM input information:
- Data from DB ecologic block (section 4.7, partially – 4.13),
- Data from HM, IZM, HGM, FFB, scenario selection block (section 3.12.1, 3.12.2),

EM output information:
- Data translation to HM, IZM, HGM (section 3.12.1, 3.12.2),
- Data translation to block of results interpretation – water quality dynamics (retrospective, forecast) over main water objects – sources, distributive network, wastewater volume and quality, CDW in some zones of pollution, fish productivity dynamics, ecologic sustainability indicators, factors negatively influencing ecologic situation in sub-basin.

Within EM, FFB functions processing GIS-information about flow formation zone dynamics where beside factors directly influencing flow formation (forests), ecosystem and erosion areas are observed.

FFB input information:
- Data from DB SWB, climatic and ecologic blocks (section 4.6, 4.11, 4.7),
- Data from GIS – GIS layers of forest and water erosion areas with area calculation and borders fixation.

FFB output information:
- Data translation to HM and EM block of surface water(section 3.12.1, 3.12),
- Data translation to block of results interpretation – forest, erosion, flood, protected and recreation zones area dynamics (retrospective, forecast), including in comparison with IZ area.

Ecosystem assessment includes:
- Assessment of ecosystem ecologic state in flow formation and dispersion zone, ecologic sustainability of water objects' criteria and indicators selection,
- Assessment of natural geo-systems in mountains and plains – top soil and biodiversity, ecologic sustainability of natural geo-systems' criteria and indicators selection,
- Assessment of agro-landscapes – irrigated farming, water-related complex – ecologic sustainability of agro-landscapes' criteria and indicators selection,
- Assessment of anthropogenic load on natural ecosystems covers zones of flow formation (mountains and pre-mountain zone) and dispersion (river lower and middle reaches, plain zone) and includes:
- Assessment of industry and municipal enterprises influence on water resources ecologic state (surface and ground waters),
- Assessment of irrigated farming and cattle-breeding impact on water resources ecologic state
- Assessment of fish-breeding impact on water resources ecologic state
- Assessment of population on sub-basin ecologic situation.

3.12. Information exchange between models, their blocks and interface blocks (basic flows).

3.12.1 Hydrologic model links:

- With IZM:
  IZM → HM:
  - Required irrigated zone water consumption from surface sources (for prediction period),
  - CDW withdrawal from IZ to the rivers, adjacent IZ, re-use in place of origin (water volume and salinity) – forecast,
  - Ground water use (wells, springs) within IZ for irrigated agriculture, rural water supply (water volume, salinity) – long-term forecast.

  HM → IZM:
  - Designed water supply to IZ along canals' system - (water volume, salinity) – long-term forecast.
- With hydrogeologic model (HGM):
  HGM → HM:
  - Losses for percolation from rivers and main canals (long-term forecast in coordination with sub-basin water availability).

  HM → HGM:
  - Ground water wedging out in separate river and canal sites – water volume and salinity (long-term forecast in coordination with sub-basin water availability).
  - Ground water abstraction for water supply within singled water supply objects and industry – retrospective and forecast (water volume and salinity).

- With ecologic model (EM):
  EM → HM:
  - Ecologic requirements to water objects (releases along the rivers, reservoirs' filling and emptying) depending on long-term ecologic scenario,
  - Wastewater releases dynamics (water volume and salinity) with regard to planning units – water consumption objects in industry depending on long-term ecologic scenario,
  - Required water supply for fish-breeding development (ponds) for separate consumers within IZ in long-term perspective.

  HM → EM:
  - River and canal water volume and salinity –long-term forecast.

- With social-economic model (SEM):
  HM → SEM:
  - Available surface water resources including natural runoff, return flow, losses, total water consumption from the river network - long-term forecast
  - SEM → HM:
  - Required water consumption over water objects and industry.

- With HM hydropower block (HPB):
  HM → HPB:
  - Water inflow to power plant and releases from them (long-term forecast),
  - Dynamics of water volume in reservoirs with power plants (long-term forecast).

- With SEM power block (PB):

PB → HM:

- ➢ Water supply and releases from power plant - long-term forecast depending on power engineering development scenario.
- Between HM hydropower block (HPB) and SEM power block (PB):

HPB → PB:

- ➢ Designed power plant generation - long-term forecast depending on power engineering development scenario and accepted criterion of flow management and regulation.

PB → HPB:

- ➢ Required energy generation depending on power engineering development scenario (for predicted period).
- With surface water block (SWB):

SWB → HM:

- ➢ Designed coefficients of natural flow hydrograph transformation due to forest coverage and climate change depending on power engineering development scenario and predicted water availability.

- Between EM block of flow formation (FFB) and HM surface water block (SWB):

FFB → SWB:

- ➢ Forest coverage percentage from total watershed area – selected limiting landscape influencing flow formation (retrospective and forecast depending on flow formation zone changes).

- With block of scenario selection (SSB):

SSB → HM:

- ➢ Reservoir management and water distribution selected criteria code,
- ➢ Ecologic requirements to water objects (river sites, reservoirs).selected scenario code.

3.12.2 Other links between models and blocks

Hydrogeologic model (HGM) →social-economic model (SEM), ecologic model (EM):

- Designed water consumption from ground water in coordination with irrigation zones, water supply objects and industry for perspective.

EM → HGM:

- Ecologic restrictions on ground water use.

SEM → HGM:

- Required water consumption from groundwater in coordination with irrigation zones, water supply objects and industry for perspective.
-

Flow formation block (FFB)→ EM:

- Indicators of ecosystems' change as a share of eroded area, protected and recreation zones from total flow formation zone – retrospective and predicted dynamics depending on scenario of FFZ changes.

Power block (PB) → SEM:

- Elements of prospective energy balance (energy generation – required generation according to development strategy).

IZM → SEM:

- Designed water consumption for each irrigation zone over scenarios for long-term perspective (irrigation, rural water supply),
- Designed water supply to each irrigation zone over sources – surface, ground and return flow, CDW re-use over scenarios for long-term perspective,
- Designed water withdrawal from irrigation zone to the rivers and other irrigation zones (through releases to canals and collectors), over scenarios for long-term perspective,
- Degree of water needs satisfaction within IZ over scenarios for long-term perspective,
- Production, gross income, irrigated and non-irrigated farming cost within IZ over scenarios for long-term perspective.

SEM → IZM:

- Investment in irrigated agriculture development within IZ over scenarios for long-term perspective,
- Agricultural production prices within IZ over scenarios for long-term perspective.

HGM → IZM:

- Ground water abstraction for irrigation and rural water supply within IZ – retrospective and forecast (water volume and salinity).

EM → SEM:

- Production, income and costs in fish-breeding over scenarios for long-term perspective,
- Wastewater dynamics, its releases reduction (according to ecologic requirements) and use (releases to irrigation canals) in coordination with water objects over scenarios for long-term perspective,
- Wastewater and collector-drainage water volume exceeding allowable values on ecologic indicators) in coordination with water objects over scenarios for long-term perspective,

IZM → EM:

- Designed CDW volumes and salinity released to the) in coordination with water objects over scenarios for long-term perspective,

EM → IZM:

- Restrictions on CDW release to rivers, canals) in coordination with water objects over scenarios for long-term perspective.

Block of scenario selection (SSB) → Surface water block (SWB):

- Input code of selected climatic scenario.

SSB → SEM, IZM:

- Input code of selected climatic scenario of social-economic development (optimistic, business as usual, investments options),

Input code of climatic scenario
SSB → HM hydropower block, SEM power block:
Input code of hydropower development scenario
SSB → EM:

Input code of ecologic requirements scenario

- To water objects (river sites, reservoirs),

Input code of selected scenario

- Ecologic requirements to pollution sources (CDW and wastewater).

SSB → EM flow formation block:

Input code of IZ changes scenario

Block of interface results interpretation → GIS:

- Modeling results in terms of indicators allowing assess water-related, ecologic and social-economic situation for perspective – irrigation zone water availability, zoneof risk stability, negative anthropogenic impact, ecologic and economic sustainability indicators.

GIS > Block of interface results interpretation:

- Indicators' visualization in terms of color indicators on GIS-layers (objects on maps and schemes).

4. Requirements to database and GIS

4.1. Software: Access 97, ARC VIEW/INFO, Visual Basic.

4.2. Main DB components:

- Surface water block,
- Ground water block,
- Agrarian production block,
- Climatic block,
- Ecologic block,
- Social-economic block

Power information is formed in sub-blocks within surface water block (hydropower engineering) and social-economic block (power engineering as a whole).

4.3. Project objectives and integrated processes' modeling principles suppose certain requirements to database formation, which can be taken into account by:

- Data standardization,
- Establishing single coding system,
- Logical data compatibility over diapason, units, information sources, object types – point, line, area (contour).

Information model supposes data summarizing during both initial information preparation stage and stage of results interpretation over scenarios:

- Scenarios of sub-basin and its separate territories' economic development,
- Climatic scenarios and their impact on natural river flow (according to types of water availability, with stress on extreme availability years, on base of historical data) and water requirements.
- Water management scenarios – options of water resources optimal distribution over the area and in time satisfying water consumers (water supply, irrigated farming) and water

users (power engineering, industry, fish farming, recreation) observing ecologic safety and consumers' ranking.

Main DB limiting factors are as follows:

- Trend of population number change (social-economic block),
- Water consumption norms over development stages (block of agricultural production),
- Quality standards and ecologic restrictions in terms of river flow, reservoir operation regime, return flow releases, ecosystems' protection, preventing groundwater exhaustion (ecologic block).
- Water and land resources potential productivity planned over development stages (agricultural production block),
- Coefficients of planned flow use efficiency supposing minimization of organizational and technical losses over development stages (agricultural production block),
- Planned trends of investments (social-economic block).

Ecologic assessment of development and management options is one of most important modeling output, which will be interpreted in suitable for user form (archiving in DB).

Output forms of ecologic situation analysis are a base of decision making in prospective planning including use of color indicators on maps, schemes fixing zones of risk, appropriate measures reducing risk according to objects' ecologic situation (satisfactory, unsatisfactory) with target requirements to drinking water quality and water bodies' preservation.

Another important link of this system are social-economic assessment output indicators with minimum set of main indicators and scenarios, assessment of probable effects and damage.

4.4. Requirements to GIS:

- Creation of GIS information layers over types of selected objects (section 2.1.1….2.1.5, 2.2, 2.3, 2.4),
- Establishing links with GIS layers and DB objects along borders (contours), lines and points.
- Development of integral GIS-model (within block of results interpretation) allowing use GIS-technology for modeling analysis.

Sources for GIS-layers creation: geographic maps, space images.

4.5. Each DB block development includes standard operations:

- Development of block structure (according to project objectives and model requirements),
- Objects' indexation and coding, information flows, logic and functional links identification,
- DB forms and tables preparation,
- Data collection from information sources or special studies and analysis,
- Data processing and DB filling,
- Development of modules for initial information processing, intermediate and output data calculation for model information provision, analytical requests and reports' formation.

4.6. Surface water DB (surface water block including hydropower sub-block) is developed according to item 1.9 of RIVERTWIN work schedule.

Main information sources on surface water use are as follows:

- BWO "Syrdarya" (section 4.14),
- MAWR of Uzbekistan and Chirchik-Ahangaran irrigation systems' basin administration (section 4.13),

- Glavgidromet (hydrologic bulletins), regional DB (SIC ICWC) AND "ARALCONSULT" (information about Kazakh objects).

Main information content:

- Technical data of hydrostructures (water works, hydropower plants) – capacity, links between water level and discharge,
- Efficiency – (designed and actual) of irrigation systems, main canals, irrigation network within IZ, hydropower plants,
- Average decade and monthly data (1980, 1985, 1990, 1995, 1998-2003) of discharge on gauging stations, hydropower plants, side inflow, return water (CDW, wastewater) transferred between Chirchik and Ahangaran basin, Uzbekistan and Kazakhstan according to accepted planning units,
- Water consumption structure – agriculture (irrigated farming, rural water supply, fish-breeding), drinking and industrial water supply, thermal power engineering (local objects).

Regional DB is used (flow time series up to 1998).

Collection and analysis of additional information is carried out according to item 2.7, 2.3, 2.4 of RIVERTWIN work schedule and for local objects –by inspection (item 2.6, 2.7).

According to surface water block, main part of HM information provision is formed, its hydropower block and surface water block (section 3.7), IZM uses local resources (section 3.9) and EM flow formation block (section 3.11).

4.7. Ecologic DB (ecologic block) is developed according to item 1.5 of RIVERTWIN work schedule for 1980, 1985, 1990, 1995, 1998-2003 indicators::

- Ecologic state of natural landscapes, agro-landscapes, and industrial zones,
- Sources of anthropogenic load on ecosystems of flow formation and use zone,
- River, ground and return water quality indicators with physical-chemical characteristics, water salinity and main ions, biogenic elements, organic matters, heavy metals.

Data are prepared according to item 2.4 and 2.6 of RIVERTWIN work schedule.

Main information sources:

- Glavgidromet of Uzbekistan – surface water quality account and control,
- Glavgeologia of Uzbekistan – ground water account and control,
- GOSSIAK – wastewater account and control,
- Hydro-reclamation expedition of MAWR – return water account and control,
- Sanitary-epidemiologic service of the Ministry of Public Health – drinking water sources quality – water sources quality control,
- Tashkent Committee of nature protection,
- State Concern "Uzbekbalik".

Main indicators of water quality are as follows:

- Physical-chemical (pH, T, dissolved oxygen, dispersed matters),
- Salinity and main ions:
    - Ca^{2+},
    - Mg^{2+} ,
    - $Na^{+}+ K^{+}$,
    - HCO_3^{-},
    - SO_4^{2-},
    - CL^{-};

- Biogenic elements:
    - Nitrogen compounds
    - ammonium
    - nitrates
    - nitrites
    - phosphates
- Organic matters:
    - CCO
    - BCO_5
- Heavy metals (chromium, copper, lead, mercury, nickel, zinc) and iron,
- Organic matters (phenols, oil products, pesticides).

Based on ecologic block data, main part of EM FFB information provision is formed (section 3.11).

4.8. DB "Ground water" (ground water block) is established according to item 1.10 of RIVERTWIN work schedule and contains following information:

- Network of groundwater sources in connection with consumers – irrigated zones, water supply objects and surface water resources,
- Retrospective data on ground water availability and use (quantity, quality, water supply regime dynamics).

Data are prepared in accordance with item 2.8 of RIVERTWIN work schedule and used for HGM information provision (section 3.8),

4.9. DB "Agricultural production" (agricultural production block) is developed in accordance with item 1.7 of RIVERTWIN work schedule and includes following information:

- Sown area including irrigated and non-irrigated lands, households including crops, sowing time, harvest and yield (is prepared in accordance with item 2.5 of RIVERTWIN work schedule),
- Data on cattle-breeding – cattle population and production (is prepared in accordance with item 2.5 of RIVERTWIN work schedule),
- Data on agro-economics (is prepared in accordance with item 2.6 of RIVERTWIN work schedule),
- Data on soil properties (is prepared in accordance with item 2.6.1 of RIVERTWIN work schedule),
-

Main information sources:

- MAWR of Uzbekistan and Chirchik-Ahangaran irrigation system basin administration,
- Goskomzem of Uzbekistan,
- Regional DB (SIC ICWC).

Tentative data structure:

- Gross area: land under agricultural production; forest; roads, canals, buildings; settlements and cities; protected area along rivers and water bodies; fallow lands, gross and net irrigated area, non-irrigated area.
- Irrigated lands: land fund (arable land, perennial vegetation, fallow lands, hey fields, pastures, households); agricultural production on irrigated lands (sown area, crop yield capacity, gross yield); specific water consumption; irrigated lands distribution over ground water table and salinity, soil salinization and fertility, drainage modulus.

- Non-irrigated lands: agricultural production on non-irrigated lands (sown area, crop yield capacity, gross yield. Sowing time on non-irrigated and rain-fed lands.
- Crop growing season on non-irrigated and rain-fed lands.
- Agricultural production forms on irrigated and rain-fed lands: average farm area.
- Cattle-breeding: cattle population (cattle, seep, goats, poultry); production (meat, milk. eggs).
- Argicultural production cost: machinery, labor, seeds, fertilizers, fuel, others; administrative and depreciation expenses.

Based on block data, IZM information provision is partially formed (section 3.9) and SEM (section 3.10).

- **4.10**. "Social-economic DB" (social-economic block and its power sub-block) is prepared in accordance with item 1.3. of RIVERTWIN work schedule,
- Water consumption data (water supply, releases) for local objects in connection with HM structure and SWB DB (is prepared in accordance with item 2.3. of RIVERTWIN work schedule),
- Social-economic parameters coordinated with IZ (is prepared in accordance with item 2.6.1 of RIVERTWIN work schedule),

Tentative data structure:

- Demography: number of residents (by the end of year), th. people, urban population; birth rate (per 1000), death rate (per 1000), life expectancy, internal migration, th. people, external migration, th. people, family composition.
- Economics: GNP, bln. $, GNP structure over sectors, %, export share, %, import share, %,
- Production, bln. $: farming, cattle-breeding, fish-breeding, poultry farming, silkworm-breeding, secondary processing,
- Agricultural production prices (purchasing, market): crops, cattle, poultry, silkworm, fish, etc.
- Expenses per unit production, th. $,
- Power engineering: KVH cost, $, ton of coal, $, 1м3 gas, $; energy consumption (agriculture), kvh, (industry), кvh, energy generation, kvh, - hydropower plants, %, ТЭС, %, required water supply for thermal power plants, return, water expenses per energy unit,
- Employment (average for year), th. people, able-bodied, th. people, economically active population, th. people, involved in economic activity, th. people, employed population structure, %,
- Investments**:** investment volume, mln.$, foreign investments, mln.$, private investments, mln.$, investment sectoral structure, млн.$, needed investments in agriculture, mln.$, real investments in agriculture, mln.$, expenses for water services, th. $,
- Population income, bln. $, GNP per capita (real and statistical), $/capita, population expenses, bln. $, income per capita, th. $,
- Industry: production volume, bln. $, development growth rate, %, industrial production structure, %., over water consumers – required water supply, return, cycle; water use norms per production unit,
- Municipal needs: over separate objects as water consumers – required water supply, release, water supply per capita,

- Fish-breeding: average fish price, $ /kg, requirements to water resources, over separate objects (ponds) – required water consumption,
- Nutrition: food consumption according to consumptive basket, medical norms of food consumption,
- Recreation and tourism: number of pensions and recreation zones, population number visiting recreation zones; average cost of 1 day, $, requirements to water and natural resources.

Based on block data, SEM and its power block information provision is partially done (section 3.10).

4.11. Climatic DB (climatic block) is developed according to item 1.11 of RIVERTWIN work schedule.

Main information is presented by parameters: temperature, precipitation (mm/month), evaporativity (mm/month), relative humidity and prepared in accordance with item 2.9 of RIVERTWIN work schedule over climatic zones, IZ, reclamation zones, flow formation zones, reservoirs.

Based on blocks' data part of SWB information provision (section 3.7), IZM (section 3.9) and SEM (section 3.10) is formed.

4.12. DB interface units all DB blocks into single system of data coding, input, processing and output (is developed according to item 1.13 of RIVERTWIN work schedule).

4.13 Based on information from Chirchik-Ahangaran irrigation systems' basin administration, following data are used for DB filling and modeling (preliminary list):

- Water discharge over river gauging stations and decades;
- Water limits and actual discharges to canals over decades;
- Ground water use with source and consumer – water supply, irrigation over rayons or cities, industrial centers,
- Side inflow to rivers and canals: (1) releases to sais, (2) releases from canals, (3) CDW releases, (4) wastewater releases over decades,
- Discharge transferred between Chirchik and Ahangaran sub-basins over decades,
- Inflow, releases and water volume in reservoirs over decades,
- Hydropower plant required water discharges,
- Water consumption structure (%) – irrigated farming, rural water supply, fish-breeding in connection with irrigation systems, rayon and main canals,
- Water diversion (discharge from surface sources – cities, industry, thermal power,
- Ground water use with sources and consumers - water supply, irrigation over rayons or cities, industrial centers,
- River, irrigation and return water salinity over decades,
- Land fund and reclamation state: geographic area, arable land, irrigated lands, non-irrigated lands, crop pattern, households, drainage, ground water level and salinity, drainage modulus (m3/ha) over rayons and irrigation systems for last 5 years,
- Production forms: water use number and composition (shirkats, private farms, dehkan farms) over rayons and irrigation systems, their characteristics (area, required water consumption),
- Surface and ground water quality indicators (chemical composition, biologic parameters),
- Main canals and irrigation systems' efficiency (average for system),

- hydrostructures – water distribution management and control points: capacity, link between water level and discharge,
- economic indicators: production volume (cattle population, agricultural production, cattle-breeding, fish catch, crop yield, prices (tariffs) on agricultural production and water supply, irrigation systems' O&M cost, production cost, irrigation, industrial and drinking water productivity,
- Linear schemes and maps, administrative rayons, settlements, industrial centers, roads, hydropower plants, thermal power plants, reservoirs, river and irrigation-drainage network, irrigated and non-irrigated lands, soil and vegetation cover, rain-fed lands, pastures, ground water sources, protected and recreation zones.

4.14 Following BWO "Syrdarya" data for 1998 – 2004is used for DB filling:

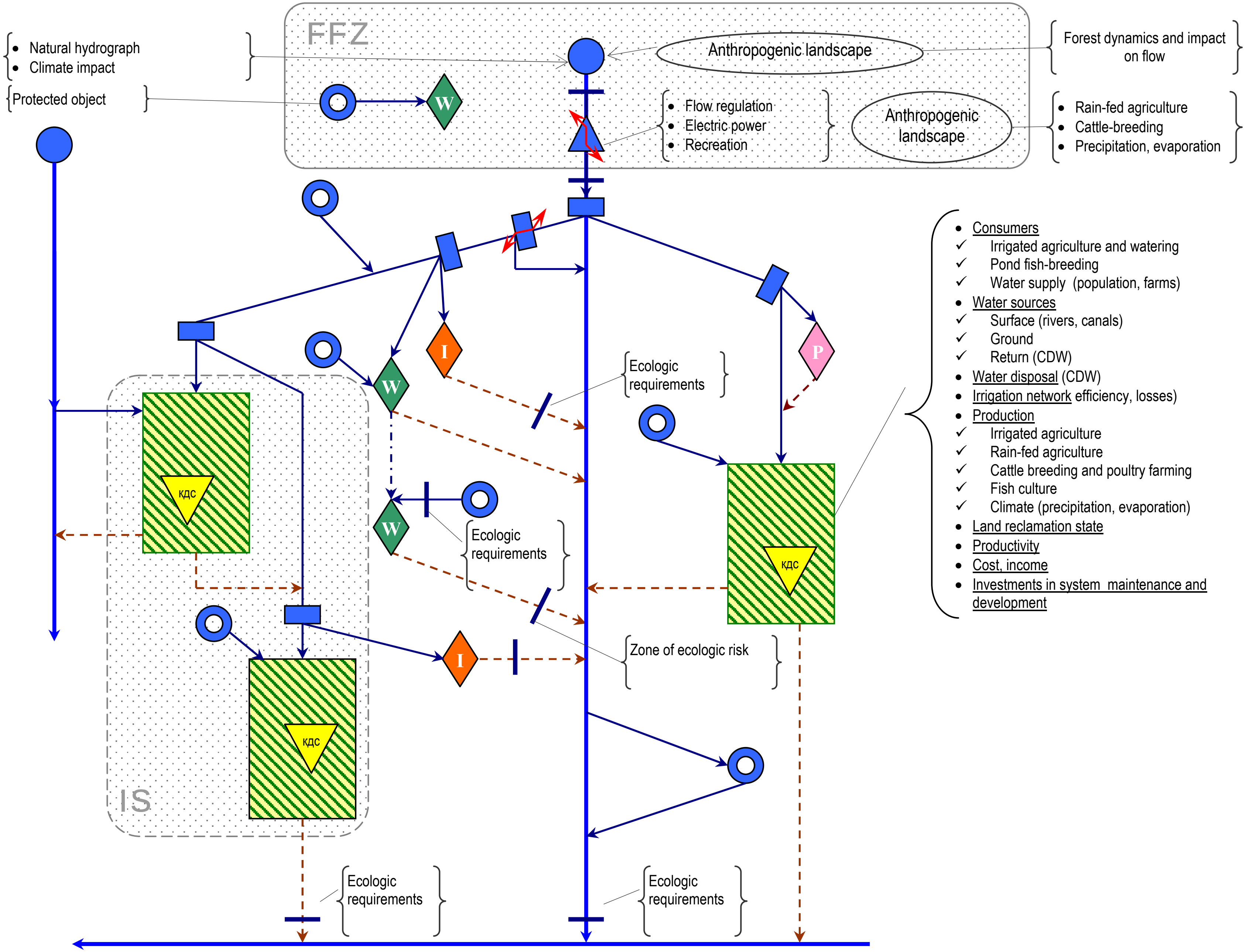
- Actual head discharges and limits over decades for typical 3 – 4 years;
- River discharges over gauging stations and decades for typical years;
- Side inflow for typical years;
- Reservoir inflows, releases and volumes for last 6 years;
- River water salinity data.

Conclusion

Integrated model connecting all components of sub-basin water-related, ecologic and social-economic situation management and assessment should allow to select (among alternatives) and justify such development scenarios, which can provide reasonable social-economic requirements and ecologic sustainability (with set of measures) under minimum investments.

Main task is to find real way of agreed interaction of all modeling components and definition (though numerical iteration) optimal regimes and sustainable functioning conditions of sub-basin and to prevent probable negative consequences of future anthropogenic impact.

Modeling objects' coordination (NAS principal scheme)



- Surface water source
- Ground water source (wells, springs)
- Water work (dam, hydraulic structure)
- Power plant
- Water reservoir
- Water reservoir with power plant
- Gauging station
- River site, water intake, escape
- Canal site, water intake (inlet), escape
- Collector site, escape
- Pipeline site within "Vodokanal" network, water supply along pipeline
- Irrigated zone
- Flow formation zone (FFZ), irrigation system (IS) (- - - - -)
- Industrial water use
- Thermal power plant (TPP)
- Water supply object (settlements)
- Natural and anthropogenic landscape
- List of factors characterizing objects
- CDW (in-contour re-use),water diversion